ΚΕΝΤΡΟΝ ΕΛΛΗΝΙΚΗΣ ΚΑΙ ΡΩΜΑΪΚΗΣ ΑΡΧΑΙΟΤΗΤΟΣ
ΕΘΝΙΚΟΝ ΙΔΡΥΜΑ ΕΡΕΥΝΩΝ

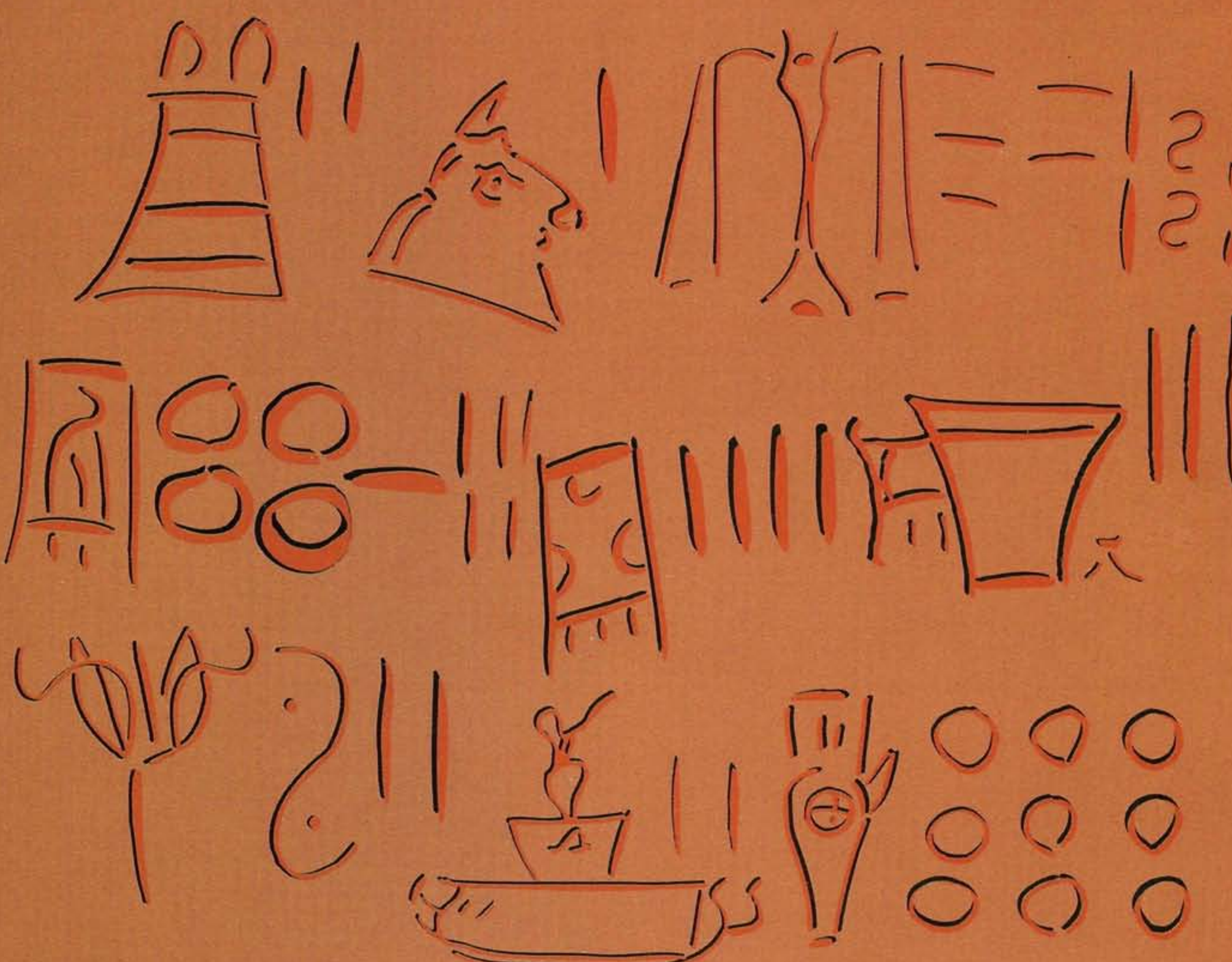
RESEARCH CENTRE FOR GREEK AND ROMAN ANTIQUITY
NATIONAL HELLENIC RESEARCH FOUNDATION

ΜΕΛΕΤΗΜΑΤΑ
33

Anna Michailidou (Editor)

MANUFACTURE AND MEASUREMENT

Counting, Measuring and Recording Craft Items in Early Aegean Societies



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Cover illustration: Selection of items recorded on various Linear B tablets
(design by M. Zacharioudakis)

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Edited with the assistance of
Pigi Kalogerakou & Katerina Voutsa

ATHENS 2001

Dedicated to the memory of Manolis Andronicos

By those of the authors
Who were his students
And by the others
Who wish they had been

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FOREWORD

The publication of each new volume of the ΜΕΛΕΤΗΜΑΤΑ series is an event which gives great pleasure. But the publication of this new volume edited by Anna Michailidou and dedicated to manufacture and measurement in early Aegean societies has a special significance. It is the first in the series to deal with second millennium archaeology and history, and it will soon be followed by others, opening a new and promising field of research for our Centre.

Early Aegean and, more particularly, Mycenaean Studies, after a rapid expansion in the third quarter of the last century, mainly due to the decipherment of the Linear B script, experienced a long period of stagnation before a new blossoming in very recent years. This we owe to two independent but converging developments: on the one hand the increase of the corpus of texts, thanks to the patient joining of fragmentary documents already known as well as to the discovery of new archives in unsuspected parts of the Mycenaean world; and on the other hand the application of novel approaches, inspired by new trends in archaeology, to their study.

Old passions, particularly passions of youth, die hard and a little fresh air is enough to rekindle the flame. Long before the stones of Macedonia, even before structural analysis of Spartan cults, my first scholarly infatuation was with the Mycenaean world. I was fortunate to be initiated to it by Michel Lejeune and to discover it in the company of my life-long friend Olivier Masson at the IVe Section of the École Pratique des Hautes Études. Since then I have followed with enthusiasm the progress of Mycenaean studies and always regretted that they are not given the importance they deserve in Greece. Recently, parallel discoveries and scholarly breakthroughs on both sides of the Aegean sea have revealed to us in its complexity and richness the political map of the Late Bronze Age. Hieroglyphic and cuneiform documents allow us to recover the political history and the historical geography of that period, while the ethnics figuring in the Linear B tablets indicate, be it indirectly, trade routes, ports of call and points of contact between Achaean Greece and Hittite Asia Minor. Such high-level history, passionately interesting though it is, would remain to a large extent unexplained, not to say incomprehensible, without the study of the humbler activities of the craftsmen who produced, measured, weighed and thus prepared for commercialisation the artefacts which followed the great trade-routes and were exchanged at Knossos, Thebes, Miletos, Ephesos or other important centres of the Aegean. To these activities is the present volume dedicated, and I am grateful to Anna Michailidou and all those who contributed to it for having conceived, planned, financed and prepared it for us to read and learn from.

Miltiades B. Hatzopoulos
Director of the Centre for Greek and Roman Antiquity

CONTENTS

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INTRODUCTION

Anna Michailidou

The writing of a book calls for a central idea that will provide the author with the necessary inspiration. While Iris Tzachili was writing in her doctoral dissertation about the different quantities of wool required for each kind of textile, I was striving to understand precisely what it was that people measured with the balance weights found in the prehistoric town at Akrotiri on Thera. Our discussions led to the central idea for this book, the connection between prehistoric technology and accounting. And, in this, we were also concerned with the role of writing, not only because in its absence we would not have even the limited knowledge we do possess of our subject,[1] but because the way in which the result of a measurement or a count was recorded by the inhabitants of the early societies of the Aegean and the surrounding area affords a clue to the economic context of the three actions involved.[2] More specifically: for which craft-industrial products, or the raw materials used in them, were records kept, by whom, how and why? The central idea acts as a stimulus to investigation, which follows routes sometimes leading to remote areas. The object of the investigation –selected archaeological finds and written testimonia– leads the inquiry into different cultures. Experience in research warns us of the dangers posed by incompletely preserved material or textual evidence, and by our inevitable subjectivity.

The writing of a book also requires an occasion: the present volume is the result of a research project submitted, on behalf of the Centre for Greek and Roman Antiquity, to the General Secretariat for Research and Technology (*ΓΓΕΤ*) for the Programme of Support of Young Researchers (*ΠΕΝΕΔ*). The proposal was approved in return for an undertaking to design a database relating to weighing activity attested in the Linear B tablets, and at the same time to train three young researchers in this field of knowledge. As a true archaeologist of the old school, however, I am drawn more to the printed page than to the screen and I therefore suggested to my colleagues in the project that a book should be published on the subject of our research.

These colleagues –old friends from the work group of the excavations at Akrotiri, Thera[3] and young postgraduate students at the University of Athens[4]– took up the challenge. I suggested

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[1] For writing, according to Thoth, the Egyptian god who invented it, is 'an elixir of memory and wisdom', while according to Socrates, it is 'an elixir not of memory but of reminding' (Plato, *Phaedrus*, 274-275).

[2] Manufacture, accounting and writing, the sequence of which varied: measurement of the raw material before the act of manufacture, measurement of the finished product, record of the former and/or latter measurement.

[3] Dr I. Tzachili, Dr K. Trantalidou and Dr A. Sarpaki.

[4] The colleagues who worked on the database for the programme, D. Kriga, A. Dialismas and K. Voutsa, were encouraged to make their first appearance as writers on subjects related to the dissertations on which they were working. The subject chosen by the first of them –the find places of the tablets– has not been included in this volume since it has now been dealt with in three articles of the journal *Minos* (1996-97). The subjects treated by the other two young researchers are meant to complement the concerns discussed in the other chapters, which are of a broader content.

subjects, discussion followed, after which the chapters were defined according to individual expertise, and then each author set off along his or her path. Other scholars,[5] whom I knew to be working in related fields, agreed to contribute to the volume. The chapters of the book correspond with only some aspects of the central idea, since each contributor was guided by his or her personal research. I did not consider it desirable to prescribe from the outset regulations relating to homogeneity and length, but felt it preferable to leave the contributors free to express what they themselves adjudged could be said, from the point of view of their own specialities. This means that the editor of the volume would not interfere with the views expressed; and this explains why, despite the fact that the original idea for the book derived from the Mycenaean tablets, the articles extend to other horizons, both chronological and geographical, either because this was rendered necessary by the methodology involved in the specific piece of research or because it was dictated by the nature of the material and the problems arising from it.

Accounting is related to the creation, storage, circulation and distribution of products. As is apparent from the title, it was decided to concentrate on craft-industrial production; the extensive agricultural production will have to form the subject of a separate volume. Generally speaking, there is a difference between the two in the method of accounting, a unit of weight being predominantly used for craft-industrial goods (such as wool and objects of metal) and a unit of volume for agricultural products (grain, wine, oil, figs, etc.). For the numerical system that lies at the bottom of every metrical system, the foundations in the investigation of the south Aegean evidence were laid by Evans (1935) even before the decipherment of the Mycenaean script, while Bennett's work (1950) on Bookkeeping in the Linear A and B documents remains a classic. After Ventris and Chadwick (1956), the article by Sacconi (1971) associated the specific *segni di misura* in the Linear B script with particular products, while Killen's article (1962) provided scholarship with the special unit *LANA*, used to weigh wool. For the metrical system of weight, in particular, the work by Evans (1906), Caskey (1969) and Parise (1964) came first and the crowning achievement of metrological research by Petruso followed (1978 onwards): these studies mark a shift in interest from the evidence of the documents to the mathematical information embodied in the instruments of measuring themselves (the balance weights). Chadwick (1976) completed the circle by converting the values of stone balance weights from Knossos to multiples of selected Linear B signs/metrograms. Cherry (1980, 1983) proposed the statistical tool for the investigation of Aegean metrology. Renfrew (1983) included the designing of a metrical system amongst the objects of study of so-called Cognitive Archaeology, or Archaeology of Mind.[6] It is thus the human mind for which we are seeking behind the evidence relating to accounting and writing.

The division of the volume into two parts was dictated by the content of the chapters submitted, since the basic aim was to exploit the special expertise of the particular scholars rather than to ask them to accommodate themselves to a predetermined general scheme;[7] for the same reason, the Aegean remains the main area of investigation. The common link between all the chapters is the search for quantity, preferably in the manufacturing process associated with a technological product, whether it is directly recorded or can be calculated on the basis of later evidence and data drawn from outside the Aegean. The first part of the book deals selectively

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[5] Dr Ch. Marangou and Dr A. Karnava.

[6] The title of Renfrew's Inaugural Lecture in Cambridge, in 1982. See also Renfrew & Zubrow 1994.

[7] For instance one could have started with the primitive counting system (using the fingers) and continued with the transference to language of the related terms –cf. the hand-numerals or digit-numerals of Tylor's classification in *Primitive Culture* (1913)– with the subdivision into digits of the ancient Egyptian length-standard, the grouping into fives found in makeshift Mycenaean records or the activity called *πεμπάζειν* in the ancient Greek, and so on.

with some stages in the evolution of prehistoric or proto-historic accounting and with its interlocking relationship with writing. The second part is concerned rather to associate the two activities with the production of particular goods.

I. For the Egyptians, mathematics and writing were not invented by a mere mortal, but by the god Thoth. The modern archaeologist, however, believes in the abilities of the human mind, so at the beginning of her chapter, Christina Marangou sets out in search of the mind of Neolithic man. In her semiotic study of 'Artefacts as signs and signs on artefacts' she assembles the probable evidence so far for counting and writing, mainly from Neolithic sites in northern Greece. Since the views on the role played by tokens in the Near East are well-known (as, too, is the criticism to which they have been subjected), she sets the material under investigation in the broadest possible context, referring to the parameters that potentially influence its operation. It having been established that in the Neolithic period there was the necessity and also the ability, to devise a system of signs for special ends, their use for other purposes, like counting, cannot be ruled out.

For the leap (or evolution?) to an accounting script, Artemis Karnava cites the example of the documents written in the Cretan Hieroglyphic script. Ideograms (or logograms) for products are followed by numbers, both integers and fractions. The existence of a fraction confirms that the quantity of the good denoted by the ideogram was measured (in contrast with the integers, which may only indicate the simple counting of items). The devising of a metrical system (for length, volume or weight) presupposes the concept of fractions. Research into the Cretan Hieroglyphic script is at a very interesting stage; this script antedates and is partly contemporary with Linear A, the fractions in which have been the subject of exhaustive (and conflicting) studies. What is certain is that by the time of Linear B, fractional numbers had been replaced by whole numbers of fractional quantities, themselves expressed by individual signs that formed the units of the metrical systems.

The content of the final chapter of part one deals with the relationship between metrology and writing. In it, Anna Michailidou discusses weights or balance weights that are inscribed with Linear A signs. It is noted that there are very few instances of deliberate or officially sanctioned inscriptions on balance weights in the Aegean, in comparison with the practices of neighbouring countries in the eastern Mediterranean, with a simple sign, or no sign at all, being much more common. The view that certain 'practical processes' were retained in the context of 'cognitive inventions'[8] is further supported by the survival of methods of standard accounting attested by specific weight units for particular goods (gold, wool, saffron). The term 'concrete weighing'[9] is proposed, and it is suggested that the reason for this phenomenon is to be sought principally in the mode of production of the goods in question, which affects their exchange value.

II. The second part of the book is devoted to the circumstances of production, circulation and accounting associated with craft-industrial products made of metal, wool, linen and other animal or vegetal processed materials, with the focus on the methods by which they were recorded.

In the first chapter on metals, the subject of the study by Anna Michailidou is quantity, as it was circulated (in the standardised form of the ingot, as waste material or rejected artefacts destined for recycling, or as finished product to which the value of the work is added), as it was recorded in the archives, and as it is documented by measuring the weight of archaeological finds. Tables of artefacts and fragments of texts are appended by the author. It is noted that the

[8] Hence the subtitle of the chapter in question.

[9] Whereas 'concrete counting', as a preliminary stage of counting, ended up in the abstract numbers, 'concrete weighing' seems to reappear, also in connection with the general (abstract) scale applied to other goods.

Mycenaean tablets do not contain the variety of records to be found in the tablets of the Orient: in the latter the weight of the metal is recorded at every stage of the metal-working process, when the production is checked, and when it is distributed at all social levels. Nonetheless, a homogeneous picture emerges of the mechanisms for the circulation of metals in the pre-coinage societies of the eastern Mediterranean, and it becomes evident that everywhere the central authority felt it necessary to take steps to control their circulation. The important feature here is that, alongside the intervention of the 'palace', it can be seen that the exchange value of the metal could be exploited at the practical, everyday level and in an urban environment.

In the second chapter, Alkis Dialismas returns to the Mycenaean tablets –with an extensive and occasionally repetitive bibliography on the subject of metals– in order to isolate the finished products and give a clear sketch of the numbers produced or at least recorded (with representative tables drawn from the relevant database of our Institute). In order to furnish a fuller context for some of the wider subjects investigated in the present volume, the objects are classified in three categories: those that are thought certainly to be of metal, either because they are accompanied by a qualifying symbol for metal, or because the use of metal for their construction is an inevitable conclusion from the function of the objects in question; objects that might be of metal, but which are not accompanied by any indication to this effect; and objects whose construction material included metal. Attention is drawn to the mature stage of the research to date, which makes it possible to draw comparisons –in terms of quantity as well as of kind– with the archaeological record, both in the sphere of production and in that of consumption.

Amidst this deluge of raw materials and finished products, a useful contribution is made by Katerina Voutsa on the human capital recorded in the Mycenaean tablets. Her study in the field of personal and craft names –a domain already at an advanced stage of research– is prefixed by an attempt to establish an overall picture of the productive process: from the moment the raw material arrives –in whatever way– in the hands of the craftsmen to the moment the finished products are delivered. The evidence is classified under three categories. For weaving and, to a lesser extent, the production of aromatic oils, leather working and the manufacture of chariots, all three factors can be established: the raw material, the craftsman, and the finished product. In the case of metal-working, the craftsman is recorded in the context of his relationship either with the raw material or with the finished product (so two factors each time of recording). The third category (one factor only) includes craftsmen recorded in isolation, who can only be identified as such on the basis of their professional name; tables are appended linking the term of the relevant trade with raw material or finished product.

There follow two chapters on textiles by Iris Tzachili. The first was read at a 1987 Aegean conference that was never published; at that time research was oriented mainly towards the wool and less to the finished product. This chapter deals with the circulation of textiles, and poses questions such as what was the relationship of the trade of textiles to the creation of a surplus in palace society, to what regions were Minoan textiles probably despatched, and with what kinds of goods were they exchanged in return. She notes that the most common archaeological evidence for weaving –spindlewhorls and loomweights– are most often found at ports in areas that do not always fall under the immediate palace authority; invoking also the testimony of the Mycenaean tablets, she suggests that the palace attempted to intervene in areas that had previously functioned independently of it.

Her next chapter concentrates on the quantities of textiles recorded in the Mycenaean archives at Knossos, with an attempt to arrive at a historical assessment of the data. This is preceded by a theoretical introduction on the meaning of quantity, in which she notes that the calculation of quantity is not to be seen as an absolute, but was almost always a comparative act; quantities are investigated mainly to establish the place occupied by a particular category of goods within the general productive system of a settlement. There follows a classification by ideogram of the textiles counted in the **KN L, Lc, Ld** and **Le** series, with special reference to textiles discussed as gifts for foreigners (?) or destined for elite recipients. After counting the number of textiles recorded, the author poses the crucial question: are 5,700 pieces many or few? This confirms the necessity of the theoretical concerns set out at the beginning of the chapter.

Our attention is turned to raw materials derived from plants by Anaya Sarpaki, who adds the perspective of the archaeologist-archaeobotanist to the varied and extensive bibliography on Mycenaean tablets relating to perfumes and spices. She deals with all plants that were used as perfumes, spices, or dyeing materials, drawing upon the archives published so far. In an attempt to establish the possible economic and social implications of the investigation, she notes the recording in Pylos and Mycenae of aromatic herbs from regions outside the Aegean. As a result, she concludes that at the two sites just mentioned these luxury goods were consumed, to a greater extent than at Knossos, which, on the basis of the corresponding archives she describes as mainly a production centre.

Reference to textiles in previous chapters leads on to the subject of raw products derived from animals –mainly wool– which takes us to the question of the processing of animal products, dealt with at length by Katerina Trantalidou in the following chapter. Her interest is concentrated on leather, which has attracted far less attention from scholarship than wool, despite the fact that archaeological finds (both small finds themselves and the iconography), ethnographic evidence and texts from the Orient demonstrate the importance of its role in production and circulation, and consequently in accounting (normally involving counting, though there are some cases of the weight of leather being recorded). Using evidence drawn from later literary sources, and appending tables illuminating the role played by quantity in early modern times, she concludes that this review of the secondary products demonstrates that the same materials, used over millennia, were counted, weighed or had their volume measured. In the case of the palace economy, in particular, the tendency was primarily to control the production of wool, which was used for clothing, and only secondarily for the palace to concern itself with other animal products which were used in defensive or offensive weapons and armour production.

The second part of the volume is followed by an Appendix giving details of the database, set out by Alkis Dialismas, with examples of tables relevant to the subjects of the chapters in this volume.

The final aim of this book is not to prove new ideas or to further document old ones; it is meant to give the archaeologist's view of the sources available and to combine in one volume crucial topics related to the subject of counting, measuring and recording craft items in pre-coinage societies. The opening of each chapter is so designed as to give emphasis to the diachronic role of mathematics and manufacturing technologies; this is why the photographs used to this end do not provide archaeological documentation but are deliberately chosen to illustrate related subjects from the life and art of much later periods.

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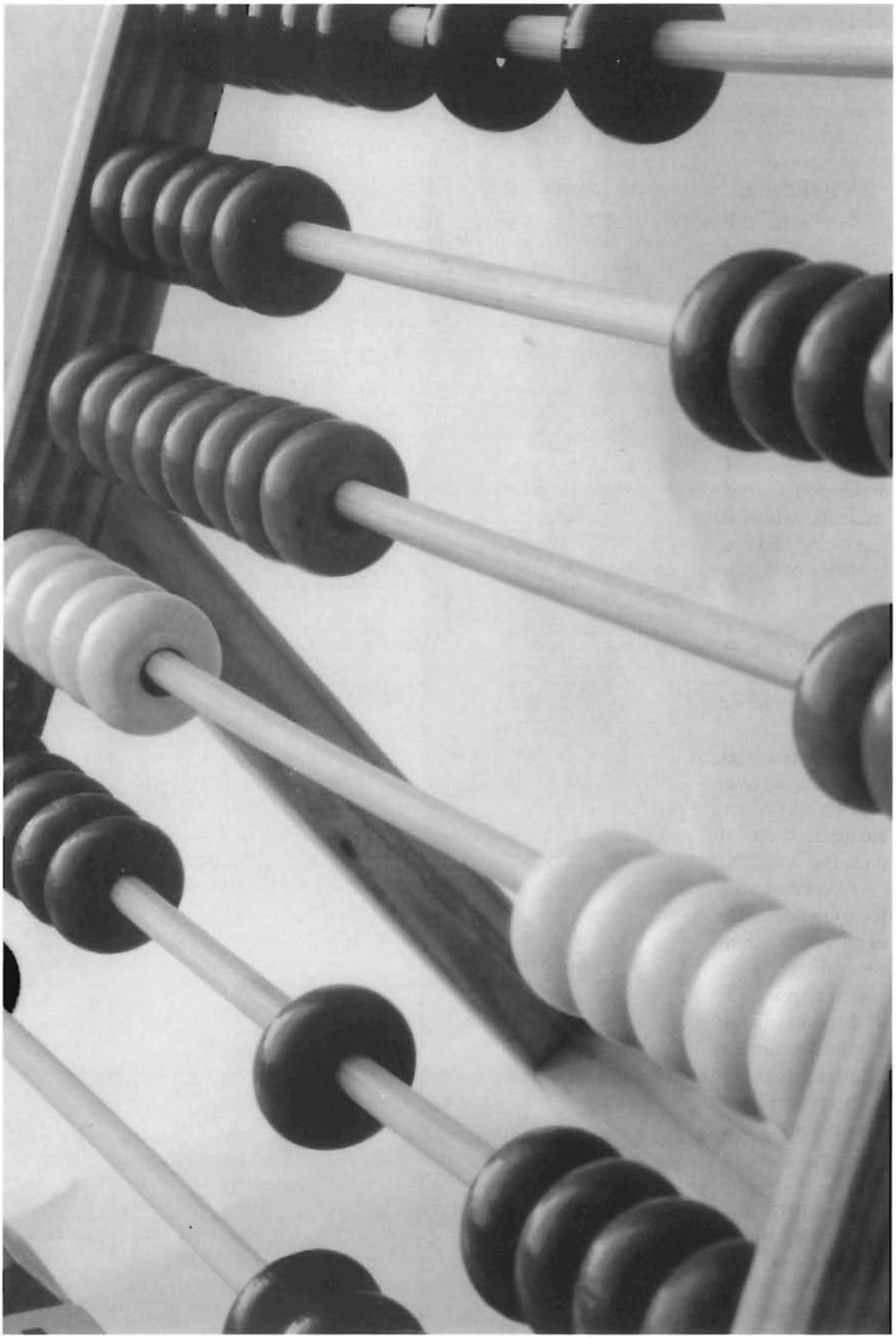
PART I

COUNTING AND MEASURING IN PREHISTORY



A modern abacus, with a long history behind it as an instrument for calculating. According to Dilke (*Mathematics and Measurement*, 1987, 22) its name is derived from the Old Semitic *abaq* (sand), and originally took the form of grooves drawn in sand, along which pebbles were moved.

EVIDENCE FOR COUNTING AND RECORDING IN THE NEOLITHIC? ARTEFACTS AS SIGNS AND SIGNS ON ARTEFACTS

Christina Marangou

Both arithmetic and recording rely on semiotic systems, necessary for storing information. Search for indications of such human operations in prehistoric periods, before the existence of deciphered texts, can only be based on material culture and on the study of human cognition and behaviour. The archaeological record in the Near East and Europe comprises three-dimensional artefacts of unknown function, as well as two-dimensional marks on various artefacts, which have both been interpreted as the materialisation of s i g n s belonging to past reckoning and recording systems in a concrete form. This hypothesis is considered here for the evidence of the Greek Neolithic, in the light of previous studies on data from other areas.

I. THEORETICAL BACKGROUND

I.1. Signs and s i g n s

The word 'sign' is used here with two different meanings. The first one consists of a 'mark, symbol, or device used to represent something or distinguish the object on which it is put' (sign). The second one refers to a 'basic element of communication, ...consisting of two indivisible elements, the relation between which is arbitrary (*signifiant* and *signifié*), and which derives its meaning only from its relationship to other signs within the same sign-system' (s i g n).[1]

According to Molino,[2] the most accurate definition of the s i g n, is something which stands for something else (*stat aliquid pro aliquo* according to the Scholastics).[3] Peirce[4] considers that a s i g n is something that means something to somebody, that it creates in this person's mind an equivalent or a more developed s i g n, the 'interpretant' of the first s i g n. An object can be represented or referred to through 'interpretants' of the original s i g n, in infinite cross-reference.[5]

Molino[6] distinguishes a semiology of communication (the s i g n is an instrument of human communication) and a semiology of representation (the s i g n is a substitute whose function is primarily cognitive). He agrees with Leroi-Gourhan that man builds concrete tools and symbols, both relying on the same fundamental equipment of the mind. Language and tool are both expressions of the same property of humankind.[7] Both human memory and tool are exteriorised

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[1] Brown 1993, 2858, 'sign' 2a, 2e.
[2] Molino 1992, 16.
[3] Something which stands for or represents something else is called a symbol (see further) by Renfrew (1994, 5).
[4] Peirce 1955, 99.
[5] Molino 1992, 16.
[6] Molino 1992, 16.
[7] Leroi-Gourhan 1964, 162-163; Molino 1992, 16.

and contained in the (ethnic) collectivity.[8] The sign, then, exists materially and can be analysed as an object.[9]

According to Peirce,[10] signs are classified into icons, indices and symbols. Iconic signs are those linked by resemblance to the things they are signs of. Indexical (indicative) signs are constrained in their form by what they indicate. Symbolic signs stand in an arbitrary relation to what they represent; they need neither resemble nor be constrained in their form by those things.[11] This shows the difficulty of assigning a material object or a mark to one of these categories. It would mean accepting that they were representing more or less accurately other things (they would be icons) or that they may refer to them by being affected by these objects (by having some common quality) (they would be indices) or without any perceivable relation to the latter (they would be symbols).

A symbol is 'a thing conventionally regarded as representing, typifying or recalling something else by possessing analogous qualities or by association in fact or thought; especially a material object representing an abstract concept or quality'.[12] Or a symbol is defined as 'that which, by custom or convention, represents something else'.[13] Because the relationship of representing is only referential, one (symbolic) sign can, in principle, be 'substituted for another with no loss of functional utility, provided that all relevant sign users are aware of the substitution'.[14]

The sign has symbolic function in particular types of behaviour, such as language, script, calculation, etc., which allow representation through signs or images.[15] The relationship between these forms of expression and what they refer to, as well as the nature of code-making are arbitrary.[16] The existence of an object of reference shows the conceptual level of the substitution during code-making; anyone who understands the reference understands the concept.[17]

As the tool represents distance from the object, the symbol represents distance from reality. Since there is mediation and distance, there is the possibility of a projection toward the past (memory) and toward the future (daydreaming, imagination, technical, artistic, and scientific creation).[18]

Renfrew[19] has recently summed up the different uses of sign systems by humans, referring to them rather as symbol systems. His approach considers, more generally, 'cognitive' archaeology as the 'study of past ways of thought as inferred from material remains'. It studies the specially human ability to construct and use symbols, as well as the ways in which symbols have been used in several categories of human behaviour. These include design (purposive behaviour), planning, measurement, social relations, the supernatural, and the representation of reality.[20]

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[8] Leroi-Gourhan 1965, 64.
[9] Molino 1992, 17.
[10] See, for example, Greenlee 1973, 70ff.
[11] Definitions in Noble & Davidson 1996, 112; cf. Peirce 1955, 102; Lieberman 1980, 341.
[12] Brown 1993, 3183, 'symbol'.
[13] Noble & Davidson 1996, 61.
[14] Noble & Davidson 1996, 63.
[15] Molino 1992, 17 with references.
[16] Noble & Davidson 1996, 58, 60.
[17] Noble & Davidson 1996, 61.
[18] Molino 1992, 19.
[19] Renfrew 1994.
[20] Renfrew 1994, 3, 5, 6.

I.2. Memory and cognitive devices

Oral societies use their own mnemotechnic devices,[21] but they may also have specific graphic (not written) complements.[22] D'Errico[23] has stressed the importance of the emergence, during a major stage of the evolution of human cognition, of symbolic forms of behaviour, resulting in the ability to preserve and use information stored away from the human body.

Sign systems, for instance art, counting, measurement, story-telling and writing, constitute reinforcing mechanisms which increase the length of time that information may be kept in short-term memory (which has a very small capacity) and accessed and brought from long-term into short-term memory.[24]

Sign systems and corresponding cognitive devices for recording and processing large quantities of information, impossible to retain by memory, can be used on several occasions, such as the above-cited examples. Another extreme case is navigation out of sight of land. Besides an understanding of the principles of boat building and sailing, knowledge of the waters, sky and wind were necessary to prehistoric mariners. The latter lacked precision instruments to guide them in directional orientation, although they had to conceptualise and calculate time, in the case of tides,[25] and measure distances and speed. Instruction of traditional seafaring in Pacific islands still uses mnemonic devices for the memorisation of sea routes, directions, stars positions, currents and winds and we can presume that some sort of cognitive devices would have been necessary also in the prehistoric Mediterranean.

Measurement requires actions in which devices for measuring and units of measure are often involved, including weights, measuring rods, etc.[26] Thus, some artefacts not only reflect cognition but also intentionally represent mental content; they have meaning; they are intended to be read.[27] Material representations, physical traces of cognitive devices, such as dials for time, direction and distance, are not, though, merely mental aids; they may include public display.[28] This social aspect seems to be often, if not always, interwoven with the expression of the mental ability and erudition of some individuals,[29] and, more generally, with knowledge and lore, including their teaching and transmission, of which the most obvious example would be initiation.

I.3. Elementary forms of counting and recording

The simplest method of reckoning is concrete counting, based on a one-to-one correspondence by comparing two sets of beings or objects, by bijection.[30] Different means may be used: shells, bones, grains, sticks, pebbles. They were possibly used very early in prehistory and are still used today: for example, some Iraqi shepherds keep track of their flocks with

[21] Hagège 1985, 84-86.
[22] Glück 1987.
[23] D'Errico 1998, 19 with references.
[24] Zubrow 1994, 189.
[25] Frake 1994, 123, 124, 128.
[26] Renfrew 1994, 6, 7.
[27] Frake 1994, 119.
[28] Frake 1994, 119, 130.
[29] Frake 1994, 119, 130.
[30] Ifrah 1994, 43.

pebbles.[31] These piles of stones and other objects manipulated for arithmetic operations led much later to the appearance of calculating instruments.[32]

This method cannot indicate what item was counted and cannot count more than one category at a time.[33] Nevertheless, it permits the attainment of several numbers, without naming or knowing the quantities.[34] Use of symbols which stand for concrete objects and convey information about their number, and which cannot dissociate numbers from the items counted, does not assume the concept of number and abstract counting. These proto-arithmetical techniques rather indicate the ability to establish correspondences between symbols and counted objects, that is, concrete counting.[35]

Yet, handling large numbers is difficult for ordinary minds.[36] Direct visual perception of numbers has its limits.[37] In oral societies, multiplication being in effect non-existent, addition is based on counting a set of objects or by visual direct representation. Counting one by one may be replaced by a cognitive process called subitizing, that is, apprehending without counting sets of six or fewer elements, a limit fixed by the structural characteristics of the human brain.[38] This can result in the 'base' principle of a system of numbering,[39] when a certain number of units is replaced by a higher unit (cf. for example the sexagesimal system of the ancient Near East).[40] Grouping objects in order to count them[41] is an important progress, the process being done by ordering them in series, and shows that the number sequence is unlimited.[42]

II. Evidence About Prehistoric Counting/Recording Sign Systems?

II.1. Palaeolithic and Mesolithic

One can easily imagine that similar simple mnemotechnic devices were invented independently and used in different times and places.[43] It is not surprising, then, that some series of prehistoric artefacts bearing sets of elements have been interpreted as counting or recording devices, such as the universal bone or wood tally sticks, used till recently,[44] which are carved, scratched or cut.[45] The simplest ones bear rows of similar notches. A single kind of mark –notch–

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[31] Schmandt-Besserat 1996, 11.
[32] Ifrah 1994, 298-299.
[33] Schmandt-Besserat 1996, 92.
[34] Ifrah 1994, 41-43.
[35] Nissen *et al.* 1993, 125. Different items are counted with different processes (Goody 1979, 52).
[36] Frake 1994, 124.
[37] Four according to Ifrah (1994, 33) and Schärlig (2001, 107).
[38] Goody 1994, 283 with references.
[39] Ifrah 1994, 234-235. Schärlig (2001, 107) refers to a very ancient base 'five' (four + one), as deriving from counting on one's fingers –a natural process (2001, 116).
[40] Nissen *et al.* 1993, 25, 131.
[41] The symbolic representation of these progressive groupings led to the earliest number symbols. Systems of 'early' or row numerals were formed according to this rule, like the Egyptian and Roman numerals (Menninger 1969, 42, 240).
[42] Menninger 1969, 39, 42.
[43] Nissen 1998, 31.
[44] Ifrah 1994, 157-160.
[45] Menninger 1969, 223.

shows that tallies could handle only one type of data at a time;[46] only quantities of objects or beings are indicated, not their nature.[47] These notches could not be abstract numerals, since the numbers they are supposed to have represented would be tied to the objects numbered.[48] Knots used as numerals in Peru attest a comparable method, but there they were used for state records (*quippus*).[49] The rows of notches on tallies may also be organised in separate groups, requiring variation[50] in marks.[51]

Groupings also mean rhythm, a concept that is inherent in man.[52] Regular rhythms in the natural world can be observed about stars, seasons and days, walking and heartbeat.[53] It has accordingly been argued that the first item to be counted was time. Measuring time in fact involves many repeated, sequential actions, which, when recorded, often display periodicities related to those of the sun and moon: the number of days, the lunar month and solar year.[54]

Thus the next step was attributing rhythmic sequences of marks incised on tallies to calendar notation. This was the main interpretation by Marshack[55] of marks on a series of Palaeolithic bone and ivory objects[56] attested since the end of the Mousterian. Counting time would then, according to Schmandt-Besserat,[57] permit dispersed communities to gather at intervals on special occasions. Others have interpreted the same marks as recording hunted animals.[58] Leroi-Gourhan[59] considered it more probable that they would be aids for rhythmic incantations and recitations and correspond to the rhythm of speech (*'dispositif rythmique de caractère incantatoire ou déclamatoire'*): a function similar to that of the Australian *churinga*, small plaques engraved with abstract patterns related to a mythical content.

According to Couraud,[60] the Mesolithic Azilian (11000-9000 BP) painted and/or engraved pebbles (*'galets aziliens'*) show a continuity of patterns since the Palaeolithic period, and exhibit a predilection for certain clusters of numbers. The lunar calendar argument would be debatable for the larger numbers, but seems impossible for the frequent small ones; the latter may have had various functions. Yet, groups of pebbles bearing small numbers may also have been considered

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[46] Noble & Davidson 1996, 223.
[47] Ifrah 1994, 160.
[48] Menninger 1969, 247. See note 35.
[49] Menninger 1969, 253; Ifrah 1994, 169ff.
[50] Menninger 1969, 240.
[51] It has been argued that bar-and-dot numerals, among the earliest recognisable Mesoamerican written signs were probably much older than writing, because they are structured as simple tallies (Justeson 1986, 440, fig. 2a), representing bars and dots.
[52] Leroi-Gourhan 1964, 265; 1965, 82.
[53] Leroi-Gourhan 1965, 142-144.
[54] Renfrew 1994, 7.
[55] For example Marshack 1970, 1991; cf. discussion and bibliography in D'Errico 1995, 55-56, 302; 1998, 20, 49.
[56] Objections as to the identification of these marks as intentional have been expressed by Noble & Davidson (1996, 223), who argue that marks in bone occur thousands of years before the appearance of modern human morphology and before the signs or symbols. Besides, they might be an unintended by-product of the action of cutting with sharp-edged stone flakes on flesh-bearing bone. They show 'increasing control of motor sequences, but would not prove that those leaving the marks noticed them'.
[57] Schmandt-Besserat 1996, 101.
[58] References in D'Errico 1998, 20.
[59] Leroi-Gourhan 1964, 263.
[60] Couraud 1985, 98-110.

as sets.[61] The same author admits the notation of some unknown 'cycles' at the end of the Palaeolithic and the last glaciation.[62]

Microscopic examination of the engraved stone and bone Mesolithic artefacts and experimentation persuaded D'Errico[63] that the engravings had been made without any slow accumulation. This led him to the conclusion that the Azilian engravings could not be calendars or marks of hunting, but that they were rather made in a quick succession of gestures with the same tool and at the same time.[64] They would not be the bearers of a specific information (word, phoneme etc.), since they are not distinguished individually. Some of them could nevertheless be schematised human or animal figures.[65] The engravings do not reflect a consequence of climatic changes, but rather resulted from a tendency towards schematisation.[66]

D'Errico further admits the existence, since the Palaeolithic, of 'artificial memory systems' (AMSs) (*'systèmes artificiels à mémoire'*).[67] Evidence about their existence in the Lower and Middle Palaeolithic is limited and controversial, but it is certain in the Upper Palaeolithic of Europe.[68] He accepts[69] that several factors are important for the elaboration of a code for such systems: morphology, spatial distribution, number and temporal accumulation of the elements. He argues[70] that, at the end of Upper Palaeolithic, marks and sets become more numerous, while marking techniques producing many marks on a restricted surface are used, and visual perception is more systematically practised for retrieving information. The codes become more complex, with hierarchical organisation of information and the use of formally differentiated marks.

II.2. Neolithic

Simple mnemotechnic means were sufficient for a very long period, but accumulation of information resulted at a certain point in the inability of the human memory to manage it and external storage became necessary.[71] In a discussion about cognitive phases in human evolution, Renfrew[72] proposes a distinct phase of 'external symbolic storage employing symbolic material culture, characteristic of early agrarian societies with permanent settlements, monuments and valuables'. This phase would follow the transition to food production (the 'Neolithic revolution') and precede the transition to the development of writing (somehow related to the 'urban revolution').

It is in this general context that some series of Neolithic finds from Greece and its neighbouring areas, notably Near East and south-eastern Europe are considered. They consist of:

- small objects of unknown function, and
- artefacts, including examples of recognisable categories, such as tools, vases or miniature objects, which bear incised signs (marks), in addition to or independently of decoration.

In the absence of any proof of function, the study of the material objects of the first category may deal with interpretative hypotheses and consider them as signs, belonging to one or more

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[61] Couraud 1985, 139-143.
[62] Couraud 1985, 148-149.
[63] D'Errico 1995.
[64] D'Errico 1995, 219, 286, 309.
[65] D'Errico 1995, 309-310.
[66] D'Errico 1995, 289.
[67] D'Errico 1995, 222-227.
[68] D'Errico 1998, 25, 43.
[69] D'Errico 1995, 222-227; 1998, 21.
[70] D'Errico 1998, 47.
[71] Nissen 1998, 31.
[72] Renfrew 1998, 4.

alternative sign systems. On a different level, since they are two-dimensional, the marks on objects of the second category, which may be utilitarian,[73] also seem to convey a message following some code, and, in this respect, they should also be considered as signs in one or more sign systems.

Both categories have been studied till now by several authors and opinions on their interpretation diverge. Yet, it has often been argued that the sign systems of notation to which they belonged were related to counting, recording or to script in one of its most elementary and archaic forms.

II.2.a. Artefacts as signs

1) Evidence from the Near East

This is how 'tokens' (Fig. 1, right), small clay, and, more rarely, stone objects of the Neolithic Near East have been interpreted as traces of concrete counting. Schmandt-Besserat developed earlier theses by Oppenheim and Amiet.[74] Based on the study of 8,162 tokens,[75] she considered them not only as counting and recording devices, but also as the immediate precursor of cuneiform writing, by mutation of the three-dimensional tokens into two-dimensional graphic symbols (cf. Fig. 1).[76]

The examples date from the 8th to the 4th millennium, have been found in a large geographical area, including Iraq, Iran, Syria, Turkey and Israel,[77] and have various geometric shapes (cones, spheres, disks, cylinders etc.) and an average size of 1-3 cm. x 3-5 cm.[78] According to Schmandt-Besserat,[79] these tokens would have evolved to meet the needs of the economy, at first keeping track of the products of farming, then extending to goods manufactured in urban workshops. Such a system would permit easy manipulation and flexible storing of unlimited quantities of information, while being open, since new signs could always be added, but their volume was difficult to use and they could not dissociate numbers from the items counted. Tallies would be more efficient for permanent records, but their data could not be disassembled.[80]

Several objections have been expressed[81] *vis-à-vis* Schmandt-Besserat's theory, mostly because she included 'plain' (geometric) and 'complex' (animals, vessels, tools) forms as part of the same reckoning system, which, moreover, would have been used during a very long period in different areas for the same function. Her six-stage model has not been proved stratigraphically.[82] Moreover, 'complex' tokens may also be interpreted alternatively as amulets, pendants, game pieces,[83] miniature vases or models.[84] Though at least some of them are clearly indices and icons, they have not been proved to fit into a single semiotic system, nor is it clear to which particular system(s) they belonged, since various other semiotic systems must have existed, among others,

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[73] The fact that an object possibly has a practical function does not preclude its having a symbolic value (cf. D'Errico 1995, 288).
[74] Lately Schmandt-Besserat 1996, 11; see also bibliography in Zimansky 1993, 517.
[75] Schmandt-Besserat 1992.
[76] Schmandt-Besserat 1996, 54. Objections in Glassner 2000, 101.
[77] Schmandt-Besserat 1996, 8.
[78] Schmandt-Besserat 1996, 15.
[79] Schmandt-Besserat 1996, 1.
[80] Schmandt-Besserat 1996, 92-95.
[81] Zimansky 1993; Glassner 2000, 87-112.
[82] Matthews 1998, 15.
[83] Ifrah 1994, 240.
[84] Zimansky 1993, 515.

play and jewellery.[85] The varied modes of representation used in these 'small clay objects' would show diversity of functions. Three-dimensional examples might be imitations of objects, but two-dimensional (flat) ones would rather be representations of representations; relative disparity in size and the presence of perforations in some cases only would also indicate functional variety.[86]

Furthermore, Schmandt-Besserat's theory has been criticised because the tokens she identified as livestock or textiles are comparatively very few, while keeping track of livestock would be expected for the Neolithic period, and textiles are common in later cuneiform documents.[87] Besides, plain tokens would not represent specific commodities constantly over the millennia over the entire Near East; similarities over this time span may be due to the fact that the basic geometric forms, which can be used in early numerical systems, are few.[88]

In spite of the critics, in the absence of any other alternate explanation, several scholars agree now that a part, at least, of the later tokens were counters.[89] The 4th millennium ones represented quantities, which would play an important role mostly in economic processes, according to Nissen.[90] If each token represented a counted unit, a small heap of tokens would represent the sum of the counted units. At a very early date, a particular number of units of the same value could be replaced by a specific symbol. By combining various symbols, relatively high numerical values could be obtained. Even though the true meaning of their shapes is not clear, the large quantities of clay tokens found in various geometric shapes may have been the representations of different numerical values.[91] With the differentiation of shapes and sizes, a second quality was added to their meaning. They were changed from indices to icons and/or symbols.[92] By the mnemonic means of differentiated shapes, specific information was transmitted concerning the nature of the represented objects, such as the product type, the units they were measured or counted in, etc.[93] If markings on tallies had unlimited possible interpretations, each clay token was now a distinct sign with a single significance; thus tokens also contained qualitative information.[94]

According to Schmandt-Besserat, from the 6th millennium tokens were often located in storage facilities and warehouses,[95] partly inside and partly outside domestic and public (since the 5th millennium) buildings,[96] most often associated with early summer deposits (4th millennium). They would have been discarded after the harvest, as soon as their (recording?) function had been fulfilled. They were therefore used primarily for record keeping rather than for reckoning and they were not related to trade and, in particular, obsidian trade.[97] In Uruk, they were discovered occasionally in fireplaces, either intentionally in order to be baked, or discarded.[98] They may be found on the floor, sometimes clustered together, as if they were kept

85 Lieberman 1980, 341 and note 10.
86 Lieberman 1980, 354-356.
87 Zimansky 1993, 516.
88 Zimansky 1993, 516-517.
89 Nissen *et al.* 1993, 125; cf. Glassner 2000, 103-104, 110.
90 Nissen 1998, 26.
91 Nissen *et al.* 1993, 11.
92 Lieberman 1980, 343.
93 Nissen *et al.* 1993, 127.
94 Schmandt-Besserat 1996, 95.
95 Schmandt-Besserat 1996, 33, 40.
96 Schmandt-Besserat 1996, 29.
97 Schmandt-Besserat 1996, 37.
98 Schmandt-Besserat 1996, 31. They occur in non-domestic architecture in later periods and were sometimes found, with other status symbols, in burials of prestigious individuals, suggesting that they were used by members of the elite (Schmandt-Besserat 1996, 37).

in vessels.[99] Small groups were actually found in vases, often of small size, besides being discovered in heaps presumably contained in perishable vessels, in Tell Abada for example.[100]

The method of accumulating pebbles or clay tokens in heaps or containers, as a temporary record of numbers, has to be seen in the context of economic control, according to Nissen.[101] The frequency of small assemblages[102] led to the assumption that the accounts dealt generally with small quantities of different kinds of commodities.[103] Small quantities are also attested in proto-Elamite notation and would reveal[104] legal rather than purely economic preoccupations.

With increasing bureaucracy, from the 4th millennium, tokens were stored in the archives in sealed clay envelopes (*bullae*), with the shapes of tokens occasionally imprinted on the surface.[105] These imprints would be pictures of the tokens used as counters rather than pictures of the items they represented.[106] Yet there are occasional discrepancies between enclosed tokens and impressions.[107] Since *bullae* are often unopened, it has been suggested that they would have been used for storing and recording, not for carrying information.[108] Solid clay impressed tablets (Fig. 2) replaced *bullae* about 3500-3000 BC.[109]

Representation of tokens as impressions (their indices) shows them to have been signs within a system. The existence of indices of the tokens shows that the latter had a relationship to something else; they were signs in a single system, as they were included within a single *bulla*.[110] Besides, enclosing the tokens into envelopes with the final sum attests the understanding of the notion of cardinality.[111]

According to Lieberman,[112] such a system of numerals and impressions on *bullae* can be based on size-value (iconic). This seems to be a basis for the development of place-value (symbolic) notation: what was represented by the (relative) size of a sign was later represented by its (relative) place. Grouping values are given by the counters' positions, instead of their sizes. This led only later to the discovery of counting boards or abaci.[113] In fact, the shapes of the objects used as counters with the *bullae* suggest that they were not suited for placing on a flat surface (in connection with a counting board), since they are not particularly stable, but were rather to be held in a container.[114] This is corroborated by contextual evidence (see above).

Bullae and counters system may have operated as an alternative form of recording, perhaps in areas without a local scribal tradition,[115] since, after the invention of writing, the counters

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[99] Schmandt-Besserat 1996, 31.
[100] Jasim & Oates 1986, 355.
[101] Nissen 1986, 324.
[102] Schmandt-Besserat 1996, 20.
[103] Schmandt-Besserat 1996, 40.
[104] Vallat 1986, 338.
[105] Schmandt-Besserat 1996, 54; Nissen 1986, 324, 325, fig. 4.
[106] Schmandt-Besserat 1996, 54. See objections in Glassner 2000, 91-92.
[107] Glassner 2000, 108-110.
[108] Jasim & Oates 1986, 350.
[109] Schmandt-Besserat 1996, 55, 57. But see Glassner 2000, 152-156 about parallel use of inscribed *bullae* and tablets.
[110] Lieberman 1980, 341.
[111] Schmandt-Besserat 1996, 115.
[112] Lieberman 1980, 342-343.
[113] The abaci cluster the numbers down into groups so that they can be handled more easily; they are movable so that they can be combined without constant erasing and rewriting (Menninger 1969, 297).
[114] Lieberman 1980, 344.
[115] Jasim & Oates 1986, 349.

continued[116] to be used.[117] While the functioning of the tokens as numerals is distinct from script, they might be 'connected with the origins of writing, in some loose sense' (cf. Fig. 1).[118]

2) Evidence from Greece and other examples

It is easier to consider 'small objects' as possible material evidence about arithmetic or recording systems when they are found in groups. Yet, a number of Greek artefacts have been found in isolation or in very small sets, partly, at least, because they have not been systematically collected and identified till now. Information about their context is also exceptional.

Some examples from Greek sites, representative of the main categories of artefacts possibly belonging to such sign system(s), are presented below.[119] These examples date from the Early Neolithic of Thessaly, Western Macedonia and Central Greece, the Middle and Late Neolithic of Thessaly, the Middle and Late Neolithic of Eastern Macedonia and Thrace and the Late Neolithic of the Aegean islands (end of the 7th millennium - 5th and possibly Final Neolithic - 4th millenium BC).[120] These consist of:

i) Rounded objects, including spheres and flattened cylinders, sometimes bearing simple marks, as well as other geometric shapes, such as disks,[121] rings, ovals, cones, sticks, rods and bottle- or vase-shaped (solid) objects; and

ii) Rectangular plaques ('tablets'), loaf-shaped objects or parallelepipeds, larger than category (i), which may also bear series of repeated identical notches, points or other simple patterns. They look like tallies but might also be tokens, although, in some cases, they may also be closer to the 'signs on artefacts' category (see further, II.3).

More precisely:

i) Some larger or smaller groups, and also isolated examples, of clay artefacts, of various geometric shapes are known, from the Early to the Late or even Final Neolithic:

Several hundred clay 'roundels' of unknown function were discovered at Nea Nikomedeia, in an Early Neolithic building,[122] the so-called 'shrine'. Five figurines were also found there, three of them grouped together, as well as two outsized stone axes, two caches of over 400 unworked flint blades, and two gourd-shaped vases. The roundels were found all together in the 'shrine', and belong to two predominant shapes (rounded and ovoid). *Pintaderas*, 'ear-studs' and sling balls were also found in the settlement.[123] Unfortunately, precise information about the context and morphology of this unpublished material is still lacking.

A ceramic ball, slightly oval in section, with one flattened side,[124] and two knob-shaped, rather geometric 'doubtful twin figurines' with a convex and hollowed out, or a flattened

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[116] Lieberman 1980, 345.

[117] The distinction between curviform numerals and words written with straight lines might represent an opposition between iconic representation of clay counters, and (symbolic) use of cuneiform (Lieberman 1980, 343).

[118] Lieberman 1980, 358 and note 122.

[119] Cf. Marangou 1992, *passim* ('unidentified objects') and Marangou in press. This is not an exhaustive list of the Greek material.

[120] For the chronology of the Greek Neolithic see Andreou *et al.* 1996, 538 and Demoule & Perlès 1993, 366, fig. 2.

[121] The abundant sherd disks, perforated or not, have not been exhaustively included at this stage in the present paper. Several perforated ones should rather be weights or spindle whorls.

[122] Cf. Pyke 1996, 23, fig. 2.10.

[123] Rodden 1964, 604-605, fig. 12.

[124] Height 2.4 cm., thickness 1.8-2.3 cm., diameter of base 2.3-2.4 cm. Wijnen 1981, 47, fig. 14, no. 14.

bottom,[125] come from Early Neolithic Sesklo (EN I). From the second 'figurine' two pieces have been cut creating two flat sides at an angle of 90°. A number of 'ear-studs', also from Sesklo EN I, have a rounded (mushroom-shaped) or flat (disk-shaped) upper segment and a bulbous lower part, or may even be nail-shaped.[126] This sort of artefact is very common on various other Early Neolithic sites, as in Nea Nikomedeia,[127] Achilleion and Argissa[128] but its precise function still remains obscure.

Ten rounded 'seats'/'drums' or tokens[129] belong to a so-called 'cult scene', allegedly 'from Northern Greece', possibly Thessaly (Middle Neolithic?), acquired by the Munich Prehistoric Collection.[130] They have notches around the edges and occasionally a point in the middle of the upper surface (Fig. 3). Five out of six rectangular four-legged 'tables'[131] from the same 'cult scene', often with short parallel notches on the edges, although possibly representing pieces of furniture, may also bear either four or five points on their upper surface (Fig. 4). Finally, three bobbin- or 'drum'- or earplug-shaped implements[132] (Fig. 5) also bear slight notches and, in one case, deep dots around the middle.[133] The decoration on the thinnest part of this artefact shows that it could not be an ear-stud, since precisely this part would be hidden if worn through the ears (or the nose). A series of miniature figurines and other implements are also included in the same 'scene' (see also (ii) for parallelepipeds).

Three rectangular solids of unknown use, up to 4 cm. tall, one decorated with a pitted design, from Early and Middle Neolithic Achilleion (Fig. 6)[134] were found in post houses IIb (end of the Early Neolithic), IIIb and in a 'cult activity' area of IIIb.

Sherd-disks were found in Achilleion, usually in groups of five to fourteen, in houses of phases Ia-IVa on the bench or in the corner of the house.[135] Several disks of unknown function come from Nea Makri.[136]

'Gaming counters' from Sitagroi II (Late Neolithic I) (Fig. 7) include several small clay discs, flat on the lower surface and in the form of a low cone on the upper surface, decorated with dot-like incisions,[137] as well as several small clay balls.[138]

Ten fragments of fired long, thin, rather irregular tapering cylinders, one complete (7.2 cm. long), another one preserved up to a length of 10.5 cm. were found in Late Neolithic Saliagos.[139] Three of them were found in the same square, and three more in the same deposit.[140] Five

[125] Height 1.82 cm. and 1.79 cm., width 1.54-2.34 and 1.42-1.61 cm., thickness 1.09-1.68 and 1.39-1.66 cm. respectively. Wijnen 1981, 45-46, fig. 14, no. 13, 18.

[126] Height 1.2-2.9 cm., width 1-2 cm. Wijnen 1981, 46-47.

[127] Rodden 1964, 607, fig. 17.

[128] See Gimbutas *et al.* 1989, 251-252 with references.

[129] Diameter 1.79-0.75 cm.

[130] There is no precise information about the original context of the objects. The 'scene' consists of sets of similar artefacts and a common origin might be presumed, at least for each set. See Marangou 1992, 219.

[131] 2.5-1.06 cm. maximum dimension.

[132] 1.58-1.4 cm. maximum dimension.

[133] *Idole*, 65-66, no. 27 and 78-79, pl. 18-19.

[134] Gimbutas *et al.* 1989, 256-257, fig. 8-14.

[135] Gimbutas *et al.* 1989, 254, fig. 8.8-8.11.

[136] Παντελίδου 1991, 4, fig. 4, 10-12, note 14, with references.

[137] Diameter 2-2.8 cm.

[138] Renfrew 1987, 366, fig. 9.

[139] Evans & Renfrew 1968, 70, fig. 84, 12-21, pl. L.

[140] Some sherd 'burnishers' (Evans & Renfrew 1968, 69-70, fig. 83, pl. L) and 11 disks of clay, 3 of stone (Evans & Renfrew 1968, fig. 85, pl. LIV), 6 from sherds, could also be considered as tokens. Disks are quite common on Neolithic sites and the largest ones at least could be covers. See also above, note 121.

slightly concave, small clay 'dishes' also come from this site, as well as six rounded sherds and three stone disks.[141]

Two decorated 'sling bullets' (?) from Dikili Tash II (Late Neolithic II)[142] bear either imprints of small cavities which cover them completely, or incised concentric lines.[143] The usual interpretation of these objects is certainly not confirmed by the decoration of these examples.[144] At Dikili Tash, the context of sling bullets sometimes includes figurines and miniature objects.[145] At Middle Neolithic Achilleion a 'sling bullet'[146] was found associated with the foundation of an early IVa building.[147]

Three irregular rings[148] from Dikili Tash II (Fig. 8)[149] may lie one on top of the other in a pile (Fig. 9). Parallels come from Goljamo Delčevo[150] and Ezero[151] and a pile of unfired disks was found in a pit at Vučedol.[152] Two of the Dikili Tash examples were found in proximity to (the third one a little further from) some animal figurines fragments and a unique rounded disk,[153] with notches on the edge and an incised pattern on each side.[154] A parallel for the latter from Šuplevec is known.[155] Other disk-shaped incised objects come from Ploskata Mogila (around 4000 BC),[156] or Medvednjak,[157] and two earlier, smaller flattened pellets from Dikili Tash I;[158] one of the latter could also be a bread model.[159]

Two Late Neolithic examples from Dikili Tash[160] look like piriform vases, but they are solid and they do not have any aperture. One of them contains an object and might also be a rattle. Parallels come from Vîhvatinţi (Moldavia) and the Cucuteni culture,[161] and include an incised object from Baniata,[162] as well as the solid, bottle-shaped figurines or 'pobbles' from Sitagroi II and III).[163] Detev[164] has interpreted some Bulgarian parallels from Plovdiv,[165] Bikovo, Ruse or Kapitan Dimitrievo as 'models of decoration'.[166]

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141 Evans & Renfrew 1968, fig. 85, pl. LIV; cf. Marangou 1992, 52-54.
142 Treuil 1992, 121, pl. 201a.
143 Treuil 1992, 121, pl. 200h.
144 Treuil 1992, 123, note 112.
145 Marangou 1992, 18-19, and in press.
146 Diameter 2.5 x 4 cm.
147 Gimbutas *et al.* 1989, 257, fig. 8.15.
148 Height 1-1.9 and diameter 3-3.7 cm.
149 Marangou 1992, 17-18, and in press.
150 Todorova *et al.* 1975, pl. 87.
151 Georgiev *et al.* 1979, 406, 541, fig. 203.
152 Schmidt 1945, 198, pl. 23, no. 9.
153 Diameter 4.5 cm., thickness 0.6 cm.
154 Marangou 1992, 17-18, 19, fig. 80.
155 Garasanin & Simoska 1976, 29, pl. IX, no. 31, level 5, period I.
156 Gimbutas 1984, 208, fig. 164.
157 Winn 1981, 355, nos. 48, 49.
158 Marangou in press.
159 Cf. for example a table model with 'bread-loafs' on it from Sitagroi (Θεοχάρης 1973, fig. 123).
160 Marangou 1992, and in press.
161 Gimbutas 1984, fig. 154.
162 Detev 1950, fig. 32.
163 Height 3-4 cm.; Gimbutas 1982, fig. 202; Renfrew *et al.* 1986, fig. 9.58, no. 15 (phase II), fig. 9.60 and 9.98, pl. LV, 3, nos. 156 and 155 (phase III); Renfrew 1987, 368, pl. F.2, 4, G.
164 Detev 1965; cf. Dumitrescu 1985, pl. LIII, 1-3.
165 Detev 1959.
166 But see Marangou 1992, 180.

Some clay rods come from the Early Bronze Age strata at Emporio.[167] A number of unperforated sherd disks also come from these strata, but two of them were found in period IX levels (Late Neolithic).[168]

Several unpublished clay objects from Sitagroi II and III of unknown function, many of which bear an elaborated incised decoration, have been linked to ideograms, symbolic design, ritual, decoration and play.[169]

ii) Several bread-shaped or parallelepiped clay plaques are known from Thessaly, in particular from Middle Neolithic Sesklo.[170] They bear 'linear symbols or ideograms' incised before drying. Others come from Prodromos[171] and the Farsala area, the Sesklo one being part of a larger set (Fig. 10).[172] One plaque is divided into four parts by a cross, with a different number of points in each quarter; a 'bread-loaf' bears lines incised perpendicularly to its long axis. Another plaque bears several parallel series of points, perpendicular to its long axis, with empty spaces of different width between the series. A unique rectangular piece with five series of points comes from Otzaki II.[173] Hourmouziadis[174] mentions some clay objects, of various sizes and shapes, including rectangular ones, bearing points, three from Prodromos, one from Otzaki (probably the same as above) and two chance finds. He thinks that they would possibly belong to the same system of 'primitive script' (*πρωτογραφή*) as the figurines (see further, III). According to Theocharis, some at least of the Sesklo tablets would have been fired by chance. This would explain why more examples have not been preserved.

Fourteen clay parallelepipeds and bread-shaped objects of the 'cult scene', in the Munich Prehistoric Collection[175] (Fig. 11, 12) bear similar features. They have parallel notches on the edges, occasional points or crosses on the sides, and they often bear parallel incisions and dots, except on the under side, but they may also be undecorated. Five or six of them have longitudinal cracks, that apparently occurred during firing, in the centre of the upper surface. On one example, there is a series of points on both sides of the crack and incised vertical lines on both ends (Fig. 11, right).

Some clay plaques with incised decoration on the upper surface and on all four edges come from Eastern Macedonia, in particular from Dimitra (Fig. 13) and Doxaton.[176] An unpublished[177] Late Neolithic example of a long parallelepiped with graphite decoration comes from Dikili Tash. It bears parallel notches on its four long edges and a deep hole on one of its large sides. Some doubtful fragments from Dimini are also incised on one large side.[178]

Other clay plaques come from Balkan sites, such as Baniata,[179] Bikovo, Ruse, Tangiru,[180] Cascioarele (18 'prisms': incised parallelepipeds),[181] Glavanesti Vechi (four-sided tablet)[182] and

[167] Hood 1982, 628 with references for parallels.

[168] Hood 1982, 634-635 with references for parallels, pl. 132, 30-31.

[169] Renfrew 1987, 361.

[170] Length 4.4 and 3.6 cm. Θεοχάρης 1965, 9, pl. 2A. Two fragmentary stone plaques from Sesklo bear incised linear motifs (length, 8 and 10 cm., width *ca.* 5 cm.; Τσούντας 1908, 338, fig. 268-269), but may also be figurines.

[171] Length 3 cm.

[172] Θεοχάρης 1973, fig. 181, pl. XIX, 3-4.

[173] Milojčić 1971, 32, pl. XVI, 26.1, 2, 5.

[174] Χουρμουζιάδης 1973, 81; 1994, 105, note 28.

[175] Complete ones, length 6.12-1.9 cm.; *Idole*, 65-66, no. 27, and 78-79, pl. 18-19.

[176] Respectively 5.6 x 2.8 x 2 cm.; 8.8 x diam. 3.5 cm.; length 10.9 cm. Renfrew 1987, 359-361, 369, fig. 6, 7, 10.

[177] Marangou in press.

[178] Μαλακασιώτη 1982, fig. 1.7 and 2.7; cf. fig. 2.6.

[179] Detev 1950, fig. 32b-c.

[180] Winn 1981, 194, fig. 30A; Masson 1984, 111-112, pl. II; Nikolov 1986.

[181] Stefan 1925, 189-190, fig. 42i and 43, 14-16.

[182] Comşa 1978, 29, 31, fig. 26.1 and 27.6.

Popiza,[183] as well as from Dikili Tash (unpublished).[184] They bear linear patterns, zigzags and sometimes spirals. The Tangiru tablet (Fig. 14) bears horizontal incised lines ('paging'), separating vertical strokes. An incised 'tally'-like object comes from 5th millennium Tell Abada, a 'kind of proto-tablet marked with a combination of fingernail and short straight incisions'.[185]

Most Late Neolithic examples are baked. Whatever the interpretation of these artefacts, it is certain that the baked examples had been incised before firing, and, we may assume, at the same time.

Under the base of an oven model from Ovčarovo,[186] a chequer-board pattern, with some of its squares filled with parallel incisions or ochre has been interpreted as a primitive calendar. If the pattern was not located under the oven model, one could suggest an interpretation as a game board or abacus. A plaque fragment from Dikili Tash[187] with graphite decoration of crossed lines on the upper surface and a series of parallel Vs on the preserved small side, while it is rather rough underneath, would be a more credible candidate. Some other fragmentary, decorated examples from the same site may again have belonged rather to oven models.[188]

The artefacts presumably belonging to such s i g n systems include different categories of shapes and sizes. 'Tokens' are found from the Early Neolithic on, while tally-like objects, plaques and parallelepipeds seem to appear first in the Middle Neolithic, when they are also more numerous. There seems to be more variation in types in the Late Neolithic.

The artefacts have been found either in isolation or in small groups, with notable exceptions in the 'Shrine' of Nea Nikomedeia and in southern Jordan (see further, III). If the 'Shrine' were in fact a storage space for precious products (stone tools) and symbolic objects (figurines),[189] the occurrence of a large inventory of tokens, either counting or ritual devices (or both) would be explicable.

The occurrence of clay cylinders of unknown function at Sitagroi II, alongside various clay tokens, may show, according to Renfrew,[190] a similar situation (or stage) to that of the cylinder seals of the Near East. The latter are connected with the sealed *bullae* bearing imprints of numerals (see above), and the earliest texts.

II.2.b. S i g n s on artefacts and early scripts (?)

1) Evidence from the Near East and the Balkans

The representation of two horses on an Upper Palaeolithic antler also bearing marks of an 'artificial memory system' shows, according to D'Errico,[191] that these images played some role

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[183] Region of Vraza; Nikolov 1986.
[184] Some objects may look either like flat seals, or round lumps of clay, and often bear meanders. An Early Vinča, oval clay plaque with incised meander, surrounded by chevrons and semicircles comes from Banjica (Gimbutas 1982, 131, fig. 89). In addition, some objects are pierced and apparently were used as amulets or pendants. Some more tablet-like objects bearing signs are considered below (II.2.b. S i g n s on artefacts).
[185] Jasim & Oates 1986, 353, fig. 3, pl. 1a.
[186] Cokhadjev 1984.
[187] Marangou in press.
[188] Marangou 1992, 17.
[189] Marangou 1996a, 149.
[190] Renfrew 1987.
[191] D'Errico 1998, 43.

in the code of the system. He argues that in this period, as in modern times, sign systems may integrate at the same time iconic and symbolic elements.

The first pictographic messages in the Near East appear, in a period (Pre-Pottery Neolithic A) corresponding to the invention of agriculture, on stone plaques, associating schematic animals and abstract signs (Jerf el-Ahmar).[192] This graphic transcription of thought shows, according to Cauvin,[193] a spectacular mental advance, but not yet urgent commercial administration. One of the plaques bears engraved signs in order; some of them are repeated, several are presented in simple or combined form. One side bears 34 horn-shaped signs, the other two simple rounded signs, one of which is combined with an arrow. Traces of use on the edges show that the plaques may have been manipulated for a long time.[194]

A combination of pictograms and repeated abstract signs may represent associated qualitative and quantitative (numerical) notations.[195] This is also attested in one of the first text categories (Uruk IV, end of the 4th millennium). The latter consists of tablets bearing a numerical notation and a small number of ideographic signs, probably a quantity of a product, the product itself and a personal name, without partitioning into columns and cases.[196]

In fact, according to Nissen *et al.*,[197] in the archaic Uruk texts, different numerical signs belonging to several different numerical systems are used. Each one is applied either in broad contexts or for recording specific categories of products or measures, thus containing qualitative information about the counted product; correspondingly, some ideograms also carried quantitative information. Some signs change their numerical value according to the field in which they are used, while others are specific and may have only one numerical value for one precise counted product.

A large category of Uruk IV tablets has a surface divided into columns and cases, each case containing a unit of information; sometimes the sum of these numerical notations is incised on the reverse.[198] The disposition of signs on tablets in horizontal parallel lines may reflect the order and parallel rows in which tokens were organised by prehistoric accountants according to Schmandt-Besserat.[199] Besides, in logographic script systems where each sign corresponds to a concept and grammatical types are not represented, the distinction of groups of written units in space is necessary to avoid confusion,[200] and this may be obtained by horizontal and/or vertical lines.

It seems probable[201] that script was discovered suddenly by an individual who realised that the substitution of a word or concept by a sign, which had long been practised for numbers, could be transposed to non-numerals.[202] Fixing and using the signs would need conventions similar to those used in previous mnemotechnic methods.[203]

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[192] *Syrie* 1998, 10, fig. 2, 187, notes 1-2; Aurenche & Kozlowski 1999, 45, pl. 2-7 and 2-12; Glassner 2000, 119-121.

[193] Cauvin 1998, 10-11.

[194] Stordeur 1998, 187.

[195] Combination or accumulation of simple elements or numerical signs and pictograms is, besides, attested in several early scripts.

[196] Nissen *et al.* 1993, 20, fig. 21.

[197] Nissen *et al.* 1993, 27, 131.

[198] Nissen *et al.* 1993, 20, fig. 22.

[199] Schmandt-Besserat 1996, 85.

[200] Justeson 1986.

[201] Nissen 1998, 29, 31; Matthews 1998, 19.

[202] Nevertheless, the elaboration to later real script systems must have been the result of a long previous procedure; these systems appear completely formed and contain many different signs (Nissen 1998, 29, 31; Matthews 1998, 19).

[203] Nissen 1998, 31.

Early graphic representations would have been used initially[204] as simple signs recalling units of a conceptual whole that the reader/narrator knew by heart. Everything expected to be known by the reader was omitted, although improvisation and variation were possible.[205] The meaning of the signs was understood only by the individuals who were immediately involved. Script was not, then, fundamentally different from its precursors: the reader had stored most of the data in internal memory and external storage was simply complementary.[206]

Therefore, in the beginning, the written message did not correspond exactly to the forms of speech and could be 'read' in several different ways, even in several languages[207] (cf. Fig. 2). This may mean that script was invented in multilingual contexts, as a recording and communication system across linguistic frontiers of multiethnic groups,[208] such as in Southern Mesopotamia at the end of the 4th millennium (Late Uruk).[209] This is when, according to several scholars, in spite of objections, uncertainties and open questions,[210] recording mechanisms of clay envelopes and tokens resulted in the written code-making of script (clay tablets with signs on one or several sides), in particular proto-cuneiform, at least in its operational forms.[211]

If marks on clay artefacts were to be transformed into some form of writing, they would be symbolic as well as indexical signs.[212] Abstract shapes already existed in earlier tokens from the beginning; if the number of signs on the earliest script tablets is larger than that of the tokens, this may be due to the use of wooden tokens, while other shapes may have originated from painting or tattoos.[213]

In the beginning writing records only very characteristic elements, calendars and distances (as in Egypt, China, Mesopotamia, or America); concepts which were known earlier, but which acquired a new meaning with the change of the economic system.[214] According to Matthews,[215] evidence for numerical recording and marking of propriety (potters' marks) before the invention of script, as well as in very early scripts (proto-cuneiform, protoelamitic, Egyptian, Chinese or Mesoamerican) would demonstrate that economic and administrative intensification led to writing. Notwithstanding this, he thinks that primitive script is linked to mediation of political power through ritual means.

Although an earliest Pre-Uruk writing must have existed, it would be impossible to find it, since this presumed script probably disappeared shortly after it was invented.[216] This situation would probably be similar to that of the so-called 'old European script' (Vinča signs).

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204 Février 1948, 17.

205 Nissen *et al.* 1993, 20.

206 Nissen 1998, 29.

207 Gelb 1969, 14.

208 Mathematical language is international because it is independent from phonetic systems; it is a system of notation very far from speech (Goody 1979, 213).

209 Matthews 1998, 19; cf. Glassner 2000, 257.

210 See Glassner 2000 for a recent overview of opinions on the beginnings of the script in Sumer.

211 This does not mean that there is necessarily a functional connection between plain tokens and the ultimate development of script (Matthews 1998, 16).

212 Noble & Davidson 1996, 113.

213 Nissen 1998, 29.

214 Leroi-Gourhan 1965, 66-68. It is impossible, according to Leroi-Gourhan, for script to have been created for things which had been preserved before by means of oral memory, evolution concerns first what is new, what cannot be fixed in memory.

215 Matthews 1998, 17, 19.

216 Lieberman 1980, 358.

According to Makkay,[217] more than 300 signs were incised on vases, figurines and weights from Tordos, belonging to the Vinča A-B culture (corresponding more or less to the Greek Late Neolithic I). Winn[218] has studied a corpus of 210 Vinča (Late Neolithic I-II) signs[219] according to the object on which they occur (spindlewhorls and loomweights, figurines, pottery and unusual objects) and, in the case of pottery, the position of occurrence.[220] Longer groups of complex signs generally occur on spindlewhorls[221] and many examples of divisions into registers with sign-like incisions are found on miniature vessels.[222]

The Vinča signs are mostly rectilinear and mostly incised before firing, sometimes in isolation (on pottery, figurines, and spindlewhorls and occasionally on other objects) and sometimes in groups. A group consists of two or more signs in reasonable proximity to one another.[223] The Vinča signs are constructed from five core signs: a straight line, two lines which intersect at the centre, two lines which intersect at one end, a dot or stipple, and a curved line, and form 18 fundamental categories.[224] The Winn signs 31 to 38 and 123 to 127 seem to be numerical signs; they consist of parallel vertical or horizontal lines, or of juxtaposed stipples, including two sets of three lines, or two or three rows of stipples,[225] with, characteristically, a maximum group of six vertical lines or five stipples (cf. above, I.3. Elementary forms of counting and recording).

Depending on their location, the Vinča signs which could be numerical are divided, according to Winn, into the following categories:

i) In general, the simplest signs are found in all positions on pottery. Signs situated only on the base or on the side near the base are generally associated with what may be considered numbers.[226] It is true that they are too varied to identify the contents of the pot or quantity or destination and could hardly be identification marks of the maker or owner.[227] They could alternatively have a magical function.[228]

ii) If many sign groups on pottery, where there is plenty of space, are composed of only two signs, a larger number of signs (up to twelve according to Winn)[229] is nearly always placed on one face of a whorl,[230] where the space is very limited;[231] one Tordos spindlewhorl bears signs on both sides.[232] On the contrary, some of the whorls seem to bear numerical,[233] 'notational, numerical or magical' marks, consisting of lines or comb-like patterns.[234]

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217 Makkay 1969.
218 Winn 1981.
219 Winn 1981, 19-40, table I.
220 Winn 1981, 11.
221 Winn 1981, 12-14.
222 Winn 1981, 48, fig. 7C.
223 Winn 1981, 138.
224 Winn 1981, 59-65.
225 Cf. Makkay 1969, 48, no. 38.
226 Winn 1981, 72, 80.
227 Cf. Potts 1981; Dollfus & Encreve 1982.
228 Winn 1981, 241, 242.
229 Winn 1981, 197.
230 Neither the order nor the direction of the inscription has been considered of importance.
231 Winn 1981, 145.
232 Roska 1941 and Vlassa 1970.
233 Winn 1981, 148, 151, 164.
234 Winn 1981, 158.

These artefacts, as well as loomweights, which also bear occasionally simple marks,[235] obviously had a practical use.[236] It is possible, according to Winn, that the whorls were used secondarily, perhaps during the actual spinning activities, to keep record of the quantity of a material used, or of the number of times a mechanical operation was performed, etc., or that the signs were apotropaic for the activity of spinning.[237] They could also be symbols of weight or propriety, or of some other *signifié*.[238]

In contrast to the unique corpus of signs of figurines,[239] whorls seem, therefore, sometimes to fulfil ordinary needs, serving perhaps as mnemonic devices. Yet, they may contain highly specialised signs, possibly for a quite different purpose.[240] The duality of whorls is reflected in their roles in both domestic and ritual affairs, therefore indicating purposeful distinctions in sign usage and an intention to communicate something meaningful.[241] Whorls are sometimes found with figurines and/or miniature vases in the Late Neolithic[242] (see further).

iii) Several miniature vessels bear signs; when not an isolated sign, it is a long group, and it seems closer to figurine signs and consequently ritual usage.[243] Miniature vases were found in connection with figurines at Late Neolithic Dikili Tash.[244]

iv) Tablet-like objects seem to be a more credible script/accounting medium. The Gradešnica plaque[245] (Fig. 15)[246] dates from Karanovo V (late Vinča-Tordos or early Vinča C,[247] Greek Late Neolithic II), and was discovered with a figurine and two vases. One of the vases bore on the bottom a human figure and the other one some signs. The face of the plaque is divided by four horizontal lines into four registers with three or more signs in each. Two at least of the horizontal registers seem to be divided into 'cases' by means of vertical lines. Some of the more isolated ones may represent divisions between ideas, while some of the vertical lines are possibly number notations.[248]

Other tablet- or plaque-like objects with simple marks have already been presented above (II.2.a.2. Artefacts as s i g n s).[249]

That more tablets have not been found might be due to the poor preservation of unfired clay (see above) or organic materials.[250] This is suggested by a wooden tablet bearing signs, which

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235 Winn 1981, 223, fig. 30C from Coka.
236 Cf. Μαλακασιώτη 1982, 181.
237 Winn 1981, 151, 195.
238 Μαλακασιώτη 1982, 181.
239 Figurines with incised signs from south-eastern Europe, as well as possible parallels from northern Greece, have not been considered here. If their signs probably belonged to some semiotic system, the latter is not proven to be related to counting or recording. One exceptional piece from Vinča bears a series of signs (Winn 1981, 330; Masson 1984, 95, fig. 3, 96-98, no. 7), some of which could also be numerical.
240 Winn 1981, 107, 163, 164.
241 Winn 1981, 235.
242 Marangou 1992, 223; 1996a.
243 Winn 1981, 147, 166.
244 Marangou 1992, 18-20.
245 12.5 x 10.5 x 2 cm.
246 Winn 1981, 210-214, fig. 28; Nikolov 1970, 1ff.; Georgiev 1970, 8.
247 Nikolov 1970, 1, 2.
248 Georgiev 1970, 8.
249 The Karanovo handled stamp seal (diameter 6 cm., thickness 2 cm.; Georgiev 1969; Mikov 1969, 4ff.; Winn 1981, 216-219, fig. 29; Masson 1984; Makkay 1971 and 1984, 93) was found in a Karanovo VI house destroyed by fire. Its patterns look rather scrambled and it is divided into four parts by a cross incision. No relationship to numerical notations is discernible.
250 Winn 1981, 241. It would have been possible to draw temporary signs even on the soil; besides, pebbles could have been used on the soil or the floor in a form of primitive abacus, according to Schärlig (2001, 118). Such a practice of drawing on sand is still attested in the 20th century, although

was discovered at Professor George Hourmouziadis' excavations at Dispilio (lake of Kastoria)[251] (see further).

The Vinča semiotic system is composed of elements of differing complexity. There is no clear evidence for an important economic role of signs, and the marks on spindlewhorls would not make an efficient or likely accounting system,[252] although ordering on tablets and special objects seems significant.[253] The fact that the distance between horizontal lines as well as the signs themselves become smaller towards the lower part of the Gradešnica tablet, and the 'paging', would corroborate the interpretation of this document as a script.[254] On the other hand, long sign groups on miniature vessels and figurines would suggest ceremonial contexts, according to Winn. The dichotomy between signs on pottery and those on 'ritual' objects argues for different levels of usage[255] (see further, III).

Winn[256] argues that the development of metallurgy in the Tordos area, where the actual use of signs seems to have suddenly emerged, increased the potential for trading networks. If the raw materials for metallurgy came from Transylvania and the Carpathians, Tordos may have been a considerable commercial centre. Several signs at Tordos can be interpreted as numerals, and many of the unique Tordos signs could be attributed to identifications, which might be required at an important site.[257] According to Todorova,[258] the development of metallurgy, trade, and movement of products, the increase of personal property and thus the necessity to count the growing quantity of information, resulted into the use of 'pictograms'. In the area of the most ancient signs flourished the Chalcolithic metallurgical centre of Rudna Glava. However, Winn considers that the techno-economic development of the Vinča-Tordos area was accompanied by an elaboration of ritual involving the use of signs, while economic developments in the Near East resulted in recording that eventually led to script.[259] It was natural, according to Todorova,[260] to borrow signs known from cult and magic in order to use them for counting when socio-economic reasons created such needs.

The Vinča system is not 'true' writing. There is insufficient sign group repetition, and there are very few long groups. Mostly abstract linear signs occur alongside early pictographic signs.[261] The preference for straight lines and avoidance of elaboration would be due to the small number of available signs to be incised on clay.[262] No evolution of the signs or sign usage can be proved, except for the possible greater use of pictograms at an earlier date (cf. above, Pre-Pottery Neolithic A pictograms and early numerical notation in the Near East). The only obvious schematisation of a pictogram is the animal representation, already present in the earliest phase at Tordos. There are a few decorative motifs.[263] Hooker wondered[264] if there is equivalence

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rather for ritual purposes, as a game or in order to transmit collective memory in general, for example by the Quiocos of Angola (Fontinha 1983).

251 Χουρμουζιάδης 1996, 46, 47 and note 16.
252 Winn 1981, 242.
253 Winn 1981, 241.
254 Masson 1984.
255 Winn 1981, 245.
256 Winn 1981, 252.
257 Winn 1981, 255.
258 Todorova 1979.
259 Winn 1981, 252.
260 Todorova 1979.
261 Winn 1981, 236.
262 Hooker 1992, 110-111.
263 Winn 1981, 236. A few signs can be derived from Starčevo decorative design on pottery, others from decorative designs of the Vinča culture. The origin of a few pictograms is self-evident (Winn 1981, 252).
264 Hooker 1992, 104.

between one sign and one concept, or one sign and one sound unit, or any intention to represent units of sound at all. A phonemic identification is precluded according to Winn:[265] the system may well be partially logographic, and some of the signs may represent words or concepts; therefore they could be combined in an unordered fashion and still be meaningful.

According to present evidence, the Vinča system of graphic representation may never have developed into a complete script system. If it never reached the stage of real writing, this is probably because it had no need to do so.[266] Maybe the economic or other need for this evolution did not appear in the Late Neolithic south-eastern Europe,[267] so that the linguistic information enters the process of code-making and decoding of the conceptual information.[268] As has been argued, when a tendency towards the creation of script appears, this tendency must either become a complete system, or disappear.[269]

In sum, in the areas under consideration, before script, signs are mainly abstract, but some pictograms occur in association with them at very early dates and might represent a combination of qualitative and quantitative information. The same combination has been noticed concerning tokens (see above). What could possibly be numerical signs are found in isolation, often on pottery, and, less frequently, in groups with other signs. They occur then more often on artefacts of unknown function, such as tablets, but also on tools related to spinning activities. This stage could be Renfrew's[270] transition period to the last cognitive phase of human evolution. The latter consists of 'theoretic culture using sophisticated information retrieval systems for external symbolic storage, usually in the form of writing, frequently in urban societies'.

2) Evidence from Greece and other examples

Some rare examples of incised signs, possibly including numerals, are known from Greece.[271] They occur on utilitarian artefacts, but also on artefacts of unknown use. More precisely:

i) Signs on pottery, in isolation or in groups, are incised on bases of vases (for example, from Tsangli)[272] or on their walls (for example, from Paradimi).[273] Series of signs including possibly numerical notation are attested on sherds from Obrenovak and Rudnik.[274]

ii) A unique Late Neolithic clay spindlewhorl from Dikili Tash, which belongs to one of the commonest, flat shapes ('plano-concave'; diameter 5 cm.)[275] (Fig. 16, 17), bears distinct signs, similar to the Vinča ones. Most Dikili Tash whorls, among those belonging to three characteristic types of the Late Neolithic, bear incised decoration: notches on the edge, as well as geometric incisions, mostly rectilinear, and sometimes points; the disposition of the motifs is radiating or in registers.[276] A flat whorl, relatively light, might be put on top of the spindle; then its decoration would be oriented upwards. A light type would be adapted for wool, while flax

[265] Winn 1981, 236, 238.
[266] Winn 1981, 253.
[267] Masson 1984, 123.
[268] Justeson 1986.
[269] Boltz 1986.
[270] Renfrew 1998, 4 with references.
[271] For a previous presentation see Marangou 1987.
[272] Wace & Thompson 1912, 91, fig. 43.
[273] Πάντος 1987-88, 96, fig. 4, drawing 2. A number of examples are cited *passim* in archaeological reports. A systematic study of such Greek Neolithic marks is lacking.
[274] Masson 1984, 101, fig. 5, 3-4.
[275] Deshayes 1972, 204; Treuil 1992, 125, 129, 130, pl. 155D, 203A, M295; Winn 1981, fig. 30B.
[276] Treuil 1992, 127.

requires heavier whorls situated on the lower part of the spindle; this seems probable for an undecorated, heavy Dikili Tash type (*biconvexe* or *biconique*).[277] Besides, a large diameter results in slower torsion and lesser tension for the yarn.[278]

Other spindlewhorls incised with signs come from Valea Nandrului[279] and Fafos.[280] Some rather flat or disk-shaped whorls from Dimini also bear linear decoration on one side, which does not seem to be 'organically linked to the surface'. The signs might for example be symbols for weight or measurement, or proprietary signs.[281] The Dikili Tash whorl exhibits either dividing vertical lines or numerals[282] and can be compared to 'paging' of tablets from this point of view.

iii) A four-legged miniature vase[283] with incised signs on the lower part also comes from Dikili Tash (Late Neolithic), but it is difficult to distinguish the signs, let alone to identify possible numerals[284] (Fig. 18). Yet, three at least of the signs disposed in a series around a small vase from Ovcarovo consist of three oblique or vertical parallel lines or of two parallel vertical lines intersected by an oblique one.[285] These might be considered as possible numerical signs. Other signs in rows on miniature vases from Vinča[286] are less clear (on the photographs).

iv) A combination of pictograms and numerals may be incised on a flattened clay cylinder[287] from Paradimi in Thrace (Fig. 19a-c). The latter should be dated, according to Pantos, to the Early Bronze Age at the latest, and more probably, because of the clay used and the colour, to earlier periods.[288] Two animal (?) figures seem to be related to small groups of repeated abstract signs, often in sets of four or two, lozenges, rectangles and Xs. All these could belong to a counting/recording system. It is not impossible[289] that the base of such a system would then be tetradic. This combination of abstract signs and iconographic representations is also found on two of the Tărtăria tablets, the third one being only iconographic.[290] One of the Tărtăria tablets,[291] a plaque from Thessaly (see above, II.2.a.2) and the Karanovo seal,[292] among other examples, are also divided into cases or quadrants.

v) A wooden tablet discovered at Dispilio (lake of Kastoria) and dated by ^{14}C to 5260 BC, bears incised 'signs of an early script',[293] for some of which a use as numerical marks is not excluded.

Some examples bearing repeated identical, simple marks have been included in the category of artefacts as signs (see above): parallelepipeds with repeated notches, as well as tablet-like (or tally-like) objects.

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[277] Treuil 1992, 130.
[278] Τζαχίλη 1997, 121.
[279] Vlassa 1970, fig. 16.
[280] Gimbutas 1982, fig. 22A.
[281] Μαλακασιώτη 1982, fig. 1, 2 and 6.
[282] Cf. Masson 1984, 104.
[283] Maximum width 4.5 cm.
[284] Marangou 1992, 16, fig. 21K, and in press.
[285] Bonev 1983.
[286] For example, Letica 1967, pl. I.9 and V.1; cf. Gimbutas 1984, 86, fig. 40.
[287] Length 4.8 cm.
[288] Πάντος 1987-88, 96, fig. 1-3, drawing 1.
[289] Πάντος 1987-88, 98, note 35.
[290] Vlassa 1963; Hood 1968; Renfrew 1979; Masson 1984, 112-122 with relevant bibliography.
[291] Masson 1984, 119, fig. 11, 3.
[292] See above, note 249.
[293] Χουρμουζιάδης 1996, 46, 47, fig. on p. 5. The tablet is under study by Professor Hourmouziadis. Its contribution will certainly be very precious for the understanding of Neolithic sign systems.

An association of qualitative and numerical marks on the one hand (Paradimi), and a mixture of numerical marks (?) (double, triple etc. vertical parallel lines), and more complex signs on the other (Dikili Tash whorl), could constitute positive elements towards an interpretation of these sign groups as belonging to a recording system.[294] If written language comes from linking numerals with elements from representational art, and if script evolves through the common use of more than one system of graphic representation in common settings (as was said about Mesoamerican systems), then only arithmetic could permit this evolution.[295] Robson[296] argues that writing was invented for the express purpose of recording numerical information. In any case, numbers were the first to be noted in Sumer: just two signs (the notch and the circle) sufficed in the beginning, while more than sixty were used later.[297]

III. Possible Counting/Recording Sign Systems In The Neolithic And Their Potential Uses And Users

A number of Neolithic artefacts, (a) some token-like objects of unknown use, and (b) artefacts bearing incised signs, have been considered as possibly related to sign systems. These two categories are probably not mutually exclusive, at least in the Late Neolithic, since they may appear on the same site during the same major phase, as at Dikili Tash (whorl with signs, tokens and parallelepipeds).

Their morphological features enabled them to be distinguished as artefacts-signs: tokens of various shapes (EN-LN or FN) and plaques (tallies or 'tablets') (MN-LN), and as artefacts bearing marks/signs: clay tools, miniature and normal vases, and objects of unknown function (mostly tablets) (LN).

Clay (exceptionally stone) tokens appear from the Early Neolithic, and possible clay tally-like objects at least from the Middle Neolithic. Yet, other cognitive vehicles, not distinguishable in the archaeological record, such as shells or pebbles, or made of perishable material, such as wooden artefacts or ropes, may also have been used, even in earlier periods.

If tokens have no obvious practical function, the artefacts on which early two-dimensional recording may have occurred may also be utilitarian. They are related to specific occupations, namely, spinning (whorls) and storage (vases) activities. The problem of the function(s) of miniature vases remains, as it is not impossible that they had some utilitarian function (for example, storing small quantities of 'precious' materials). As seems to happen with Upper Palaeolithic 'artificial memory systems',[298] Neolithic sign systems may fit transportable objects, including tools.

The usual difficulty for the interpretation of objects of 'unknown function' is whether they belong to a single sign system or not, and if so, if this is a counting and/or recording system. Furthermore, multifunctionality is always conceivable. Other sign systems of communication must have existed in the Neolithic economic and social environment, including that of figurines/models.[299] The latter were presumably used, according to Hourmouziadis, as

[294] Marangou 1987.
[295] Justeson 1986.
[296] Robson 1999, V.
[297] Glassner 2000, 168-169, 170.
[298] D'Errico 1998, 47.
[299] Marangou 1996a, 150.

'*σήματα*/ideograms' of a Neolithic 'proto-script' (*πρωτογραφή*), constituting an early and primitive form of script (see above, II.2.a.2).[300]

The relationship of certain Neolithic sign systems of south-eastern Europe to counting or recording, among other alternatives, seems to be a likely explanation. Nevertheless, were this accepted, the field in which this counting or recording would have functioned is unclear. Candidates include exploitation, storage and exchange of raw materials, commodities and processed or finished products, agriculture, animal herding, and spinning (and/or weaving). There is no evidence for the precise categories of quantities measured, for example, number of individual beings, length, distance, space or weight. There could be a qualitative differentiation, as the variety of examples from a same site, and indeed, the two types of the Nea Nikomedeia as well as of the Jordan tokens (see further) and the variety of form of the Munich 'cult scene' objects, suggest, unless this diversity of shape rather reflected variety of quantities (but see further).

In fact, hundreds of unworked flint flakes have been associated with a great collection of clay tokens, belonging to two different types, at least once, in Early Neolithic Nea Nikomedeia. The presence, at the same time, of some symbolic objects, figurines, could serve a different purpose, apotropaic or cultic for example.[301] If the building ('Shrine') was a public one, this could mean a common interest or care for important items stored in abundance, of which tokens would be part. Tokens, if counting/recording devices, and therefore control mechanisms, may well have been kept with important objects, yet not necessarily with the items counted. In other words, it may have not been desirable to keep counters in the same storage space as counted commodities.

Recently, 473 'standardised' tokens ('geometrics') belonging again to two different types, animal and presumed human figurines were discovered in the same space in southern Jordan (Es-Sifiya, Late Pre-Pottery Neolithic B). It has been argued that they were manufactured together for a specific purpose, possibly to be used in some transaction, an isolated event that required some kind of symbolic recording.[302] Joint manufacture of very small anthropomorphic figurines, tokens and tallies is not impossible concerning the 'cult scene' in Munich;[303] unfortunately its original context is unknown. This is all the more unfortunate, as it seems particularly significant that each type of artefacts in the Munich ensemble, including the anthropomorphic figurines, can be further subdivided into two or three sets according to size (scale). This could indicate addition of quantitative or qualitative information to each category of objects, meaningful precisely if they were counting/recording devices. Would then also the figurines themselves (of two different types) have constituted such devices, used in order to count/record humans (of both genders), for example, according to age or function?[304]

The possibility exists that the Nea Nikomedeia 'roundels' belonged to some other semiotic system, such as sympathetic magic, play or cult, for example. One could even assume that they might be some sort of tool, but there is no information about them revealing any use wear. It is of course impossible, without a detailed description of the material, or a global view of the context, as long as the Nea Nikomedeia material is unpublished, to make any valid suggestions. It is certain though that these possible counting devices could change their location and grouping, since they are movable objects. They may have been kept together after manufacture and before use. They could be at some point at the disposal of individuals or specific households.

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[300] Χουρμουζιάδης 1994, 228. Glassner (2000, 79) is against the concepts of pre- or proto-script, as well as against a pictographic origin of the script (2000, 69-86).

[301] On this subject see Marangou 1992, 1996a, 2001.

[302] Mahasneh & Gebel 1999.

[303] Marangou 1992, 1999.

[304] Marangou 1999.

This would explain the fact that these objects are usually found in small groups or in isolation during the whole of the Neolithic period. It must also be noted that sometimes the coexistence of whorls, figurines and tokens (LN Dikili Tash) might indicate the parallel occupation of adults (women?) and children in the same domestic space, in which case play could be retained as an alternative for the interpretation of some tokens.[305]

Mobility is not feasible with signs incised on Late Neolithic clay artefacts, which should represent a fixed (unchangeable) state of affairs. Whorls, possibly for wool, do bear signs occasionally in the Late Neolithic, and some rare objects bear pictographic animal figures associated with abstract signs. Counting and/or recording may then be related to some crafts, such as spinning and consequently wool, yarn, textiles, or herding and animal products, but the data presumably recorded cannot be changed. This means of course a permanent situation, possibly ownership.

On the other hand, the combination of counting devices and food storage is not proved for the moment (but see above). It is again plausible that counting devices were kept in a different space, not together with the counted items, all the more so, if they are testifying some transaction. Food storage may sometimes be connected with other symbolic items instead. For example figurines, occasionally bearing incised marks on the top of the head, were found in grain bins or in vases, and anthropomorphic figures have been applied in relief to large storage vessels.[306] All these cannot be connected convincingly with numbers, but rather with sympathetic magic or apotropaic ends. If counting was applicable to stored quantities of raw/perishable materials, then the attested simple signs incised on Late Neolithic pottery could constitute relevant evidence, again if they do not have an apotropaic or proprietary function. In addition, some other method was conceivably used for counting stored commodities, for example, the number of actual vases of constant dimensions and containing a fixed volume of foodstuff.

The relationship of counting to finished products and status or symbolic artefacts (jewellery) is not attested for the moment either. The miniature vase bearing signs from Dikili Tash was found in association with several *spondylus* bracelets,[307] but its signs cannot be proved to include numerals. Articles of jewellery seem, in fact, occasionally to be connected with some categories of miniature vases or figurines in the Late Neolithic.[308] These may at the same time be connected with whorls (see above). From this point of view the situation recalls the connection of storage (a domestic activity) and sign systems (figurines or/and miniature vases), though ones other than counting/recording systems. If not fortuitous, this relation may in fact reflect a sign system with a distinct purpose, in this case, the protection of valuables, for example.

Coexistence of sign systems is possible: The context of possible counting/recording tokens may include other symbolic objects, such as figurines (Achilleion, Es-Sifiya), indeed at the same time as stored articles (Nea Nikomedeia), including zoomorphic figurines (Dikili Tash, Es-Sifiya). The utilitarian may be interwoven with the ritual in the Neolithic, and the evidence for domestic ritual during everyday activities[309] corroborates this assumption.

Middle and Late Neolithic clay 'tallies', if tallies they were, had all their patterns incised at the same time, not successively, and their arrangement was as definitive as that of Late Neolithic artefacts bearing signs (see above). Repetition of identical marks, as sets of identical tokens, could show counting/recording of similar objects or beings. Occasional differentiation of marks

[305] Marangou 1996a, 149.
[306] Marangou 1992, 222-223; 1996a, 149.
[307] Marangou 1992, 18.
[308] Marangou 1996a, 149; 2001.
[309] Marangou 1996a, 148-149; 2001.

might indicate the parallel use of qualitative information, two or more categories of units being counted, or the representation of different quantities by means of distinct signs (as of larger and smaller tokens).

Counting space and quantities cannot be separated from time regularity; calendar cycles of farmers are marked by star cycles, but also by concrete, operational time,[310] for practical use in agriculture. It is not impossible that the tally- and 'abacus'-like plaques with paging (rather than the decorated reverse side of ovens) are calendars, although the hypothesis cannot be tested. If these artefacts were not counting/recording devices, they could be connected with play. Idleness is not inconceivable in Neolithic times. Moreover, some games develop counting capacities with cognitive aids, such as the *warri* social game of the Ashantis by subitizing.[311] It needs a lot of subtlety to distinguish between a gaming counter and an accounting reckoner.[312]

Besides, use of numbers may result not only from play, but also from ritual; the supernatural is sometimes difficult to distinguish from children's or adults' play.[313] Furthermore, story-telling, rhythmic recitation, dancing, singing or music (cf. the Neolithic bone flutes from Dispilio[314] and Sesklo[315]) should constitute part of the life of the community including its ritual life.[316] Internal memorisation of collective cognitive heritage might need some external storage, even if this was only a complement, the transmission being made mainly orally. Rhythm and notation are common features of all these systems, but it is impossible today to distinguish between the functions of Neolithic signs and maybe no such distinction was made then, but the same objects at the same time served various functional ends.

The ambiguity of archaeological traces has often been stressed.[317] It is difficult to distinguish drawings from signs, decoration from early script.[318] This ambiguity of the archaeological record probably originates from the particular polysemic approach of humans when conveying meaning through material representations.[319] 'If decoration and notation are not mutually exclusive possibilities in the engraver's mind, how can we separate them when we analyse archaeological objects?'.[320] Here, as in the Palaeolithic, analytical and theoretical tools are not able and probably never will be able to provide clear-cut answers in all cases.[321]

The unequal distribution of tokens, but also the fact that only a few utilitarian artefacts bear signs, shows that a limited number of individuals or/and households used them, suggesting therefore some social or functional differentiation of the users. Few individuals needed or had the right to control the counting/recording operations. In the Early Neolithic of Nea Nikomedeia there is only one[322] space containing tokens in abundance, and finds in all Neolithic phases and sites normally consist of rare, small groups.

If fabrication of tokens is easy, some standards of shape and dimensions are observed at local level, such as two standardised types repeated even hundreds of times. More obviously, incision

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310 Leroi-Gourhan 1965, 145.
311 Goody 1994, 283.
312 Jasim & Oates 1986, 352.
313 Renfrew 1994, 8.
314 Χουρμουζιάδης 1996, 52, fig. 17.
315 Θεοχάρης 1973, colour plate 210.
316 Cf. Marangou 1996b.
317 Cf. Molino 1992, 24; Marangou 2001.
318 Treuil 1983, 506-507; Treuil *et al.* 1997, 156.
319 D'Errico 1998, 46.
320 D'Errico 1998, 46.
321 Cf. D'Errico 1998, 43.
322 However, one should keep in mind that the site has not been entirely excavated.

of Late Neolithic signs on clay follows some patterns, thus necessitating knowledge of some code. We do not know if the same individuals made and used these artefacts, but some persons were aware of the codes and had control of the standards and the systems. This necessitates transmission of competence to other individuals in the social group, at least at intervals, so that 'collective' or 'joint' memory[323] persists from one generation to the next. This means, therefore, teaching and apprenticeship or initiation. Consequently, and as public display of knowledge and teaching may be involved in material vehicles of thought or cognitive devices,[324] an additional valorisation of such objects, for example by decoration, may result.

Competence in storing information may have constituted only one aspect of the role of these individuals within prehistoric societies.[325] This situation could be similar to that of connoisseurs or guardians of other Neolithic sign systems, such as those of figurines and models.[326] Individuals specialised in storing memory among preliterate human groups could be older members of the community,[327] or individuals with some special status. These would have the knowledge and the right to create and handle the cognitive devices, as well as their control and the ability to employ, understand and transmit the codes.

CONCLUSIONS

If the evidence tends to imply that counting and/or recording exist from at least the beginning of Upper Palaeolithic, relatively few artefacts have been identified as possibly belonging to such sign systems in the Greek Neolithic. They often lack secure dating or precise contextual information, and debate about their possible function(s) continues.

However, an evolution is discernible from the Early to the Late/Final Neolithic: tokens – plaques/parallelepipeds– tablets and utilitarian artefacts with signs, although tokens probably persist through all periods. The absence of evidence for continuity into the Early Bronze Age (with exceptions), if not due to excavation hazards, may show the replacement of those sign systems by some other memory scheme. This contrasts with the situation in the Near East, where script and large-scale accounting emerge at the end of the 4th millennium. Changes in the use of other sign systems are attested at the same time in the Aegean region, such as a mutation in the forms, places, and possibly actors of ritual, and a modification in the use of figurines and models.[328]

The discovery of large quantities of possible tokens is very uncommon. Both tokens and parallelepipeds are usually few in number on a site and have been found together only in restricted groups. Utilitarian artefacts with signs are also rare in a series of similar articles, and tablets are exceptional. These special objects could then be bestowed on or possessed by select households or individuals.

Lack of extensive and systematic study, as well as of contextual information does not permit the evaluation of all parameters of morphological, spatial and temporal variations of this material. The possible users, products or units measured or recorded, and purposes aimed at, may to some extent be conjectured, but much more data are indispensable in order to perceive the patterns in all their complexity.

[323] D'Errico 1998, 47.
[324] Frake 1994, 130.
[325] Cf. D'Errico 1998, 47.
[326] Marangou 1992, 221; 1996a, 148-149.
[327] Cf. D'Errico 1998, 47.
[328] Marangou 2001.

Nevertheless, it has already become apparent in this brief overview that several types of cognitive aids may have been used in the Neolithic period, some of them possibly in relation to counting and recording. Evidence shows the existence in the Neolithic of the necessity and the capacity to create and use such sign systems. Some of the latter attained a spectacular evolution in later periods, and are still progressing today.[329]

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[329] My interest for tokens and signs started in 1981, after my first contact with the Neolithic figurines and models, including objects of 'unknown use', from Dikili Tash, Eastern Macedonia (excavations Jean Deshayes).

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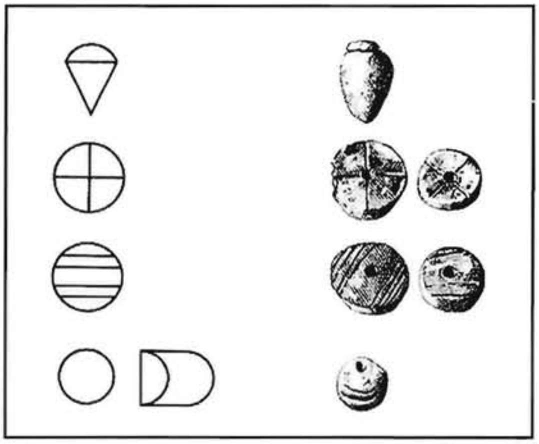

Fig. 1. Comparison of written signs from Uruk (left) and clay tokens from Habuba-Kebira-south. After *Syrie*, 16, fig. 1. By kind permission of the Société Générale de Belgique.

Fig. 2. Numerical tablet bearing imprints of rounded or oblong shape, probably indicating counted products. Djebel Aruda, end of the Uruk period. After *Syrie*, 194, 18. By kind permission of the Société Générale de Belgique.

Fig. 3. Clay rounded miniature 'drums' or 'seats'. Northern Greece, Middle Neolithic (?). Photograph by the author.

Fig. 4. Clay rectangular 'tables' or 'seats' from the Munich 'cult scene'. Northern Greece, Middle Neolithic (?). Photograph by the author.

Fig. 5. Clay miniature 'ear-studs', bobbins, or 'drums' from the Munich 'cult scene'. Northern Greece, Middle Neolithic (?). Photograph by the author.

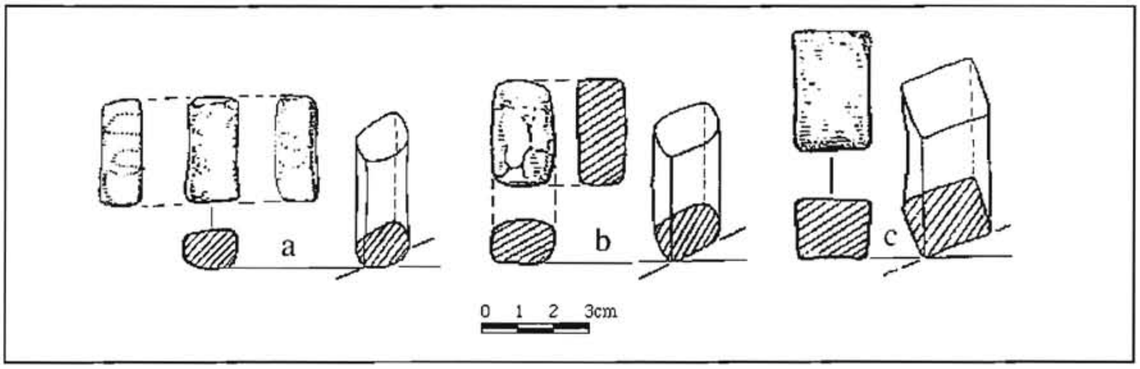

Fig. 6. Rectangular solids from Achilleion, Early and Middle Neolithic. Adapted from Gimbutas *et al.* 1989, 257, fig. 8.14.

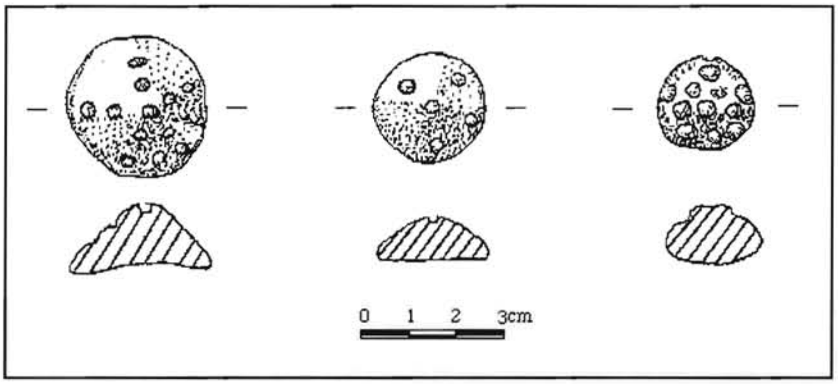

Fig. 7. Clay 'gaming counters' from Sitagroi, Late Neolithic. Adapted from Renfrew 1987, 367, fig. 9.

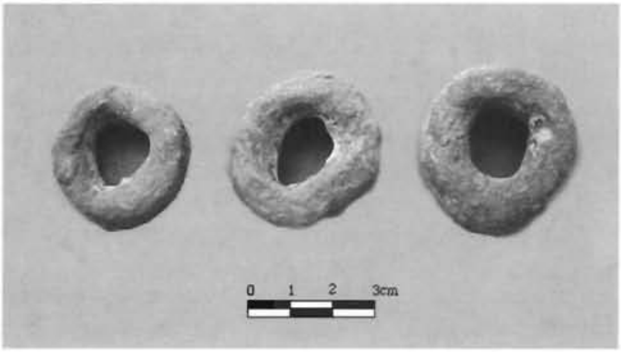

Fig. 8. Clay 'rings' from Dikili Tash, Late Neolithic. Photograph by the author.

Fig. 9. Clay 'rings' from Dikili Tash, Late Neolithic. Photograph by the author.

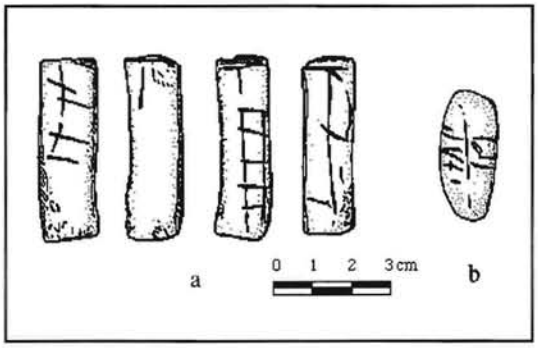

Fig. 10. Clay plaques/parallelepipeds from Thessaly, Middle Neolithic. After Θεοχάρης 1973, fig. 181.

Fig. 11. Clay plaques/parallelepipeds from the Munich 'cult scene', Middle Neolithic (?). Photograph by the author.

Fig. 12. Clay plaques/parallelepipeds from the Munich 'cult scene', Middle Neolithic (?). Photograph by the author.

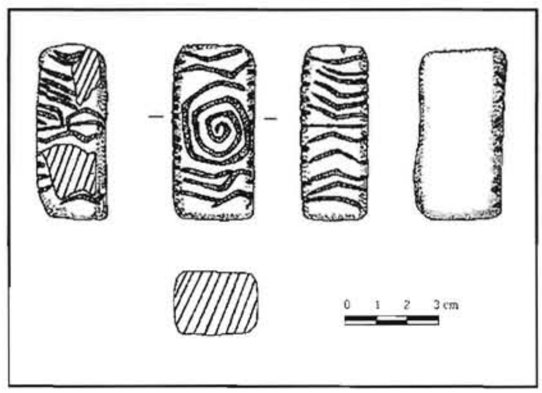

Fig. 13. Clay incised plaque from Dimitra, Middle (or Late?) Neolithic. Adapted from Renfrew 1987, 362, fig. 7.

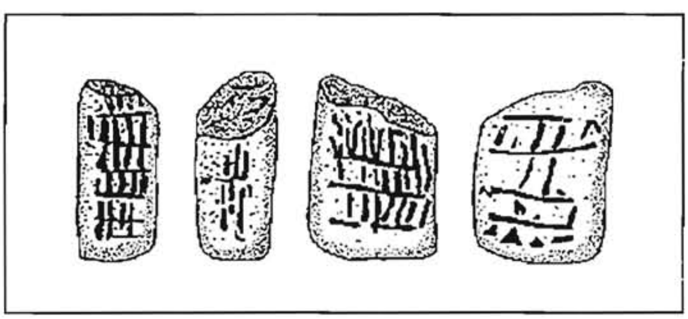

Fig. 14. Clay 'paginated' tablet from Tangiru, Gumelnitsa IIc period (*ca.* 4000 BC). Adapted from Winn 1981, 222, fig. 30a. No scale.

Fig. 15. The plaque of Gradešnica, Late Neolithic (Early Chalcolithic). Adapted from Nikolov 1986, 183, fig. 15a-b.

Fig. 16. Clay spindlewhorl with incised signs from Dikili Tash, Late Neolithic. After Treuil 1992, pl. 203A. By kind permission of the École Française d'Athènes.

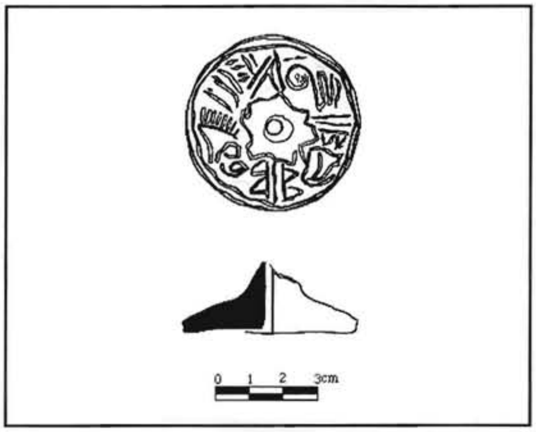

Fig. 17. Clay spindlewhorl with incised signs from Dikili Tash, Late Neolithic. After Treuil 1992, pl. 155D. By kind permission of the École Française d'Athènes.

Fig. 18. Miniature vase from Dikili Tash with incised signs (?), Late Neolithic. Photograph by the author.

a

Fig. 19a-c. The clay flattened cylinder from Paradimi. Its roughly elliptical bases bear deep, oblique, parallel incisions, and its flattened side is almost completely undecorated (not shown on the photographs), as the incisions end under its edges. The revolution (curved) surface, delimited by double parallel incisions along the ends near the bases, bears various incised patterns.

On the two lateral sides of the curved surface (a, c), two quadrupeds (male and female?) are incised, parallel to the cylinder axis, one on each side. Over each animal, two abstract signs, consisting of a series of triple or quadruple Xs or lozenges, parallel to the cylinder bases, are formed by deeply incised crossed lines and points. There are three more rectangular shapes, two of which, inscribed with crossed lines, over the 'male'.

b

c

On the upper part of the curved surface of the cylinder (b), between the two ensembles of animals and abstract signs, a series of four parallel lozenges have been incised very lightly, parallel to the bases. The frequent repetition of the same pattern up to four times, the combination and the order of the marks and animal representations seem significant (photographs by the author).

Containers used till recent times as measures of dry capacity –the wooden barrel– and of liquid capacity –the metal vessels arranged in a graded series (collection of A. Michailidou). In ancient times the metric systems of volume, associated with agriculture, are considered to have an older tradition than those of weight. Fractional quantities are recorded in the Hieroglyphic script and the Linear A by fractional numbers.

FRACTIONS AND MEASUREMENT UNITS IN THE CRETAN HIEROGLYPHIC SCRIPT

Artemis Karnava

THE CRETAN HIEROGLYPHIC SCRIPT: INTRODUCTION[*]

Despite the fact that the Cretan Hieroglyphic script (*ca.* 1900-1650 BC) is the most poorly studied prehistoric Aegean script, it is certain that it was used for the registration of products and the control of their movement, like its contemporary Linear A and their successor, Linear B.

At the present state of affairs very little is known about the structure of the script; it has nevertheless been established that it is for the most part a syllabic script with a number of 'syllabograms' equivalent to those of Linear A and B.[1] The 'syllabograms', signs which had a phonetic value, gather in groups (sign groups), which constitute the phonetic registration of words. Some signs which appear in isolation, the 'logograms', were used to indicate in a pictorial manner the argument dealt with in the registration; presently, besides the assertion that these logograms had a similar function to those of Linear A and B,[2] we are not in a position to say more about them.

The sign groups and the logograms are followed in certain cases by numerical entries in the decimal system. The numerical system used by the Cretan Hieroglyphic script has been recognised owing to the fact that it is common (with a few differences) to all three scripts.

'KLASMATOGRAMS' ON CRETAN HIEROGLYPHIC DOCUMENTS

In a small number of cases, numerical entries (which count a product in integers) are followed by script signs called 'klasmatograms'. In the body of the Cretan Hieroglyphic script inscriptions klasmatograms are admittedly rare,[3] a fact which does not allow the secure

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[*] This article is a sub-product of the work carried out for the completion of my doctoral thesis on the Cretan Hieroglyphic script in the Free University of Brussels, Belgium (U.L.B.). In the present study, the following conventional terms and diacritics, taken from the corpus of the Cretan Hieroglyphic script inscriptions, are used: the sharp ('#') followed by a number refers to the number given to each inscription; the 'klasmatogram' comes from the Greek word *κλάσμα*, which means 'fraction'; the 'logogram' comes from the Greek word *λόγος* and it denotes the signs which are used to express the smallest segment of speech, i.e. a word, and not its idea (as the term 'ideogram' implies).

[1] Olivier 1986, 378-379.

[2] Olivier 1976, 20.

[3] Only 41 signs have been so far recognised as klasmatograms in the Cretan Hieroglyphic script, whereas in Linear A there are more than 500; Linear B has more than 1,700 fractional measures (Lebessi *et al.* 1995, 66, note 12). These numbers correspond to the total number of signs in all three scripts.

extraction of conclusions regarding their use or what exactly they stand for (if they are indeed fractions, as their name states, or if they are measurement units).

Klasmatograms are found mainly among the registrations on some of the four-sided bars (5 out of 31 from various find-spots),[4] the majority of which come from the Hieroglyphic Deposit in the Knossos palace (#059, #065, #066, #067), and only one from the *Dépôt* in the Malia palace (#118) (Table 1). Two other documents bearing klasmatograms are tablets, one from Knossos (#068) and one from Phaistos (#122), which, however, due to the fact that it is doubtful whether they are written in the Cretan Hieroglyphic or in Linear A script, are best examined separately (Table 4).

Recently, a new find came to be added to the few klasmatogram samples in the Cretan Hieroglyphic: a two-sided bar fragment (*lame à deux faces*) from the sanctuary of Syme Viannou[5] bears two logograms followed by the same klasmatogram (308), which was previously known only from inscriptions on seal faces.

'KLASMATOGRAMS': MEASUREMENT UNITS OR FRACTIONS?

In the corpus of script inscriptions, *CHIC*, the signs which are listed under klasmatograms always follow logograms, sometimes with the intervention of (integer) numbers (see Table 1). Generally speaking, logograms in the Cretan Hieroglyphic script, in the relatively few instances they are attested, are followed in their majority by numerical entries. Some of the logograms, however, which are followed by klasmatograms, are followed on certain occasions only by numerical entries. On the four-sided bar #065, to mention but few examples, on side b, logogram **161*, which obviously symbolises a (liquid?) product stored in a jar, is registered the first time followed by klasmatogram 303Θ, and immediately afterwards it is repeated, this time followed by the numerical entry '300'; then, logogram **156*, appears on #065.c followed by the numerical entry '2' and klasmatogram[6] 304Λ, on #067.a followed by the numerical entry '1' only, while on #118.c followed by the numerical entry '20' and klasmatogram 304Λ again.

Supposing that the klasmatograms in these cases represent measurement units for products (liquid or solid), the first question that comes to mind is how is it possible that the same products are counted sometimes in these 'units' and sometimes in integers. The second question is what quantity of these 'units' one should imagine coming between the logogram and the klasmatogram in cases with no numerical entries. Finally, the third question, in case we decide to interpret these entries as measurement units, is how to explain the presence of two klasmatograms one after the other, following a logogram or a logogram and a numerical entry.

The first question could be answered if we assume that each 'measurement unit' was so well known that it was implied. By looking at logograms, it seems that some are followed by the same klasmatogram in two separate instances: **161* by 303Θ,[7] **156* by 304Λ.[8] Logogram **155*, however, which appears more frequently than all the logograms on these bars (four times), is

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[4] Nineteen were part of the Hieroglyphic Deposit from the Knossos palace, eight of the *Dépôt* of the Malia palace, two were found in *Quartier Mu* in Malia (one bears no inscription) and two were found during recent research (1996) in Petras, Seteia, unpublished yet; in preliminary reports, however, no klasmatograms are mentioned (Tsipopoulou & Hallager 1996, 165).

[5] Lebessi *et. al.* 1995, 63-67.

[6] Doubtful reading.

[7] #065.b and #066.d.

[8] #065.c and #118.c.

accompanied by different klasmatograms and different klasmatogram combinations: 302Δ-303Θ,[9] 304Λ,[10] 304Λ-302Δ.[11] It seems therefore that there is no specific 'unit' for each product; if such were the case, the 'unit' does have subdivisions, which would have to be stated in every appropriate instance.

The second question is less likely to be answered, because, even if we were to assume a quantity of one where the numerical entry is missing, we see that 'one' in other instances is not omitted before a klasmatogram[12] and it is for this reason that it was not considered superfluous (no quantity is self-evident).

The third question, lastly, cannot be answered either, because one would expect a single and not two measurement units after a logogram or a logogram and a numerical entry.

'KLASMATOGRAMS' AS REPRESENTATION OF FRACTIONS

The most probable interpretation, therefore, is that the Cretan Hieroglyphic script 'klasmatograms' truly represent fractions, subdivisions of an integer. One such sign in this case represents a specific fraction, whereas the combination of these should denote the total value of the corresponding single fractional value, as has been suggested for Linear A.[13] When it comes, however, to the study of fractional entries in the Cretan Hieroglyphic script, one must bear in mind that it is not possible to distinguish between logograms that are counted (in integers) and the ones that are weighed (as can be done in the Linear scripts),[14] because certain logograms are invariably followed by an integer or a fraction, as has already been mentioned.

An observation to be made is the fact that the combinations of klasmatograms[15] seem to be registered hierarchically; assuming that, as with numerical entries, a smaller value follows a larger,[16] three klasmatograms come in a specific order, which shows their relative value (Table 3). It is, however, impossible to assign absolute values to these klasmatograms, since their total is never given in the Cretan Hieroglyphic texts. As far as values of klasmatograms which are never attested as part of a combination of klasmatograms are concerned, it is impossible to place them in a scale even of relative values.

Two final observations concern the Syme two-sided bar and the two tablets, which bear klasmatograms but were not taken under consideration in this presentation of Cretan Hieroglyphic fractions data. The two-sided bar is the only specimen of this category that bears klasmatograms, assuming one is prepared to accept the suggestion made in their publication, that the sign which follows two different logograms, 308, is in fact a fraction. In the present state of affairs the author's argumentation seems quite convincing, although the problems which he himself sets forth allow for some doubts to be kept (the identification of logogram **159*, the presence of klasmatograms on seal faces). One could also add a question that concerns the kind

[9] #065.d and #067.a.

[10] #066.a.

[11] #118.c.

[12] #118.a and b.

[13] See Bennett 1950, for the most systematic study of Linear A fractions.

[14] Bennett 1950, 205.

[15] On bars #065, #066, #067 and #118.

[16] In a script like the Cretan Hieroglyphic, the registrations of which do not follow a fixed order (inscriptions can be invariably written clockwise or counter-clockwise), and the signs themselves have no 'up' or 'down', 'left' or 'right', a logogram is considered an indication of the beginning of a numerical entry.

of registrations on a two-sided bar: even though some two-sided bars contain numerical entries,[17] the presence of logograms on such documents is extremely rare,[18] and that of klasmatograms non-existent; additionally, even the general impression concerning their use does not refer to registration of agricultural products, in small quantities, as has been suggested for the Syme bar.

As far as the two tablets are concerned (Table 4), finally, they were left out of the present study, mainly because they exhibit a series of characteristics better explained if integrated in the Linear A inscriptions corpus: the Knossos tablet bears one klasmatogram, 306Π, so far known only in Linear A, whereas the Phaistos tablet constitutes the only archival document[19] in Cretan Hieroglyphic from the Phaistos palace, where Linear A was primarily used.

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[17] #090, #105 and #108 out of a total of 17 two-sided bars from various find-spots (the bar from Syme included).

[18] Only on bar #108.

[19] Although the tablet contains a klasmatogram, 302, known in the Cretan Hieroglyphic script.

Table 1. Logograms followed by klasmatograms in the Cretan Hieroglyphic script (the dotted signs are doubtful readings).

TEXT NUMBER	SIDE	TRANSCRIBED LOGOGRAMS	TRANSLITERATED LOGOGRAMS	TRANSCRIBED KLASMATOGRAMS
#059 (Knossos)	dA	[ ]	-	
#065 (Knossos)	b		*181	
	c-d		*156	2
			*178	
	d		*158	
			*167	
			*155	
#066 (Knossos)	a	]	-	
			*167	
			*155	
	d		*181	
#067 (Knossos)	a		-	]
			*155	
#118 (Malia palace)	a		*159	10
			*171	1
			*153	1
	b		*177	1
			*178	2
	c		*155	4
			*156	20
SY Hf 1 (Syme)	a	]	]*171	
			*159	

Table 2. Klasmatograms in the Cretan Hieroglyphic script (*CHIC*, 17 and Lebessi *et al.* 1995, 63-67). The first column concerns a conventional arithmetic term for the klasmatograms; the second column, the signs found incised on clay script documents; the third column, the signs found carved on seal faces.

KLASMATOGRAMS		
Enumeration	**Incised signs**	**Seal signs**
301 Γ		
302 Δ		
303 Θ		
304 Λ		
305 Ξ		
306 Π		
307 Σ		
308 Ϙ		
309 Ϡ		

Table 3. Relative klasmatogram values (304Λ, 302Δ, 303Θ).

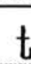
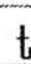
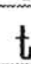
TEXT NUMBER	FIRST VALUE (BIGGEST)	SECOND VALUE	THIRD VALUE (SMALLEST)
#065.d			
#066.a			
#066.a			
#067.a			
#118.c			

Table 4. Tablets with klasmatograms (the dotted signs are doubtful readings).

TEXT NUMBER	SIDE	TRANSCRIBED LOGOGRAMS	TRANSLITERATED LOGOGRAMS	KLASMATOGRAMS
#068 (Knossos)	***r.* A**		*175	1
	***r.* B**		*154	8
#122 (Faistos)	***r.* 1**		*153	20
			*158	20
			*154	20
			*155	20
	***r.* 2**		*153	25 +
			*158	25 + [ ]
			*154	25 +

Record book of journeyman Kratz, 18th century (Deutches Apotheken-Museum, Heidelberg; museum guide, fig. 10). The balance as an instrument for comparing the mass between two products –its use without balance weights is considered an old tradition– never ceased to be used for relative measurement as well.

SCRIPT AND METROLOGY: PRACTICAL PROCESSES AND COGNITIVE INVENTIONS*

Anna Michailidou

'Mathematics and Writing have, it has become clear in recent years, a close, symbiotic relationship. Born at the same time, their destinies have always been closely linked, even if the latter has to a large extent –and long since– liberated itself from the constraints of the former.'[1]

INTRODUCTION

Researchers have been much concerned with the relationship between counting and writing. It has been argued that writing was the 'by-product of abstract counting',[2] which is tantamount to accepting that writing did not exist in the preceding stage of concrete counting.[3] First of all it is important to clarify what we mean by the term writing, whether we are referring to an inscription (in the sense of word or text) or simply to a sign. In both cases, particularly when an unknown script is concerned, there is also the possibility of signs having an aesthetic function. Writing is not only a cognitive invention but also an art form.[4]

Alexander Marshack is probably right in maintaining that the first thing man measured was time,[5] the Palaeolithic incisions on bones –which count the moons– record the result of concrete counting. Schmandt-Besserat distinguished the concept of 'computing' (which also subsumes the above action) from the concept of 'accounting', and attributes in principle the first to egalitarian societies and the second to ranked societies. She considers the system of 'tokens' as the first evidence of 'accounting',[6] it seems that the system of tokens further led to the first tablets of which the earliest examples –from Uruk– are also the first numerical texts.

The above views inevitably lead us to the thought that man began to write in order to record the results of counting. Script is therefore considered as an invention to serve the needs of bureaucracy[7] and is linked with the centralizing regimes. However, just as we can distinguish various stages in counting (e.g. one-to-one correspondence, concrete counting, abstract counting),[8] so we can in writing, which is not necessarily associated only with the stage of the

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* I warmly thank Alexandra Doumas for the translation of my Greek text.

[1] Benoit *et al.* 1992, 3.

[2] Schmandt-Besserat 1992, 199.

[3] On the terms abstract and concrete counting, see indicatively Schmandt-Besserat 1996, 112.

[4] Cf. the phrase 'the art of writing', in Evans 1921, 636.

[5] From Schmandt-Besserat 1996, 101.

[6] Schmandt-Besserat 1996, 103.

[7] The study of sealings has led in the same direction, namely that 'record-keeping was a phenomenon that preceded writing' (Response by J. Aruz, in Palaima 1994, 331).

[8] Schmandt-Besserat 1996, 112.

texts in the tablets, which represent a highly organized textual 'system'.[9] In my view the individual signs of the script are linked –as cognitive function– with the so-called 'potters' marks' that appear as early as the Neolithic Age, and writing is a means of expressing diverse subjects (ownership for instance) rather than a solely bureaucratic tool. On the contrary, the development of writing into a recording system acceptable in a wider domain and the invention of the metrical system for the same purpose, are both objectives of a central authority.

In this chapter I shall discuss the advanced stage during which metrical systems developed. The reference to the above issues was made because we shall face the problem of the continuity or not of 'primitive' methods of counting and calculating. For example, it is not certain that the method of 'tokens' was abandoned –at least as intellectual practice– with the establishment of writing,[10] after all, both historians and ethnologists give us examples. The practice of counting with pebbles still exists today among certain peoples[11] and Herodotus (IV.92) mentions the characteristic case of calculating the size of Darius's army by estimating the volume of accumulated stones deposited by the soldiers as they passed by.[12]

So, the term 'practical processes' in the subtitle of this article means ways of practical calculation and related signification, methods which we believe continue to be used to a certain degree in parallel with systematic bureaucratic recording.[13] Whereas in the term 'cognitive inventions'[14] we include the devising of the metrical system and especially the system of measuring weight. Powell believes that in Mesopotamia this is the latest of the three metrical systems (of length, volume and weight), and it is interesting that he considers the other two as antedating the 'invention' of writing.[15] He also refers clearly to 'metrological organizers'. Kopcke also notes that: '...to proclaim standards by which things can be weighed and measured appears to be a time-honoured prerogative of central authority'.[16] It is, moreover, characteristic that the invention of measuring weight using a balance is attributed by the Egyptians to the god Thoth, the inventor of writing and of mathematics. In the *Instruction to Amenemore* we read:

'*The Ape sits by the balance, his heart is in the plummet;*
Where is a god as great as Thoth,
Who invented these things and made them?'[17]

The view has been expressed that the invention of the balance scale with two pans perhaps preceded the invention of weights.[18] The balance-scale permitted first of all the comparison of two quantities that had to balance the horizontal axis (beam) of the scale, thus confirming either

[9] Particularly interesting in this respect is the discovery of the wooden tablet at Dispilio, see Χουρμουζιάδης 1996 and the chapter by Marangou in this volume.

[10] See also Oates 1993, 151 on the complex tokens.

[11] Such as the example of the shepherds in Iraq, cited by Oates (1993, 149).

[12] From Bennett 1992-93, 334, where another two cases of practical calculation in Herodotus and Homer are cited.

[13] I am grateful to I. Tzachili for first pointing out this phenomenon, in expressing similar views about the clay cylinders from Akrotiri, Thera, at the two-day colloquium on the 30th anniversary of the excavation, held in the Archaeological Society at Athens, 19-20 December 1997.

[14] Influenced by the term 'Cognitive Archaeology', introduced by C. Renfrew (1983), which also includes the ponderal system as a subject of study.

[15] Powell 1971, 208-209.

[16] Kopcke 1987, 257.

[17] English translation of the Egyptian text, from Lichtheim 1976, 156. The ape is one of the epiphanies of the god. The plummet is the pendent stone or lead weight that constituted a technological improvement of the accuracy of the balance-scale in the age of the New Kingdom.

[18] See by way of example Μιχαηλίδου 2000, with relevant bibliography.

equal parts of the same product,[19] or double a given quantity (that is the sum of the content of the two pans). At the level of relative measuring, a stone –of suitable weight– in one pan is verification of the quantity that was placed in the other pan. However, the absolute measurement of mass demands the standardization of the stone weights and their inclusion in a metrical scale, and this is linked with workshop and bureaucratic needs. The invention of balance weights was linked with the weighing of gold[20] and with the development of metalworking in general, since metals are a non-fluent material and therefore cannot be measured using measures of volume. Consequently, we can consider that measurement with the help of balance weights began with the stage of 'concrete counting', and so introduce the term 'concrete weighing' for the measuring of gold. Moreover, the Egyptian unit of gold (about 13.5 gr.) is considered as the oldest and most enduring ponderal unit.

That the balance weight is in essence the stone that measures emerges easily from the words themselves: In Akkadian it is called *abnu* (= stone), while the dominant ponderal unit in Mesopotamia (and subsequently in the Orient in general) is *manu* (Sumerian MA-NA) which means 'count or counter'[21] (from which the Greek word *mna* derives). Therefore the original method of calculation with the help of a stone remains as a concept. As man modified the stone's natural weight, to achieve the desired weight, he gave it different shapes, more varied in Egypt and with a greater tendency towards standardization in the Near East, ending up with shapes (such as the bullet or barrel-shaped weights, the duck-shaped or zoomorphic weights in general)[22] that helped the ancient user (and the modern researcher) to recognize their role and sometimes even the system to which they belonged. Of these, the disc shape (Fig. 2) is particularly characteristic of the so-called 'Minoan' ponderal system, from the late Middle Bronze Age onwards. The reasons for this preference should perhaps be investigated, as well as the eventual use of metal –lead– for making many of these weights.

The most obvious relationship between writing and weighing is apparent in the cases of inscriptions on weights, both Egyptian and Near Eastern ones. Such inscriptions may denote the weight, the name of the king, the name of the deity, the name of the owner and so on. However, the percentage of inscribed weights is small in relation to their total number,[23] and there are cases of simple signs, such as plain lines or geometric shapes.[24] Since there are even fewer instances of inscriptions on Aegean weights (and these undeciphered), it is pertinent to collect together the existing data from the Aegean world.

AEGEAN BALANCE (?) WEIGHTS WITH INCISED SCRIPT SIGNS

It is well known that some of the (disc-shaped) balance weights found in the Aegean and dating from the Middle and Late Bronze Age bear diverse incised signs, usually referred to as denominational marks.[25] This designation had been proposed by Evans[26] for certain balance

[19] This does not mean that the balance-scale ceased to be used for comparison of quantities without the use of balance weights. There are several examples from ancient Greek vase-painting; perhaps the possibility that this is for monitoring standardized packing of commercial products should be investigated.
[20] Skinner 1954, 779.
[21] Powell 1995, 1955.
[22] See *in passim* Petruso 1992 and work in general on metrical systems of Egypt and the Orient.
[23] Cour-Marty 1985.
[24] Petrie 1926.
[25] Petruso 1992, 61, table 27.
[26] Evans 1935, 650-655.

weights in the Herakleion Museum (cf. Fig. 1), as well as by Petrie for some balance weights from Egypt.[27] These signs (Fig. 3) in comparison with potters' marks[28] or masons' marks display less variety and appear to contain a 'mathematical message' of inclusion in a given system. The commonest case on balance weights is small circles (to a lesser degree triangles or the cross) and the number of circles has been interpreted sometimes as a multiple and sometimes as a fraction of the 'Minoan' (according to Petruso) or 'Aegean' (according to Parise) basic ponderal unit of 60-65 gr.[29] These signs have little to do with script, even though this is not entirely absent: a few specific cases exist, for which reason we shall focus our interest on those balance weights bearing at least one sign recognizable as a script sign.

1. The large lead disc-shaped balance weight from Mochlos (Fig. 4)

I begin with the most certain case of an inscription incised on a real balance weight, namely the largest of the 11 lead weights recovered from the old excavations by Seager at Mochlos and now in the Herakleion Archaeological Museum.[30] This weight is 11 cm. in diameter and weighs 1,458 gr.[31] The inscription was revealed much later, in the course of cleaning the oxidized incrustation from the weight, and was published by Olivier. The inscription **MO Zf 1** includes the following Linear A signs:

A 333 - AB 31 - AB 23

or

AB 18 - AB 31 - AB 23

and is a *hapax* in the inscriptions known to date.[32] It ends with a 'punctuation mark', while on the same side of the weight there are five vertical lines.[33] The incision[34] is shallow, giving the impression that the inscription post-dates the making of the weight (contemporary or not with the lines?).[35] What might this mean?

On the other side the weight bears a deeply incised cross sign that was made while the lead was still soft and whose presence was therefore planned from the outset (this is reinforced by the fact that strips of lead added later to adjust the weight were applied over the cross). Theoretically the cross could be included among the signs denoting mass; Petruso suggests that it indicates the multiplier 24 of the Minoan unit of 60 gr.[36] Since the same sign (cross) appears on the smallest weight in this group too (weight 19 gr. = 1/3 of the Minoan unit, cf. the three dots on the other side of the same lead disc), Petruso sought an explanation in the possibility that the cross on the smallest weight denotes 1/24 of Evans's *mna* of 483 gr.[37] But even if we accept that the cross can denote both the denomination 1/24 and the multiplier 24, this must have applied on a limited

[27] Petrie 1926, 5.
[28] See indicatively Bikaki 1984, 9.
[29] Petruso 1978, 1992; Parise 1971.
[30] Petruso 1992, 40-41, context unknown. Others have been found in more recent excavations, see indicatively Brogan 1998, 391.
[31] Petruso 1992, 41, no. 84 (Herakleion Museum inv. no. 83).
[32] Olivier 1989, 145.
[33] Olivier 1989, 140-141.
[34] To be precise, the signs are '*ciselés et non pas gravés*' (Olivier 1989, 141).
[35] Olivier (1989, 139) also believes that the inscription is not necessarily contemporary with the making of the weight and that we could perhaps accept '*une datation plûtot basse pour l'inscription...*'.
[36] Petruso 1992, 41.
[37] Petruso 1992, 42.

scale (perhaps local?) because on a disc-shaped balance weight –of stone– from Zakros[38] the same ratio (24 x 60) is marked in a different way: by two large circles (for number 20) and four small ones (for number 4).

Could the cross be related in some way to the script signs, AB 02 (Linear B phonetic value: *ro*) or A 702 (a fraction)? There is an additional line in the incision, parallel to one of the arms of the cross, and another trace (Fig. 4).[39] The weight of the balance weight, about 1.5 kg., is close to the value of half the special unit –in the Linear B records– for weighing wool (*LANA*), which was equivalent to 3 kg.[40] Could the cross, as inscribed in the circle of the weight's circumference, denote the participation of the object bearing it in the metrical system for wool, since in Mesopotamia a cross inscribed in a circle was the abstract sign for the sheep?[41] There is, however, a large time interval to account for. The script sign no. 77 of Linear A and Linear B (cross inscribed in a circle) is the acrophonic (phonetic value *ka*) of the word *χλαρῆεις* (*ka-ra-re-we*), which characterizes stirrup jars in the Linear B tablets, and this sign *ka* is drawn both in the ideogram of the stirrup jar and on the shoulder or the belly of actual stirrup jars[42] thus indicating that these vases were for oil;[43] it is reasonable to expect the same indication by the cross-inscribed in a circle on the shoulder of a Canaanite jar (Fig. 5) found at Akrotiri.[44] But if the sign denotes oil, I should point out that oil is not among the products that are weighed but is measured in units of volume,[45] so there was no need for such an indication on a balance weight. I think it is more likely that the cross sign on balance weights has a taxonomic value (that is it assigns the weight to some kind of category) than that it constitutes a numerical symbol.

2. *Stone disc-shaped balance weight from Knossos* (Fig. 6)

This particular balance weight, 4.3 cm. in diameter and of weight 96.4 gr.(-) comes from the area of Hogarth's House A on Gypsades hill (LM IA period)[46] and bears on one side two (?) Linear A signs (inscription **KN Zg 21**):[47]

AB 41 - AB 07

Godart and Olivier present the inscription as consisting of just one sign, that is the composite sign A 528, which derives from the complex of sign AB 41 and AB 07.[48] Another four cases of a

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[38] Petruso 1992, pl. 8, no. 86.

[39] See description by Olivier 1989, 140.

[40] This ponderal unit of 3 kg. most probably existed even in the time of the Linear A script, cf. Michailidou 1990, 416. Parise (1994, 14) is of the opinion that the cross on this balance weight indicates ¼ of the value of a double *LANA* unit.

[41] Nissen 1993, 60.

[42] The other viewpoint is that it represents '*ro?*', as Hallager & Vlasakis 1976, 216 argue for three stirrup jars from Knossos, on which the cross is incised within the disc of the false mouth. On the motif of the cross inscribed in a circle, painted on the body of stirrup jars see Raison 1963, 136-137. Of course, other stirrup jars were for wine, cf. the inscription *wi-na-jo* on stirrup jars from Midea, Knossos and Armenoi: Shelmerdine 1997, 565 and note 173, for the bibliography up until 1997.

[43] *Documents*, 551.

[44] *Prakt* 1994, pl. 84β. Doumas compares the sign on the Canaanite jar with the letter *kap* in the Protocanaanite alphabet (*Prakt* 1994, 161).

[45] I also add *karpatu*, Akkadian name for the transport vase of measured capacity (Powell 1989, 504) and the Babylonian measure of volume *qa* (Thureau-Dangin 1921, 128ff.) as working hypotheses for further research on this sign on stirrup jars and the Canaanite jar.

[46] Petruso 1992, 38, no. 69, with relevant bibliography on its publication.

[47] *GORILA* 4, 164.

[48] *GORILA* 5, xxiv, xxxv and 159.

complex of sign 41 perpendicular to other Linear A signs are mentioned, which give the composite signs A 529, A 530, A 531, A 532, while in other cases sign 41 is linked horizontally to give complexes such as A 533 or A 590.[49] Consequently it could be a monogram and not an inscription of two signs. Nonetheless, I am intrigued by the fact that in Kea there is a potter's mark exactly the same (that is a combination of a horizontal line with three vertical lines) as the sign above the AB 41 on the Knossos weight, and Bikaki's observation that certain potter's marks at Kea are similar to corresponding signs on lead weights from Kea is interesting in this respect. I add, however, that the signs she parallels occur on imported pottery.[50]

3. Rectangular fragment of schist from Hagios Stephanos, Lakonia (Fig. 7)

The stone, of dimensions 4.21 x 1.9 x 0.62 cm., has four smooth surfaces with rounded edges but is broken at both ends. It bears two incised Linear A signs and is dated most probably to early Mycenaean times (LH I-IIA). I mention this piece because the hypothesis has been proposed that it may have been a balance weight: its weight is 9.8 gr.[51] The publisher of the object states that: 'it is difficult to believe that anything has been lost at the ends, but surprising that these ends are not neatly finished like the other surfaces', and mentions the possibility that the likewise rectangular object –of clay– from Kythera may also be a balance weight (see below no. 4). The inscription on the schist object from Hagios Stephanos (**HS Zg 1**)[52] is:

AB 08 - AB 80

and with the phonetic values of Linear B can be read as *a-ma*.[53] According to Ventris and Chadwick the word occurs in Linear B tablets recording large quantities of grain, therefore it perhaps means harvest there, deriving from the verb *ἀμάω*, which means to reap, as well as to cut, to cut off (in middle voice *ἀμάομαι*, meaning to collect).[54] It seems that the first sense was to cut or to reap and the concept of gathering was secondary. Of interest is the phrase in Hesiod «*ἤμησαν καλῶς*» which means they tried their luck.[55]

4. Clay weight from Kythera (Fig. 8)

It is possible to identify a Linear A ideogram with a sign-fraction (?) next to it, on a *peson en argile* from Kythera, found in a MM IIIB horizon; unfortunately the object is not intact and so its original weight is unknown. Although well made, its material (clay) does not advocate its use as a balance weight and it bears two holes. It could be a loom-weight. It measures 5.8 (pres. length) x 5.6 x 4.8 cm. and the inscription (**KY Zg 1**) comprises:

AB 120 and the Linear A fraction E, giving the composite sign A 581.[56]

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[49] *GORILA* 5, xxiv-xxv.

[50] Bikaki 1984, 9, 4: 'Composite marks survived in Keos into the early part of the LBA, and always on imported pale ware... They are of special interest because they are similar to marks on lead weights found in Keos, ...and therefore might be interpreted as expressing values of measurement'.

[51] Janko 1982, 98, 99.

[52] *GORILA* 5, 16.

[53] See Janko 1982, 100. *Ἅμα* is an adverb that denotes synchronization of two actions (see Liddell & Scott, *s.v.*), but there is the possibility that it is the Doric type of the ancient Greek word *ἄμη* which means shovel or pick or hoe or even a little bucket for drawing water (see Liddell & Scott). The Akkadian word *ammatu* denotes a measurement of length (Thureau-Dangin 1921, 133). Was it perhaps a broken 'yardstick'?

[54] *Documents*, 530; cf. Killen 1994-95, 333: '*a-ma e-pi-ke-re*' = harvest at hand.

[55] Liddell & Scott, *s.v. ἀμάω*.

[56] *GORILA* 4, 166; 5, xxv and 274.

It could perhaps be regarded as an indicator of a fractional quantity of AB 120 (= barley).[57] However, the sign's possible affinity with the incised potter's mark on the second Canaanite jar (Fig. 9) from Akrotiri, Thera,[58] should be investigated; in this case it might function as a label perhaps denoting a product analogous to the content of the jar and not a weight.

5. Lead disc-shaped balance weight from Akrotiri (Fig. 10)

The weight is 3.7 cm. in diameter, weighs 86 gr.(-) and bears an incised sign that can be identified as AB 31, with the reservation that the three arms are of equal length. In Linear B the ideogram **31* denotes flax (its phonetic value *SA* is also the acrophonic of *sa-sa-ma*). Flax is measured by weight in the Knossos tablets but we do not know if **31* had the same meaning in Linear A.

6. Stone disc-shaped balance weight from Zakros

The object is of limestone and weighs 220 gr. Incised on one side is a sign that is perhaps an ideogram of cloth; on the other side are six small circles.[59] The sign on one side is associated with the Linear B ideogram **164*, occurring on the tablet **L 520** (Fig. 26, first sign on the right). On tablet **L 698** the same ideogram is introduced with the term *pe-ko-to* therefore it denotes a special type of cloth.[60] Since the balance weight is of MM III date (it was found in a room of Hogarth's House H), we are more interested in the appearance of the same ideogram in Linear A, with four variants (**164 a-d*).[61] This is found incised on 'roundels'[62] at Chania and there is only one stamp on the circumference of the roundel in the examples known so far.[63]

7. Stone disc-shaped object from Hagia Triada (Fig. 11)

A sign that perhaps represents a Linear A fraction is incised on a disc-shaped object of steatite, perforated with a hole at the centre, of diameter 3.15 cm., height 0.5 cm. and weight 8.40 gr. Its *terminus ante quem* is LM IB.[64] The publisher precludes its interpretation as a pendant, an amulet, a loom weight or a spindle whorl, and suggests that it was most probably a balance weight. He believes that the hole was perhaps used for keeping it on a string, together with others of the same system. He parallels its weight with the disc-shaped alabaster balance weight from the Palace of Knossos (8.54 gr.),[65] with a lead balance weight from the same site (8.45 gr.)[66] and, primarily, with a sphendonoid limestone weight in the Metaxas Collection, in the Herakleion Archaeological Museum (8.40 gr.).[67] The comparison of the weight of the disc-shaped object with stone balance weights is more reliable (in contrast to comparison with metal balance weights). Militello believes that instead of comparing it with the Babylonian shekel

[57] On the interpretation of the ideogram see Palmer 1992.
[58] *Prakt* 1994, pl. 83β.
[59] Petruso 1992, 42; Hogarth 1900-01, 136; Evans 1935, 662.
[60] *Documents*, 321.
[61] *GORILA* 5, xliv-xlv.
[62] *GORILA* 5, 279.
[63] Hallager 1996.
[64] Militello 1988-89, 163-172.
[65] Evans 1906, 347 (no. 8); 1935, 655; Petruso 1992, 37 (no. 58).
[66] Evans 1906, 348 (no. 12); 1935, 655; Petruso 1992, 37 (no. 57); Grumach 1962, 163.
[67] Grumach 1962.

(8.40 gr.), we can include it in the 'Aegean' ponderal system, considering it as equal in weight to ⅛ of a basic unit of 67.2 gr., which is quite close to Parise's unit of 65.25 gr. (or 65.5 gr. of Evans and Caskey). He considers it possible to identify the sign on the 'balance weight' as the Linear A sign A 705, even though it is reversed –a not unusual occurrence for Linear A. Sign A 705 is one of those which Evans himself had recognized as fractions, whose value –like that of the rest– is, however, debatable. Militello notes that this particular fraction is of secondary order, because only 22 appearances are known to date (16 of them from Hagia Triada)[68] and opts for Bennett's value of ⅛, which fits his interpretation of its weight representing ⅛ of the basic unit of 67.2 gr. He points out that if we accept this coincidence of weight with the value of the fraction, then we undoubtedly have a case of the abstract function of this number, since the same sign was apparently used for fractional quantities both of volume and mass: he refers of course[69] to the known inscriptions **MA 10a, c, d** (cf. Fig. 12 in which this fraction seems to denote the volume of the first vase) and **HT 44.b.**1, **125.b.**4 (where it seems to denote a special quantity of grain). He rightly stresses that if the stone disc from Hagia Triada is indeed a balance weight, then it is possible to correlate two classes of data in the field of the ponderal unit: on the one hand the archaeological documentation and on the other the textual evidence.

This is indeed the first possible instance of marking a balance weight with a Linear A numerical sign.[70] (The identification of the Mycenaean unit for wool in the Linear B tablets with two balance weights –at Akrotiri and at Thebes– of 3 kg. weight[71] is another example of textual documentation of actual weight-values). As for the disc-shaped object's weight, the unit of 67.2 gr. that emerges is close to the ponderal unit (68 gr.) proposed by Weingarten[72] for a serpentine disc-shaped balance weight marked with three circles, from the Royal Villa (?) at Knossos, which weighs about 204 gr. (she attributes it to a heavier unit of the Mycenaeans at Knossos, even though its dating to LM IIIA or B cannot be proven). On the pretext of the Hagia Triada balance weight, Militello makes the useful observation that the same geometric signs (more often circles) on weights, of which there is a corpus in Petruso,[73] sometimes denote a multiple and sometimes a subdivision of a unit, and are consequently of local character and do not belong to an official system of signifying weight-value. I add to this comment that in certain cases they are accompanied by a different sign on the other side of the balance weight. For example, the same weight can bear small circles on one side and a sign reminiscent of a potter's mark or script on the other. If the sign on the Hagia Triada balance weight is indeed a Linear A fraction, then it might belong to an official –palatial (?)– metric system.

8. The ovoid stone from Hagia Photia (Fig. 13, 15-16)

The largest Linear A inscription known to date on a weight (?) is incised on a 'melon'-shaped stone[74] also bearing an incised fish motif. In the publication of the inscription the bearing surface

[68] Militello 1988-89, 170.
[69] Militello 1988-89, 171.
[70] There is also the possible identification of the sign of double cross on two lead weights from Kea with the script sign *PA* or the fraction A 701, but the two items are of different weight values: ½ and ? of the 'Minoan unit' (Petruso 1992, 33-34, nos. 14 and 23).
[71] Petruso 1986; Αραβαντινός 1995.
[72] Weingarten 1994, 85-86.
[73] Petruso 1992, 61.
[74] 'Near Hagia Photia, Siteia, a strange melon-shaped object was found, bearing an incised fish. A similar object, without decoration, was collected at Praisos. Bronze double-axes and a slightly curved knife come from this area' (Πλάτων 1957, 340). Unfortunately it is not clear whether the bronzes were found

is referred to as a *pierre ovoide*,[75] which prompted me to seek out the object in the Herakleion Archaeological Museum some years ago, suspecting that it might be a barrel-shaped balance weight. It is of limestone,[76] which has been carefully smoothed, of length 17 cm., max. width 11.5 cm. and weight 3,405 gr.

I believe that this object could have been used as a counterweight in weighing. Indications are the working of the stone to achieve a bullet shape, the absence of use marks that would classify it as a tool and its heaviness, since it is obvious that the makers of balance weights would have selected material that enabled them to weigh the largest possible quantity (of the heavier metals) with the smallest possible (in volume) balance weight (this is the main reason for the frequent use of lead for making Aegean balance weights). However here we have the additional element of the representation of a fish, the significance of which we must try to interpret.

First of all, what species of fish is represented? Mylona makes the following suggestions:[77] '1) The shape of the tail refers to fish that swim swiftly and over long distances, such as the migratory members of the Scombridae and Carangidae families (tunny, mackerel etc.). Most of these fish are large and seasonal fishing of them yields large quantities of meat, much of which is preserved for consumption later. 2) The fins are mainly of members of the Sparidae (gilthead, red snapper) or Serranidae (e.g. garfish) families, of coastal fish. 3) The representation is an assemblage of 'typical' features denoting a 'fish', without reference to a particular species. Perhaps the fact that the features of seasonal, migratory fish predominate denotes indirectly their importance. It is in any case characteristic that in the iconography of fish from the Bronze Age Aegean, only the dolphinfish held in a bunch by one fisherman in the wall-painting from the West House at Akrotiri, are rendered with accurate ichthyological features'.[78]

Of particular interest is Mylona's information that to catch migratory fish requires the organization of a communal effort. We could propose theoretically that the weight was not necessarily a regular balance weight but a standard weight for the specific quantity to be shared out after the end of the venture, to those who had participated in it. Indeed, since seasonal fishing of this species yields large amounts of meat, which can be kept (e.g. dried) for consumption later, we could even propose the periodic use of this oval stone also as a counterweight for weighing a specific portion of food for labourers other than fishermen. This thought is prompted by the archaeological evidence of the Egyptian balance weights with representation of fish, that were used for the distribution of portions of dried fish to labourers in the mines in the Sinai peninsula,[79] as well as by written testimonia and similar balance weights from the village at Deir el-Medina.[80] I note that the only weights with representation of a fish that I know of are from Egypt (cf. Fig. 14).

If we consider the ovoid stone as a counterweight in weighing, then the questions arise as to whether we should then include it as a balance weight in a specific ponderal system (which does

at Praisos or at Hagia Photia. In the Herakleion Archaeological Museum inventory both stones (inv. nos. 2615 and 2616) are referred to as handed in. First publication of the item 2615 (the inscription had previously appeared in a *GORILA* volume) by Alberti (1998) who does not believe it to be a balance weight. See also Μιχαηλίδου 2000, fig. 18.

[75] *GORILA* 4, 168.

[76] Macroscopic examination identifies the stone as marly limestone, which exists in Crete (I am grateful to Marina Panagiotaki and the geologist Ch. Fasoulas for this information).

[77] I quote from a letter (in Greek) from Dimitra Mylona, whom I thank warmly for her help with the problem of identifying the incised fish with a specific species.

[78] See also Mylona 2000.

[79] Hodges 1970, 112, fig. 124.

[80] Brovarski *et al.* 1982, 62.

not seem to be Petruso's Minoan one); whether we should assign to it periodical and repeated use; whether we should consider it *'en fonction d'une pesée déterminée'*,[81] as is the case with a special class of inscribed weights from Deir el-Medina in Egypt (mainly of the Ramesside dynasty), without any Aegean parallel so far. Several of these Egyptian weights are ordinary pebbles from the desert, others are pieces of limestone (like the inscribed *ostraca* from the same village) bearing an hieratic inscription in red or, more commonly, black ink, from which it is deduced that they were normally used for one weighing;[82] in a few cases of repetition of weighing, there was a reduction of the original mass of the stone and a corresponding replacement of the first inscription. These weights are published by Valbelle who, on the basis of the commonest type of inscription –*'poids de tel objet pour un tel ± circonstances de la pesée'*– remarks that: *'Un poids de cette sorte offre un double intérêt: il garde la trace d'une opération (distribution de matériel ou de vivres, échange, partage, inspection...) reposant sur une pesée et il permet de vérifier celle-ci à tout moment. Il doit donc concerner une action en cours ou, du moins susceptible de se répéter'*. As an example she cites Černy's analysis of those *ostraca*-weights that denote the weight of bronze tools issued to the stone-masons working on the royal tombs and afterwards returned by them.[83] However the fish could not be returned, therefore the action was repeated only with regard to the quantity, which leads us to ask what the quantity of 3,405 gr., which is the weight of the stone from Hagia Photia, represents. (The heaviest of the regular balance weights for weighing fish, from Deir el-Medina, which Valbelle also cites, weighs 3,250 gr.).[84]

If we class the ovoid stone in this particular category of objects (for which we have no other evidence from the Aegean to date), then we should consider that it was used, like the Egyptian ones, *'pour une opération particulière'*,[85] but without necessarily considering that it was used only once. Weighing could have been repeated, if the weight quantity was predetermined for some reason. Moreover, in comparison with the Egyptian examples, it is more like the regular Egyptian balance weights –of diverse shapes– bearing a representation of a fish.[86] Whether we consider that it weighed –each time– a specific weight (of a dismembered large fish or several small ones), in the distribution of food or collection of 'tax', or we presume that it weighed –just once– the catch and then constituted the 'proof' of the weight of a large fish offered to a shrine or perhaps an heirloom or a grave good in a tomb,[87] the question is whether it falls within the function of the Minoan bureaucratic system, on account of the Linear A inscription it bears and which, fortunately, dates it –at least some stage of its use, if not its making– within the chronological *termini* known for Linear A, that is the period MM IIA - LM IIIA. P. Stephanaki, who made the drawing of the balance weight (Fig. 15), is of the opinion that the inscription and the fish motif (Fig. 16) were not incised by the same hand.[88] So, who was the scribe of the inscription and who the artist of the graffito?[89] Did the head of priestly or palatial control weigh

[81] Valbelle 1977, 1 and 1.
[82] Valbelle 1977, 1 and 1, and note 6. The smallest is of weight 22 gr. and the largest 13.870 kg.
[83] Valbelle 1977, 5 and 5; cf. Michailidou in the present volume, the chapter on the recording of metals.
[84] Valbelle 1977, 2-3 and note 4.
[85] Valbelle 1977, 1 and 1.
[86] See also Hodges 1970, fig. 124; Brovarski *et al.* 1982, 62; Valbelle 1977, 2 and 3.
[87] Since the find spot of the ovoid stone is unknown; it was handed in to the museum.
[88] For the first facsimiles of the graffito of the fish and the Linear A inscription see *GORILA* 4, title page and p. 168 respectively.
[89] See a graffito of a fish caught by a hook, on the wall-painting of the fisherman from the West House at Akrotiri, Thera (*Thera VI*, pl. 89b).

with this? Did a scribe specially charged with the management of fishing weigh with it?[90] (From the MM IA period there existed at Hagia Photia a monumental walled complex in a strategic location for control of the plain between Palaikastro and Siteia).[91] Perhaps, on the contrary, the inscribed stone was an 'agreed upon' distribution tool for the catch of collective fishing; it is explicitly stated in an Egyptian papyrus that the tomb-robbers in the Valley of the Kings kept safe in one house the stone balance weight with which they shared out the loot, but when they were forced to hand over their portions they presented another, smaller, balance weight.[92]

We return now to the Linear A inscription, which Godart published as **SI Zg 1** (Fig. 17) and consists of four signs:[93]

AB 08 - [.] - AB 01 - AB 118

the second of which is not legible and the last depicts the balance scale. The prevailing view is that sign **118* is a metrogram only in Linear B where it denotes the highest ponderal unit (the talent). Its meaning in Linear A is not certain.

The advantage of the above mentioned Egyptian balance weights is that we are able to read the inscription on them. For example, the inscription 'weight for fresh, cleaned fish' is engraved on a stone weight (not much smaller than the one from Hagia Photia), which is considered to have been used for weighing food distributed to workers (cf. also Fig. 18).[94] There are various standardized inscriptions on the *ostraca*-weights from Deir el-Medina, on which the last hieroglyph is usually Gardiner's A 9, which shows a man holding a basket on his head[95] (Fig. 18) a sign denoting load, weight. If the ovoid stone from Hagia Photia is a balance weight for weighing fish, then theoretically the sign **118* in the same position, that is at the end of the inscription, could play a similar role to A 9 representing a word corresponding to the Egyptian *f*', which according to Valbelle is the noun deriving from the verb to weigh.

However, could **118* be independent of the word preceding it (despite the absence of a separator) and denote the weight or the process of weighing of a product (fish?) with the name 08 - [.] - 01? Or, instead of the kind of product weighed, could it be the name of the person charged with weighing? The absence of a separator between the possible name and the sign for weighing would not be a problem if there was a consensus on the meaning of **118*.[96] What could the name *a*-[.]-*da* mean (if we transfer to it the phonetic values of Linear B)? If it is *a*-[*pu*]-*da* it could be related to the Linear B word *a-pu-da-se-we* (= *ἀπυδασσεύς*, that is distributor, derivative of the verb *ἀπυδατέομαι-ἀποδατέομαι*)[97] or with the ancient Greek words *ἀπόδασμα* (the part), *ἀποδασμός* (part-portion of a whole). Leaving the area of hypotheses aside, I shall summarize only that this combination of signs in the inscription is a *hapax* in the Linear A corpus, and that the textual data on the various positions of sign **118* are as follows:

On four tablets (**HT 12, HT 24b, HT 38** and **KN 2**) it is possible that it functions as an ideogram,[98] followed by numbers:

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[90] At Deir el-Medina, 'the relatively frequent references to deliveries of fish and wood "by the hand of scribe so-and-so" are to be taken as references to commodities due from the fishermen and woodcutters under his control' (Eyre 1980, 115).

[91] Dierckx & Tsipopoulou 1999, 286. It is near the sea too.

[92] Peet 1930, 160, 163.

[93] *GORILA* 5, 273. Alberti (1998) adds a shallow Z-shaped incision as a possible fifth sign (?).

[94] Brovarski *et al.* 1982, 62; cf. Μιχαηλίδου 2000, fig. 19.

[95] Gardiner 1957, 443.

[96] Cf. Evans's comments (on tablets) that '...the "balance" may be taken as a determinative indicating that the individual referred to was some kind of accountant' (1935, 658).

[97] *Documents*, 533; Προμπονάς 1978, 179-180.

[98] See *GORILA* 5, 273 and *GORILA* 1 for the above tablets.

On **HT 12**.4 and 5, it is preceded by the monogram for wool, from which is separated by the dot, and followed by the number 5. It could –theoretically– define quantities-weights of wool, since it is known from the Linear B tablets that wool was measured by weight. Palaima transcribes it as *L* 5, perhaps 150 kg.,[99] though it is not generally accepted that it functioned as the subsequent talent in Linear B.

On **HT 24b.**1.2.2 it is depicted three times singly, followed by the unit 1, and in two of the cases also by the composite fraction A 732 (so perhaps the number 1 and ¾).[100] Palaima considers it possible that it is mentioned as a unit of weight (talent?) for the commodity on the first side of the tablet, that is wool.[101]

On **HT 38.**3 it is quite clearly one of the seven ideograms counted and is followed by the number 3; two textiles of the type *TELA+KU* and one textile of the type *TELA+ZO* are also recorded.

On **KN 2.**2 it is followed by the number 3.

In the remaining instances of its appearance in Linear A, it seems to function as a syllabogram. It occurs at least three times inside a word. However, in most cases it is encountered at the end of a word (as on the stone weight): at least 7 times it occurs at the end of 2-5 syllable words.

Regarding the barrel shape[102] of the object from Hagia Photia, which was the reason for its characterization as a weight, this shape is more widespread in Cyprus and the Near East. Minoan (or Aegean) balance weights are as a rule disc-shaped (of stone or lead), although stone barrel or bullet-shaped balance weights –firstly called sphendonoid by Evans– are not unknown in Crete. I cite the published ones, such as one of haematite, from Knossos (Fig. 19), of weight 12.6 gr. (around the Egyptian gold unit),[103] and five balance weights from Tomb H at Katsambas (of gypsum, diorite, serpentine and jasper), weight 10-48 gr.[104] (dated in the LM IIIA:2 at Katsambas).

A third published example (Fig. 20), of limestone and unknown provenance (in the Metaxas Collection), weighs 8.4 gr. and bears the incised representation of an amphora and three stacked arcs.[105] Grumach explored the possibilities that it denotes a quantity that is treble a unit of 2.8 gr., that it denotes ¾ of the Cypriot shekel and, of course, that it represents 1 Babylonian shekel. Last, Grumach also compares its weight with the two Knossian disc-shaped balance weights already mentioned, the lead one of weight 8.45 gr. and the alabaster one of weight 8.54 gr.[106] Whether the incised signs are secondary remains a matter for speculation, although the smallness of the surface (length 2.7 cm.) suggests that they are primary. There is no counterpart for this amphora motif in the ideograms of Linear A and Grumach rightly approaches it in ideogram **209* of Linear B, but he also identifies it with the amphora imprint that is exactly the same on a clay rectangular object (a comparable case to the Kythera weight?), of weight 113.55 gr., among Hogarth's finds from Zakros.[107] In my view the sphendonoid shape was more widespread in Crete than we believe and perhaps balance weights that may not correspond exactly to the classical, small, carefully made haematite balance weights (Fig. 19), which were used for

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[99] Palaima 1994, 318.

[100] 'On **HT 24** the same "weight ideogram" AB 118 is found on the verso after a ligature of AB 13, which itself occurs next to A 559 in three entries on the recto. This lends some support to an identification of the Linear A and Linear B signs' (Palaima 1988, 326, note 82).

[101] Palaima 1994, 317.

[102] For this term see Evans 1906, 348.

[103] Evans 1935, 655f.; Petruso 1992, 37, no. 59.

[104] Αλεξίου 1967, 54, pl. 28α; Petruso 1981; 1992, 52-54; Μιχαηλίδου 2000, fig. 30.

[105] Petruso 1992, 50, no. 178.

[106] See above p. 59.

[107] Grumach 1962, 163, Taf. a, b; cf. Hogarth 1900-01, 128, fig. 40: Herakleion Museum inv. no. 2263.

precision weighing (usually of weight less than 100 gr.),[108] await identification: there must have been larger ones of other stones. In an excavation report for the Palace of Zakros, 'seven stone weights of ovoid shape',[109] are mentioned; I suspect that these are sphendonoid balance weights, which are unpublished.[110]

It is perhaps pertinent here to add, as a comparandum for the 'non canonical' shape and the large size[111] combined with the practice of incising an inscription, a diorite sphendonoid balance weight from Mesopotamia, dating from the era of the third dynasty at Ur (Fig. 21). This is 19.8 cm. long and of max. width 9.3 cm. Its inscription dates to the years 2037-2029 BC, to the reign of the king mentioned: '*Cinq mines, certifiées. (le dieu) Shu-Sin, roi fort, roi d'Ur, roi de quatre regions*'.[112]

We summarise that with regard to the fish graffito the Hagia Photia weight is reminiscent of balance weights from Egypt, and with regard to its shape is reminiscent of balance weights from the Near East. Nevertheless, examples from Praisos, Zakros, Katsambas, Knossos, the Metaxas Collection, indicate that the shape was known in Crete, as well as in the rest of the Aegean; I cite the carefully made sphendonoid balance weight from Akrotiri, Thera, which could have been made *in situ*, since waste from the same stone was found at site (Fig. 22, left and centre).[113] Its weight is 478.1 gr., perhaps referring to the Mina of North Syria.[114] We shall not extend the discussion to the barrel-shaped artefacts of the Early Bronze Age from the Northeast Aegean, what interests us is the continuity in the habit of using the stone for measuring.

It was the stone that was first used as a counterweight in weighing and it was the stone that first became –after choice of kind and appropriate working– the codified balance weight. This emerges both from the number and antiquity of stone examples, and from the corresponding names for the balance weight. As mentioned at the beginning of this chapter the Akkadian name was *abnu* (= stone),[115] frequently qualified by adjectives meaning 'standard', 'true', 'heavy'.[116] The Egyptian name is *f', n inr* (= weight of stone), which is also abbreviated as *inr* = stone.[117] The term stone exists already in the Old Kingdom and is encountered in tomb paintings, in scenes of craftsmen weighing.[118] I cite indicatively the formula '*Pierre d'un deben et demi*', on a regular stone balance weight (of weight 1½ *deben*); or the inscription '*12 deben, poids en deux pierres, du fil de X*' on a stone ostracon-weight from Deir el-Medina,[119] which states clearly that this ostracon, of weight 12 x 91 gr., is a witness of the weight of the yarn measured on scales with the help of two stone balance weights.

9. The catalogue of inscribed weights from the Aegean ends here with the hypothesis that perhaps the earliest inscribed relevant artefact might be (Fig. 23) 'a stone with incised Linear B

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[108] Petruso 1992, 1, with comments on the advantages of haematite for precision weighing.

[109] *Prakt* 1962, 162.

[110] There is no mention of the shape –perhaps because they are disc-shaped?– of other 'four stone weights' mentioned in the same report, recovered from Building A at Zakros (*Prakt* 1962, 144). I do not know whether these have been published.

[111] The two main arguments against its function as balance weight (Alberti 1998, 17).

[112] The quotation is in the language into which the Sumerian text was translated (*Naissance de l'écriture*, 79).

[113] Michailidou 1990, fig. 19.

[114] 'The mina of Karchemish may represent an old and commonly used norm (470+ or -5 gr.) in the North Syrian area' (Powell 1989, 516).

[115] *CAD* A/1, 59f.

[116] Powell 1971, 242.

[117] On papyri and on ostraca, Valbelle 1977, 5.

[118] Cour-Marty 1990, 18, note 3.

[119] Valbelle 1977, 3 and 4.

syllabograms from a late MH context at Kafkania, 7 km. north of Olympia. No numbers or logograms appear on this isolated find, however, and it shows at best an early stage of Mycenaean writing, not the kind of written administration seen later'.[120] If it could function as a balance weight, then this would explain why it does not bear a usual bureaucratic text. If one accepts Godart's translation, the owner of this 'circular pebble of dimensions 4.9 x 4.08 cm. and weight 48 gr.',[121] will have been Charops, whose trade, if he was indeed a metalworker,[122] would have entailed the use of balance scales and balance weights. In the presentation of the object, no identification is proposed for a 'graffito', which seems to be outside the text of the inscription[123] and brings to mind a fraction in Minoan hieroglyphic script or the fraction A 713. Furthermore, on the back of the object is the graffito of a double axe; it may be mere coincidence that the shekel in the Sumerian language is called GIN, which originally means axe, and that the weight of this stone is *ca.* 6 shekels (6 x 8 gr. = 48 gr.) equivalent to the number of the incised lines around the representation of the axe.

REMARKS

It is time to summarize whether the above catalogue of selected items with incised signs relating to contemporary script leads to some thoughts or observations. Since we are unable to read the Linear A signs, and therefore understand what we have,[124] we shall analyse what we do not appear to have in the Aegean examples in comparison with the Egyptian or Near Eastern ones. It is obvious at first glance that the examples of inscribed balance weights are few, particularly if we exclude those whose identification as balance weights is uncertain. However, the difference from the Egyptian ones, for example, is not so much quantitative (although thousands of Egyptian balance weights have survived the percentage of incised ones remains considerably low) as qualitative: so far we have a normal inscription on only two examples –the balance weight from Mochlos (no. 1) and that from Hagia Photia (no. 8)– and in both it is not absolutely certain that we have a primary inscription. Neither of the weights is sufficiently carefully made to be regarded as an official standard. On the other hand, the monogram on the disc-shaped balance weight from Knossos (no. 2) and the ideogram on the stone disc-shaped balance weight from Zakros (no. 6) seem to be primary signs that belonged to the balance weights, and the latter case is particularly interesting because there the script sign on one side is possibly combined with a signification of practical measuring on the other side (6 small circles).

The conclusion so far is that certainly no institutionalized or even customary practice of incising inscriptions on Aegean balance weights emerges. If as the first aim of an inscription on a balance weight we posit the validation of its weight value, theoretically we would seek this in the palatial weight-standard. However, comparison between the uninscribed-pyramidal porphyry 'talent' with relief octopus motif, from the Palace of Knossos (height approx. 40 cm.) with the diorite weight (Fig. 24) of the same shape (unusual in both cultures), from third-dynasty at Ur (height 6.2 cm.), shows the difference in custom: An entire text is written on the smaller weight confirming its weight of half a mina (about 250 gr.):[125]

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[120] Shelmerdine 1997, 559, and note 137.

[121] Αραπογιάννη *et al.* 1995, 251-254. For the common use of pebbles as balance weights: Petruso 1992, 1, 3.

[122] As Αραπογιάννη *et al.* 1995, 253.

[123] Arapogianni *et al.* 1999, 40.

[124] This does not mean, however, that endeavours will not continue. E.g., the inscription on the weight from Hagia Photia has been read recently as *a-re-tar-wi* and translated as *araire* (La Marle 1998, 308).

[125] Weight equivalent to the –later– Mycenaean unit *N* in the Linear B tablets.

'Pour (le dieu) son maitre, Shulgi, l'homme fort, le roi d'Ur, le roi de Sumer et d'Akkad, a certifié (ce poids d'une) demi-mine'.[126]

Another indicative case is the stone duck of the Old Babylonian period, on which there is a cuneiform inscription: '*2 minas, certified, belonging to Šamaš*'.[127]

The same corresponding weight (of 2 minas) is certified on an inscribed Egyptian porphyry balance weight, of weight 954 gr. (slightly less than its original weight) and bearing the inscription: '*Senusret, given life eternally, 70 gold debens*', that is 70 units of gold (of 13.6 gr.) in the Middle Kingdom.[128]

It emerges from the above examples that, if we did not have the special signs for units of weight in the Linear B script, we would not be able to certify them from the surviving balance weights of the period. For example, the relationship 1 *L* (talent) = 30 *M* (double mina) emerges from tablet **Jn 415.**1-7 from Pylos; the relationship 1 *M* = 4 *N* from tablet **Jn 845.**1-8 from Pylos and so on.[129] However, even though we know the numerical signs of the –decimal– system, not only of Linear B but also of Linear A,[130] in the aforementioned inscriptions on Aegean balance weights no numbers are included. If it were the case that instead of the symbols of the numbers we had the corresponding words, then I should mention: a) the possibility of the existence of various words for the same number (as is the case with Sumerian numbering, where they are an indication of the previous stage of 'concrete counting'),[131] b) the fact of the testimony of just six words for absolute numeration in Linear B: these are the words for the numbers 1, 2, 3, 4, 6, 9.[132] One could perhaps suggest identification of the last sign (of the balance scale) in the inscription from Hagia Photia not with sign **118* but with sign no. 90 of Linear B (*dwo*), but the design of the balance scale is I think closer to **118*. The only possible case of denoting number –the 5 vertical lines on the same side as the inscription on the balance weight from Mochlos– does not seem to be a numerical symbol when compared to the 12 lines on a smaller weight in the same group. Also in other cases of Aegean balance weights, the dots or circles do not denote tens or hundreds (as in the numerical system of Linear A and B). There remains the case of the fraction-sign on the balance weight from Hagia Triada. It is obvious that the devising of a metrical system presupposes the concept of the fractional quantity. I cite the view of Bennett[133] that any Linear A ideogram followed by a fraction refers to a commodity that is measured (and not counted). It is very possible that the special signs/metrograms in Linear B are no more than a systematization of the various units for measuring area, volume and weight, which are denoted by fractions in Linear A. This also explains the absence of fractional numbers in the Mycenaean tablets.

We summarize that the cases of officially institutionalized script signs on Aegean balance weights are almost absent and that inscriptions giving diverse information, like those encountered in balance weights from Egypt or the Near East (such as the examples cited indicatively), are lacking. If few persons knew writing in the era of Linear A, then we could

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126 *Naissance de l'écriture*, 213, no. 152.

127 Al-Rawi 1994, 38, fig. 5-6. Weight equivalent to the –later– Mycenaean unit *M* in the Linear B tablets.

128 Catland 1917, 89, fig. 5. Weight also equivalent to the –later– Mycenaean unit *M* in the Linear B tablets.

129 Parise 1964, 6-7.

130 The first studies by Evans, 1906, 1935, and Bennett 1950.

131 Powell 1971; Schmandt-Besserat 1996, 113: 'Several Sumerian numerations based on a three-count system suggest that abstract counting in the Near East may have been preceded by an archaic concrete counting system which used different numerations to count different items. These numerations are ...'.

132 Hooker 1994, 114: *e-me, dwo, ti-ri-si, qe-to-ro, we, e-ne-wo*. In Sumerian arithmetic 'only one through ten ... and the numerals twenty, thirty, forty, fifty and sixty are attested in the lexical lists with phonetic glosses' (Powell 1971, 47).

133 Bennett 1950, 205.

consider that both inscriptions, from Mochlos and from Hagia Photia, point to individuals with a special social status if they are inscriptions of ownership. The Hagia Photia inscription might not be secondary and might be the name of the scribe charged with weighing. But why only in this case? If again it were the name of the fisherman, he could have been the person in charge of fishing;[134] or the one who succeeded in obtaining a large catch[135] (and the inscription is commemorative or dedicatory). There remain the hypotheses that have been mentioned already, that it is an explanatory inscription of the product or of the redistributionary role of the specific stone. In the end, this is the only possible case of an 'official' inscription from the catalogue 1-8 (I exclude the exceptional object no. 9).

Since there are no widespread cases of an 'official' script on balance weights, are we justified in considering the circles or triangles on balance weights as a practical signification for everyday use, or as denoting validity by a central authority? In this direction I shall compare two balance weights from Knossos. One, which has already been mentioned, was published by Weingarten (see above p. 60) and has three circles made by drilling. It possibly comes from the Royal Villa Pillar Room and is perhaps dated in the LM IIIA or LM IIIB period.[136] The other is unpublished, is registered as purchased in 1903, and 'was found in the rubble of the road'[137] and has five incised circumferences of circles. I mention these weights together because they are both of serpentine, come from Knossos and have a particular detail in their workmanship: both the circular surfaces are surrounded by a shallow groove. The weight of the first (204 gr.) is considered to be 3 x 68 gr., and of the second (329.52 gr. -) can be interpreted as 5 x 68 gr. So they might belong to the same system. The circles made on one by removing the material certainly affected the weight, so were they planned from the outset or were they made after control of the weight?

The incised circle on the Egyptian balance weights denotes the *deben*, that is the ponderal unit, followed however by a number (sometimes also by the hieroglyph for gold),[138] or incorporated in a text. Does the simple circle on the Aegean balance weights denote their participation in a specific ponderal system, further to the mathematical information given by the number of examples (i.e. circles)? And how do we interpret the triangles? We can say that whatever the role of the simple signs was, these were not essential, since they exist on a small proportion of the total of balance weights.[139] What is more important is that they appear the same (e.g. two triangles) on balance weights of different weight.[140] Certainly, as far as the subject of this chapter is concerned, we can conclude that although Aegean balance weights constitute part of a cognitive invention (of a full metrical system), they function more with the manner of the tradition that exists behind them, since even in the cases of incised signs, the system of simple signification prevails over that of the regular inscription.

For the issue of the continuity of tradition in the sector of measuring, I shall return to the case that I called 'concrete weighing', on the pretext of the special units for weighing specific products. The Mesopotamian system itself was based on two defined values: on the weight of the load of an ass, as the largest value, and on the weight of a grain of barley as the smallest. However, the system had to be organized also on the basis of the numerical system –of the

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[134] E.g., in the 'Turin Strike Papyrus' from Deir el-Medina, the fisherman named Sethi is characterized as 'Chief Fisherman' and it seems that members of the same family participated in fishing: Eyre 1980, 155.

[135] See the wall-paintings of the fishermen at Akrotiri, Thera. Papageorgiou 2000.

[136] Weingarten 1994, 85. Diam. 6.8 cm.

[137] This is the information in the inventory. Diam. 7.5 cm.

[138] Cf. balance weights of the Middle Kingdom, e.g. in Petruso 1981, fig. 2.

[139] See Petruso 1992; Michailidou 1990.

[140] Cf. Kea, Akrotiri.

Sumerians– which is based on multiples of 60, which is why Powell believes that it is the result of high-level planning and perhaps commissioned by a ruler.[141]

Whereas 'concrete counting' as a preliminary stage of counting ended up in the abstract numbers, 'concrete weighing' seems to continue or to recur as a special scale for certain goods. This is the case of the Egyptian balance weights belonging to the system for weighing gold, with basic unit of 13.6 gr.; beginning from the Predynastic period, balance weights which bear the hieroglyph for gold (followed by numerical symbols) are securely recognized both in the Middle[142] (Fig. 25) and the New Kingdom,[143] although there functions in parallel in the New Kingdom, a ponderal unit which is the *deben* of 91-93 gr., used in general for any commodity plus metals. Vercoutter argues for the Middle Kingdom the existence of another special unit for weighing copper, double the value of the gold unit, that is 27.2 gr.[144] An even clearer indication of 'concrete weighing' is the existence in certain areas and certain periods of a special –heavier– unit for weighing wool. The earliest indication is the kidney-shaped stone balance weight, of weight 680 gr., from Lagash in Mesopotamia, which bears the inscription: '*1 mina in wool [guaranteed by] the priest Dudu*'[145] and it is a fortunate coincidence that the same name appears on another –regular– mina of weight 497 gr.[146] At Ebla (which basically follows the Babylonian system), three standard measures exclusively for weighing wool are attested in the surviving texts.[147]

A special unit for wool, the *nariu*, reappears at Nuzi. This is a much larger quantity –3 kilos– that finds exact correspondence in the *LANA* unit of the Mycenaean tablets.[148] What is interesting is that the *LANA*, although a special unit for measuring wool, is part also of the regular metrical system of the Mycenaeans, since it is equivalent to 1/10 of the talent and subdivided to three *M* units (the subdivision 1/30 of a talent).[149] Only in the Thebes tablets does a special subdivision of the *LANA*, the *PA* unit, appear.

Some of the special units have a long history, such as that for gold in Egypt and for wool in Mesopotamia. An interesting subject for research is when and for what reason these special ponderal units were incorporated in the current general ponderal system or abandoned.[150] At Nuzi there is reference to stone balance weights with incorporated unit of cloth.[151] It is possible that one of the balance weights in our catalogue, no. 6 from Zakros, is a special balance weight for weighing cloth of the type of the ideogram it bears on one side, AB 164. On the Linear B tablet **L 520** (Fig. 26) it seems that the cloth is woollen, each counted piece manufactured from 6 units of wool (*LANA* = 3 kg.). There are six circles on the other side of the balance weight, but the balance weight is of weight 220 gr. (and not 18 kg.!). There is another possible designation of cloth on the stone disc-shaped balance weight from Knossos, with the denoting of 24 (by two large and four small circles) on one side and a rectangular motif (cloth?) on the other.[152] Its weight of

[141] Powell 1971, 209.
[142] Vercoutter 1959, pl. XXXIIb.
[143] Dilke 1987, fig. 44.
[144] Vercoutter 1977, 438.
[145] The English translation of the inscription is from Petruso 1986, 32.
[146] Powell 1971, 198.
[147] Sollberger 1986, 5.
[148] Cf. Petruso 1986; Melena 1987.
[149] The possibility of the participation of the wool unit in the ponderal system of the Linear A period as well, also emerges from the study of the total of the balance weights from the West House at Akrotiri, Thera. See Michailidou 1990; see also Petruso 1986, 34.
[150] Other examples of weighing products with heavier units are mentioned by Powell (1971, 201).
[151] Powell 1989, 515 and VB.3b. For Aegean units for cloth cf. Parise's view (1987).
[152] Evans 1935, 653-465; Petruso 1992, 38, no. 72; see also Parise 1987, 4-6.

about 1.5 kg. associates it with the balance weight from Mochlos already discussed. I propose the hypothesis that the weight of 18 kg. for each item in the tablet refers to a standardized large quantity of cloth, so that the tablet **L 520** is a collective inventory of 3, 2 and 4 'bolts' or 'bales' of this particular cloth,[153] whose weight is checked before record; in such a case the Zakros balance weight would weigh only one piece of cloth, but taking into account the ratio of the standard quantity of the specific kind of cloth to the weight of wool (6 *LANA*). The possibility of recording cloth in a large unit may be the reason why the general ideogram for cloth (AB 54) on the Linear A tablets is followed by *different* fractions.[154] Of course, a possibly standard quantity in Linear A (in the period to which the Zakros balance weight dates) did not necessarily include the same length or weight of cloth as the corresponding one in Linear B. The subject of standardization of the weight or area of a principal transactional commodity, such as cloth, is a special chapter in research.[155] (For example, Veenhof deduces that the Old Assyrian merchants were probably trading large standard pieces of cloth –and not garments– of area 18 sq.m. and weight 5 minas, and comments that the weight of 130-140 gr. per square metre that emerges is acceptable for hand-woven woollen textiles).[156] Certainly the Zakros balance weight (no. 6) combines the signs of practical signification on one side with a script sign on the other, and in contrast to the Mochlos balance weight (no. 1) the signs on both sides of the stone disc all belong to the stage of its making, therefore they are indicative of a planned function for this balance weight. Consequently, the Zakros balance weight well represents the two aspects in Metrology: the practical process and the cognitive invention.

The volume and the composition of the product are mentioned as reasons for the function of special units for measuring certain products.[157] However, I think that the reason lies more in the manner of production (since the relationship between the *LANA* and four fleeces has been certified),[158] perhaps also the exchange value and the means of distribution. In the end, I believe that the special ponderal units survive or reappear for the needs of recording. It is logical that the smaller (or more valuable) the quantity distributed the smaller the basic unit on the metrical scale, and *vice versa*. For example, the crocus in the Mycenaean tablets seems to have its own metrical scale, on account of the lightness of the stamens of saffron, the rarity of its dyeing property, perhaps also of its religious significance: the units symbolized by acrophonic ideograms *RO* and *QI* are used on for this.[159] I present tables from the relevant database in our Institute, in which it is obvious that the regular units *N*, *P* and *Q* were used along with the special units *RO* and *QI* included in the general metrical system (as is the case with the *LANA* unit). It is well known from the general inventories of products that in the Mycenaean system the *P* unit is

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[153] Some Egyptian tomb paintings are eloquent in this regard.

[154] See tablets **HT 16**.2.3, **HT 20**.4 (*GORILA* 1). 'The ligatured cloth signs are found on tablet **HT 38**.3 in quantities of 2 and 1 respectively. We do not know what units are being used. The pure cloth ideogram occurs on two other tablets, **HT 16**.2 and **HT 20**.4, by the same scribe (10 HT), in both cases followed by a fractional sign. This may indicate that the units in question are fairly large and are subdivided by fractional amounts. Finally, cloth appears on roundel **HT Wc 3019**, again in connection with a fractional sign written over a seal impression on the edge of the roundel'. Palaima 1994, 317.

[155] It is included in A. Michailidou, *Weight and Value in the Prehistoric Aegean and the Near East* (in preparation).

[156] Veenhof 1972, 93 and note 151.

[157] As Ruipérez & Melena 1996, 88, maintain for wool.

[158] Killen 1964, 9.

[159] From Ruipérez & Melena 1996, 88-89.

larger than the *Q* unit. From the tables (1-5)[160] and the tablets (Fig. 27-29) relating to saffron (crocus) it emerges that:

tablet **Np(1) 270**: *CROC P* 2 *QI* 4

tablet **Np(1) 7508 + 8594**: possibly *CROC*,] *RO* 1 *Q* 1

tablet **Np(1) 271**: *CROC RO* 1 *QI* 1

Consequently the *RO* unit for crocus is certainly larger than the *QI* unit for crocus or the current unit *Q*. It emerges that the largest quantity of saffron recorded is approx. 500 gr. (*N* 2), that is as much as the Babylonian mina, though commoner is the record of 250 gr. (*N* 1). The basic unit of inventorying crocus seems to be *P* of the general metrical system (the most records). Perhaps the measuring of the stamens of the saffron in the stage of collecting together, was made with the special units *RO* and *QI*, whereas the recording during the storing also used the current units. And so we are led to the other end of the relationship between metrology and script: to the question of when the result of a weighing is recorded directly and when indirectly, with the sum of many measurements. But here we end, because we have now entered the world of pure texts.

[160] The tables are in the Greek language because they come from the Institute's databank.

Table 1. Saffron, *N*-unit.

ΠΙΝΑΚΙΔΑ	ΣΤΙΧΟΣ	ΑΓΑΘΟ	N	L	M	P	Q	QI	RO
KN Np(1) 286	01	κρόκος		0	0	0	0	0	0
KN Np(2) 1000 + 5004	01	κρόκος		0	0	0	0	0	0
KN Np 2138	01	κρόκος		0	0	0	0	0	0
KN Np(2) 8249	01	κρόκος		0	0	0	0	0	0
KN Np(2) 5725 + 5886 + 8515	01	κρόκος	1	0	0	0	0	0	0
KN Np(2) 856 + 7915 + 7917	01	κρόκος	1	0	0	0	0	0	0
KN Np(2) 861	01	κρόκος	1	0	0	0	0	0	0
KN Np(1) 274	01	κρόκος	1	0	0	1	0	0	0
KN Np(2) 5721 + 5945 + frr.	01	κρόκος	1	0	0	0	0	0	0
KN Np(2) 5982 + fr.	01	κρόκος	1	0	0	0	0	0	0
KN Np(2) 7418	01	κρόκος	1	0	0	0	0	0	0
KN Np(2) 7439	01	κρόκος	1	0	0	0	0	0	0
KN Np(2) 8003	01	κρόκος (;)	1	0	0	0	0	0	0
KN Np(2) 5002	01	κρόκος	1	0	0	0	0	0	0
KN Np(1) 7423 + 7641 [+] 7445	01	κρόκος	2	0	0	0	0	0	0
KN Np(1) 8059	01	κρόκος (;)	2	0	0	0	0	0	0

Table 2. Saffron, *RO*-unit.

ΠΙΝΑΚΙΔΑ	ΣΤΙΧΟΣ	ΑΓΑΘΟ	RO	L	M	N	P	Q	QI
KN Np(1) 267	01	κρόκος		0	0	0	0	0	0
KN Np(1) 268	01	κρόκος	1	0	0	0	0	0	0
KN Np(1) 271	01	κρόκος	1	0	0	0	0	0	1
KN Np(1) 7508 + 8594	01	κρόκος (;)	1	0	0	0	0	1	0

Table 3. Saffron, *Q*-unit.

ΠΙΝΑΚΙΔΑ	ΣΤΙΧΟΣ	ΑΓΑΘΟ	Q	L	M	N	P	QI	RO
KN Np(1) 272 + 7419 + fr.	01	κρόκος	1	0	0	0	0	0	0
KN Np(1) 7508 + 8594	01	κρόκος (;)	1	0	0	0	0	0	1

Table 4. Saffron, *QI*-unit.

ΠΙΝΑΚΙΔΑ	ΣΤΙΧΟΣ	ΑΓΑΘΟ	QI	L	M	N	P	Q	RO
KN Np(1) 271	01	κρόκος	1	0	0	0	0	0	1
KN Np(1) 270	01	κρόκος	4	0	0	0	2	0	0
KN Np(1) 277	01	κρόκος	4	0	0	0	0	0	0
KN Np(1) 85 + 5047 + 7938 + 8057	01	κρόκος	6	0	0	0	0	0	0

Table 5. Saffron, *P*-unit.

ΠΙΝΑΚΙΔΑ	ΣΤΙΧΟΣ	ΑΓΑΘΟ	P	L	M	N	Q	QI	RO
KN Np(2) 7420	01	κρόκος		0	0	0	0	0	0
KN Np(1) 8462	01	κρόκος (;)		0	0	0	0	0	0
KN Np(1) 8459	01	κρόκος		0	0	0	0	0	0
KN Np(2) 7442 + fr.	01	κρόκος		0	0	0	0	0	0
KN Np(1) 274	01	κρόκος	1	0	0	1	0	0	0
KN Np(1) 5013	01	κρόκος	1	0	0	0	0	0	0
KN Np(1) 7441 + fr.	01	κρόκος (;)	1	0	0	0	0	0	0
KN Np(2) 7447	01	κρόκος (;)	1	0	0	0	0	0	0
KN Np(1) 8123 + 8460 + fr.	01	κρόκος (;)	1	0	0	0	0	0	0
KN Np(2) 9306	01	κρόκος (;)	1	0	0	0	0	0	0
KN Np(1) 8062 + fr.	01	κρόκος (;)	2	0	0	0	0	0	0
KN Np(2) 8649 + 9677 + fr.	01	κρόκος (;)	2	0	0	0	0	0	0
KN Np(1) 270	01	κρόκος	2	0	0	0	0	4	0
KN Np(2) 860	01	κρόκος	2	0	0	0	0	0	0
KN Np(1) 278 + 7436 + fr.	01	κρόκος	2	0	0	0	0	0	0
KN Np(2) 855 + 7434	01	κρόκος	3	0	0	0	0	0	0
KN Np(2) 860	01	κρόκος	4	0	0	0	0	0	0
KN Np(1) 273	01	κρόκος	5	0	0	0	0	0	0
KN Np(2) 855 + 7434	01	κρόκος	6	0	0	0	0	0	0
KN Np(2) 5980	01	κρόκος (;)	7	0	0	0	0	0	0
KN Np(2) 859	01	κρόκος	9	0	0	0	0	0	0
KN Np(2) 5008	01	κρόκος (;)	10	0	0	0	0	0	0
KN Np(2) 8457	01	κρόκος (;)	10	0	0	0	0	0	0
KN Np(2) 9678	01	κρόκος (;)	10	0	0	0	0	0	0

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***AE/NB* 1902, p. 65.**

Notes on weights found in different areas

[p.] 65

Weights   Another (o) 19.4

Gyps.[um]
1 Alabaster, (o on one side). In Myc. Meg.
below E. Terrace (with big Pithoi)
Wt[weight] as found, 58,5 grammes

2 Limestone (or Gyps) At S.E. Corner
(o o o o on one side)
Wt[weight] as found, 232,0 grammes

(Kapheneion)   E. slope.
3. Black Steatite. o o o o o on both sides W   Wt as found 272. 75

To ~~At~~ N.E. of Palace on Myc. floor level with Steatite lamp of Typical class

4 Black Steatite.   o O o o O o   Moulding

1507.5

		grammes	
Plaster. o	broken	20.5	- unbroken, 21.
— o o o o	broken	89.5	- unbroken 105.5
— o o o o o	broken	120.1.	unbroken, 144
o O o o O o	broken	669.	unbroken 696.6

Leadweights. 8.45 grammes   130.5 grs. $\frac{1}{2}$ Shekel
22.05 —   340 —   (3 Phan $\frac{1}{2}$ shekels)
42.7 —   ~~680~~ 659 $\frac{1}{5}$ = 131.8
(or 3 'Phan' Shekels 9 c 14 grammes)

Fig. 1. A page from the Note Book of A. Evans (transcribed by Vasso Fotou).

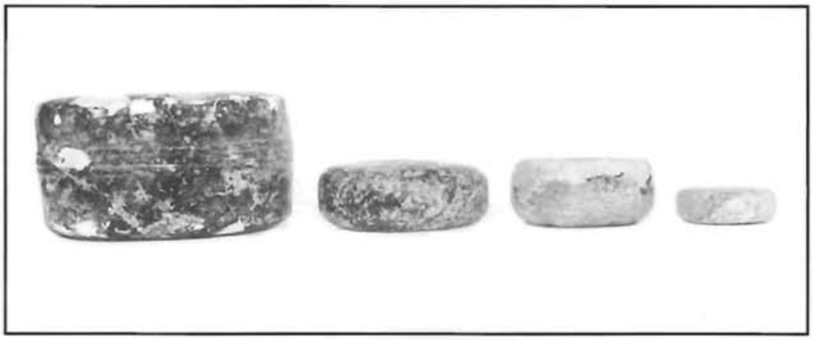


Fig. 2. Stone disc-shaped balance weights from Knossos (courtesy of Herakleion Museum).

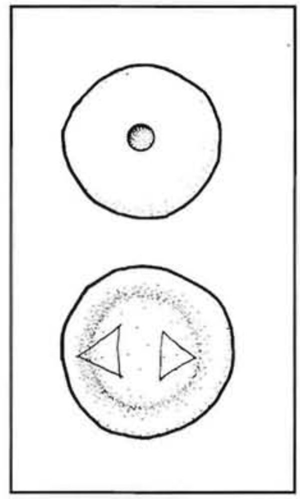


Fig. 3. Inscribed signs on lead weights from Kea (after Petruso 1992, pl. 5).

Fig. 4. The two sides of the lead weight from Mochlos (courtesy of the Herakleion Museum).

Fig. 5. Canaanite jar from Akrotiri on Thera (after *Prakt* 1994, pl. 84β).

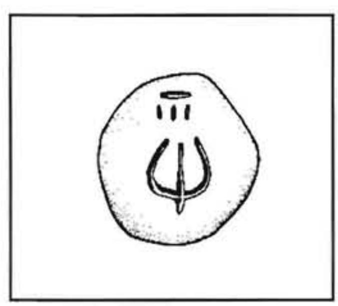


Fig. 6. Stone discoid balance weight from Knossos (after Petruso 1992, pl. 6).

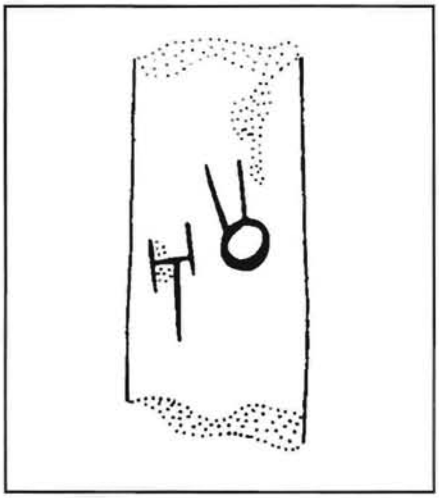


Fig. 7. Fragment of schist from Hagios Stephanos, Lakonia (after *GORILA* 5, 16).

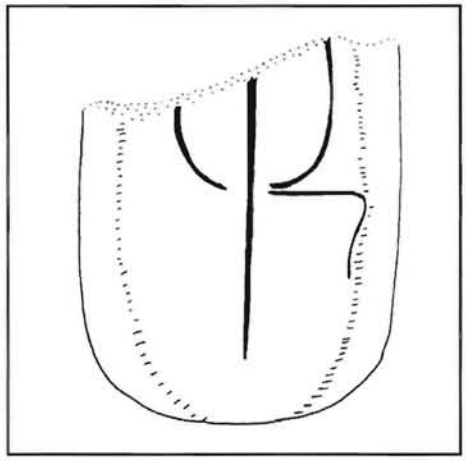


Fig. 8. Clay weight from Kythera (after *GORILA* 4, 166).

Fig. 9. Canaanite jar from Akroriri on Thera (after *Prakt* 1994, pl. 83β).

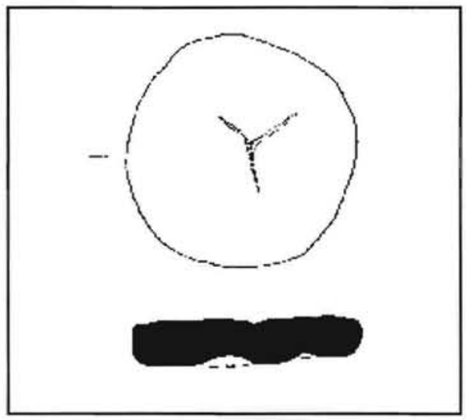


Fig. 10. Lead balance weight from Akroriri on Thera (by O. Apergi).

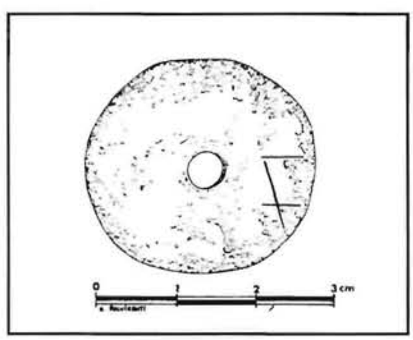


Fig. 11. Stone disc-shaped object from Hagia Triada (after Militello 1988-89, fig. 2).

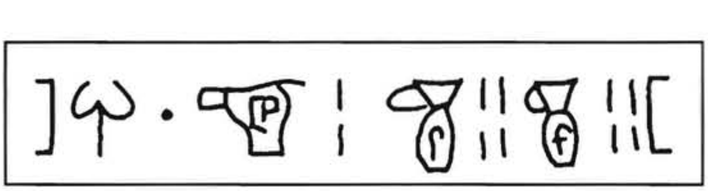


Fig. 12. The inscription **MA 10a** (after *GORILA* 5, 51).

Fig. 13. The ovoid stone from Hagia Photia (courtesy of the Herakleion Museum).

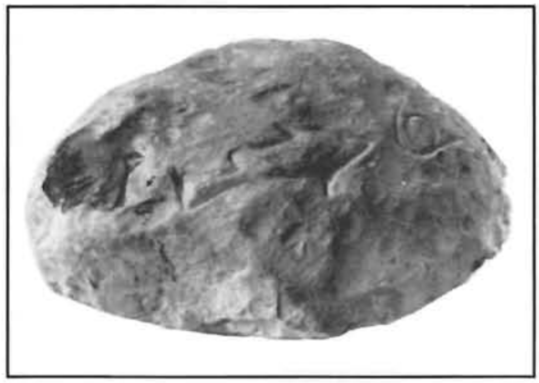


Fig. 14. Stone weight from Deir el-Medina (after *Naissance de l'écriture*, no. 221).

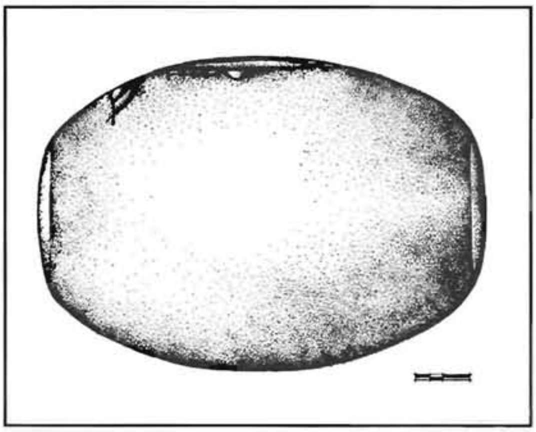


Fig. 15. The sphendonoid shape of the stone from Hagia Photia (by P. Stephanaki).

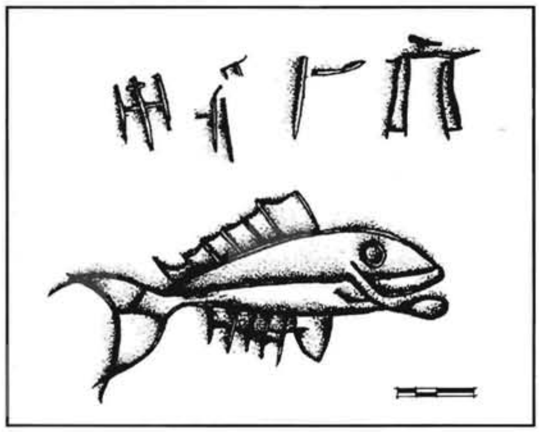


Fig. 16. The inscription on the stone from Hagia Photia (by P. Stephanaki).

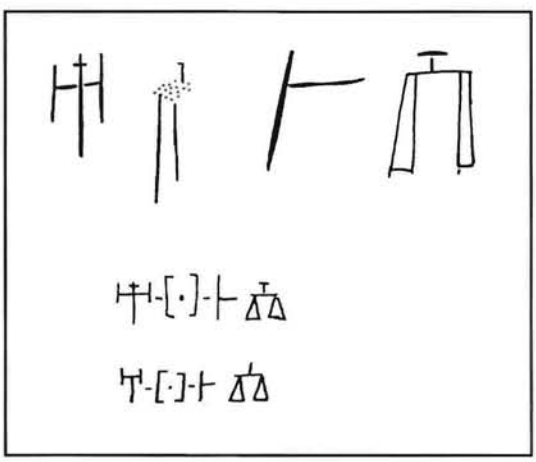


Fig. 17. The inscription on the stone from Hagia Photia as transcribed by L. Godart.

Fig. 18. Egyptian stone weight from Deir el-Medina (after Brovarski *et al.* 1982, 62).

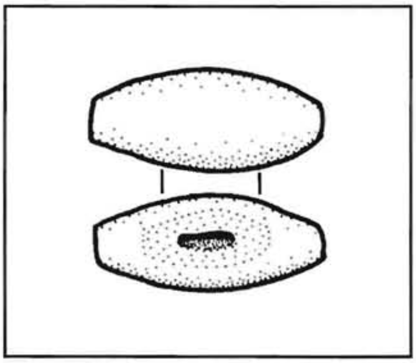


Fig. 19. Stone sphendonoid weight from Knossos (after Petruso 1992, pl. 6).

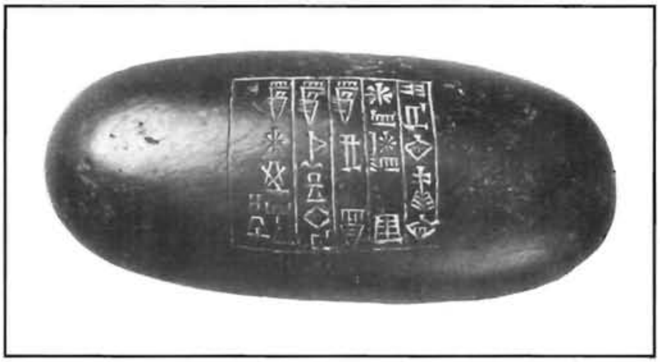


Fig. 21. Stone sphendonoid weight of Ur-III period (after *Naissance de l'écriture*, no. 34).

Fig. 20. Stone sphendonoid weight from the Metaxas Collection (after Petruso 1992, pl. 9).

Fig. 22. Stone sphendonoid weights from Akrotiri on Thera.

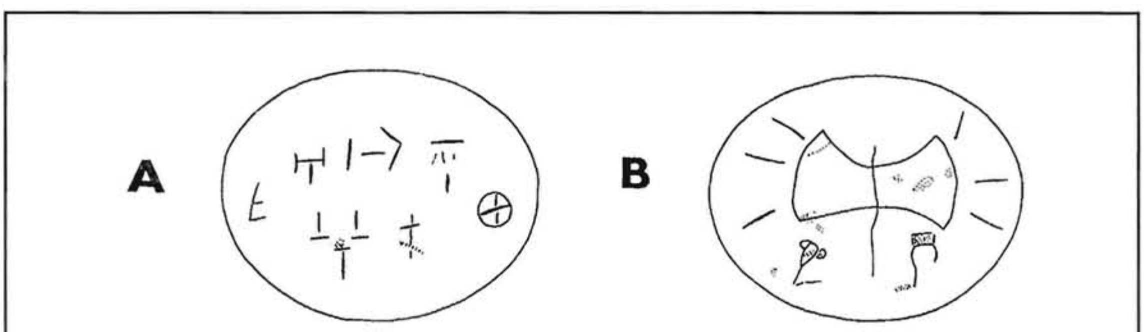


Fig. 23. The pebble from Kafkania (after Arapogianni *et al.* 1999, 40).

Fig. 24. Stone weight of Ur-III period (after *Naissance de l'écriture*, no. 152).

Fig. 25. Egyptian stone weight from Nubia, 12th Dynasty (after Schoske & Kold 1996, 11).

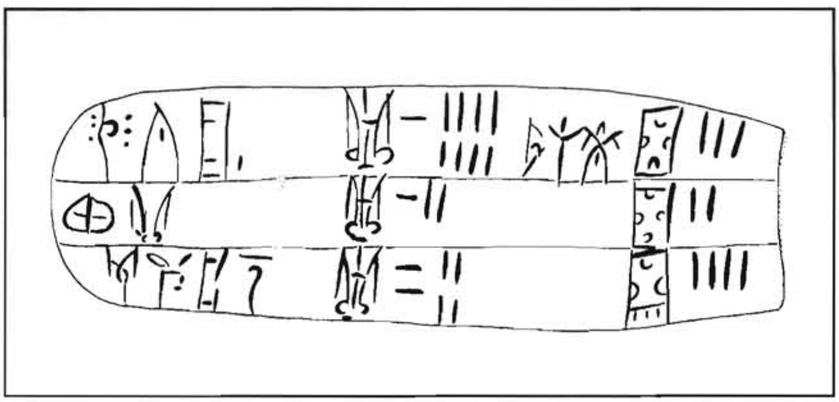


Fig. 26. Tablet **L 520** from Knossos with records of wool in *LANA* units followed by the corresponding quantities of cloth (after *CoMIK* I).

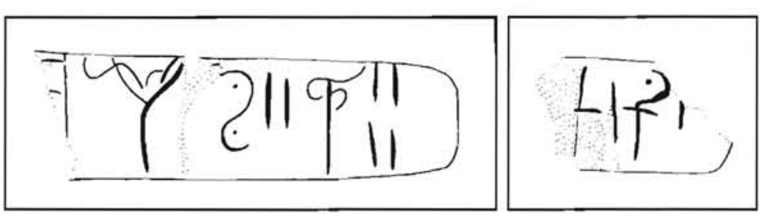


Fig. 27-28. Tablets **Np(1) 270** and **Np(1) 7508 + 8594** from Knossos with records of saffron (after *CoMIK* I and III).

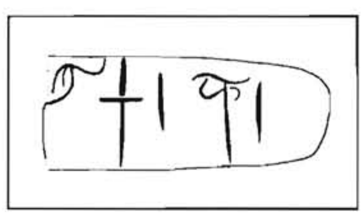
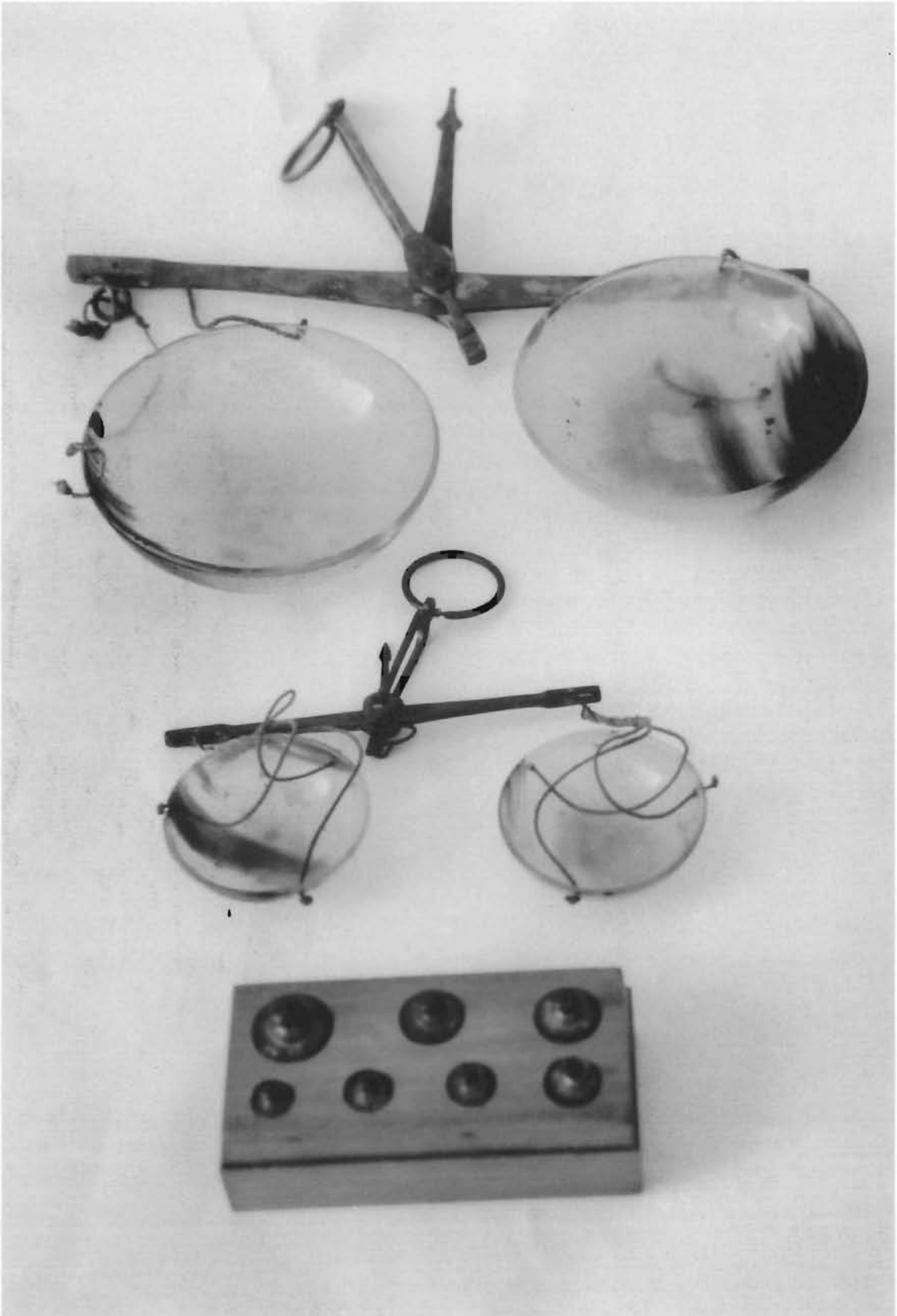


Fig. 29. Tablet **Np(1) 271** from Knossos recording a quantity of saffron (after *CoMIK* I).

PART II

RECORDING PRODUCTS OF TECHNOLOGY



Small balances with two pans made of tortoise-shell (or sometimes entirely of bronze) were in use till recent times for the precise weighing of precious materials; the lower one –together with the balance weights in the box– was used for checking the weight of gold coins (collection of A. Michailidou). In ancient times the invention of balance weights will have been associated with the need to use them for the absolute measurement of gold.

RECORDING QUANTITIES OF METAL IN BRONZE AGE SOCIETIES IN THE AEGEAN AND THE NEAR EAST*

Anna Michailidou

INTRODUCTION

Metal is known to have circulated over a wide geographical area in standardised form and in large quantities: one has only to recall the large number of ox-hide or bun ingots of copper and tin in the Uluburun (*Ακρωτήριον*) shipwreck,[1] or the gold ring-ingots in the wall-painting depicting Nubians bearing offerings to the Pharaoh of Egypt.[2] The high value of the metals was due, of course, to the great demand for them as raw materials. Zaccagnini eloquently summarises the uses of metal: '*nei lavori agricoli, nei vari artigianati, in guerra, comme strumento dei tesaurizzazione, mezzo di scambio e di computo del valore dei beni*'.[3] That metals could be preserved –in contrast with grain and other products that deteriorate– and therefore easily stored and also recycled, are the main reasons that they had the greatest exchange value, especially for long-distance trade, in which 'the network of exchanges needs to be balanced at each stage by some commodity which is generally acceptable and can be both stored and adventitiously converted into different materials as occasion demands. This requirement is filled by metals, especially precious metals'.[4]

The feature of interest to the present study is that metals are measured by weight, since they are not fluid and cannot, therefore, be measured by volume.[5] It was necessary to measure the weight of metals both for craft-industry purposes and for trade, and it was not only raw materials whose weight was so measured, but also finished products; 'for an elite concerned with the movement of high-value materials, the notion of equivalence by weight is fundamental, and the wealth stored as plate, weapons and ornaments (my emphasis), including the added value of expert manufacture, represented a convertible reserve of value which could be mobilised for exchange'.[6] For this reason, any failure to find a vessel made of precious metal in an excavation is not an indication that it was actually absent, but demonstrates 'the extent to which it was

* My warmest thanks for the translation of the Greek text are due to David Hardy. I want also to thank Antigoni Zournatzi for the encouraging discussion during a Sunday lunch.

[1] More than 354 ingots of copper –that is, more than 10 tonnes– and about 1 tonne of tin, see Muhly 1996, 48, and especially Pulak 1998, 193-200, where all the shapes of ingots found are recorded. For the ancient name of Uluburun, see Lolos 1989.

[2] The wall-painting is in the British Museum: James 1985, fig. 23.

[3] Zaccagnini 1976, 325.

[4] Sherratt & Sherratt 1991, 360.

[5] Gold dust might have been an exception; in Egyptian wall-paintings it is stored in bags of equal size but, because of the nature of the material –leather or cloth– of variable capacity. So the balance will again have been essential for measuring this highly valuable material. It has been argued that 'weights and balances were first used for weighing gold dust' (Skinner 1954, 779).

[6] Sherratt & Sherratt 1991, 360 (cf. the views on 'social storage' by Halstead & O'Shea 1982).

retained in circulation and mobilised when necessary'.[7] The occasional depiction of a particular type of vessel in the iconography of different cultures indicates the degree of internationalisation of certain types that circulated in various directions as exchange value. With regard to the perceived value of metals, in particular, it should be noted that this varied both geographically and over time. A. and S. Sherratt, for example, notice that silver was regarded as twice as valuable as gold in Egypt, whereas in Mesopotamia it was one tenth the value, and in the Aegean gold probably had a higher value than silver; in the case of tin, they give the indicative ratio of tin to silver of 1.5:1, for Ebla.[8] The supplying of gold to Egypt by the mines of Nubia and of silver to Mesopotamia by Asia Minor undoubtedly played a role in establishing the 'value' of gold and silver in these regions. In addition to precious metals, however, copper, alongside its consumer value, 'occupied an increasingly strategic role as a material for weapons, and this required the movement of large quantities of metal'.[9]

For all these reasons, the interest of the 'palace' regimes in the concentration and movement of metals was to be anticipated, and the recording of metal artefacts in Mycenaean tablets and Near East archives comes as no surprise.[10] The main topics with which we are concerned here are: the nature of the metal that circulated (or was recorded at least), the forms in which it was moved, and above all the quantities that were distributed or owned. The sources used for the investigation are: the Mycenaean tablets (for the quantities recorded by the palace bureaucracy), the archaeological finds from Akrotiri, Thera (for the demands of urban ownership), and a selection of Near Eastern documents (for the technological and economic processes determining the quantities recorded in public and private archives).[11]

1. Metals In the Mycenaean Tablets

There is a large bibliography on Mycenaean tablets containing references to metal. Already, according to the introduction selected from the article by A. and S. Sherratt, we may anticipate records of precious metals and records of plates, weapons and ornaments, as was stressed above.

1.1. Gold

As is generally known to date, only the tablet **Jo 438** mentions quantities of gold –as a contribution to the palace of Pylos– and gold is otherwise referred to in the tablets as defining vessels,[12] or decorating various objects.[13] Since the sources of gold are not the concern of this

[7] Sherratt & Sherratt 1991, 360.

[8] Sherratt & Sherratt 1991, 377, notes 11, 12.

[9] Sherratt & Sherratt 1991, 360.

[10] For the Mycenaean tablets in particular, see the chapter by Dialismas in the present volume. I would like to thank A. Dialismas for his contribution in the *ΠΕΝΕΔ* Research Programme in the Centre for Greek and Roman Antiquity and his assistance to the present writer. But the first credit is due to D. Kriga who was the one that helped all members of the team to start the project.

[11] The comparative study of Near Eastern and Mycenaean texts, with all due caution, is steadily gaining ground. See by way of example Uchitel 1988, De Fidio 1992, Sheldmerdine 1998, 296-298 or Tournavitou & Sugerman in press.

[12] *Documents*, 351.

[13] See note 10 (Dialismas).

chapter, we may leave aside the theory that the word *ku-ru-so* is a Semitic borrowing,[14] or that *AUR* is derived from an Indo-European term,[15] and concentrate our investigation on the quantities of the metal recorded. From this point of view, interest attaches to the comments made some time ago by Bennett on the 'unusually small quantities with this ideogram in **Kn01**'[16] or the view expressed by Dialismas in the present volume that one would not have anticipated there to be only one inventory of gold in the Pylos archive.[17] Are the quantities in the tablet **Jo 438** (**Kn01**) really small? Godart appears to take a different view.[18]

1.2. Silver, tin and lead

We turn now to comments already made in connection with silver (sole reference as a material added during manufacture) and tin (dubiously identified in the word *ka-te-ro*, accompanied by the metrogram *L*, meaning for talent), in order to draw attention to the question of their absence in the tablets. A record of lead has survived in one tablet, at Knossos, mentioning quantities of 3 kilograms (the metrogram *M*) for each reference.[19]

1.3. Copper

The references to copper are much more numerous.[20] We will start with the comment made by J. Smith in her general presentation of the tablets of the **Jn** series: 'The metal referred to in the **Jn** series could be copper, bronze or both. Not only is it difficult to be certain of the composition of the metal listed in the **Jn** tablets, but also it is difficult to be certain whether it is in ingot form or the form of a scrap metal'.[21] We should also draw attention to Zaccagnini's useful observation that in general we may assume that metals were transported as whole ingots, fragments of ingots, scrap metal, and finished craft products.[22] As in the case of gold, the quantities of copper recorded have been considered to be small: 'the small sizes of the allotments suggests that workers probably did a service for the palace through the *ta-ra-si-ja* service in addition to working their crafts for customers other than the palace'.[23] Zaccagnini concludes from the evidence of the tablets of the **Jn** series that 'in most cases, copper handed over to the smiths was shaped in the form of oxhide ingots, since the figures reproduce the weight of one or more ingots (i.e. *ca.* 26/30 of a talent) and possibly also of half ingots',[24] and Smith concurs (at least in the case of ten tablets): '6 ingots were distributed to smiths in the south and more than 8 to smiths in the north'.[25] The quantities per coppersmith ranged from 12 kg. (*M* 12) to 1.5 kg. (*M* 1 *N* 2).[26]

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[14] Akkadian *hurasu*, Ugaritic *hrs*, Hebrew *harus* (Witczak 1992, 90).

[15] Witczak 1992, 91.

[16] Bennett 1950, 218.

[17] See note 10.

[18] Godart & Tzedakis 1992, 206: '*la quantité d'or traité est considérable*'. The same opinion by Chadwick 1976, 145.

[19] The bibliography on the above metals is assembled in the chapter by Dialismas.

[20] *Ibid.*

[21] Smith 1992-93, 173.

[22] Zaccagnini 1986, 414.

[23] Smith 1992-93, 180.

[24] Zaccagnini 1986, 415.

[25] Smith 1992-93, 191.

[26] Chadwick 1976, 140-141. *M* and *N* are the conventional names for the metrograms **117* and **116*, which denote quantities of 1,000 and 250 grams respectively.

The objects produced by working the copper were probably weighed on delivery.[27] And if account is taken of the likelihood that the adjective *qa-si-re-u* (in three tablets recording copper) refers 'to supervisors who oversaw metal allotments from the palace to individual smiths throughout the Pylian kingdom ... perhaps responsible for the return of finished products',[28] then the distribution pattern is possibly analogous to that of the Near Eastern tablets. (I cite by way of example the documents from Mari, in which Mukannišum is the official in charge of the royal workshops: see below, p. 93).

In the palace at Knossos the total quantities of copper recorded are not small: the 60 ingots weighing a total of 1,562 kilograms in tablet **Oa 730**[29] are consistent with the large numbers of ingots found in shipwrecks, though the number remains understandably greater than finds made so far in palaces or 'villas' (cf. the specimens in Herakleion Museum). For the problem of whether the Linear B ideogram **167* (for ox-hide ingot) refers to a standard quantity of copper or bronze (or even tin?),[30] the archaeological record to date has suggested copper for the ox-hide ingot (which is of standard form and weight),[31] and bronze for the bun ingot (which is standardised only with regard to its form, usually weighing from 1 to 5.5 kilograms), though this does not preclude the existence of bun ingots of copper (or tin).[32] Vandenabeele and Olivier regard the ideograms **167* and **167+PE* as certainly referring to ingots of metal, since the tablets record their weights. As for the *AES* (**140*) accompanying the ideogram **167+PE* in one instance, it is not clear whether it is used to define bronze or copper.

Smith holds the interesting view that when the total recorded in the tablets happens to be equal to or greater than 26 kilograms, then 'the similarity of this weight to the weight of a single oxhide-shaped ingot *ca.* 26 kg. suggests that smiths on these tablets received fragments of copper ingots'. In the case of other tablets recording totals of smaller quantities, e.g. 12 kilograms, she posits the distribution 'of ingots of bronze', possibly 'bun shaped', while for yet other tablets, in which no total is recorded, even if the individual allotments produce a large total, such as 26 kilograms, she assumes an allotment of 'scrap metal possibly of bronze'.[33] This is an ingenious hypothesis: we may imagine the palace sending an 'ox-hide ingot' to some place and fixing the quantities to be allotted to the individual craftsmen there. It remains a hypothesis, however, as does the possible distinction between copper and bronze in the above records. Even in the Near Eastern tablets, in which copper is distinguished from bronze by name (see below, p. 93) matters are not entirely clear.

1.4. Final picture

In summary, the picture emerging so far from the study of the –palace– Linear B tablets is that (a) we have only a single tablet recording quantities of gold and one mentioning lead,

[27] As Chadwick 1976, 140. For a record of 1,046 kg. of copper (?) as total (tablet **Ja 749**) cf. *Documents*, 356 and Chadwick 1976, 140.

[28] Smith 1992-93, 182. But see the comments of Lindgren 1973, II, 126-130 and note 4; cf. also tablet **Jo 438**.

[29] Chadwick 1976, 142.

[30] Since the same standard shape is also attested for tin by some of the ingots from the Uluburun shipwreck; see the article by Bass 1997, 157. For other shapes also, see Pulak 1998, 199-200.

[31] For the metrologic significance of the standard shape(s) and weight(s) of the ingots, see Zaccagnini 1986, 413 (views of Muhly, Parise). There are also ox-hide ingots weighing less than a talent (cf. Pulak 1998, 194-195), though I believe that these too are of a standard form and weight (cf. ingots from Kyme, Euboia, e.g. *Mycenaean World*, no. 269 of 9.9 kg.).

[32] Smith 1992-93, 175; Bass 1997, 157. Pulak refers in general to copper bun ingots (1998, 193).

[33] Smith 1992-93, 185, 194, fig. 14.

virtually no inventories of silver and tin, while more frequent references to copper or bronze; (b) there are records of metals in the form of either ingots or objects (Sherratt's plates, weapons, and to some extent ornaments, though not jewellery);[34] and (c) the individual quantities of copper or gold recorded (whether for distribution or as a contribution) are considered small by scholars.

What of the Linear A tablets? The question, here, is why have we failed to identify records of metals in these. The sign L 8 (A 327), which is similar to the Linear B *AES*, occurs in isolation (on two occasions) only at Hagia Triada,[35] where it might be taken as an ideogram for copper. Even if we limit the recording of metals solely to the level of the palace, and only at the time of the centralised system reflected by the Linear B tablets, we cannot, of course, limit the circulation of the metals solely to these higher strata, for Limet, in his classification of goods into '*biens necessaires*', '*biens utiles*' and '*biens superflus*', very properly assigns metals to the second category.[36] For the period of Linear A script (and also that of Linear B), it would be useful to consult also the archaeological record with a view to documenting the written texts by archaeological evidence (though taking into account the parameters touched upon by Bennet in his relevant article).[37]

2. The Circulation of Metal

2.1. The circulation of metal within the community

Leaving aside the material deposited 'eclectically' in tombs as grave offerings,[38] I turn to a settlement dating from the period that saw the spread of Linear A script (where we noticed the 'absence' of metal recording) and having an urban character. The settlement in question is Akrotiri on Thera, where the volcanic destruction has reduced the factor of 'eclectic preservation' to the minimum, so that the site potentially provides interesting evidence for the circulation of metal within a city through the study of the 'household equipment' owned by the inhabitants.[39] This question was a matter of persistent concern to Zaccagnini in his study of records of metal in the Nuzi tablets (which, it may be noted, are roughly contemporary with the Mycenaean tablets): 'Once again, what did people do with these metals? Notice that there is practically no hint whatsoever for the circulation of metal in the form of finished objects: tin, copper and bronze were handed over exclusively as raw (or semi-elaborated) material... Through redistributive (and commercial?) mechanisms –that admittedly escape us– a certain amount of these metals found their way outside the sphere of the palace and circulated not only in the Arraphean socio-economic elite but also among the lower strata of the population, being essentially employed as exchange-goods and means of payment. It is quite possible that a percentage of this circulating mass of metals reverted to the palace, through fiscal mechanisms that, again, escape us'.[40] From the point of view of methodology, Akrotiri enjoys the advantage of not belonging directly to the Minoan palace system or to the later Mycenaean bureaucratic

[34] See the chapter by Dialismas in the present volume.

[35] Pope & Raison 1978, 14; Palaima 1988, 325; see also Watrous 1984, 130 and note 55.

[36] Limet 1977, 58.

[37] Bennet 1988.

[38] See, by way of example, Voutsaki 1997, 41-43.

[39] A paper on 'Household equipment in metals' was presented by A. Michailidou at the two-day conference celebrating 30 years of excavation at Akrotiri, Thera, held in Athens, 19-20 December 1997. It will be published in the proceedings of the conference, by the Archaeological Society at Athens.

[40] Zaccagnini 1984, 158, 159.

environment; we can therefore examine elements of the everyday use –and ownership– of metal in the economic life of a city that was less susceptible to the control of a palace, and which probably retained sufficient quantity of the original household equipment.

a) The first category to be established is the standardised form of raw material, which is still under investigation in the case of Akrotiri. (At another settlement, Gournia, small pieces of ingots have been identified retrospectively through metallography.[41] For obvious reasons I do not cite the examples from 'villas', but it is interesting that an entire 'ox-hide' ingot has been found in the area of the settlement of Poros-Katsambas).[42] One wonders if the strips of copper found in Δ 16 at Akrotiri[43] are purely functional, or whether they form part of the circulation pattern of smaller –standard– quantities of pure metal (see Table 1).

b) Of the other forms identified by Zaccagnini in the records of metals in Near Eastern tablets, the second category consists of amorphous scrap (that is, fragments that were deliberately kept by the owners) and disused objects, which could also be repaired or recycled. An example from Akrotiri is the repair to the bottom of a small copper tripod cauldron in the West House, together with the observation that one of its legs is incomplete (unless due to bad preservation). It reminds us of a palace record of a tripod cooking-pot 'with one leg' (*e-me po-de*) in tablet **Ta 641** from Pylos.[44] And also of the letter sent by an Old-Assyrian merchant from Kaniš in Asia Minor to his wife at Aššur, promising that he will bring a quantity of copper for a new cauldron, but that in the meantime she is to have the old one repaired.[45] This makes it easier to assess the third, and main form of circulation.

c) The main form in which metal was circulated was that of the complete finished product, with the embodied value (?) of the workmanship. Some of these products were luxury items. Two braziers have been found at Akrotiri,[46] for example, and I am aware of published examples from elsewhere in the Aegean: one with *repoussé* ivy leaves from the palace at Zakros, one undecorated (and much larger) from the tholos tomb at Vapheio, and one from the Unexplored Mansion at Knossos, which is larger than the vessels from Akrotiri but has the same *repoussé* spiral ornament. Others will be found, or have been found, but they are fairly rare.[47] Some finished products thus acquired great exchange value outside the borders of a city, and became merchandise that was transported in all directions. They ultimately acquired the characteristic of 'internationalisation' referred to at the beginning of this chapter, which is eloquently reflected in some wall-paintings in Egyptian tombs of the 18th Dynasty.[48]

Taking as given the view held to date, that even the metalworkers of the Pylos tablets worked in the place they lived (and also the theory that there were 'part-time smiths or smiths working on a seasonal basis')[49] I turn to the question of whether their work could have been also destined for local consumption. Having traced, albeit to a limited extent, the presence of metalworkers at Akrotiri,[50] I have attempted to identify their customers in the non-palace environment of the city, beginning with the 'household equipment', as it arises from the picture of the distribution of

[41] Betancourt *et al.* 1978, 7-8. But see the information in Fotou 1993, 29, 97, pl. XVII.
[42] Dimopoulou 1997, 435, pl. CLXXIa.
[43] Michailidou 1993-94, 173, pl. 24a, and Μιχαηλίδου 1997b.
[44] Hooker 1994, 214. More on the tripod cooking-pot from the West House, in the forthcoming publication of the metal artefacts from the house (Μιχαηλίδου in press).
[45] Dercksen 1996, 74. The merchant thus had a quantity of copper that he could use for his own home.
[46] *Thera V*, pl. 76; Μιχαηλίδου 1997b.
[47] They are cited here for this reason, despite the differences in date between them.
[48] Cf. wall-paintings from the tomb of Rekhmire: Wachsmann 1987, pl. XLI-XLIII.
[49] Killen 1979, 133-134.
[50] Michailidou 1993-94, 170ff.; Μιχαηλίδου 1997a, 647-648.

metals amongst the buildings of the settlement.[51] All the inhabitants of Akrotiri were customers of the coppersmith, for one reason or another –either for tools or for vessels used for household or professional purposes. A ready example is furnished by the fishhooks that were found in different parts of the settlement and outside it, sometimes *in situ* stored in pithoi, and sometimes retrieved by sieving the soil excavated, and in a wide range of sizes, suitable for catching anything from bream to swordfish. Fishing is not one of the professions recorded in the Mycenaean tablets, nor are fish mentioned,[52] but how did people get their fishhooks? We might also consider the variety of knives, the most useful tools in the household, agricultural, and craft-industrial spheres. The carpenter, too, of course, needed his tools, the saw and chisel, and the question of who owned tools has received great attention from scholars.[53]

2.2. Comparison with the Mycenaean tablets

The point shared in common, that makes it legitimate for select comparisons to be made between information recorded in the Linear B tablets and any corresponding archaeological evidence for the household equipment at Akrotiri, is that in both cases we are mainly dealing with the 'internal', regional circulation of metal, since 'Mycenaean texts provide almost no direct evidence for the management of extraregional trade, whether by sea or land'[54] and 'the mechanisms for exchange beyond the borders of the Pylian kingdom are not found in the existing Linear B tablets'.[55] Akrotiri is selected because of its good state of preservation,[56] while scales and balance weights discovered in the buildings attest to the fact that goods were measured on the spot. The Linear B tablets are a good source for what kinds of goods were weighed,[57] and for the units used in this purpose.

To summarise: the scanty nature of the references to gold and silver in the tablets is reflected in the archaeological record (though in the latter case it is completely explicable). On the other hand, lead occupies a different position –most of the metal objects left at Akrotiri are made of lead, a clear indication of the low value attached to this metal– while tin, of course, is invisible in the archaeological record. As for the nature of the objects (recorded or found) we are well informed by the book by Vandenabeele and Olivier identifying ideograms with archaeological finds. At first sight, it is apparent that the palace's record was selective and referred only to certain types: there is no mention of most tools (apart from fire-tongs and dubious and indirect references to saws),[58] while weapons are in the majority. I believe that the difference in the social (and chronological) context of the sources (the Akrotiri settlement and the palace Linear B archives) will help us to a better understanding of both. For example, what might be the significance of the record of 50 daggers (or swords) in a single tablet from Knossos (Fig. 1), and the discovery of three or four daggers at Akrotiri? The first explanation that comes to mind, of

[51] Μιχαηλίδου 1997b.
[52] Palaima 1991, 284.
[53] E.g. Μιχαηλίδου 1997b. Of the workers at Deir el-Medina in Egypt, Bierbrier writes (1989, 42) that 'several workers owned their own expensive copper tools, quite distinct from those provided by the government'.
[54] Palaima 1991, 276.
[55] Smith 1992-93, 213. Shelmerdine (1998, 291) has observed that 'the Mycenaean documents do not contain any direct evidence for foreign trade, an omission which continues to surprise and attract various explanations'.
[56] We should not overlook Gournia or Malia, for example.
[57] See Μιχαηλίδου 1990, 72-75, and Michailidou 1999.
[58] For the saw, see Hiller 1992, 309 and note 32, where the relevant bibliography is cited.

course, is that arms production was mainly of interest to the palace,[59] in support of which I cite a comment by Gates,[60] for the Old Assyrian colony at Kaniš in Asia Minor: here, in addition to the usual copper smithies, was found a workshop that, according to the excavator, 'specialized in weapons, although never swords, which were apparently reserved for the palace –that at least is the only place where they have been found.' He thus hints at three levels, at least, of copper production (general production - weapons - swords). The view that the palace controlled the production of weapons has also been expressed by Liverani, in his commentary on letter EA 77 from Amarna, in which the ruler of Byblos declares himself unable to send to Pharaoh certain copper objects, called *šinnu*, which are interpreted by Liverani as arrow- or spear-heads, or blades.[61] Control of weapons-production by the Mycenaean palaces may be supported by Gregersen's observation that '*ka-si-ko-no* and *pi-ri-je-te* both seem to be producing weapons[62] and receive payment in kind, but the smiths *ka-ke-we* are never registered for payment in kind'.[63] The question then arises as to the significance of the daggers found in the settlement (e.g. Fig. 3): are we to deduce a specialised local production, or suggest elite recipients/owners or recipients/distributors of imported weapons?[64]

3. Recording the Quantity of Metal

With regard to the quantities of metal recorded by the palace and those that can be identified in the archaeological context, Ventris and Chadwick already commented that of the most frequently recorded allotments to coppersmiths, the greatest quantity –5 kilograms of copper– was enough to make 14 swords (average weight 357 gr.), and the smallest –1.5 kilograms– enough for 1,000 arrow-heads (average weight 1.5 gr.).[65] This leads us to the following picture:

Pylos palace → Quantity of copper *M* 1 *N* 2 → 1 craftsman → ability to produce: 1,000 arrows.

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[59] See the chapter by Voutsa in the present volume. I would like to thank K. Voutsa for her contribution in the *ΠΕΝΕΔ* Research programme in the Centre for Greek and Roman Antiquity, and for her assistance to the present writer.

[60] Gates 1997, 257.

[61] Liverani 1997, 4, 122-123: 'Byblos seems to have been an active copper-producing center, exporting processed items like weapons to other cities nearby (Tyre, cut away from its hinterland, was probably short of fuel for metal working) as well as to Egypt. Metal working, and especially weapons production, was carried on under royal control, and organized into "quotas" to be completed and delivered by individual artisans or groups of artisans to the Palace (to be exported therefrom).' He notes that the word *mahβsu* in the text of the letter probably refers to the hammering that followed casting, the final process carried out by the craftsmen before delivering the finished product to the king.

[62] The identification of *ka-si-ko-no* with sword-maker was made long ago and is generally accepted. The interpretation of *pi-ri-je-te* continues to occupy scholars; see, e.g., Lindgren 1973, 74 (*ka-si-ko-no*) and 117 (*pi-ri-je-te*); Hooker 1994, 153 (*pi-ri-je-te*); Hiller 1992, 309, note 32 (*pi-ri-je-te*).

[63] Gregersen 1997, 401. Palatial control of weapons-production may also be indicated by the description of *e-te-do-mo* (= armourer?) as *wa-na-ka-te-ro* (= of the King), see Palaima 1997.

[64] For the question of weapons at Akrotiri, see also Kilian 2000. The possibility that many daggers were removed from the settlement, taken away by their owners when they fled, does not interfere with the question of their original availability as weapons. Cf. discussion on weapons in LM I tombs and in the Warrior graves, especially by P. Warren in Driessen & Schoep 1999, 401.

[65] *Documents*, 356, where also the weight 695 gr. is given for the copper helmet from an LM II tomb in the area of Knossos (Hood & De Jong 1952, 256).

Interestingly, many copper arrow-heads have actually been found together at Pylos.[66] I note in this context the letter by the king of Mari to Mukannišum, the official responsible for his workshops, with an exclusive order for 1,000 arrow-heads, the weight of each defined as about 2 gr.:

'mille fleches en bronze de ¼ (de sicle) chacune, avec le bronze rouge ... dont tu disposes'.[67]

This means that the king was aware that the official (still?) had 2 kilograms of bronze at his disposal (this would be written *M* 2 in Linear B).

Similar records in the Mycenaean tablets refer to totals of 50 swords (Fig. 1) or 42 spears or 6,010+2,630 arrows (Fig. 2). For these many arrows, it has been calculated that a total quantity of 13 kilograms of copper would have been required.[68] Chadwick's calculation that 5 kilograms would produce 14 swords of 357 gr. per sword demonstrates that even the smallest quantity despatched, 1.5 kilograms per craftsman, was not very small, since it was enough for at least four swords.

3.1. Documentary evidence from the Near East

A search in the Near Eastern texts for evidence for quantities of metal, reveals that the smaller quantities of copper include those used to give textiles and leather a green colour: the Isin archives, for example, contain the information that 33-34 gr. of copper were needed to dye a goatskin[69] (the corresponding Linear B record would have been *P* 1 *Q* 4).[70]

a) If we have recourse to the earlier tablets of Ur-III period (approx. 2150-2000 BC) on the grounds that these very often record not only the number, but also the weight of finished metal products, we may note:

Records of tools. For example *'1 ciseau en bronze, d'1/3 de mine, 1 ciseau en bronze de 17 sicles, 1 ciseau en cuivre, metal durci, de 2 mines et 15 sicles'.*[71] The weight for each chisel is respectively 167 gr., 142 gr., 1 kilogram and 126 gr., with the further provision in the last case that it might be of hammered copper.[72] Limet comments[73] in the case of carpenter's chisels that, whether of copper or bronze (there are different words for these in Sumerian, *URUDU* for copper and *ZABAR* for bronze), the weights recorded vary, from ½ shekel (a mere 4.2 gr.) to 17 or 20 or 28½ shekels, as well as the above-mentioned example of 2 minas and 15 shekels.[74] It is notable that many more kinds of tool are recorded in the Ur-III tablets than in the Mycenaean tablets. For example, one copper sledge weighs 3 minas[75] (1,500 gr., or *M* 1 *N* 2 in the Mycenaean script). Also eight hoes, brought by the craftsman himself, have a total weight of 4 and 2/3 minas and 5 shekels[76] (that is, a total of *M* 2+), while elsewhere, seven hoes weighed 2 and 2/3 minas

[66] Blegen & Rawson 1966, I, 325, II, fig. 317.

[67] Translation by Rouault 1977, 29-31. There are cases in which heavier arrow-heads are ordered (40, 24, 16 and 8 gr. each, in smaller quantities, of 50 to 200 arrow-heads), see Dalley 1984, 63.

[68] *Documents*, 361.

[69] van de Mieroop 1987, 30.

[70] These are the Linear B metrograms **115* (*P*) and **114* (*Q*), for weights of about 20 and 3.6 gr. respectively.

[71] Limet 1960, 39. I retain the French, English or German text, depending on the translation provided for the Mesopotamian document by each individual author. See *UET III* 735 (Legrain 1947, 227).

[72] Cf. Limet 1960, 185.

[73] Limet 1960, 221.

[74] Mina, *Maneh* = about 500 gr. and Shekel, *Sicle* = 1/60 of a mina, that is, about 8.40 gr. (though there are different values for the above units in the general area of the Near East).

[75] *UET III* 735 (Legrain 1947, 227); see also note 71.

[76] Limet 1960, 172.

(that is, a total of *M* 1 *P* 16). Weights are also recorded for axes: one axe weighs 2/3 mina and 4 shekels (that is, 334+32 = 366 gr., about *P* 18), and axes in general (of copper or bronze) usually weigh 1 mina (500 gr.) each (though some examples weigh two minas).[77]

Records of vases. The Ur-III tablets record great weights: for example, '*1 copper vessel pisannu nasbu of 44 1/3 maneh weight, from the treasury, 1 copper vessel of 18 1/2 maneh weight from the Sabru treasurer, Ur-(d)-Nigal the smith received*'[78] (probably for repair), and also the heaviest: '*one copper kettle weighing one-half talent* (as pledge)'.[79] Smaller weights are also recorded: for example, a vessel of pure copper weighing 23 shekels and 2/3 shekel. Frequent mention is made of a special copper vessel for storing oil (!) weighing 1 mina or 2/3 mina or 1/2 mina. A bronze washing bowl has a weight of 1/2 mina and 5 shekels,[80] a broad vessel that Limet calls a krater usually weighs between 1/2 and 1 mina (that is *N* 1 to *N* 2), and even a vessel that is described as smaller (!) weighs 5 minas (that is, 2,500 gr., or *M* 2 *N* 2).[81] The capacity of a vessel is frequently stated: for example 1,842 litres.[82]

One interesting object (*hu-bu-um*) recorded is made of bronze and ranges in weight from 1/2 to 10 minas; Legrain asserts that this is a 'wheel cover', while Limet comments: '*il s'agit du bandage de la roue, puis par dérivation, d'un anneau de métal*'.[83] This recalls the description of *ka-ko de-de-me-no* for wheels in the Mycenaean tablet **PY Sa 794**.

b) In Hittite tablets, especially in the so-called 'Metal Inventories', the weight of the axe is fixed at 2 minas (twice the weight normally found at Ur): 64 *HASINNU* are recorded with a total weight of 128 minas, and 46 *HASINNU* with a total weight of 92 minas, in the same inscription.[84] What is of importance is not so much this difference in itself, as the theory that has been advanced, that the weight of 2 minas was standard and represents a unit of weight for the metal used in its circulation.[85] (This recalls of the Mycenaean metrogram *M*, equivalent to two minas.) In the same tablets, there is reference to the breaking of an actual ingot of copper, weighing 1 talent, and its division into minas; and also to the manufacture of 10 daggers from 7 minas and 20 shekels of copper.[86] Two daggers from Akrotiri weigh about 163 gr. and 303 gr., as compared with the average of *ca.* 350 gr. for the daggers in the above-mentioned Hittite document. Again, the smallest allotment of copper in the Mycenaean tablets, 1.5 kilograms, would have been enough for at least four daggers. Account has to be taken, of course, of the percentage of metal lost during manufacture, cf. the relevant evidence, again from Near Eastern texts, referring to the refining of copper or silver: '*I refined the silver and from five minas (only) 3 1/3 minas came out (of the kiln)*'.[87]

c) It would be useful to note at this point that the Mari archives are a valuable source for the metalworking processes of the 18th century BC, as well as for comparisons of the weights of

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[77] Limet 1960, 247.

[78] *UET III* 305 (Legrain 1947, 211).

[79] See Salonen 1966, 252 (from Stevenson, CIS II.1, no. 65).

[80] Limet 1960, 222.

[81] For all these, see Limet 1960, 198ff.

[82] Salonen 1966, 252. On page 253 he gives the different examples of *Kessel* (of bronze or copper) ranging from a capacity of 1 litre to a weight of 15 kilograms.

[83] Legrain 1947, 225; Limet 1960, 198ff. See for instance the technical study of the wheel of the royal Assyrian chariot; the wheel has a diameter of 0.90 m. and is reckoned to have a metal tie: Spruytte 1994, 38.

[84] Kempinski & Košak 1977, 91-93.

[85] Otten 1955, 128.

[86] Kempinski & Košak 1977.

[87] *CAD*, *s.v. kaspu* (CCT 1).

metal products. I refer, by way of example, to one –of the various– tablet from Mari (*ARM* XXV, 719), for the alloys perscribed for the manufacture of particular items:

'1 1/2 mine 2 sicles de cuivre pur d'Alasia, 5 1/3 sicles d'étain, pour 1 vase ... et 1 poignard de bronze de 7 sicles.

1 mine de cuivre pur, 10 sicles d'étain, pour 1 hache.

2 mines 5 sicles de cuivre, 2 1/3 sicles d'étain, pour 2 houes de cuivre...'.[88]

Also to tablet *ARM* XXV, 354, for a detailed record of the quantity used during the manufacture of the item:

'2 1/3 mines 4 [sicles] de cuivre lavé, pour 24 étoiles diverses, de chacune 6 sicles, pour diverses portes...'.[89]

3.2. Comparison with the Mycenaean tablets

If we transpose to the above Near Eastern sources the data taken from the Mycenaean tablet **Jn 658**, which records despatches of a quantity of copper *M* 5 (five kilograms) to each craftsman (that is, 10 –Babylonian– minas or 600 shekels), we may imagine what the craftsman would be able to manufacture from this quantity:

10 axes (or 5 at least Hittite axes), since each axe weighed about 1 mina (Hittite axe 2 minas, possibly of lighter weight)

or

from 16 to 26 hoes, of average weight 36 or 23 shekels, respectively

or

from 10 to 20 kraters (does this perhaps mean cauldrons?), weighing ½ to 1 mina, or just two large vessels, each of 5 minas weight

or

from 20 to 30 chisels weighing 28 or 20 shekels, respectively

or

more than 14 daggers, etc.

The output per mina (that is, the weight *N* 2 in Linear B) might be reckoned at 1-2 kraters or two 'oil vases' or an axe or a hoe or a dagger, though with a smaller usable (?) excess, indicating that the smallest quantity allotted in the Mycenaean tablets is quite properly *M* 1 *N* 2, equivalent to 3 minas.

It may be concluded from the above that, at the opposite process recorded in tablet **Jn 829**, the copper contributed to the palace, which is grouped together in quantities of *M* 2 (4 minas), *M* 3 *N* 3 (7½ minas) and *N* 3 (1½ minas) might have taken the form of finished products, whether still functional or not. The smallest quantity of copper found to date in a Linear B tablet is *N* 3; according to the standards of the Near Eastern sources, therefore, every *po-ro-ko-re-te* could theoretically contribute 1 axe and two hoes together, or 2-3 chisels, or one large and one small cauldron, and so on, for recycling in order to manufacture the weapons recorded in the same tablet. This might better account for the ownership of copper in this case: that is, it was owned in the form of vases or tools. The great value attaching to ownership of metal objects is apparent from a document from Deir el-Medina, relating to the trial of a woman who stole a chisel that someone had buried beneath the threshold of his house;[90] or from a statement in a

[88] Limet 1986, 218.

[89] Limet 1986, 113.

[90] Rommer 1984, 79.

tablet from Ugarit relating to a Hatti merchant who confessed that he had stolen two copper vases and had been sentenced to pay three times their value to their owner.[91]

In any case, the conclusion to be drawn with regard to the large or small quantities of copper in the tablets depends on who the final recipient of the artefacts was. In other words, on whether or not the palace expected the copper to be returned by the coppersmiths of Pylos in the form of finished products, or (and) supplied the raw material to meet the needs of the district. Most importantly of all, we are still unaware of the frequency of the supply within a single year. If the palace wanted to control the production of weapons, it would theoretically have to control not only the supply of copper, but also all forms of ownership of it, though it seems to me that this would have been difficult. Was the only recourse open to it therefore to control the know-how in weapons-manufacture[92] (possibly even to ban their production)? One answer might be that the palace enjoyed a monopoly of tin, in which case ordinary people would only be able to recycle the bronze from vessels and tools. Control of tin by the palace, combined with control over the spread of technology, might restrict the ability of private individuals to manufacture weapons, at least in significant quantities.

The answer to the question of the absence of tin from the Mycenaean tablets may thus lie in the nature of the documents at our disposal, which related to the internal circulation of goods, between the palace and its subjects, or between the palace and its region.[93] As already mentioned, the Mycenaean documents do not deal with international relations, and do not therefore record the despatch of tin (as at Mari, for example –though it should be noted that Mari was a transit centre in the distribution of tin).[94] If *ka-te-ro* means tin, we have a record of 4 talents kept in the palace storerooms (tablet **KN Og 5515 + 5518 + 5539**). If, however, tin is not mentioned at all in Linear B, does this mean that the palace never supplied tin to meet the requirements of the settlements (and never made payment in tin, as in certain situations in the Near East)?[95] Craftsmen might be able to procure the necessary tin by blending in recycled bronze. Proof of this might possibly be furnished by investigation of the, probably constant, quantity of tin used in daggers (with the acceptance that these were made only in palace workshops), in contrast with the great variation observed in the percentage of tin in tools, such as chisels.[96] So, would the palace have sent only copper, or rather a combination of copper and bronze, for the needs of the regions? And if so, what were these needs in terms of bronze or copper?

4. The Requirements of a Settlement: Quantities of Copper

The requirements of the inhabitants of a settlement might be calculated by measuring the weight of actual objects of household equipment, and to this end finds from the excavation of

[91] From Rainey 1963, 321, see note 78. The same penalty was imposed in an Egyptian document for the same offence, though it is not clear whether three times the weight in copper is meant, or three times the value: see Janssen 1975, 410.

[92] Cf. also views by Driessen & Schoep 1999, 396-397.

[93] This simply implies the existence of other type of documents for recording the overseas exchange of the specialised products recorded in the tablets. Tin belongs to the 'materials and goods of high prime or convertible value' traded by 'formal, high-level exchange procedures' (Sherratt 1999, 179).

[94] See Heltzer 1989, 10-12, 13-14, 24 and note 23 for the publication and interpretation of the document A 1270 from Mari, which refers to the despatch of tin, destined for Cretan recipients, amongst others.

[95] See, by way of example, Dalley 1984, 64 (VII 218).

[96] See Μιχαηλίδου 1997a, 646.

Akrotiri, Thera, have been weighed.[97] I append a number of measurements that I believe are indicative of the small quantities of copper required (Table 1):

Table 1. Copper/Bronze Artefacts from Akrotiri (Thera) with their weight-values.

METAL ARTEFACT	PRESERVATION	WEIGHT (grams)
Fish-hooks	Complete	0.9 or 4.6 or 12.2
Needle	Complete	2.2
Hinges	Complete	1.2 or 2.5 (each)
Pin	Complete	7.1
Pin	Almost whole, oxidized	4.3
Balance pans	Complete	13 or 16.2 or 52.5 (each)
Miniature dagger	Complete	9.9
Knife	Almost whole	42.8
Miniature laver	Complete	94.7
Miniature pitcher	Complete, oxidized	55.6
Daggers (Fig. 3)	Complete	163 or 303
Chisels (Fig. 4)	Almost whole	129.7 or 272.8
Tripod cauldron	Incomplete	Estimated *ca.* 2,000
Laver	Incomplete	Estimated *ca.* 1,500
Bands or strips One strip	Complete	A cluster of them: 9.5. Of standard size maybe (9 cm. x 4 mm.): 1.5

The two chisels weighed at Akrotiri have weights of 129.7 gr. (Fig. 4) and 272.8 gr. (the latter value corresponds with the weight of chisels in the Ashmolean Museum).[98] Each of the above chisels falls within the range of the smallest quantity of *M* 1 *N* 2 = 1.5 kg. in Linear B, from which each craftsman could make at least 5 chisels weighing 300 gr., or 10 chisels weighing 150 gr. (cf. also the relevant weights in the Ur-III tablets cited above).

Another way of estimating the quantities of metal in circulation in a certain settlement would be to consult the records of metal if any were found inside the settlement. To this end, the best evidence comes from Egyptian sources:

For Egyptian chisels, we have references on *ostraca* (inscribed potsherds and limestone flakes) and papyri from the workmen's village at Deir el-Medina: '*...[sc]ulptor Amen<nakh>te (?), one chisel of six deben, complete for the crew*'.[99] This weight (6 x 91 gr. = 546 gr.) seems to be standard for the chisel that in this case had to be heavy enough for use by stone-masons working on the construction of tombs in the Valley of the Kings.

The above weight is that of a tool that was issued by the central authority; three types of tool –the cold chisel or spike (*h3*), the mortising chisel (*md3t*) and the hoe (*krdn*)– are frequently

[97] Unfortunately, it has not been the practice so far to give the weights of bronze objects in publications of excavation material, and it is not possible at present to compare the Akrotiri figures with Mycenaean copper objects.

[98] Evely & Northover 1995, 97, 100.

[99] Eyre 1980, 110.

recorded together and seem to have formed the basic equipment of stone-masons who worked on tombs.[100] The person responsible for issuing tools to these workers, and also for taking them to the coppersmith for repair, was a kind of 'warehouse-keeper'. One such official, named *Karo*, is said to have been in correspondence with the general *Pi'onkh* about copper to be collected and issued to coppersmiths: the general asked for spears needed in the ongoing fighting in Nubia, so in place of tools, the coppersmiths were making arms.[101] Interesting evidence is also supplied by a special category of the inscribed potsherds or stone flakes, functioning as counter weights, one example being marked as '*Weight of copper of Menna*', which means that instead of noting the exact weight in *deben* or *kite (qedet)*, a stone of equal weight and suitably inscribed was kept as evidence.[102]

As we have already seen, the inhabitants of this village also had their own tools that they used for private work. The tool '*nt* for example, is the carpenter's adze, frequently depicted in representations in art (Fig. 5), though not included in the documents referring to the distribution of tools at Deir el-Medina. One *ostracon* records the loan of a '*nt* to make Menna's wooden bed and three spoons. The weight of this tool is defined as 4 *deben* (4 x 91 gr. = 364 gr.) by one reference.[103] Another tool, the axe, is frequently qualified as a 'carpenter's axe', and the record of 5-7 *deben* on the *ostraca* may indicate its value, though it will certainly not have been far removed from its actual weight?[104] The axes used by shipbuilders are expected to be heavier: the *Reisner II* papyrus (dating from the Middle Kingdom) gives a weight for them of 40 to 50 *deben*.[105] At this earlier period, though, *deben* meant the unit for gold equivalent of 12-14 gr., and the above higher weight values would in fact correspond with 6-7½ *deben* of the New Kingdom. In the same papyrus from the shipyard some axes weigh only 19 Middle Kingdom *deben*, or about 3 New Kingdom *deben*, making them even lighter than the axes of the Deir el-Medina sherds.[106] The different theory advanced by Vercoutter should be noted here, however: that in the Middle Kingdom a special *deben* of copper was used, that was twice the value of the *deben* of gold, that is 27.5 gr., a value that in fact gives the shipbuilder's axe a considerable and appropriate weight.[107] Another tool, the *wp*, translated as 'carver' by Gardiner, has a weight of two *deben*.[108] Finally, the only weapon recorded on the ostraca is the *niw*, which is thought probably to mean spear; the references in papyri to 2 *deben* for each one of the eight large and to 1½ *deben* for each one of the nine small ones indicate their weight, and must therefore refer to the heads of the weapon.[109]

In the case of vessels, I refer to an interesting source for the distribution of copper amongst private individuals: papyrus *P. Cairo* 65739 (period of Rameses II), in which a woman, *Erknofre*, lists amongst the goods she gave in exchange for a slave-girl, some copper vessels she had acquired from her neighbours, citing first their weight in copper and then their value in silver.[110]

[100] Janssen 1975, 312-319.
[101] Černy 1973, 159.
[102] Peet 1930, 160.
[103] For all this information, see Janssen 1975, 321.
[104] Janssen 1975, 322-323. Metal objects invariably present this problem.
[105] Simpson 1965, 25.
[106] Janssen 1975, 323.
[107] Vercoutter 1977, 444.
[108] Janssen 1975, 324.
[109] Janssen 1975, 326.
[110] Gardiner 1935, 142. The problem of the translation with the word 'bought', or of the concept of the 'value' of goods is not dealt with in the present chapter, but is reserved for a special study (see by way of example Michailidou 2000, 198ff.).

'...*Bought from the citoyenne Kafy, 1 g3y-vessel of hsmn-bronze, makes 18 deben, makes 1 2/3 kite of silver.*

Bought from the head of the storehouse Pyiay, 1 g3y-vessel of hsmn-bronze, makes 14 deben, makes 1 1/2 kite of silver.

Bought from the wκb-priest Huy-(10)Pinhas, 10 deben of beaten copper, makes 1 kite of silver.

Bought from the wκb-priest Aniy, 1 g3y-vessel of hsmn- bronze, makes 16 deben, makes 1 1/2 kite of silver; 1 mnt-vessel of honey, makes 1 hekat, makes 5 kite of silver.

Bought from the citoyenne Tjuiay, 1 cauldron of hsmn-bronze, makes 20 deben, makes 2 kite of silver.

Bought from the steward of the house of Amun, Teti, 1 kbt-vessel of hsmn-bronze, makes 20 deben, makes 2 kite of silver;...'.

Gardiner comments on this document: 'Copper vessels or corn passed in Ramesside times as regular currency, their value (here given in terms of silver) being assessed by weight... Much more probable is the conjecture that one or other of the articles given [to the merchant] was already in her possession when he approached her, and that in the deed of sale which she gave him was merely recorded the price she had previously paid for the article in question, and the person to whom she paid it. Indeed, it is conceivable that a prudent housewife might keep by her a little stock of goods belonging to and priced by her neighbours which she did not desire for her own use, but might keep handy for such unexpected barter as we are here considering'. He naturally notes the ratio of 100:1 between copper and silver in the 16th year of Rameses II. Gardiner continues: 'This ratio is given in l. 10 where a weight of 10 *deben* (or 100 *kite*) of beaten copper is valued at 1 *kite* of silver. Further indirect confirmation is provided by the values attached in the adjacent lines to objects of *hsmn*-bronze. We do not know the exact distinction between *hsmn* and copper, but the former is doubtless an alloy of the latter and not so very different from it. Of the five vessels of *hsmn* here mentioned, two have a silver-value exactly one-hundredth of their actual weight. The other three are priced at either a little less or a little more than this proportion. The fluctuation may have depended partly upon the condition and workmanship of the articles, and partly upon the comparative keenness of buyer and seller'.[111]

I note that the cauldron of 20 *deben* has a weight of 20 x 91 gr. = 1,820 gr. –slightly less than that calculated for the tripod cauldron from Akrotiri (Table 1). The quantity of 10 *deben* of beaten copper may refer to a fragment of a vase or fragments of vases, given that vases were often manufactured from a pure copper sheet. These are thus Zaccagnini's categories b and c, mentioned at the beginning of this chapter (p. 90) as forms in which copper circulated.

5. The Palace Again: Quantities of Gold

Of the quantities of gold recorded in the Linear B script, Petruso has well observed that 'they amount from one double mina down to –incidentally– a weight equivalent to our unit of *ca.* 61 grams',[112] I do not agree, however, with the view that the reference in tablet **Jo 438** to the quantity *P* 3 is a fortuitous coincidence with the basic unit of 61 grams on Petruso's system. This was the way of recording the old 'Minoan' unit in the Mycenaean talbets; it has been calculated that the total quantity in this tablet does not exceed 6 kilograms[113] recorded as follows: one

[111] Gardiner 1935, 145-146. The values of the vessels do not all conform exactly with the ratio 1:100, as Janssen notes (1975, 106, note 28).

[112] Petruso 1992, 64.

[113] Chadwick 1976, 145.

contribution of 1 kilogram (*M* 1), at least eight contributions of 250 gr. (*N* 1), one of 500 gr. (*N* 2), four of 61 gr. (*P* 3), two of 80 gr. (*P* 4), four of about 100 gr. (*P* 5), and five of 122 gr. (*P* 6). In my view, these quantities are not small, but are related to the form in which the raw material was in circulation: as is evident from Egyptian wall-paintings (Fig. 6) gold might be stored (a) as gold dust in bags, (b) as ingots or nuggets, and (c) as ring-ingots. I note by way of example that 124 gr. is the average weight of gold ring-ingots (of the Chalcolithic period?) found at Samaria.[114]

Weights of gold artefacts are recorded in the Near Eastern tablets, beginning with very small quantities. The process of manufacture is described as follows in an Ur-III tablet:

'*1 feuille (?) d'or fin,*
dont le poids est d' ½ sicle
a été fondue;
6 grains de cuivre ont été melangés
l'alliage d'or a été produit
pour (faire) 2 boucles d'oreilles'.[115]

Earrings normally weighed 1/3 shekel each, though there are also references to gold earrings weighing 1/4 or 1/6 shekel (giving 2.8 gr., 2 gr. and 1.4 gr. –weights smaller than 3.6 gr., the estimated value of the Linear B metrogram *Q*). Another example of a small weight is provided by the reference to a gold vase for the New Year ritual, which weighed 2 and 2/3 shekels (about 22 gr., the equivalent of the Linear B metrogram *P*).

I believe that the quantities contributed to the palace of Pylos in tablet **Jo 438** are far from small, when account is taken of the view that in a Middle Assyrian letter 2 shekels of gold (about 17 gr.) are sent with a commission to organise a banquet.[116] It would be interesting to take into account the measurements of weights made on intact Mycenaean vessels by E. Davis[117] (see Table 2, where the equivalence to the 'Minoan unit'[118] is given in the column under the heading *M*).

Table 2 reveals the following possibilities with regard to the quantities recorded in tablet **Jo 438** from Pylos.[119] The record of a donation of gold weighing *M* 1 could represent the gold goblet inv. no. 351 in the National Archaeological Museum, Athens (Fig. 7), weighing 1,004 gr. The contribution of a quantity of *N* 1 (at least by eight people) could have been made in the form of the cup no. 629 in the National Archaeological Museum (Fig. 11), weighing 253.6 gr.

[114] See Gopher 1995, 79, for the gold rings in a Chalcolithic (?) context in the Qanah cave. They have been considered cast products that were then beaten and form '*ingots ainsi préparés pour en faciliter le transport*', and attributed to a mine in Nubia. Cf. also *Documents*, 359 for what has been written so far on the weight of gold rings from the citadel at Mycenae, but see also the objections by Petruso 1992, 12-13.

[115] Limet 1960, 45, from where the French translation of the Akkadian text is taken; cf. Legrain 1947, *UET III* 452.

[116] van Driel & Jas 1991, 65.

[117] Davis 1977. E. Davis was the first to take weight into account in studying metal vases; cf. her intervention in the paper read by Michailidou 1990, 419.

[118] Of 61 gr. (Petruso 1992, 60), 65.5 gr. (according to Evans, Caskey and Parise), 68 gr. (Weingarten 1994).

[119] Webster has already pointed out that the contributed amounts of gold in **Kn01 (Jo 438)** fall within the range of weights shown by cups from the Mycenae shaft graves, and might be designed as such (see *Documents*, 359).

Table 2. Gold Mycenaean vessels.

A	IM	P	W	D	M	B
Miniature pyxis with lid (gold)	EAM 85	Mycenae Shaft Grave III	9.95		1/6 (-) unit	Davis 1977, 241, no. 94.
Miniature vessel with lid (gold)	EAM 84	Mycenae Shaft Grave III	12.4			Davis 1977, 243, no. 96 (restored).
One-handled cup (gold)	EAM 220	Mycenae Shaft Grave II	26.55	2 (13.3)		Davis 1977, 139, no. 32.
Conical cup (gold)	MM 61.71		28	2 (14)	1/2 (-) unit	Davis 1977, 326, no. 145.
One-handled cup (gold)	EAM 912	Mycenae Shaft Grave VI	28.1	2 (14)	1/2 (-) unit	Davis 1977, 137, no. 31.
One-handled cup (gold)	EAM 627	Mycenae Shaft Grave V	35.2	2½ (14)		Davis 1977, 190, no. 33.
Miniature vessel with lid (gold)	EAM 83	Mycenae Shaft Grave III	44.95	3½ (12.8)	2/3 unit	Davis 1977, 242, no. 95.
Ewer (gold)	EAM 74	Mycenae Shaft Grave III	47.85	3½ (13.6)		Davis 1977, 237, no. 91.
One-handled cup (gold)	EAM 392	Mycenae Shaft Grave IV	60	5 (12)	1 unit	Davis 1977, 174, no. 58.
One-handled cup (gold)	EAM 73	Mycenae Shaft Grave III	65.5	5 (13.1)	1 unit	Davis 1977, 235, no. 89.
One-handled shallow cup (gold)	EAM 6441	Marathon Tholos Tomb	66.7	5 (13.3)	1 unit	*Mycenaean World*, 121 (59); Davis 1977, 304.
One-handled cup (gold)	EAM 393	Mycenae Shaft Grave IV	66.5	5 (13.3)	1 unit	Davis 1977, 175, no. 59.
One-handled cup (gold)	MH 758	Hag. Ioannis Grave	68	5 (13.6)	1 unit	Davis 1977, 109, no. 19.
Kantharos (gold)	MM 07.286.126		71.5	6 (11.9)		Davis 1977, 324, no. 143 (restored).
One-handled cup (gold)	BM 1900.7.27.1		72	6 (12)		Davis 1977, 323, no. 142.
Pyxis with lid (gold)	EAM 72	Mycenae Shaft Grave III	81.4			Davis 1977, 240, no. 93; *Mycenaean World*, 82 (12).
Cup (gold)	EAM 442	Mycenae Shaft Grave IV	96.2	8 (12)	1½ unit	Davis 1977, 172, no. 56.
One-handled semi-globular cup (gold)	EAM 8743	Dendra Chamber Tomb 10	95.7	8 (12)	1½ unit	*Mycenaean World*, 92-93 (22); Davis 1977, 267.
One-handled cup (gold)	EAM 441	Mycenae Shaft Grave IV	101.2			Davis 1977, 172, no. 55.
Shallow one-handled cup (silver with gold)	EAM 1875	Vapheio Tholos Tomb	117.6			*Mycenaean World*, 102 (31); Davis 1977, 260.
One-handled goblet (gold)	EAM 656	Mycenae Shaft Grave V	127.7	10 (12.7)	2 units	Davis 1977, 165, no. 52; Βασιλικού 1995, 45, fig. 19.

Table 2. (Continued).

A	IM	P	W	D	M	B
One-handled cup (gold)	EAM 313	Mycenae Shaft Grave IV	169.5	13 (13)		Davis 1977, 173, no. 57; *Myceanaean World*, 81 (11).
One-handled cup (gold)	MC 2634	Peristeria Tholos Tomb III	175.5	13 (13.5)		*Mycenaean World*, 109 (41); Davis 1977, 251.
One-handled cup (gold)	EAM 628	Mycenae Shaft Grave V	176.7	13 (13.6)		Davis 1977, 140, no. 34; Βασιλικού 1995, 45, fig. 17.
One-handled semi-globular cup (gold)	EAM 7341	Dendra Tholos Tomb	195	15 (13)	3 units	Βασιλικού 1995, 130, fig. 98; Davis 1977, 276.
Kantharos (gold)	EAM 440	Mycenae Shaft Grave IV	205.2	15 (13.7)	3 units	Davis 1977, 175, no. 59; Βασιλικού 1995, 46, fig. 20.
Lidded vessel (gold)	EAM 391	Mycenae Shaft Grave IV	216	16 (13.5)		Davis 1977, 176, no. 61.
One-handled cup (gold)	EAM 629	Mycenae Shaft Grave V	253.6	20 (12.7)	4 units	Davis 1977, 141, no. 35; Βασιλικού 1995, 45, fig. 18.
Vapheio cup (gold)	EAM 1759	Vapheio Tholos Tomb	280.5	21 (13.3)		Βασιλικού 1995, 126, fig. 92, 93; Davis 1977, 256.
Vapheio cup (gold)	EAM 1758	Vapheio Tholos Tomb	276	21 (13.1)		Βασιλικού 1995, 127, fig. 95, 96; Davis 1977, 257.
Two-handled 'Nestor's cup' (gold)	EAM 412	Mycenae Shaft Grave IV	295.8	22 (13.4)		Davis 1977, 183, no. 63; Βασιλικού 1995, 46, fig. 22.
Two-handled goblet (gold)	EAM 959 (957-960)	Mycenae Akropolis	314.7	24 (13.1)	5 units	*Mycenaean World*, 69 (1); Davis 1977, 291-293.
Kantharos (gold)	EAM 7381	Kampos, Kalamata	336.6	25 (13.5)		*Mycenaean World*, 108 (40); Davis 1977, 305.
Vapheio type cup (gold)	EAM 630	Mycenae Shaft Grave IV	339.5	25 (13.6)		Davis 1977, 144, no. 38.
One-handled goblet (gold)	EAM 427	Mycenae Shaft Grave IV	449.5	35 (12.8)	7 units	Davis 1977, 220, no. 84.
Lion rhyton (gold)	EAM 273	Mycenae Shaft Grave IV	633	50 (12.7)	10 units	Davis 1977, 179, no. 62.
One-handled goblet (gold)	EAM 351	Mycenae Shaft Grave IV	1,004	80 (12.6)	16 units	Davis 1977, 204, no. 82; Βασιλικού 1995, 46, fig. 21.
One-handled goblet (electrum, gold, niello)	EAM 390	Mycenae Shaft Grave IV	1,057	84 (12.6)	17 units	Davis 1977, 208, no. 83; Βασιλικού 1995, 49, fig. 24.

A: Artefact; IM: Inventory of the Museum; P: Provenance; EAM: Athens, National Archaeological Museum; MM: Metropolitan Museum (New York); MH: Museum of Herakleion (Crete); BM: British Museum (London); MC: Museum of Chora (Pylos); W: Weight in grams; D: Egyptian *deben* of gold (12-14 gr.); M: 'Minoan' unit (60-68 gr.); B: Bibliography.

The contribution of a quantity of *P* 5 (four records) could have taken the form of the gold cup no. 441 in the National Archaeological Museum, weighing 101.2 gr. The donation of a quantity of *P* 3 (four records) could have been in the form of the gold cup no. 73 in the National Archaeological Museum (Fig. 9), weighing 65.5 gr., and so on. Of course, the majority of the vases in Table 2 are of an earlier date than the Linear B tablets at our disposal, but they are helpful in indicating the possible size or form of the circulating gold.[120] Besides, some forms are recognizable in Linear B ideograms, e.g. the vases in Fig. 17-18.

From the point of view of manufacture, some of them clearly fall within the 'Minoan' unit, but since a smaller unit was surely needed for the weighing of gold, and A. Evans has considered the Minoan unit as a 5th multiple of the Egyptian *deben* of gold (12-14 gr.)[121] in the column under the heading D, I have tried the equivalences to this unit, which was predominant during the Middle Kingdom and still attested in the beginning of the 18th Dynasty in the time of Amenophis I at least (1551-1524).[122] They seem to fit well in this system. Of course, the range in the value of *deben* is most convenient, but I have tried to use the one closer to the optimum of 13.6. And I am aware of the discussion such an equivalence may rise again on the subject of the provenance of the gold of the Shaft Graves. I must add that the purity of the gold of the vessels is another matter; also that bronze wires in the handles or other copper reinforcements[123] would influence the total weight. In other cases, like the kantharos from Kalamata (EAM 7381) or the vase from Mycenae (EAM 656) of Fig. 16, no such reinforcements are reported, and the weight of 25 Eygptian deben of gold (of the optimum value of 13.5 gr.) for the former and the weight of 2 'Minoan' units (of the value of 63.85) for the latter, might therefore be considered as predetermined quantities of gold. For those vessels in the Table 2, that are of a later date than the Shaft Graves contents, the estimation of value could be calculated according to the New Kingdom *deben* of 91-93 gr.: for example the cup from the tholos tomb at Dendra (EAM 7341) is equivalent to 2 *deben* (and as noticed by Davis is twice the weight of the cup EAM 8743 in Fig. 19, coming from a chamber tomb at Dendra).

6. Quantities of Silver: Palace and Private Individuals

Why is silver not recorded in the Linear B tablets? And what about lead (since silver was produced in the Aegean by cupellation of lead)? In the case of the tablets in the **KN Og** series the view has been advanced that they probably contain records of metals;[124] I mention this here purely as a possibility, precisely because in these tablets the commodity –the nature of which escapes us– was measured in units of weight. In the Near East, silver is usually recorded in minas and copper in talents.[125] Of course this is not so in instances of quantities of copper smaller than a talent; for example in some texts from Mari recording the loss during the process of refining copper, the calculation is made in minas for obvious reasons: '*12 m URUDU.KUR* (mountain copper) *washed, loss of 2 m., result 10 m mesü* (refined copper)'.[126] The interesting

[120] See also the hypothesis (Palaima 1999) that the gold vessels recorded in the tablet **Tn 316** were heirlooms.
[121] Evans 1906, 345.
[122] From the 18th Dynasty onwards it is replaced by the *qedet* unit of 9.1 gr. resulting to the New Kingdom *deben* of 91-93 gr.: Cour-Marty 1990, 23.
[123] E.g. Davis 1977, 334-337.
[124] See, e.g., the chapter by Dialismas in the present volume.
[125] In the Hittite 'Metal Inventories' (Kempinski & Košak 1977), for example, I note that copper is reckoned in talents and silver and gold, and also tin, in minas.
[126] Dercksen 1996, 112. *m* = mina.

feature of the **Og** tablets is that the quantities of the unknown commodity recorded are not converted into talents (*L*) even when they are of more than one talent (or 30 *M*). We have, for example, weights –possibly of metal– not only of 30 *M*, but also of 80 and 130 *M*. If the commodity recorded is the same in all these tablets, this feature argues in favour of its being gold or silver, especially when the same commodity is recorded in small subdivisions such as *P* 4 (cf. the weight of the golden vessel inv. no. 72 in Table 2 above), and particularly when it is recorded in multiples of the type *P* 20 (tablet **KN Og(1) 7432**), without the quantity being converted –as one would expect– into *N* 1 *P* 8. The impression given is that the record was made in the same way as the actual measurement –that is, in units of *P* (around 20 gr.) or *M* (1,000 gr.). As for the equivalence of *M* to 2 minas, this recalls the Hittite reference to 2 minas of silver in eagle weight, which seems to indicate that silver was measured with a weight in the shape of an eagle and weighing 2 minas. In the context of a possible correlation of the metrogram *P* (**115*) to a basic unit for measuring silver, it is perhaps not fortuitous that the Linear B term *ta-to-mo* coexists on the same sealing,[127] as the sign *143*, which Chadwick associated with silver,[128] in view of the similarity between the signs *143* and **115*. The weights of objects made of silver in the Near Eastern tablets vary, but silver rings (which may have been another form of ingot) in the Ur-III period were made with a weight of 5 or 10 shekels, that is about 42 gr. (*P* 2) or 84 gr. (*P* 4). The Mycenaean record *P* 20 could thus –theoretically– refer to 10 or 5 rings of silver of the corresponding standard weights. (We have already seen that gold earrings normally weigh 1/3 of a shekel, that is 2.8 gr., less than *Q* 1.) In the Near East, silver is usually recorded in small quantities, but Lambert believes that it circulated at all social levels as early as the Ur-III period.[129] I do not deal here with the view that silver serves as a kind of capital[130] for commercial exchanges, an example being the well-known loans of various quantities of silver ranging from 2.66 gr. to 500 gr., recorded in private archives of the Old Babylonian period.[131] Small quantities are also recorded for craft-industry use –the quantity of 2.8 gr. of silver, for example, is given for the sheathing of a rivet on a dagger.[132] In the Mycenaean tablets there is only one possible reference of this kind.[133] We might also note the weight of 261 gr. (around *N* 1) of a silver cup found in Chamber tomb 78 of Mycenae (Fig. 15). Is it possible that *ku-ru-so-wo-ko* is a general name for a craftsman in precious metals (like *ku-dim* in the Near East), and that these craftsmen worked only in palace workshops? Or that they were supplied with the gold or silver when they were summoned to the palace for some specific job (see Homer)?[134]

In the case of the single reference to lead, it might be claimed that the Mycenaean palace did not take an interest in the distribution of this metal, which had a less varied use. At Mari,

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[127] Killen 1985, 149-152.

[128] *Documents*, 51.

[129] Lambert 1963, 86.

[130] In the form of rings, moreover. See, by way of example, the rendering of the word for silver ring *HAR KU.BABBAR* in a document from Mari (*ARM* X, no. 114, 9) which is translated 'ring money', in contrast with the gold 'earrings' regarded as jewellery in the same phrase of this document. The phrase is contained in a letter written by a prominent woman to the queen, to whom she complains that she has fallen victim to theft; the interpretation given to the items stolen is that they consist of jewellery and money (Malamat 1998, 179 and note 11, with the relevant bibliography). But I think we should be more cautious in using the term 'money'.

[131] van de Mieroop 1992, 204.

[132] Limet 1960, 154.

[133] *Documents*, 346-347; see Μιχαηλίδου 1997a, 646.

[134] *Odyssey*, iii 432-438: Nestor gives gold to the 'coppersmith' who has come to his court in order to gild the horns of a sacrificial ox.

however, things are different (possibly because in Mesopotamia lead was often used in an alloy with copper, to make it easier to cast). A document makes it clear that Mukannišum, the head of the workshops, '*s'occupait également de plomb: dans la lettre XIII no 3 il annonce au roi qu'il va lui faire porter immédiatement 10 talents de plomb, poids de 20 kubdu de 30 mine chacun, ce qui (represent) 1/3 de mine d'argent*',[135] Rouault therefore draws the conclusion that *kubdum* = ingot.[136] It would be highly interesting if the half-talent weight of lead discovered at Akrotiri (weighing precisely 30 minas) represented the weight of a *kubdum*, that is the quantity used in the distribution of lead (= *M* 15 in Linear B). It is now time, therefore, to turn to the implements used to measure weight –that is, the balance weights. The reference in a Hittite text to a two-mina weight in the shape of an eagle, has already been mentioned. Repeated references in the tablet **Og 1527** to a quantity of lead of *M* 3 (= 3 kilograms) is consistent with the discovery at Akrotiri and Thebes of actual lead weights in the form of discs weighing 3 kilograms (which have been identified with the *LANA*, the special Linear B weight unit used for wool).[137] The objects recorded in the Near Eastern tablets are often weighed by officials, but balances and weights were also privately owned.[138]

Returning now to the question of private ownership, we may note that the list of items owned by a Sumerian includes metal vessels, grain, clothes, fruit, furniture, and wooden objects, and also a copper-sheathed weighing scale with copper discs.[139] Evidence may also be derived from documents recording dowries. From Ur in the Old Babylonian period, for example, a document from the private archive of Tab-ilisu records the substantial dowry brought by his wife, Rubatum: 1.5 kilograms of silver (that is, *M* 1 *N* 2 in Linear B), five slaves, and many pieces of furniture and household vessels.[140] We may also note wills, like the one from house no. 2 in Church Lane in Ur of the Old Babylonian period, the text of which is preserved in tablet *UET* V, no. 112:[141] five brothers share a roofed area of 143 square metres, a demolished house of 60 square metres, two slaves, 276.25 gr. of silver (that is, a little more than *N* 1 in Linear B) and a large number of items of different materials. The movable property includes twelve doors, five beds, ten chairs, two buckets and a vessel holder, all made of wood or palm-fibre. The metal objects recorded in this list are six bronze knives, five bronze vessels, one copper container, half a kilogram of copper (that is, *N* 2 in Linear B), seven scales, and two vessels for measuring capacity. The stone items are one vessel, five plaques of lapis lazuli, three millstones and three mills for cress. The brothers also shared three spoons, three balances, a reed item and four baskets. Balances, then, were an appreciable part of the household equipment. Metals, too, mainly copper/bronze, though also silver, circulated (in a variety of forms) not only in the palaces but also in an urban environment. The example of the will indicates that they were also recorded in private documents. The existence of private documents in the Aegean is still disputed, but I believe that the preceding discussion has demonstrated that metals were owned in by no means negligible quantities by various social strata.

[135] Rouault 1977, 164.
[136] Rouault 1977, 164.
[137] Petruso 1986; Αραβαντινός 1995.
[138] See also Michailidou 1999.
[139] Limet 1960, 196.
[140] Limet 1960, 144 (from *UET V*, no. 793).
[141] van de Mieroop, 1992, 226.

EPILOGUE

The introduction to this chapter began with the sentence 'Metal is known to have circulated over a wide geographical area in standardised form and in large quantities'. Its main theme has been to seek out the quantities recorded in documents or attested by excavation evidence. We have sought these quantities of metal in archives and documents of various kinds, and we have measured them in ancient objects. We have ranged widely not only geographically but also chronologically, in the belief that the use value and the exchange value of metals were similarly combined in the substructure of the advanced Bronze Age societies from the Aegean to Mesopotamia, since these societies all belong to the pre-coinage level of economy. We exploited any relevant evidence that looked promising to our aim, which was to form as broad as possible a picture of the place occupied by q u a n t i t y in the circulation and recording of metals.

Hitherto, research into the ancient world has sought, with the aid of specialisation, to establish chronological and geographical parallels. The world of Akrotiri at the time of the Linear A script is of course different from the world of the Mycenaean palaces of the period of the Linear B script, and is even further removed from the multi-faceted world of the Near East. However, it is through these differences that we may better approach the mechanisms by which metal circulated, thereby forming a picture that might perhaps escape us if the evidence is viewed only from the fragmented perspective of specialisation. Most importantly, this method establishing differences between cultures, gives rise to further questions. Research should progress from a specialist to a synthetic approach, to the formation of a global picture, and then turn again to new –specialised– problems.

Something of the desired picture with regard to quantity –the factor we set out to examine– has perhaps emerged from this chapter.[142] The important thing is not so much that –for example– the axe recorded in Ur-III documents mostly weighs 1 mina, while in Hittite texts it has a weight of 2 minas, for there will undoubtedly have been a range of different weights for all categories of object.[143] What is important is that in both cases, the weight is accurately recorded, whereas in Mycenaean documents it is not recorded at all: so far, we have records either of the weight of the raw material, or the name of the end product, but not the two together.

Of course there is the circumstance that the texts have been preserved selectively, new Linear B tablets may be expected to fill the gaps mentioned. But if we ignore this convenient –though also probable– factor, one explanation of the absence of the concept of weight for artefacts in the tablets might be that some of the Mycenaean coppersmiths were not expected to return the finished products after they had taken receipt of the copper/bronze from the palace. In this case we would be obliged to abandon the idea that any smith receiving raw material from the palace belongs to the dependent personnel. The palace needed to know where the copper/bronze went, so what was recorded were the names and places of the receivers and the quantities supplied for the requirements of the settlements –and we have seen the uses to which these quantities might be put. In this case, however, the coppersmiths of the tablets in question (**PY Jn** series) would not have been those working for the needs of the palace;[144] this would explain why

[142] In comparison with Tournavitou & Sugerman (in press), I am more hopeful in using the data from the Orient. We need not try to find an answer (or a model) ready for transportation to our specific investigation.

[143] Depending on the occasion of recording: e.g. in the Hittite Laws the manufacture of a 2-minas weight bronze axe and of 1-mina copper axe are both mentioned, in regard to the different corresponding 'wages' to the smith (Hoffner 1997, 128).

[144] I agree with De Fidio's comment for '*une interaction complexe entre palais et communautés*' (De Fidio 1992, 189).

there are –as yet– no records of copper tools, which would have been produced by them locally for the needs of the population and therefore were not recorded by the palace. If this was the case, we are obliged to posit the existence of other coppersmiths, working for the palace and delivering the products of their work directly, possibly without recording them on clay tablets.[145] If we assume that there was such a clear distinction between two categories of coppersmiths, to which category did the tax exemption (mentioned in the tablets **PY Ma** and **Na**) apply? Comparison with weavers might be of assistance here; like the coppersmiths, they were also involved in the *talasia* system, though in their case the weight of both the raw material and the finished product was indicated: when the textiles were delivered, their weight was often recorded, depending on the type of fabric. We might also contemplate where we should classify the coppersmiths of the Potnia, and also wonder about the status of the jewellery maker in Linear B period: if the latter was the same artisan as the *ku-ru-so-wo-ko*, who is possibly assigned to the palace, and if we assume in consequence that jewellery produced *in situ* was not recorded (we have noted the absence of jewellery from the tablets so far), then we need to wonder what was the mechanism for the distribution of jewellery, which was by no means limited in scale. Obviously, answers to the above questions cannot be given solely from the point of view of the metals. The products and craftsmen of the Mycenaean documents should be considered together, as a whole. It might be useful, however, to summarise some of the differences –with regard to metals– that have emerged from comparison with the Near Eastern documents, for these differences have furnished us with a certain knowledge of what the Mycenaean metal records might have contained –and yet such details do not exist at present, or have not been identified, or were possibly written on other perishable material, that has not survived in the Aegean climate.

First, we may make the general observation that the Mycenaean tablets do not contain, for the metals mentioned above, the records of their weight at all stages in the process of manufacture. In Near Eastern societies, in contrast, the weight is recorded in the process of metalworking, invariably in great detail, at the stage of control, and at every level of distribution.

We may then move on to the more specific observation that there is no record of tools, at least on a broad scale, or of jewellery.

In the case of gold vessels, recorded as ritual offerings in the tablet **Tn 316** from Pylos, the type is indicated by the appropriate ideogram, but not their weight.

The impression given is that there were no documents –or at least no documents have been found– referring to the output of palace metal workshops, at least on the large scale of many of the Near Eastern documents.

There was an exception in the manufacture of weapons;[146] here we may add the fact that the tablet **R 4482** from Knossos, which records weapons, comes from the 'Arsenal' (so named after the tablets), where also a vast number of copper arrow-heads were found in wooden chests (which also contained the relevant sealings).[147]

The absence of silver, if not fortuitous, points to two things. First, that we have no record of silver-working, e.g. of the application of silver to the heads of dagger rivets (found in the

[145] And so we are in front of the problem: Who is today invisible for us, the craftsman working independently, not supplying the palace (as Tournavitou 1997, 31 logically infers) or/and the directly connected artisan working perhaps inside the palatial environment and not mentioned in tablets?

[146] For the attention that the Linear B tablets of Knossos lay to weapons-production, cf. Driessen & Schoep 1999, 393ff. 'Were these items then manufactured by palace workshops to serve as alliance gifts?' (Driessen & Schoep 1999, 395).

[147] Evans 1935, 836-840; Palmer 1963.

Aegean, e.g. Fig. 3),[148] and this may perhaps be interpreted in terms of the direct dependence on the palace of the *ku-ru-so-wo-ko* (worker in precious metals). Second, that silver may not have been provided by the palace to its subjects as 'capital'. It is possible, however, that a record of this kind may have taken a less makeshift form than that of the tablets. It should not be forgotten that the Aegean tablets, of unfired clay, had a much more ephemeral function than those of the Near East, where they were fired in special furnaces. The transference of a precious material such as silver may conceivably have been recorded on more enduring material.

The failure to identify tin in the tablets has been noted already and has been attributed to the fact that the Linear B tablets so far discovered are associated with the internal circulation of goods between the palace and its subjects.[149] However, among the so-called loan-contracts at Nuzi, there is the category of the 'interest-bearing' loans, where tin occupies first place along with the other metals, though here too we are dealing with the internal circulation of goods and with private documents, so Zaccagnini's concerns are understandable: 'Quantities of conveyed metals add up to *ca.* 70 talents of tin, 25 talents of copper and only 21 minas of bronze. What is the meaning of these loans, especially in relation with the loans of subsistence commodities (e.g. barley)? In other words, what did these people do with these metals?'.[150]

The feeling that much is escaping us in the Aegean as a result of our failure to discover private documents is discouraging. We can form some picture of what we might expect, again from Nuzi, for example: 'Sales, sale-adoptions, real adoptions, marriage contracts, testaments, loans of various kinds with or without securities, exchanges of real estates, merchant agreements for business ventures, etc.'.[151] If no private documents have been found, however, we cannot be certain that they did not exist. Are the tablets of unbaked clay found in a house of the settlement at Akrotiri, Thera, perhaps the first example?[152] In any case, even if we have no relevant documents, or if we decide that people in Aegean societies did not need them, we may still deduce the private ownership of metal in surplus quantities and qualities, as attested by finds and depictions in art throughout the entire Aegean. We thus come to the crucial question: despite the lack of relevant documents, is there any evidence of ownership of metal for its exchange value in the Aegean too? First, metal vases from the Aegean may have played a corresponding role to the copper, silver and gold vessels of the eastern documents referred to in the preceding sections; one has only to compare vases from Table 2 with similar vases in the tablet **PY Tn 316**,[153] recording ritual offerings of gold vessels (see also Fig. 17-18). Reference has already been made to the fact that copper vessels could be exchanged with other goods (p. 99), and the great variety of copper items in the Aegean could also indicate an exchange value alongside its use value. Vessels made of precious metal might function as a form of currency, along with other forms, such as rings (e.g. the gold rings or the gold bracelet from the Aegina treasury[154] are comparable with the ring-ingots in the wall-painting of the Nubians, with regard to the practice of making a notch on the ring so as to insert one inside the other).[155] I would like to add some silver rings from Akrotiri, Thera, which weigh 2.8 gr., that is about 1/3 of the Babylonian shekel.[156]

[148] Μιχαηλίδου 1997a, 646.
[149] See above pages 91, 96 and note 55.
[150] Zaccagnini 1984, 147.
[151] Zaccagnini 1984, 141, note 7.
[152] *Prakt* 1993, 183; Μιχαηλίδου 1997b; Boulotis 1998; Michailidou 2000.
[153] Vandenabeele & Olivier 1979, 210-211; and Palaima 1999.
[154] Higgins 1979, no. 38 and 11.
[155] James 1985, fig. 23.
[156] *Thera V*, pl. 17b. This issue forms part of a more specialised and extensive study by A. Michailidou (in preparation).

The societies of the eastern Mediterranean, at least as far east as Mesopotamia, shared a common perception of the value of metal,[157] despite any differences in the purposes and methods of recording it. As to the mechanism of the circulation of metal, weight was everywhere and at all times the primary and most important factor. As Parise has shown,[158] the metrical systems of Western Asia were at times interconnected in such a way that they were able to function at an interregional level. It remains to determine whether there was an internationally recognised metrical system, in much the same way that the Babylonian language (in cuneiform script) formed the international language of correspondence. For example the value of the gold of the two Vapheio cups could, if necessary, be estimated as 3 New Kingdom *deben* (of 93 gr.) or 30 Syrian shekels of 9.3 gr. And a similar 'international' estimation can be applied to the vessels of Fig. 18-19.

Despite the risk of anachronism on our part, we have to pose the question of whether value was measured only on the basis of weight, or also on that of the added labour. The Near Eastern documents frequently give detailed descriptions of vessels –especially when they were made of more than one material– followed by the weight of the precious metals used for the individual parts of the artefact. Of the Aegean examples, it is useful to consider the two cups of the same craftsmanship and weight (of 1 'Minoan' unit) in Fig. 14. And especially the goblet of Fig. 17 which though exceptional nevertheless belongs to a set of four similar ones possibly forming a hoard. It may be that fine workmanship was not assessed separately but was taken for granted when such vessels were sent as taxes or compulsory exchange gifts; their elegance was an element that projected the prestige and preserved the dignity of the (obligatory) donor.[159]

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[157] Even though at one period (e.g. the Fara period) copper and at another (e.g. the period of the Cassite dynasty) gold played the role normally reserved for silver. For copper as '*métal d'échange par excellence*', cf. Limet 1972, note 1.

[158] Parise 1984.

[159] See, by way of example, Liverani 1990. Of course, concerning non-metallic merchandise, I think S. Sherratt is right for the gradual development of production to other export-oriented items 'whose sole value lies in the added value of manufacture' e.g. pottery or faience (Sherratt 1999, 176). For a broader discussion on how value is created, see Voutsaki 1997.

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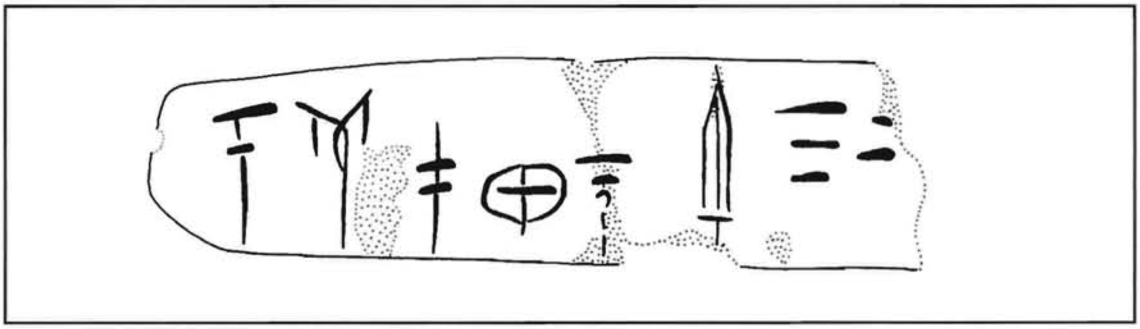


Fig. 1. Tablet **KN Ra(1) 1540** recording a total of 50 swords (after *CoMIK* II).

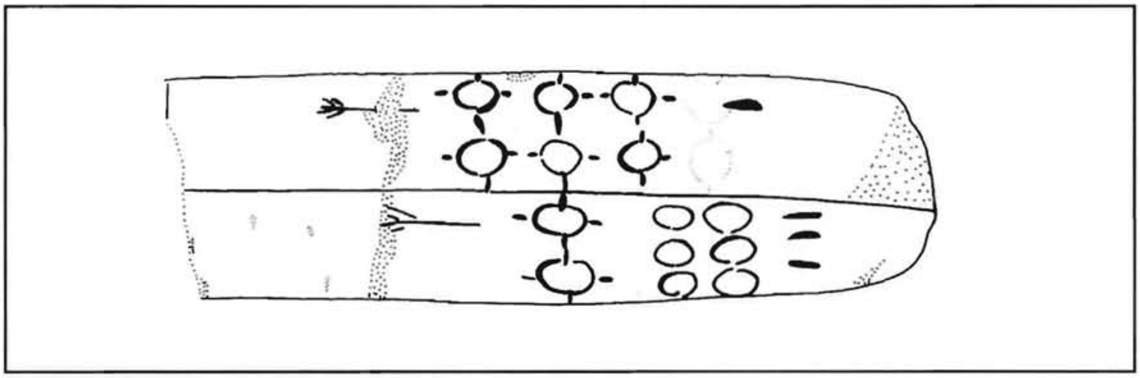


Fig. 2. Tablet **KN R 4482** recording 6,010 and 2,630 arrows (after *CoMIK* II).

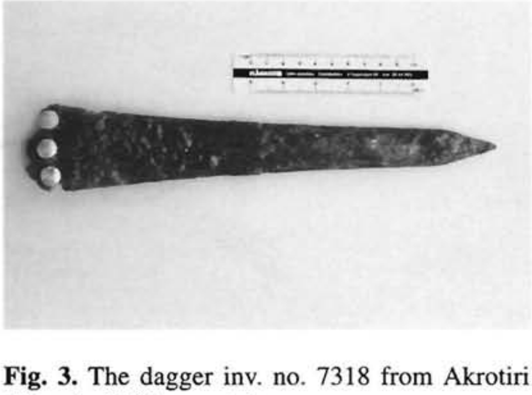


Fig. 3. The dagger inv. no. 7318 from Akrotiri (Thera) of 303 gr. weight.

Fig. 4. The chisel inv. no. 3606 from Akrotiri (Thera) of 129.7 gr. weight.

Fig. 5. Carpenter at work: fragment of a wall-painting from an Egyptian tomb. 15th century BC (Berlin, Ägyptisches Museum).

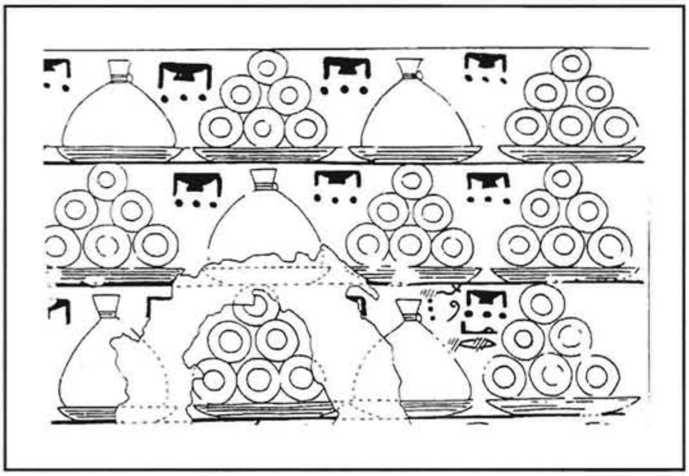


Fig. 6. Gold rings and bags with gold dust (cf. the Hieroglyphic sign of gold above them); detail of wall-paintings in an Egyptian tomb (after De Garis Davies 1933, pl. XXIV).

Fig. 7. EAM 351. Mycenae, Shaft Grave IV. Height 15 cm. Weight 1,004 gr. (after Βασιλικού 1995, fig. 21).

Fig. 8. EAM 220. Mycenae, Shaft Grave II. Height 6.6 cm. Weight 26.5 gr. (2 *deben* of 13.3 gr.) (after *Τροία, Μυκήνες, Τίρυνς, Ορχομενός*, no. 210).

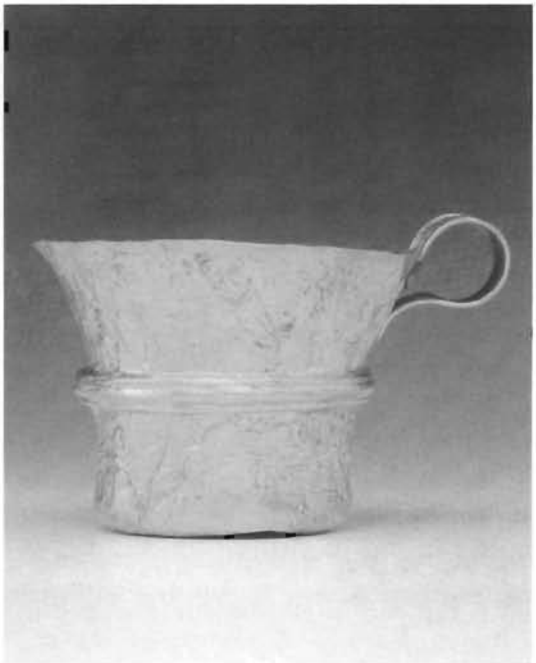


Fig. 9. EAM 73. Mycenae, Shaft Grave III. Height 8.1 cm. Weight 65.5 gr. (5 *deben* of 13.1 gr. or 1 'Minoan' unit) (after *Τροία, Μυκήνες, Τίρυνς, Ορχομενός*, no. 215).

Fig. 10. MC 2634. Peristeria, Tholos tomb. Height 12.5 cm. Weight 175.5 gr. (13 *deben* of 13.5 gr.). Date: LH I (after *Mycenaean World*, no. 41).

Fig. 11. EAM 629. Mycenae, Shaft Grave V. Height 10.5 cm. Weight 253.6 gr. (19 *deben* of 13.3 gr. or better 20 *deben* of 12.7 gr. = 4 'Minoan' units of 63.4 gr.). This weight value is later recorded as *N* 1 in Linear B tablets (after *Τροία, Μυκήνες, Τίρυνς, Ορχομενός*, no. 257).

Fig. 12. EAM 440. Mycenae, Shaft Grave IV. Height 9.2 cm. Weight 205. 2 gr. (15 *deben* of 13.68 gr.) (after *Τροία, Μυκήνες, Τίρυνς, Ορχομενός*, no. 237).

Fig. 13. EAM 7381. Kampos, Kalamata. Height 9.6 cm. Weight 336.6 gr. (25 *deben* of 13.5 gr.). Date: LH I (after *Mycenaean World*, no. 40).

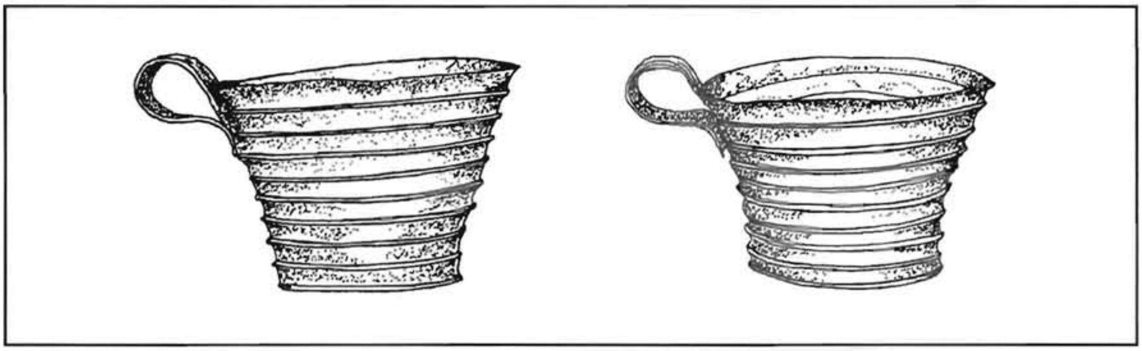


Fig. 14. EAM 392, 393 (by P. Kalogerakou). Mycenae, Shaft Grave IV. Same size (height 7.2 cm.), same craftsmanship, weights respectively 60 gr. (5 *deben* of 12 gr.) and 66.5 gr. (5 *deben* of 13.3 gr.). They are evidence for the fluctuation in the value of the *deben* and demonstrate a degree of tolerance in the value of the 'Minoan' unit of at least 6.5 gr.

Fig. 15. EAM 3122 silver cup. Mycenae, Chamber tomb 78. Height 7.7 cm. Weight 261 gr. (20 *deben* of 13 gr. = 4 'Minoan' units of 65.25 gr.). Date: LH II-III A:1. Record of weight in the Linear B script: *N* 1 (after *Mycenaean World*, no. 18).

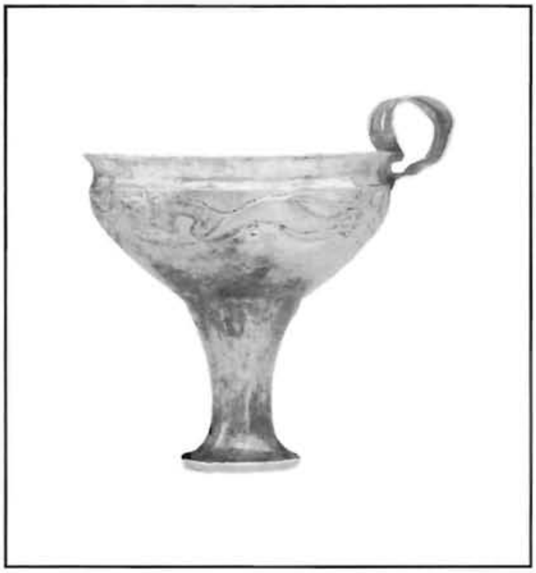


Fig. 16. EAM 656. Mycenae, Shaft Grave V. Height 10.8 cm. Weight 127.7 gr. (10 *deben* of 12.7 gr. = 2 'Minoan' units of 63.8 gr.) (after Βασιλικού 1995, fig. 19).

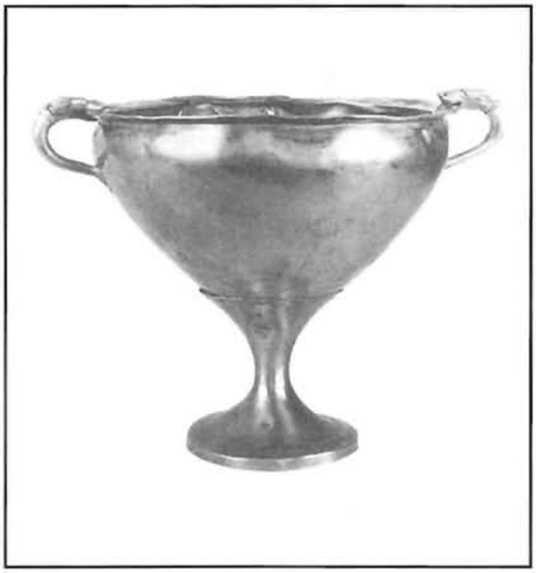


Fig. 17. EAM 959. Mycenae, Akropolis. Height 13.5 cm. Weight 314. 7 gr. (24 *deben* of 13.1 gr. or 25 *deben* of 12.6 gr. = 5 'Minoan' units of 63 gr.). Possible date: LH II-IIIA:1. Related to shape with Linear B ideogram of vase **215* (Vandenabeele & Olivier 1979) ; could be recorded as *N* 1 *P* 3 or *P* 15 in Mycenaean texts (after *Mycenaean World*, no. 1).

Fig. 18. EAM 6441. Related with the Linear B ideogram of vase **221* (Olivier & Vandenabeele 1979). Marathon, Tholos tomb. Height 3.7 cm. Weight 66.7 gr. (5 *deben* of gold of 13.3 gr. = 1 'Minoan' unit). Since it is of a LH III date, its value in weight of gold could be also estimated as 7 Egyptian *qedet* or 7 Syrian shekels of 9.5 gr. and it could be recorded as *P* 3 (if *P* = 22 gr. cf. below) (after *Mycenaean World*, no. 59).

Fig. 19. EAM 8743. Dendra, Chamber tomb 10. Height 5 cm. Weight 95.7 gr. Approx. 1 $^1/_2$ 'Minoan' unit of 63 gr. But since it is of LH II-III A:1 date, its value of gold can be estimated as 1 New Kingdom *deben* or 10 Syrian shekels (of 9.5 gr.) and recorded in Linear B script as *P* 4 *Q* 2 (if *P* = 22 gr.) (after *Mycenaean World*, no. 22).

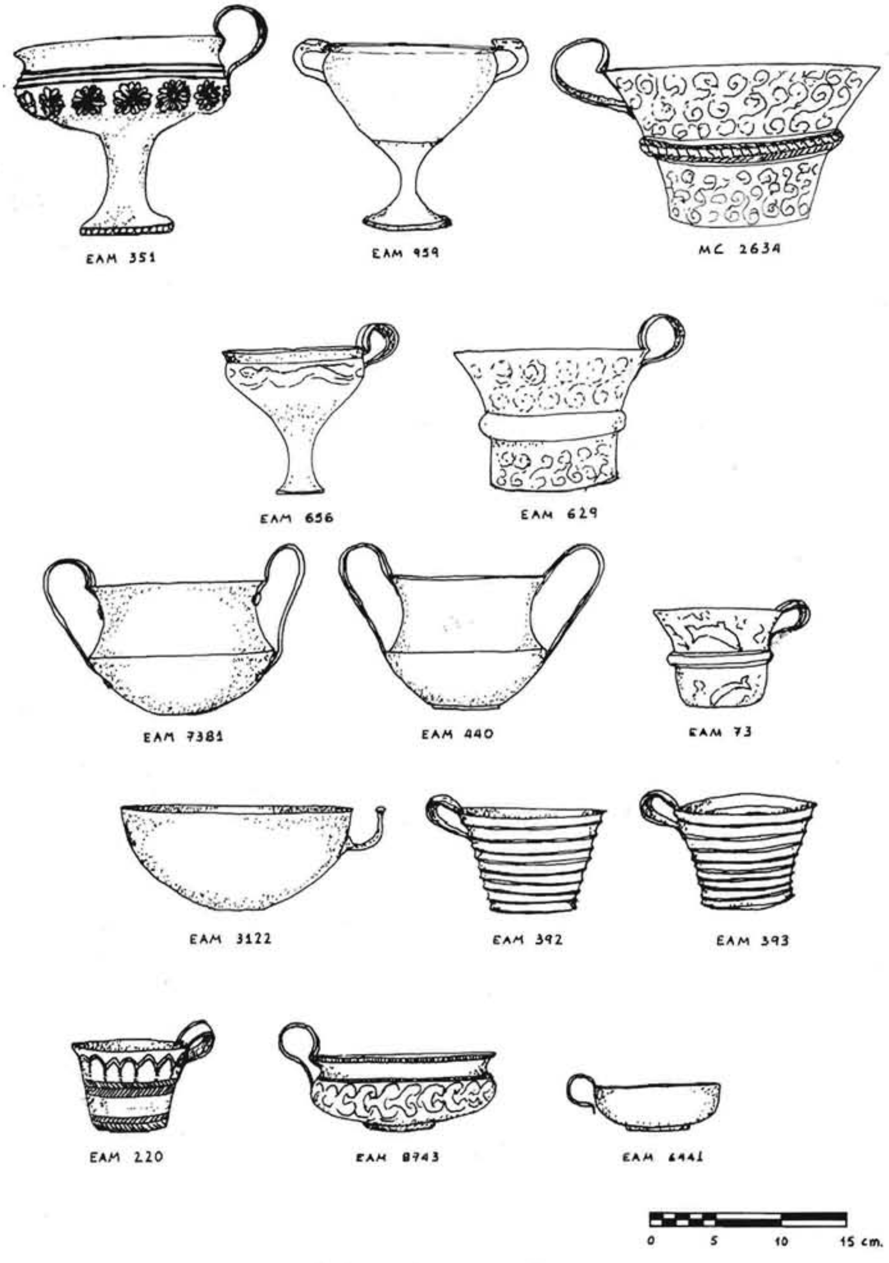
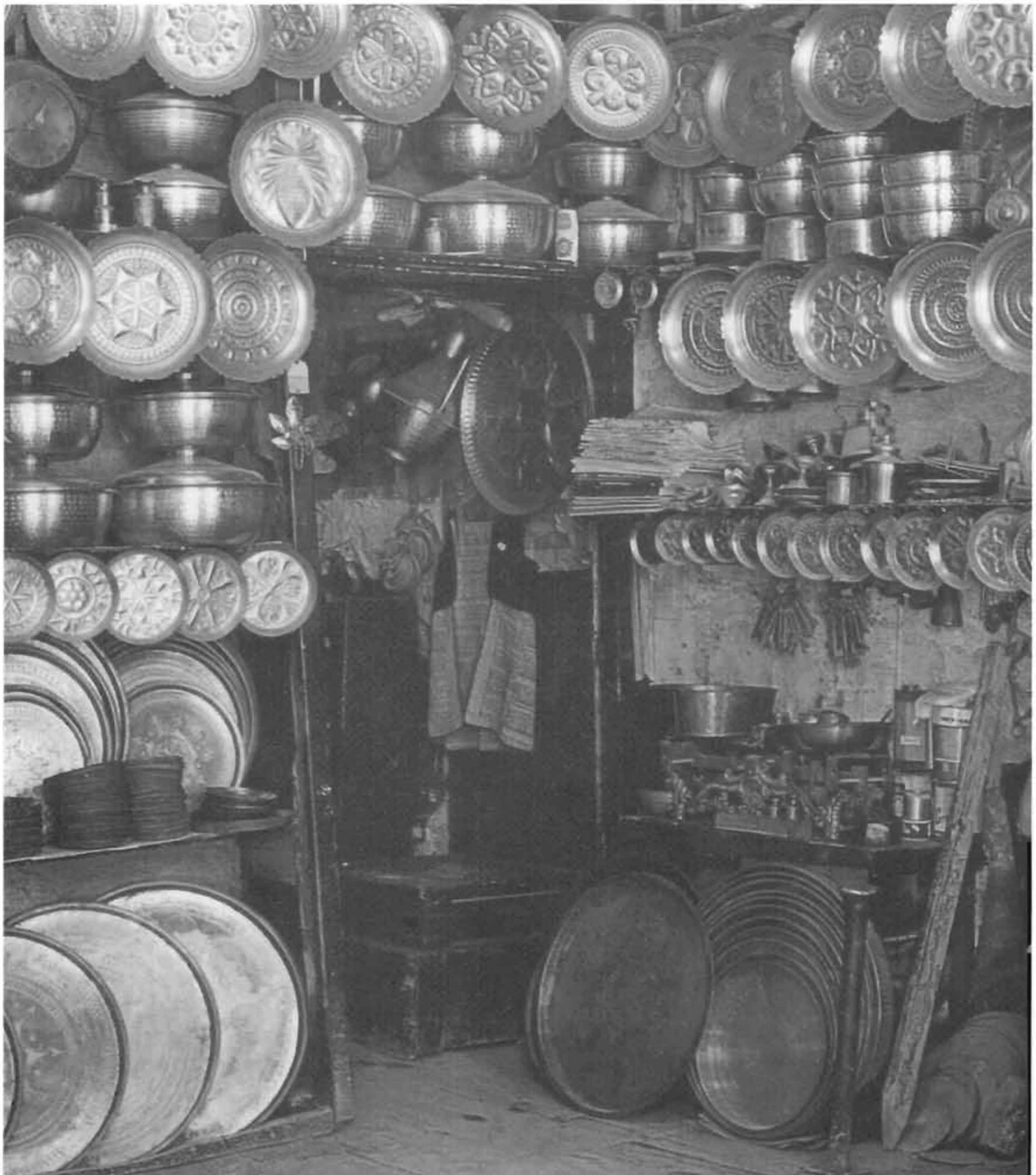


Fig. 20. The vessels of Fig. 7-19 ranged in order of height (by P. Kalogerakou).



Items of bronze still occupy a brilliant place in modern craft-industry; the workshop of the artisan Ch. Tsivilidis at Volos is depicted in K.A. Μακρής, «Μεταβυζαντινή και Νεώτερη Μαγνησία», fig. 75, in the book: *Μαγνησία, το χρονικό ενός πολιτισμού*, ΚΑΠΟΝ editions, 1982.

METAL ARTEFACTS AS RECORDED IN THE LINEAR B TABLETS

Alkis Dialismas

INTRODUCTION

It is customary to give prominence at the beginning of an article to the importance of the subject studied therein, either in order to acquaint the reader or to document and give due acknowledgement to the time and trouble involved in its investigation.[1] In the present case, however, the need to enter upon such a course is virtually redundant, since the great importance of metal-working to the development of a cultural period that is conventionally known by the name of a metal is now widely accepted, and has left its traces on every expression of Mycenaean culture.

The picture of metalworking to be derived from the Linear B archives has already been outlined in both older and more recent studies,[2] and references to it are justifiably included in publications of a more general character.[3] The more limited subject of the present article is included in the present volume rather as a pretext for displaying some of the potential of the K.E.R.A. database.[4] The treatment will confine itself to the boundaries set by the title of the article –that is, to what metal objects are recorded in the archives and in what quantities, always bearing in mind that quantities cannot be established with a very high degree of accuracy, since new tablets continue to be found, new corrections and readings are made, and many of the numbers are not completely preserved.

1. THE STARTING POINT: KINDS AND QUANTITIES OF RAW MATERIALS

It may be useful, before enumerating the products of metal technology, to give a brief account of the kinds and quantities of metals recorded in Linear B.[5] The most important metal in the Mycenaean world, as we know from archaeological finds, was copper or bronze, an alloy of

[1] Time and trouble which, in the case of the present article, would not have born fruit had it not been for Dr Anna Michailidou who not only entrusted to me a place on this programme but also offered unstinting support and above all guidance during the two years the work lasted. I would also like to thank Dr K. Trantalidou, Dr A. Sarpaki and Dr I. Tzachili for their advice, and, of course, my colleagues D. Kriga and K. Voutsa for their willing cooperation from the very first moment to the last –cooperation in a project that held many difficulties and unexpected turns of events in store. Many thanks are also due to Prof. J. Killen for his remarks and to Dr D. Hardy for the translation of my Greek text.

[2] See Lejeune 1971; Killen 1987; Smith 1992-93; Gillis 1997.

[3] E.g. *Documents*, Hooker 1994, Ruipérez & Melena 1996, etc.

[4] See the Appendix to the present volume. The tablets are in Greek as deriving from the Institute's database.

[5] More specifically, in the Pylos and Knossos archives, since the other archives do not preserve any information about metals used as raw materials.

copper and tin.[6] Other metals used were gold, silver and lead. Bronze, gold and lead are attested in the form of raw materials in the archives. Silver is found only as a finished product, and the presence of tin is highly dubious.

1.1. Bronze

Pylos

Bronze (*AES-*140*, *ka-ko*) is found as a raw material in groups of tablets preserved from Pylos: records of bronze occur in the well-known **Ja** and **Jn** series, which usually refer to quantities of the metal issued by the palace to smiths.[7]

Complete records of bronze have been preserved at Pylos in quantities of 2 *L*-weight units, 660 *M*-units, 168 *N*-units, and 6 *P*-units, the equivalent of a total of about 762 kg.[8] Account must be taken, however, of the fact that not all the original records have survived in some tablets, and the above total may be raised to about 820 kg. if the basis for the calculation is taken to be not the sum of the preserved records on each tablet, but the statement at the end of each giving the total quantity of bronze, naturally in the case of those tablets for which the relevant elements survive (e.g. tablet **PY Jn 320** preserves allocations of 43 *M*-units of bronze, while at the end, the tablet records a total allocation in the order of 56 *M* : *L* 1 *M* 26) (see Table 1).

When account is taken of the fact that totals of this kind are recorded in only about one third of the tablets (10/29), of the state of preservation of the others, and of probable losses of tablets

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[6] Henceforward, I shall use the term bronze while referring to *ka-ko* and the ideogram *AES* in the archives. There is of course much debate on whether the pure metal or the alloy is meant by these terms in the tablets (see a recent account of bibliography in Gillis 1997, 506-509 and note 9). The adoption here of the term 'bronze' rests mainly on two different aspects. First that the terms *ka-ki-jo*, *ka-ke-ja-pi* and the ideogram *AES* when related to final products, in all probability, are equivalent to bronze. The analysis of metal objects from the Late Bronze Age Aegean has shown that the majority of objects were made of bronze (Mangou & Ioannou 1997, 66, 70; 1998, 94-95, 99; 1999, 92-97, 99) and there is no need to conclude that it was different for the Linear B products. Since the Mycenaeans did not make any distinction themselves between the terminology of raw material and finished products (although it might have been obvious for them), since the debate on the nature of the composition of the raw material recorded in the tablets has not yet found a resolution, and since the habit has been so far in favour of the term bronze, an attempt to change or expand the terminology seems quite confusing and not within the scope of this article.

[7] Here we should note that Gillis (1997, 509-513) supports the old view that these records are actually quantities of metal in the form of finished products that the smiths owe to the palace. Though this proposition in its final form is not easily acceptable –since we expect the palace to record the expected products– there is still enough space to re-evaluate the relationship between the palace and the smiths, and assign to *ta-ra-si-ja* system the meaning of taxation or obligation.

[8] In converting quantities into kilograms the traditional proportions $L = 30\ M$, $M = 4\ N$, $N = 12\ P$ etc. have been used, and *M* is regarded as representing 1 kg. (see *Documents*, 54-58). In the case of the present measurement, the quantity of bronze in the tablet **Jn 829** (about 50 kg.) is included since, even if it is taken as a record of a quantity not allocated but collected by the palace (see *Documents*, 357-358, 511-514; Borgna 1995, 39; and the objections of Hooker 1982, 214-216), it is still bronze that will be used by the palace to produce metal objects. The records summarising the total quantity distributed are not included (e.g. in **Jn 415** the allocation of bronze ends with the phrase *to-so-de ka-ko AES L* 1 *M* 4). The totals recorded in **Jn 725** are included, however, since this tablet records simply the names of the coppersmiths and the total quantity of bronze, without stating the quantity allocated to each (the bronze was presumably divided equally among them).

in general, it becomes apparent that the total amount of bronze recorded at Pylos must have been in excess of 1,000 kg. This conclusion is supported by the well-known tablet **PY Ja 749**, which records the quantity of *L* 34 *M* 26, or 1,046 kg., and is thought to be a record of the entire quantity of bronze allocated and recorded in the **Jn** series.[9] The above balance-sheet, the large number of craftsmen and slaves mentioned, the fact that many smiths do not receive an allocation of metal, and the probable 'commandeering' of metal (suggesting a shortage of raw material?) in the tablet **Jn 829** (see note 8) indicate that a very significant proportion of the archives relating to the distribution of bronze have been preserved and, therefore, that we should assume that there were not large amounts of excess bronze to be distributed at the time of the destruction of the palace.[10]

Knossos

The relative clarity and abundance of information from Pylos stands in complete contrast with the picture yielded by the palace of Knossos, where, despite the great size of the Knossos archive, only minimal information can be derived on bronze as a raw material. No tablets contain the ideogram for bronze accompanied by quantities of the metal[11] and there are very few occurrences of the terms coppersmith or slave[12] which usually accompany the records of bronze at Pylos. This lack may be attributed to coincidence: that is, either the relevant tablets have not been preserved, or at the time of the destruction of the palace, the palace scribes were not working on bureaucratic matters relating to metalworking. The various attempts to approach this phenomenon in terms of economic or administrative criteria are not, in my opinion, adequate explanations. Even if we take into consideration Killen's proposition of more decentralised Knossian industries, which might mean a different recording system,[13] and Gillis' view of a relative independence of smiths,[14] still we would have normally expected some reference to smiths, either in form of taxation, or simply recording their names or slaves.

The tablets in the **KN Oa** and **Og** series (Table 2) offer an alternative explanation of this paradoxical gap, and possibly go some way towards filling it. The **Og** series, as we know, consists of a group of tablets recording weighed raw materials. In the majority of the records, the name of the commodity is not stated or has not been preserved. In the few cases where it is preserved, the raw materials involved are ivory, lead, the unidentified syllabogram *MU*,[15] flax and the term *ka-te-ro* (conceivably meaning tin, see below). If the above cases are discounted, 37 records of unknown goods remain, distributed amongst 21 tablets, which record a total of 511 kg. of raw materials. Impressive amongst them is **Og(1) 180**, which mentions 234 kg. (*recto* and *verso*) of a raw material, the nature of which was presumably self-evident to the scribe, and

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[9] This tablet, which is not included in the calculations in Table 1, does not record a confirmed quantity of bronze (the ideogram is missing), but the quantity and the nature of the record (a weighing, the phrase *to-so-pa*, which also occurs in **Jn 601**) leave no doubt as to the nature of the product. See *Documents*, 356.

[10] Assessment of the proportion of tablets preserved varies from scholar to scholar, ranging from Chadwick's diffident 65-70% (1976, 140-141) to Smith's optimistic almost 100% (1992-93, 172, note 4).

[11] The only exceptions are **KN L 693**, which will be discussed below and which probably does not involve a record of bronze as raw material and **KN Oa 734** (see below).

[12] See *Index Généraux*, 53, 88.

[13] Killen 1984, 60-61.

[14] Gillis 1997, 510-513.

[15] In the case of this syllabogram, Melena (1983, 120-122) has suggested that it is a storage vessel for oil. For another explanation see chapter by Sarpaki in the present volume.

Og(1) 8038 (*verso*), with 80 kg. The temptation to regard the tablets in this series as records of the allocation or a stock-taking of bronze is undoubtedly great. Note should be taken however, of certain features that argue against the allocation theory: the characteristic absence of the *talasia* system,[16] and of the terms *ka-ko*, *ka-ke-we*, *do-e-ro*, etc., the omission of the ideogram for bronze and/or other metals, and the large amounts recorded (there are no records of the allocation of characteristic quantities of bronze of the order of *M* 1 *N* 2 etc.); all of these features, of course, are known from the recording system used at Pylos and may simply not have characterised the archive of Knossos.

Finally, the **Oa** series is even more interesting. Five tablets of this series (**Oa 730-734**) record very large quantities of weighed material, three of them containing the ideogram **167*, which bears a close resemblance to a drawing of an ox-hide ingot. In one of them, indeed (**Oa 734**), the symbol for bronze can be seen above the ideogram (Fig. 1), while in the other cases the tablet is broken precisely at the sign for 'ingot', and the ideogram for bronze might therefore have been recorded but not preserved for us. A total of 1,742 kg. of bronze is recorded (probably not the complete total, given the fragmentary nature of the tablets), which is divided into 70 'ingots'. This total is enough to meet the seasonal needs of a palace, judging by corresponding total at Pylos.[17] The tablets of the **Oa** and **Og** series, then, probably represented records of bronze at Knossos, but the questions posed in the previous paragraph relating to the difference in structure between these documents and those from Pylos remain unanswered. The difference, in any event, does not seem to extend to other comparable tablets from the two archives (such as, e.g., those with lists of personnel).

1.2. Other metals

With regard to records of gold (*AUR-*141*), the information available in both archives is significantly more scanty. Objects made of gold were certainly not used on a wide scale and the demand for this metal was much more limited. It is nevertheless somewhat surprising that records of gold in the archives are confined to a single tablet at Pylos (**PY Jo 438**). This tablet mentions amounts of gold with a total weight of *M* 1 *N* 10 *P* 71 (the total is an approximation, since not all the records are preserved), that is, about 5 kg. If this represents the annual account for the contribution of gold (scholars are generally agreed that the Mycenaean tablets are records of annual accounts),[18] it would hardly cover the palace's needs. The manufacture of the 13 gold vases recorded in **PY Tn 316** would alone require at least 2.6 kg. of gold.[19] Along with the gold vessels, account should also be taken of the manufacture of jewellery, inlays –e.g. for weapons and furniture– and perhaps of other ritual or votive items. There were quite probably, therefore, other tablets recording the allocation of gold that have not survived. The same must also hold good for Knossos, where no tablets relating to gold have been preserved, unless, of course, the **KN Og** series is regarded as listing quantities of gold, a reasonable hypothesis, given that some of the amounts recorded, such as those in **Og(1) 7432**, are appropriate to the distribution of gold.

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[16] Known to have existed at Knossos, see **KN Lc(1) 535 + 538** etc.

[17] See Bass 1987, 719-720, where it is calculated that about six tonnes of copper from the Ulu-Burun shipwreck, blended with tin, would have been enough to make 300 helmets, 300 corslets, 3,000 spearheads and 3,000 swords.

[18] Ruipérez & Melena 1996, 41.

[19] If, for the sake of argument, an average weight of 200 gr. per vase is assumed.

The case of lead (*mo-ri-wo-do*) is also interesting. Unlike gold, lead is recorded at Knossos (in a tablet of the **Og** series, **KN Og 1527** –see Table 2). The quantity of at least 10 kg. mentioned,[20] is relatively small given the specific gravity of the metal, possibly because lead was used widely in the Mycenaean world mainly for the production of stoppers and clamps, which did not require a constant supply of the metal.

The absence of silver, on the other hand, is striking. Not only is it not mentioned anywhere as a raw material (here, as in the case of gold, the hypotheses relating to the **Og** series are applicable), but records of silver products are also very few in number and occur only at Pylos. More specifically, there is a single reference to a wheel bound with silver (*a-ku-ro de-de-me-no*, **PY Sa 287**), and it has also been suggested that the word *pa-ra-ku-we/pa-ra-ke-we* found in the **Ta** series from Pylos (**Ta 642**; **714**; **715**) as a decorative material may be rendered as **φάλαργυς*,[21] a compound of an archaic form of the word *ἀργυρός*. This interpretation has met with little support, however. The gap here is similar to that in the case of gold and is probably to be explained in the same way.

The lack of information relating to the procurement of tin is even more surprising. In the Late Bronze Age, tin was used on a very large scale in metalworking as a hardening ingredient in bronze objects. One would therefore expect to find references to tin similar in quantity and recording manner to those for bronze, and indeed allocated to craftsmen in the same proportion. Paradoxically, however, the only possible mentions of tin are at Knossos, and the relationship of these references to tin is highly dubious. They occur on two tablets, one of which (**KN Og 5515 + 5518 + 5539**) contains the term *]ka-te-ro* accompanied by the amount *L* 4 *M* (the number is nor preserved for the second weight unit), while the other (**KN V 684**) has the term *ka-so ke-ma-ta*, which might be rendered (though not very probable) as *κέρματα κασσιτέρου* ('slices' of tin) followed by the number 8. However, despite the fact that the amounts, at least in the former case, correspond to a satisfactory degree with what one would expect, the terms used do not seem to be linguistically appropriate to the word tin.[22]

One possible solution, of course, apart from the possibility that not all the relevant tablets have been discovered during excavation, is that behind the term *ka-ko* and the ideogram *AES* lies not simply pure copper, but also the alloy of copper and tin. This possibility cannot be ruled out on linguistic grounds (since in modern Greek such compromises are constantly in use, why not in Mycenaean Greek as well).[23] This might also account for the paradoxical situation at Pylos, where the distribution of the metal by the palace is attested, but where only quantities of bronze, not tin, are mentioned. However, on archaeological grounds, very few ingots made of bronze have been found, in sharp contrast with copper and tin ingots.[24] Of course the palace could have first alloyed the copper and then distribute it to the smiths, but as Gillis notes, we don't have any archaeological evidence for that.[25] In any event, whether this interpretation is adopted, or

[20] The tablet is not completely preserved and contains other records of weight without the name of the good.

[21] *Documents*, 340.

[22] *Documents*, 552; Smith 1992-93, 173, note 9; Ruipérez & Melena 1996, 173.

[23] In modern Greek the word *χαλκός* is used both for copper or bronze, despite the presence of the words *ὀρείχαλκος* (the alloy of copper and zinc) and *κρατέρωμα* (the alloy of copper and tin). For the use of the word *χαλκός* in ancient Greece see Gillis 1997, 508.

[24] For bronze ingots see Bass 1967, 78 and Appendix III, 169 (1 bun and 1 slab ingot); Mangou & Ioannou 2000, 211-212, 216 (1 bun ingot, 1 slab ingot and a bronze mass). For tin ingots see for example Pulak 1988, 8-10.

[25] Gillis 1997, 508.

whether it is assumed that the records of tin are contained in the **Og** series, or that the tablets simply have not been found, it is highly unlikely that the palace was indifferent to the procurement of tin and did not attempt to have a say in this aspect of the metals economy.

It is thus clear that, although metalworking was one of the most important sectors of the economy, the quantity of raw material recorded in the Mycenaean archives is not very great (when compared, for example, with wool or even flax). Only the records at Pylos can be used as the basis for an endeavour to understand the administrative system related to the supply of metals –that is, the relationship between the craftsman and the final product– and to connect the quantity of metal with the production of metal objects.

2. The End of the Process: Metal Artefacts

In contrast with the material of which they are made, metal artefacts have a dynamic presence in the palace archives. Their large numbers on this occasion reflect the proportional size of the archives, with the majority of references being found at Knossos, followed by Pylos, and finally, with a few references at the other palaces (Tiryns, probably Mycenae and Thebes).[26]

Despite the abundance of records, however, it is not always easy to identify with any certainty the material of which all the products recorded were made. There are a number of felicitous cases of records in which the material of which the product was made is indicated either by an ideogram (*AES*, *AUR*) or by a word (*ka-ki-jo*, *ku-ru-so-jo*, etc.). In the case of other artefacts, it is obvious from their nature and function that they were made of metal (e.g. swords). Apart from these, however, a range of objects has emerged from the Mycenaean documents that could equally have been made of metal or of some other material (especially the vases), and the records of which are not accompanied by any clarification on this point. Finally, one category of artefacts is found in the tablets (e.g. corslets, helmets, etc.) that were probably made of a combination of metal and some other material.

Several interpretations have been advanced for the last two categories, some more convincing than others. The lack of clarity and the uncertainty at present militate against an authoritative computation of the amount of metal produced by the palace. It seems profitable, therefore, to turn first to a consideration of those cases that have been of concern to scholars, before proceeding to comment on the kinds and quantities of metal artefacts.

2.1. Artefacts stated to be, or whose function makes it obvious that they were made of metal

The following artefacts are known to have been made of metal, either because of some indication to this effect, or because of their function:

- Vases and vessels stated to be of metal in the tablets.
- Weapons –that is, daggers, swords, arrow-heads and spear-heads.[27] Corslets only if accompanied by an explicit statement to this effect, cf. **KN K(1) 740** (*AES*, *qe-ro*$_2$: *γύαλος*).

[26] The doubt here resides in the circumstance that we cannot be sure whether some of the objects in the tablets from Mycenae and Thebes are of metal or not.

[27] We would normally expect arrow- and spear-heads to be made of bronze. This assertion derives from Linear B itself and the **PY Jn 829** tablet that registers demand of bronze for heads for javelins and spears, from the archaeological record and also from the very fact that bronze is more effective than stone. Though the archaeological record suggests that flint heads were still in use and, according to Killen (1999, 349, 350)

- Tools and equipment: *pi-ri-je*, if translated as *πρίην* (cf. classical *πρίων*, saw),[28] *wa-o-*232*, if the ideogram represents a double axe,[29] *pa-sa-ro*[30] - *ψάλω* ('chains' in dual), the object *o-pi-i-ja-pi* (attachments to reins?),[31] chariot-wheels with metal binding (bronze or silver), and the objects in the tablet **PY Ta 709**.

- Decorative inlays for furniture made of metal (gold and *pa-ra-ku-we*),[32] for footstools (*ta-ra-nu-we*, if classical *θρᾶνος*), thrones (*to-no*), and tables (*to-pe-za*).

At this point we should note a number of special cases in which there is a direct reference to a metal, but in which the purpose of the record is not clear. The first involves the well-known Knossos tablet **L 693**[33] (Fig. 2), which contains records of garments combined with amounts of bronze and the term *qe-te-o*. Three interpretations of this tablet have been advanced. The first asserts that the amounts of bronze serve as weight standards, indicating the weight of these textiles.[34] Bronze weight standards are not common, however, and it is considered unlikely that a thin linen *chiton* would weigh a kilogram.[35]

The second interpretation proposed is more interesting for the purposes of this article –that the combined reference to bronze and textiles is intended to describe a corslet[36] made of metal attachments sewn on garments. However, the presence of fine linen, a material not suited to bear the weight of 2 kg. of bronze sewn attachments, militates against including the present tablet amongst the items of interest to the present article.

The third interpretation, finally, suggests that the amount of bronze recorded represents the value of the garments.[37] This theory accounts for the unusual structure of the tablet and the presence of an economic term like *qe-te-o*, but removes the tablet in question from the subject of the present investigation.

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there is also a slight possibility that the word *ki-wa-ra* attested in **PY Vn 1341** (related to javelins as well) might represent flint arrow-heads, still, for the reasons expressed above, we prefer to consider arrow- and spear-heads as made of bronze.

[28] See Melena 1987, 414-415, where it is suggested that the object recorded is an ivory comb, and Hiller 1992, 309.

[29] *Documents*, 502.

[30] See Palmer 1963, 358, and *Documents*, 502 for the interpretation of the word *pa-sa-ro*. See also Μιχαηλίδου 1997, 646.

[31] See *Documents*, 365, 565.

[32] If, of course, this term is related to silver (see above p. 125).

[33] The full text of the tablet (in transliteration) is:
ri-no ,/ re-po-to , 'qe-te-o' ki-to , AES M 1 [
sa-pa P 2 Q 1 e-pi-ki-to-ni-ja AES M 1[
I refer briefly to the interpretations offered for the terms; *ri-no re-po-to* and *ki-to* are universally agreed to mean 'fine linen' and 'chiton' (Hooker 1994, 171). The term *e-pi-ki-to-ni-ja* is translated as *ἐπιχιτωνία* (feminine) or *ἐπιχιτώνια* (neuter) (Προμπονάς 1983, 125). As a neuter, it could mean roundels or cutouts attached as a protective web to the fabric during the manufacture of the corslet (*Documents*, 488). The term *sa-pa* has not yet been interpreted, but probably indicates some garment (Hooker 1994, 171). It is not impossible that the weighed quantity next to it should itself have been accompanied by the ideogram for bronze (*Documents*, 320). The word *qe-te-o* represents an economic term and probably applies to all three products (garments?) (*Documents*, 320; Hooker 1994, 171; Hutton 1990-91, 109-110).

[34] *Documents*, 320; Lejeune 1971, 175; Hooker 1994, 172.

[35] *Documents*, 320; Hooker 1994, 172.

[36] *Documents*, 487; Hooker 1994, 172; and Heubeck 1986, 144-145, where the suggestion is made, and the counter-arguments presented.

[37] Sacconi 1967, 97-134; Lejeune 1971; Hooker 1994, 172, 175.

The second special case involves **KN Sc 223** (Fig. 3), in which the ideogram for bronze *AES* is drawn precisely beneath the ideogram *BIG* (chariot with wheels). In the case of any other product (a vase, for example), we would have no reservation in assuming that the ideogram symbolises the material of which the object was made. The difficulty in this particular case resides in the fact that there is no evidence for metal chariots in the Bronze Age, either in Linear B (in which several dozen chariots are recorded) or in vase- or wall-paintings, or in the archaeological record, or in later literary sources. This also seems to be true of the rest of the eastern Mediterranean and the Middle East, where the earliest references to metal chariots date from the 10th century (chariots of iron in Judaic myths relating to the capture of Canaan).[38] If, then, this is regarded as a genuine reference to a metal chariot, it would be better to regard it as a luxury vehicle and an exception, made for reasons of self-promotion or ritual. On the other hand, it is quite probable that the ideogram simply refers to a bronze-leaf inlay for the chariot-frame, or to bronze accessories.[39] As we shall see below, however, such cases are referred to in the tablets by qualifying terms such as *ka-ki-jo*, *ka-ko de-de-me-no*, *ka-ko-de-ta*.

The third special case involves the trihedral sealing **KN Ws 8497**, which has the ideogram of a square object and the ideogram of bronze above it on one side and the word *ἀσάμινθος* (*a-sa-mi-to*) on another. This might indicate a bronze *asaminthos* (bathtub), possibly one that had to be moved for some reason (since the reference occurs on a sealing, not in a tablet), in which case this is another example of a metal object. The third side of the sealing has the word *ke-ni-qa*, which is rendered as *χέρνιψ* (basin), and it is conceivable that the ideogram for bronze refers to this vessel as well.

Finally, the sealing **KN Ws 1703** is particularly interesting in that one side of it records the term *ta-to-mo*, which might be translated as *σταθμός*,[40] while the other has the weighing unit *P*. The two could obviously be combined (balance weight and weighing unit *P*) and the sealing might have accompanied (?) one or more lead weights of this value.

2.2. *Artefacts which may have been of metal*

The following objects may have been made either of metal or of some other material, on the basis of the probabilities and the archaeological parallels, and there is no further clarification of them in the record.

1) Vases with no further qualification.[41] Reference has already been made to records of vases for which metal is the standard raw material used. Most of the references to vases, however, are not accompanied by a qualification of this kind. The records themselves do not mention the content of the vases and it may therefore be assumed that it was the vase itself that was of interest to the scribe, and by extension to the palace. The kinds of vases involved are normally not rare, nor particularly difficult to make (with some exceptions, of course, like the rhyton in **KN K(1) 872**), the most commonly represented being jugs, amphoras, hydrias and the depas. All this might suggest that the only reason the palace would have gone to the trouble of recording these vases is because they were made of metal, especially when we are dealing with records of only one or two vases. A revealing example is provided by **PY Ta 641** which records, *inter alia*,

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[38] Drews 1993, 212-213.

[39] In the north-east workshop at Pylos, for example, a strip of bronze over 1 m. long was found that could have been used as an inlay for a chariot, see Palaima & Shelmerdine 1984, 84-85.

[40] See *Documents*, 584, where other possible translations are mentioned.

[41] See *Documents*, 324-325; Μαυριγιαννάκη 1980 (on tripods); Ruipérez & Melena 1996, 174-175.

3 tripods (vessels which are very familiar in metal versions) that have, moreover, suffered damage. Why would the palace wish to record a ceramic tripod with burnt legs?

On the other hand, it is clear that certain records could not have referred to metal vases, either because of the large number involved, or because of the kind of vase. The palace would hardly have maintained 1,800 metal vases (**KN K 700**) without, moreover, specifying the material, and it is improbable that it would have manufactured metal stirrup jars, a vase with a specific function of which no metal examples have been found. It may also be noted that the meticulous palace scribes almost always record the material of which objects are made when it is not obvious –and in the case of vases, clay was most probably considered the obvious material.

It is evident from the above that no comprehensive approach can be adopted, nor any clear criterion established by which the material of the vase can be determined. Not even the number is a clear criterion: 900 may be a huge quantity, and 1 very small, but what are we to make, for example, of the 10 hydrias in **KN K(2) 9242**? It is preferable to consider each case separately and correlate it, where possible, with the other references in the tablet or polyptych (see, e.g., the much-discussed case of the **Ta** series from Pylos, in which, if it is regarded as an inventory of the contents of a monumental tomb,[42] the vases are probably of metal, but if it is simply a record of the stock in some storeroom,[43] they may have been made of clay).

2) Accessories of corslets and helmets, probably of metal, though this is not certainly confirmed. These are the *o-pa-wo-ta* and *e-pi-ko-ru-si-jo*, items that are thought to have been sewn to corslets and helmets respectively, to give protection,[44] and cheekpieces (*PA* or *pa-ra-wa-jo*). The fact that the material of these is not recorded implies that it was self-evident to the scribe. The archaeological, literary and iconographic evidence from the Aegean and the Middle East reveals that metal attachments sewn to corslets were quite common,[45] and we might therefore fairly safely assume that the corresponding records in the tablets refer to bronze items. Moreover, the nature of the protection that these objects were called upon to provide calls for something of the kind.

The corslets and helmets themselves, since we know that there were actual examples made of metal (see the corslet from Dendra[46] and the tablet **KN K(1) 740**, which has a reference to a bronze *γύαλος*). There were probably two kinds, however –that is, corslets made of sheets of metal and other made of leather or linen with metal attachments sewn to it.[47] Indeed, this may possibly account for the use of two different ideograms to record corslets, *ARM* and *TUN*, the second recalling the Dendra corslet and a version similar to those in vase-paintings.[48]

It should be noted that in the case of these disputed artefacts, the comparison drawn is between non-metal items and objects made of bronze, since the meticulous recording in the archives and the rarity and value of other metals would have led to their being mentioned. It would

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42 See Palmer 1957, 58-92; 1960, 57-63.

43 Hiller 1971, 72.

44 *Documents*, 376, 544, 565.

45 Drews 1993, 110-111 and 174-180, where the evidence is summarised and further references given.

46 Βερδελής 1968.

47 See Snodgrass 1965; *Documents*, 375-381, 524; Heubeck 1986, mainly for the relationship of the tablet **KN L 693** with this theory, Ruipérez & Melena 1996, 204-206; Driessen 1996, 489-491.

48 E.g. the 'Warrior Vase' from Mycenae. See also Vandenabeele & Olivier 1979. It should be noted, however, that the ideogram *ARM* appears to be used exclusively at Pylos and Tiryns, and *TUN* at Knossos. This may be due to the fact that different kinds of corslets were used in the two areas, but it may also simply reflect a different rendering of the ideogram by the scribes (see below, p. 133).

be absurd not to record a gold or silver vase, when note was being taken of gold inlays for furniture (see the **PY Ta** series) or the silver sheathing of a wheel (**PY Sa 287**).

2.3. Artefacts for which metal is one of the materials of manufacture

Reference was made in the previous section to the strong probability that corslets and helmets belong to this category. We have also seen that some of the items of furniture mentioned in the Pylos tablets include metal decoration. Metal parts of chariots have also been noted at both Knossos and Pylos.

In addition to these, it is virtually certain that a variety of objects also included metal parts which, though small in size, fulfilled an essential role (such as nails, clamps, hinges, etc.). Obviously, we would not expect these to be recorded in the tablets, except in the case of some outstanding decorative item, such as the gold chains in **PY Ta 716** (*pa-sa-ro* - *ψάλω*).[49] Nevertheless, it is important to bear this factor in mind when attempting to calculate the number of metal products, the applications of metallurgy and, of course, the work carried out by a metal-craftsman.

Finally, account should always be taken of the possibility that amongst the undeciphered ideograms and obscure terms in the tablets lurk metalworking products. The picture that emerges from the following presentation of the metal artefacts in the Linear B archives, therefore, cannot be considered either final or non-negotiable.

3. KINDS AND QUANTITIES OF METAL ARTEFACTS

This section is devoted to a presentation of the metal artefacts in the tablets, organised first by metal, then by archive, and finally by product category.

3.1. Metal artefacts by kind of metal

As one would expect, bronze objects form the greatest quantity. They are to be found in all the archives (except the Midea and the Chania archive), and cover a variety of objects such as vases, vessels, weapons and their attachments/accessories (e.g. *a_3-ka-sa-ma* - *αἰχμές*, **PY Jn 829**), attachments to corslets and chariots.

Despite the large numbers involved, however, it is apparent that one very important category of bronze goods is missing –that of tools and ordinary implements, the only possible exceptions being *pi-ri-je*, if this can be translated 'saw',[50] and the implements on **PY Ta 709**, which should probably be viewed in the specific context of the records in the **Ta** series.[51] This phenomenon stands in complete contrast with the archaeological picture, in which the majority of the bronze objects found are tools (tweezers, knives, etc.) or implements (nails, metal sheets, strips etc.). Their absence from the records may, of course, be due to the destruction of the relevant tablets,

[49] See Palmer 1963, 358, and *Documents*, 502 for the interpretation of the word *pa-sa-ro*, and Μιχαηλίδου 1997, 646.

[50] Melena 1987, 414-415; Hiller 1992, 309.

[51] See above p. 129 and notes 41 and 42. The tablet in question refers mainly to objects connected with fire (perhaps brazier, grill, small shovel; for discussion of the terminology here see *Documents*, 499-500).

but despite the gaps in the preservation of the archives it would be a singular misfortune if no mention of any of these widely found objects had survived in a total of over 10,000 records.

The logical explanation is that these objects were not recorded because they were of no interest to the palace, and by extension to the scribes. This might mean either that the palace did not control their production and distribution, or that it was interested in recording only products that had exchange (and export) value, prestige objects, and stockpiles of weapons (a sector just as crucial as the economy). Moreover, there are other objects, in addition to metal tools, that appear to be missing from the records –such as ordinary household equipment (furniture, cooking vessels, etc.).[52] However, the palace had to procure its supplies of household equipment, too, from somewhere (and its requirements will have been considerable and constant in populous complexes like that at Knossos) and one would expect the orders and transactions to have been recorded.

Leaving bronze artefacts on one side with several unanswered questions, we turn now to objects made of other metals. As we have seen, the majority of these are gold (mainly vases and decorative inlays), and we may note that we have only a single reference to silver –as the binding for a chariot wheel (**PY Sa 287**). In the light of a number of silver-plated objects and inlays that have been discovered, one would certainly expect more references than this (as, too, in the case of lead). The lack may, again, be due to the destruction of the relevant tablets, but the fact that it is combined with a similar lack of references to the metal as a raw material makes it less likely that we are dealing here with mere coincidence. We cannot tell if it might be due to a temporary shortage of raw material, or whether it was a question of seasonal supply and production. Finally, the absence from the record of jewellery, made preeminently of gold and silver, should be stressed. Were orders placed, executed and paid for by non-palatial mechanisms? It should be noted that the overwhelming majority of records of luxury items comes from Pylos (23/27 records); if we had more information from the other palaces, of course, the picture might be different.

3.2. Metal products by archive

Our basic information here comes, as is to be expected, mainly from the archives of Knossos and Pylos, where large numbers of records are preserved. Due to two apparently exceptional cases that have survived (the contribution of gold vases in **Tn 316** and the **Ta** polyptych with its references to valuable furniture and vessels), Pylos gives the impression that it made most use of gold, while Knossos, again due to the volume of the records, gives the impression that it had a majority of objects made of other metals (mainly bronze).

In other respects, the basic axes are the same in both palaces. The overwhelming majority of bronze products consists of vases (a few of which are accompanied by the qualifying ideogram or the word for metal), and defensive and aggressive arms and armour, such as bronze sewn attachments, corslets, cheekpieces, swords, daggers, and spear- and arrow-heads. A similar picture emerges at Tiryns (corslets), Thebes (metal sewn attachments, if *O* in the **Ug** series refers to *o-pa-wo-ta*) and Mycenae (vases). It is true that at Knossos there are more records of daggers (at least 213 as against only 2 at Pylos), arrow- and spear-heads (8,640 against a single consignment on **PY Jn 829** of incalculable quantity –though this might have been as many as the number at Knossos–[53] and approximately 280 spears and javelins recorded in the **Vn** series), and corslets (at least 78 as against 10), though this may be due to coincidence or to the relative size

[52] The precious items in the **PY Ta** series do not fall within the category of ordinary household equipment, even if they are the object of stock-taking.

[53] See *Documents*, 358.

of the two archives and palaces (at Knossos at least 110 tablets and sealings referring to weapons and armour have survived, whereas there are only 16 from Pylos and, of the other archives, 11 at Thebes, and two at Tiryns). It is probably not due to differences in production or policy.

One notable difference, however, has already been noted: the apparent restriction of the use of the ideogram *ARM* to Pylos and Tiryns, and of *TUN* to Knossos. If this is not due simply to a different rendering of the ideogram for corslet, it may conceal an actual difference in manufacture. An interpretation of this nature might lead to an investigation of the type of corslet in use in the 14th century (if this is the date of the Knossos archive) and at the end of 13th century, or to comparison between Cretan and mainland preferences on the basis of the archaeological finds and reconstructions.

Apart from all this, however, what emerges clearly from the specific picture yielded by the palace archives is the value of bronze in the Mycenaean world. It formed the foundations of weapons and armour, both aggressive and defensive, at this period. If, in our imagination, we add to the metal vessels (mainly luxury items) the bronze tools (for building, farming, etc.), we gain some idea of the metal implements, the wealth accruing from the sources of metal to those that owned or controlled them and the powerful incentive to those who did not enjoy access to them, the likely consequences of a shortage of bronze, and even the revolution that would have been involved in replacing this metal with the cheaper, more common, and more durable iron.

3.3. Metal products by kind

As we have seen, first place in records of metal artefacts was occupied by items of armour and weapons (e.g. 110/138 tablets at Knossos). The most interesting category amongst them possibly consists of the corslets, both because these are rare as actual finds, and on account of the large number of them in the records.[54] At Knossos in particular, this form of defensive armour is represented by at least 78 examples, 46 of them of the *TUN* type, 7 *TUN+QE* and 25 of the type *qe-ro*$_2$ (*γύαλος*). (It is not impossible, of course, that *TUN+QE* and *qe-ro*$_2$ are the same thing). At Pylos the evidence for corslets is comparatively limited (*ARM* and *to-ra*), though in this case we have a more detailed description of the component parts of the corslet. Each tablet in the **PY Sh** series (Table 3) records a particular number of metal (probably) parts that together form a corslet –22 or 20 large metal plates, 12 or 10 small ones– 4 plates for each helmet and 2 cheekpieces. The total record is of 356 metal plates (to make 10 corslets and presumably a similar number of helmets). The tablets from all the archives together contain a total record of at least 90 corslets (78 at Knossos, 10 at Pylos and 2 at Tiryns), 419 metal plates for corslets and helmets (only 4 at Knossos, 356 at Pylos, and 59 in the **Ug** series from Thebes, which permit the conjecture that there may have been records of corslets and helmets at Thebes), 4 helmets (at Knossos, not counting the 10 referred to indirectly at Pylos through the metal plates to be used in their manufacture), at least 2 cheekpieces at Knossos (plus, of course, the 20 mentioned at Pylos for the 10 helmets).

We are not, of course, in a position to know with any degree of accuracy the type of corslets described, and by extension the extent to which metal was used in their manufacture. However, from archaeological finds (e.g. the Dendra corslet, metal roundels from shaft graves at Mycenae), the iconography (vase-paintings, wall-paintings etc. from the Aegean, Egypt and the Middle East), and from the literary sources, we know or can conjecture that a variety of combinations of materials and forms was possible. There were corslets made entirely of metal,[55] or which had

[54] Reference has already been made to the use of different ideograms at Knossos and Pylos.

[55] Like the Dendra corslet, see Βερδελής 1957, 15-18; 1968, 128-133, for its relation to the tablets.

two or more metal parts, corslets of leather or linen with metal pieces sewn to them (the number of which is unclear),[56] corslets that covered the body down to the shins, and other, shorter corslets for charioteers and foot-soldiers.[57] These different versions could well lie behind the references to corslets in the tablets, and several ingenious hypotheses have been advanced on this matter,[58] extending also to helmets and cheekpieces.

Finally, the apparent absence of references to shields and greaves is striking. These items are known to have formed part of the Mycenaean panoply (cf. wall-paintings, vase-paintings, the Dendra find, etc.). The attempt to account for their absence by attributing these artefacts to hitherto undeciphered ideograms has not yet produced any certain results,[59] and, as usual, the possibility cannot be ruled out that the relevant tablets have not yet been discovered (or were lost).

With regard to offensive equipment, the daggers, javelins, spears and arrows that one would expect have been recognised in the tablets. The overwhelming number of references to daggers is at Knossos (213 as against only 2 at Pylos), where they are registered by the ideogram *PUG* (and *GUP*) and the term *pa-ka-na* (*φάσγανα*), while at Pylos they are referred to by the term *qi-si-pe-e* (dual of *ξίφος*). It is evident, principally from the archaeological finds,[60] that there was a wide variety of daggers, but this variety cannot be distinguished in the tablets. A reasonable hypothesis is that *pa-ka-na* means daggers[61] (so much is clear from the form of the ideogram) while *qi-si-pe-e* means swords, though it is possible that different kinds are included.[62]

The same is true of spears. It is clear from the evidence of the literary sources that there were probably long spears and javelins of various sizes and weights, some suitable for skirmishing, and others for hunting or throwing from a distance.[63] In the archives we encounter the term *e-ke-a*, *e-ke-si* (*ἔγχεα*),[64] and the ideogram *HAS* (both symbolising the –large– spear) and the term *pa-ta-ja* (cf. *παλτόν*) and the ideogram *JAC* (symbolising the –small– javelin; it might also be a symbol for arrow, but is not followed by the feathered end of the ideogram for arrow).[65] Another interesting record is to be found in **PY Va 1324**, referring to 20 (*ἔγχεα*) *pe-di-je-wi-ja*, a term translated as 'spears for foot-soldiers' (though with some reservation, of course), which confirms the existence of many categories of spears.[66]

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[56] See Chadwick 1976, 160-164; Ruipérez & Melena 1996, 205-206.

[57] See Drews 1993, 174-176.

[58] See Drews 1993, 174-178; Schofield & Parkinson 1994, 157-170; Driessen 1996, 489-491.

[59] See Chadwick 1976, 163-164; Ruipérez & Melena 1996, 204-205.

[60] See e.g. the wide variety from the Shaft Graves at Mycenae.

[61] Snodgrass 1965, 107-109; Vandenabeele & Olivier 1979, 49-56; Hooker 1994, 152.

[62] Vandenabeele & Olivier 1979, 49-56; Hooker 1994, 151-152.

[63] Höckmann 1987, 329-358; Drews 1993, 180-192.

[64] See also Killen 1999, 348 for the probable relationship of the adjectives *e-ke-i-ja* and *e-ke-ja* to *ἔγκος* but also Ruijgh 1967, 204, who suggests that the term is meant for wooden parts of chariots. However the combination of the tablets **PY Va 1324**, **Vn 1339 [+] 1456**, and **Vn 1341** seems to support an interpretation related to spears.

[65] The ideogram is accompanied by the term *pa-ta-ja* (*παλτά*), the Classical word for javelin, though the size of the ideogram is more appropriate to an arrow. The result was that the ideogram was translated arrow for a time, though javelin finally became accepted: Vandenabeele & Olivier 1979, 58. See also on **PY Vn 1341** which records 200 *pa-ta-ja* (Killen 1999, 347-350).

[66] *Documents*, 569. There is also some doubt expressed by Killen (1999, 348) whether this record and also the ones in **PY Vn 1339** and **1341** refer to finished products or raw materials for these products. Although the tablets are not very well preserved I think that their form –as Killen notes– points to records of products, especially when contrasted to **PY Jn 829** where the function of the record as raw material for products is clearly indicated.

Finally, the record of 8,640 arrows at Knossos (**KN R 4482**) is highly interesting, and of importance mainly on account of the volume of material; if it is assumed that this large number of arrows is to be associated with the equally impressive number of chariots, it strengthens the thesis that Mycenaean archers rode on chariots, either during the hunt, or more probably at time of battle (though there is no direct evidence for this).[67]

We now turn to another category of artefacts, that of metal chariot accessories. The possibility has already been discussed that the tablet **KN Sc 223** records a metal chariot, and all that remains is to note the records of bronze rein-attachments (*o-pi-i-ja-pi*: tablets **KN Sd 4409 + 4481** + *frr.* (3); **Sd 4412** + *frr.*; **Sd 5091 + 6066** + *fr.*), metal wheels (*ka-ki-jo*: **KN So 894**), and wheels with metal sheathing (*ka-ko* and *a-ku-ro de-de-me-no*: **PY Sa 794**; **Sa 287**). Rein-attachments, whether decorative or functional, were probably quite common, for there are references to others made of bone and ivory (and reins made entirely of bronze have been discovered during excavations). By contrast, metal wheels were probably the exception, as is indicated by the fact that only three pairs are mentioned (though the number of pairs in **KN So 894** is missing) amongst the vast number of wheels recorded.

The other kinds of artefact recorded are metal vases and vessels (Table 4). The problems relating to these have already been mentioned. Of the large list of vases and vessels, those that are definitely of metal are the following:

a) Bronze: 30 *di-pa* (*depas*), 7 *a-te-we* (a kind of jug, the precise nature of which is unknown),[68] 3 *po-ka-ta-ma* (kind of vase or qualifying term),[69] 1 *asaminthos* (*a-sa-mi-to*) and possibly a *chernips* (*ke-ni-qa*).

b) Gold: 13 vases (bowls, skyphoi and kylikes) in **PY Tn 316** and 1 vase *po-ka-ta-ma* in **PY Tn 996**. None of the other vases mentioned in the tablets are accompanied by a qualifying term and we cannot therefore be sure of the material of which they were made, with the possible exception of the tripod cauldrons (a total of 14 in all the archives), which were probably bronze,[70] and the vases referred to in large numbers, which were probably made of clay.[71]

The other metal items consist of various gold inlays (human heads, lion's heads, palm-trees) and gold and silver (?) decorative items, probably tools (*pi-ri-je*,[72] *qa-ra-to-ro*,[73] etc.), the probable balance weight (*ta-to-mo*),[74] perhaps a chain (*pa-sa-ro* - *ψάλω*) and other objects, the identification of which is still problematic but which were probably metal tools or accessories.[75]

4. Epilogue

The above detailed evidence, not completely unknown to scholars of Linear B, has been collected together in the present article –at least at a preliminary stage– thanks to the K.E.R.A.

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[67] See Drews 1993, 122-124.

[68] *Documents*, 535.

[69] *Documents*, 572.

[70] Μαυριγιαννάκη 1980, 324-325, where reference is made to the theories advanced from time to time on this subject, though no clear position is adopted. On the other hand, the rest of the article refers to them as though they were metal vessels.

[71] See p. 129 above.

[72] See note 27.

[73] *Documents*, 576, one of the objects in **Ta 709** –see note 50.

[74] See p. 128.

[75] **MY Ue 611**: 5 *ka-na-to* (*γνάθοι?*: clamps) (*Documents*, 550), 30 *pa-ke-te-re* (*πηκτῆρες*: pegs?) though in this case made of wood (*Documents*, 567). **PY Vn 46**: 40 *o-pi-ra₃-te-re* (hammers, clamps?) (*Documents*, 504).

database containing quantitative data from the Linear B tablets. A tool of this kind renders the Mycenaean script accessible to archaeologists, who, discouraged by the volume of the philological and linguistic material, frequently maintain a discreet and silent distance. The database may well prove to be of valuable support in the endeavour to combine the archaeological and the written evidence, and the study of tables such as 1-4 may provide the stimulus to new approaches to the archaeological finds, viewed quantitatively. Comparison, in the present context, of metal finds from the palaces of Pylos and Knossos with the corresponding archives will help us to assess the extent of the preservation of the rest of the archives at these two palaces, and also their degree of accuracy, relative to the actual finds that have been preserved to the present day.

This article leaves many unanswered questions: paradoxical though it may seem, this was largely its purpose –that is, to demonstrate that the study of Linear B from the standpoint of the archaeologist leads to specialist concerns and hypotheses that are of use for all who study these prehistoric documents.

Table 1. Comparison of the sum of the rations of bronze per craftsman with the quantity of metal recorded as the total distributed.

ΠΙΝΑΚΙΔΑ*	ΣΤΙΧΟΣ	ΑΓΑΘΟ	ΕΙΔΙΚΟ ΧΑΡΑΚΤΗΡΙΣΤΙΚΟ	L	M	N	P	Q	QI	RO
PY Jn 320	.11	χαλκός	to-so-de ka-ko - τόσος χαλκός, ka-ke-we - χαλκείς, ta-ra-si-ja e-ko-te - ταλασία ἔχοντες	1	26	0	0	0	0	0
Sum of rations in PY Jn 320 (deficit: 13 kg.)				0	43	0	0	0	0	0
PY Jn 389	.09	χαλκός	to-so-de - τόσος, ka-ke-we - χαλκείς, ta-ra-si-ja e-ko-te - ταλασία ἔχοντες	0	27	0	0	0	0	0
Sum of rations in PY Jn 389**				0	23	16	0	0	0	0
PY Jn 413	.07	χαλκός	to-so-de ka-ko - τόσος χαλκός	0	0	0	0	0	0	0
PY Jn 415	.07	χαλκός	to-so-de ka-ko - τόσος χαλκός, ka-ke-we - χαλκείς, ta-ra-si-ja e-ko-te - ταλασία ἔχοντες	1	4	0	0	0	0	0
Sum of rations in PY Jn 415				0	34	0	0	0	0	0
PY Jn 431	.07	χαλκός	to-so-de ka-ko - τόσος χαλκός, ka-ke-we - χαλκείς, ta-ra-si-ja e-ko-te - ταλασία ἔχοντες	1	24	0	0	0	0	0
Sum of rations in PY Jn 431, lines 2-5				0	54	0	0	0	0	0
PY Jn 431	.20	χαλκός	to-so-de ka-ko - τόσος χαλκός, ka-ke-we - χαλκείς, po-ti-ni-ja-we-jo - της πότνιας, ta-ra-si-ja e-ko-te - ταλασία ἔχοντες	0	27	0	0	0	0	0
Sum of rations in PY Jn 431, lines 17-18				0	27	0	0	0	0	0
PY Jn 478	.07	χαλκός	to-so-de ka-ko - τόσος χαλκός, ka-ke-we - χαλκείς, ta-ra-si-ja e-ko-te - ταλασία ἔχοντες	0	26	0	0	0	0	0
Sum of rations in PY Jn 478 (deficit: 1 kg.)				0	25	0	0	0	0	0
PY Jn 601	.09	χαλκός	to-so-pa - τόσος πας, ka-ke-we - χαλκείς, ta-ra-si-ja e-ko-te - ταλασία ἔχοντες	3	14	0	0	0	0	0
Sum of rations in PY Jn 601 (surplus: 3 kg.)***				0	107	0	0	0	0	0
PY Jn 658	.11	χαλκός	to-so-de ka-ko - τόσος χαλκός, ka-ke-we - χαλκείς, ta-ra-si-ja e-ko-si - ταλασία ἔχουν	3	20	0	0	0	0	0
Sum of rations in PY Jn 658 (deficit: 25 kg.)				0	85	0	0	0	0	0
PY Jn 706	.14	χαλκός	to-so-de ka-ko e-ko-si - τόσο χαλκό ἔχουν, ka-ke-we - χαλκείς, ta-ra-si-ja e-ko-si - ταλασία ἔχουν	1	0	0	0	0	0	0
Sum of rations in PY Jn 706 (deficit: 17 kg.)				0	13****	0	0	0	0	0
PY Jn 845	.08	χαλκός	to-so-de ka-ko - τόσος χαλκός, ka-ke-we - χαλκείς, ta-ra-si-ja e-ko-te - ταλασία ἔχοντες	0	12	0	0	0	0	0
Sum of rations in PY Jn 845				0	8	16	0	0	0	0
Total of deficit: 56 kg.										

* The table includes all the tablets in the **Jn** series which, in addition to the individual allocations of bronze, also record the total quantity.

** According to the corpus of Pylos tablets (*PTT* I) the last record in line .6 is *AES M* 3. However Ventris & Chadwick (*Documents*, 355, 510) claimed that it should be restored as *M* 1 *N* 2 in order to be in accordance with the rest of the records and to harmonize the total amount of individual allocations with the record of total amount distributed. The same in Duhoux 1976 (69, note 183). It is this restoration that we follow.

*** It is possible though that in the recording of the total *L* 3 *M* 14 the quantity *M* is not fully preserved.

**** Probably the number of *M* units is larger, but the condition of the tablet does not permit secure reading.

Table 2. Og tablets from Knossos recording unknown goods, possibly metals.

ΠΙΝΑΚΙΔΑ	ΣΤΙΧΟΣ	ΑΓΑΘΟ	L	M	N	P	Q	QI	RO	?
KN Og(1) 180	.01 (verso)	άγνωστο	0	40	0	0	0	0	0	0
KN Og(1) 180	.01	άγνωστο	0	130	0	0	0	0	0	0
KN Og(1) 180	.02 (verso)	άγνωστο	0	4	0	0	0	0	0	0
KN Og(1) 180	.02	άγνωστο	0	60	0	0	0	0	0	0
KN Og(1) 1804	.a	άγνωστο	0	0	0	0	0	0	2	0
KN Og(1) 1804	.b	άγνωστο	0	0	0	1	0	0	0	0
KN Og(1) 5095	.01	άγνωστο	0	0	0	1	1	0	0	0
KN Og(1) 7432	.01	άγνωστο	0	0	0	12	0	0	0	0
KN Og(1) 7432	.01	άγνωστο	0	0	0	20	0	0	0	0
KN Og(1) 8038	.01 (verso)	άγνωστο	0	80	0	0	0	0	0	0
KN Og(2) <4467>	.02	άγνωστο	0		0	0	0	0	0	0
KN Og(2) <4467>	.02	άγνωστο	0	30	0	0	0	0	0	0
KN Og(2) <4467>	.03	άγνωστο	0	15	0	0	0	0	0	0
KN Og(2) 8150	.01	άγνωστο	0	12	0	0	0	0	0	0
KN Og(2) 8150	.02	άγνωστο	0	9	0	0	0	0	0	0
KN Og 1527	.01	μόλυβδος	0	3	0	0	0	0	0	0
KN Og 1527	.02	άγνωστο, μόλυβδος (;)	0	0	0	0	0	0	0	2
KN Og 1527	.02	μόλυβδος	0	3	0	0	0	0	0	0
KN Og 1527	.03	μόλυβδος	0	3	0	0	0	0	0	0
KN Og 1527	.03	άγνωστο, μόλυβδος (;)	0	0	2	0	0	0	0	0
KN Og 1527	.04	μόλυβδος	0	1	0	0	0	0	0	0
KN Og 5019	.01	άγνωστο	0	0	0	4	0	0	0	0
KN Og 5019	.02	άγνωστο	0	0	0	4	0	0	0	0
KN Og 5515 + 5518 + 5539	.01	άγνωστο, κασσίτερος (;)	4		0	0	0	0	0	0
KN Og 5551	.01	άγνωστο	0	10	0	0	0	0	0	0
KN Og 7430 + fr.	.01	άγνωστο	0	6	0	0	0	0	0	0
KN Og 7435	.02	άγνωστο	0	1	0	0	0	0	0	0
KN Og 7440	.a	άγνωστο	0		0	0	0	0	0	0
KN Og 7443	.01	άγνωστο	0	0	0	7	0	0	0	0
KN Og 833 + 959	.03	άγνωστο	0	6	0	0	0	0	0	0
KN Og 833 + 959	.04	άγνωστο	0	6	0	0	0	0	0	0
KN Og 833 + 959	.05	άγνωστο	0	5	0	0	0	0	0	0
KN Og 833 + 959	.06	άγνωστο	0	9	0	0	0	0	0	0
KN Og 833 + 959	.07	άγνωστο	0	4	0	0	0	0	0	0
KN Og 833 + 959	.08	άγνωστο	0	9	0	0	0	0	0	0
KN Og 833 + 959	.09	άγνωστο	0	47	0	0	0	0	0	0
KN Og 8466	.02	άγνωστο	0	0	0	7	0	0	0	0
KN Og 9005	.01	άγνωστο	0	5	0	0	0	0	0	0
KN Og 9679	.01	άγνωστο	0	0	2		0	0	0	0
KN Og 9681	.01	άγνωστο	0	21	0	0	0	0	0	
KN Og 9776	.01	άγνωστο	0	0	1	0	0	0	0	0
KN Og 9886	.02	άγνωστο	0		0	0	0	0	0	0

Table 3. The **Sh** tablets from Pylos.

ΠΙΝΑΚΙΔΑ	ΣΤΙΧΟΣ	ΤΕΛΙΚΟ ΠΡΟΪΟΝ	ΕΙΔΙΚΟ ΧΑΡΑΚΤΗΡΙΣΤΙΚΟ	ΑΡΙΘ.	ΖΕ
PY Sh 733	.01	PA - παραγναθίδα		2	0
PY Sh 733	.01	O - o-pa-wo-ta - ελάσματα (;)	ko-ru-to - κόρυθος	4	0
PY Sh 733	.01	O - o-pa-wo-ta - ελάσματα (;)	me-u-jo-a_2 - μείονα	10	0
PY Sh 733	.01	O - o-pa-wo-ta - ελάσματα (;)	me-zo-a_2 - μείζονα	20	0
PY Sh 733	.01	ARM - θώρακας		1	0
PY Sh 734	.01	PA - παραγναθίδα		2	0
PY Sh 734	.01	O - o-pa-wo-ta - ελάσματα (;)	me-u-jo-a_2 - μείονα	12	0
PY Sh 734	.01	ARM - θώρακας		1	0
PY Sh 734	.01	O - o-pa-wo-ta - ελάσματα (;)	KO - ko-ru-to - κόρυθος	4	0
PY Sh 734	.1 (verso)	ARM - θώρακας		1	0
PY Sh 734	.01	O - o-pa-wo-ta - ελάσματα (;)	me-zo-a_2 - μείζονα	22	0
PY Sh 735	.01	ARM - θώρακας		1	0
PY Sh 735	.01	O - o-pa-wo-ta - ελάσματα (;)	me-zo-a_2 - μείζονα	22	0
PY Sh 735	.01	O - o-pa-wo-ta - ελάσματα (;)	KO - κόρυθος	4	0
PY Sh 735	.01	O - o-pa-wo-ta - ελάσματα (;)	me-u-jo-a_2 - μείονα	12	0
PY Sh 735	.01	PA - ελάσματα (;)		2	0
PY Sh 736	.01	to-ra-ke - θώρακες	a-me-ja-to o-pa, me-za-na wo-ke, ne-wo - νέοι	0	5
PY Sh 737	.01	pa-ra-wa-jo - παραγναθίδα		2	0
PY Sh 737	.01	ARM - θώρακας		1	0
PY Sh 737	.01	O - o-pa-wo-ta - ελάσματα (;)	me-zo-a_2 - μείζονα	20	0
PY Sh 737	.01	O - o-pa-wo-ta - ελάσματα (;)	me-u-jo-a_2 - μείονα	10	0
PY Sh 737	.01	O - o-pa-wo-ta - ελάσματα (;)	ko-ru-to - κόρυθος	4	0
PY Sh 738	.01	PA - παραγναθίδα		2	0
PY Sh 738	.01	ARM - θώρακας		1	0
PY Sh 738	.01	O - o-pa-wo-ta - ελάσματα (;)	me-zo-a_2 - μείζονα	22	0
PY Sh 738	.01	O - o-pa-wo-ta - ελάσματα (;)	me-u-jo-a_2 - μείονα	12	0
PY Sh 738	.01	O - o-pa-wo-ta - ελάσματα (;)	KO - κόρυθος	4	0
PY Sh 739	.01	ARM - θώρακας		1	0

Table 3. (Continued).

ΠΙΝΑΚΙΔΑ	ΣΤΙΧΟΣ	ΤΕΛΙΚΟ ΠΡΟΪΟΝ	ΕΙΔΙΚΟ ΧΑΡΑΚΤΗΡΙΣΤΙΚΟ	ΑΡΙΘ.	ΖΕ
PY Sh 739	.01	O - o-pa-wo-ta - ελάσματα (;)	me-u-jo-a_2 - μείονα	12	0
PY Sh 739	.01	O - o-pa-wo-ta - ελάσματα (;)	KO - κόρυθος	4	0
PY Sh 739	.01	PA - παραγναθίδα		2	0
PY Sh 739	.01	O - o-pa-wo-ta - ελάσματα (;)	me-zo-a_2 - μείζονα	22	0
PY Sh 740	.a	PA - παραγναθίδα		2	0
PY Sh 740	.a	ARM - θώρακας	pa-ra-jo - παλαιός	0	5
PY Sh 740	.a	O - o-pa-wo-ta - ελάσματα (;)	wi-so-wo-pa-to, me-zo-a_2 - μείζονα	20	0
PY Sh 740	.a	O - o-pa-wo-ta - ελάσματα (;)	ko-ru-to - κόρυθος	4	0
PY Sh 740	.a	O - o-pa-wo-ta - ελάσματα (;)	me-u-jo-a_2 - μείονα	10	0
PY Sh 741	.01	O - o-pa-wo-ta - ελάσματα (;)	me-zo-a_2 - μείζονα	20	0
PY Sh 741	.01	ARM - θώρακας		1	0
PY Sh 741	.01	PA - παραγναθίδα		2	0
PY Sh 741	.01	O - o-pa-wo-ta - ελάσματα (;)	me-u-jo-a_2 - μείονα	10	0
PY Sh 741	.01	O - o-pa-wo-ta - ελάσματα (;)	KO - κόρυθος	4	0
PY Sh 742	.01	O - o-pa-wo-ta - ελάσματα (;)	me-zo-a_2 - μείζονα	20	0
PY Sh 742	.01	O - o-pa-wo-ta - ελάσματα (;)	me-u-jo-a_2 - μείονα	10	0
PY Sh 742	.01	O - o-pa-wo-ta - ελάσματα (;)	KO - κόρυθος	4	0
PY Sh 742	.01	PA - παραγναθίδα		2	0
PY Sh 742	.01	ARM - θώρακας		1	0
PY Sh 743	.01	PA - παραγναθίδα		2	0
PY Sh 743	.01	ARM - θώρακας		1	0
PY Sh 743	.01	O - o-pa-wo-ta - ελάσματα (;)	me-zo-a_2 - μείζονα	20	0
PY Sh 743	.01	O - o-pa-wo-ta - ελάσματα (;)	me-u-jo-a_2 - μείονα	10	0
PY Sh 743	.01	O - o-pa-wo-ta - ελάσματα (;)	KO - κόρυθος	4	0
PY Sh 744	.01	PA - παραγναθίδα		2	0
PY Sh 744	.01	O - o-pa-wo-ta - ελάσματα (;)	KO - κόρυθος	4	0
PY Sh 744	.01	O - o-pa-wo-ta - ελάσματα (;)	me-u-jo-a_2 - μείονα	10	0
PY Sh 744	.01	ARM - θώρακας		1	0
PY Sh 744	.01	O - o-pa-wo-ta - ελάσματα (;)	me-zo-a_2 - μείζονα	20	0

Table 4. Vases from all the archives which are known certainly to have been made of metal.

ΠΙΝΑΚΙΔΑ	ΣΤΙΧΟΣ	ΑΓΑΘΟ	ΤΕΛΙΚΟ ΠΡΟΪΟΝ	ΕΙΔΙΚΟ ΧΑΡΑΚΤΗΡΙΣΤΙΚΟ	ΑΡΙΘΜΟΣ
KN K(1) 740	.02	χαλκός	di-pa - *214vas+DI - αγγείο - δέπας	AES - χαλκός	30
PY Tn 316	.03	χρυσός	*215vas - αγγείο - κύπελλο/κύλικα (;)	AUR - χρυσός, po-ti-ni-ja - Πότνια	1
PY Tn 316	.03 (verso)	χρυσός	*215vas - αγγείο - κύπελλο/κύλικα (;)	AUR - χρυσός	1
PY Tn 316	.04	χρυσός	*213vas - αγγείο - φιάλη/σκύφος (;)	AUR - χρυσός, ma-na-sa - γυναικεία θεότητα	1
PY Tn 316	.04	χρυσός	*213vas - αγγείο - φιάλη/σκύφος (;)	AUR - χρυσός, po-si-da-e-ja - Ποσειδωνία (όνομα θεότητας)	1
PY Tn 316	.05	χρυσός	*216vas - αγγείο - κύπελλο/κάλυκας (;)	AUR - χρυσός, ti-ri-se-ro-e - Τρεις Ήρωες (όνομα θεοτήτων)	1
PY Tn 316	.05	χρυσός	*215vas - αγγείο - κύπελλο/κύλικα (;)	AUR - χρυσός, do-po-ta - δέσποτας (όνομα θεότητας)	1
PY Tn 316	.05 (verso)	χρυσός	*213vas - αγγείο - φιάλη/σκύφος (;)	AUR - χρυσός, pe-re-*82-jo Περσεφόνη (;)	1
PY Tn 316	.06 (verso)	χρυσός	*213vas - αγγείο - φιάλη/σκύφος (;)	AUR - χρυσός, di-u-ja - Διεία (όνομα θεότητας)	1
PY Tn 316	.06 (verso)	χρυσός	*213vas - αγγείο - φιάλη/σκύφος (;)	AUR - χρυσός, i-pe-me-de-ja - Ιφιμέδεια (όνομα θεότητας)	1
PY Tn 316	.07 (verso)	χρυσός	*216vas - αγγείο - κύπελλο/κάλυκας (;)	AUR - χρυσός, e-ma-a_2 - Ερμής, a-re-ja - Αρεία (όνομα θεότητας)	1
PY Tn 316	.09 (verso)	χρυσός	*213vas - αγγείο - φιάλη/σκύφος (;)	AUR - χρυσός, di-we - Δίας	1
PY Tn 316	.09 (verso)	χρυσός	*213vas - αγγείο - φιάλη/σκύφος (;)	AUR - χρυσός, e-ra - Ήρα	1
PY Tn 316	.10 (verso)	χρυσός	*213vas - αγγείο - φιάλη/σκύφος (;)	AUR - χρυσός, di-wo i-je-we - υιός/ιερεύς του Διός (όνομα ήρωος;)	1
PY Tn 996	.03	χρυσός	αγγείο (;)	AUR - χρυσός	
PY Tn 996	.03	χαλκός	a-te-we - *205vas - αγγείο - προχοειδές (;)	AES - χαλκός	7
PY Tn 996	.04	χρυσός	po-ka-ta-ma - *208vas αγγείο	AUR - χρυσός	1
PY Tn 996	.04	χαλκός	po-ka-ta-ma - *208vas - αγγείο	AES - χαλκός	3

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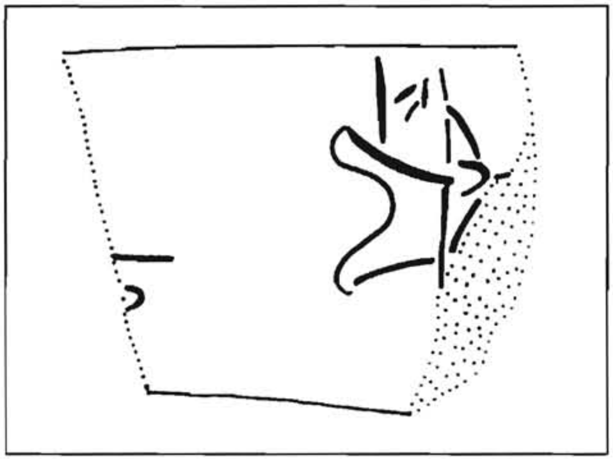

Fig. 1. The tablet **KN Oa 734** (after *CoMIK* I).

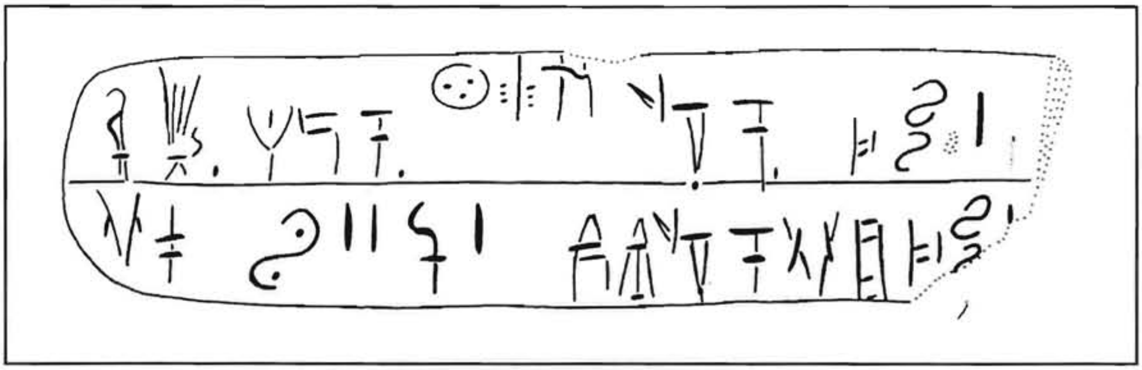

Fig. 2. The tablet **KN L 693** (after *CoMIK* I).

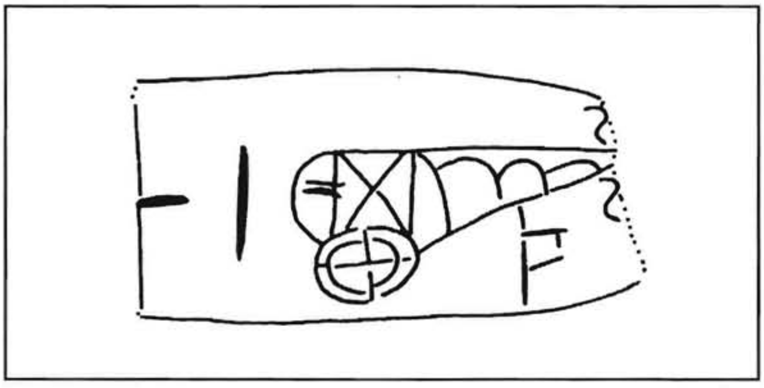

Fig. 3. The tablet **KN Sc 223** (after *CoMIK* I).

Greek artisans at work; detail of a painting by Yiannis Tsarouchis, 1931 (courtesy of the Benaki Museum at Athens).

MYCENAEAN CRAFTSMEN IN PALACE ARCHIVES: PROBLEMS IN INTERPRETATION*

Katerina Voutsa

INTRODUCTION

When I set out to write this article on Mycenaean craftsmen, I followed the advice of the Greek novelist Ch. A. Chomenidis on the composition of books: 'We should start with a theme that is half known and half unknown, and proceed carefully like the explorers, using the words as our Ariadne's clue, until we arrive at the centre of the labyrinth, where an astonishing secret will be revealed to us'.[1] I aspire, however, to follow only the first part of this method –that is, to pose a number of questions and concerns– without claiming to have arrived at the 'astonishing secret of the labyrinth' –the discovery of the answers to them.

The questions are posed principally at the theoretical level. The usual definitions of the craftsman as a person who knows and practices some art, or, at the level of technology, the person who knows and uses means by which raw materials are converted into industrial goods, help us to establish the context within which the subject of the article is considered. That is, the subject of study consists of specific categories of individuals mentioned in the tablets, to whom the definition of craftsman may be applied, fully or partly.

At the practical level, the basic method is to compare the archaeological record with the evidence of the tablets: how far do the palace archives lend confirmation to the production model of the period formed on the basis of finds yielded by the archaeologist's spade? To put it another way, what do we expect to encounter in the texts, and what do the texts in fact contain? How, for example, are we to account for the almost complete absence of reference to craftsmen in branches whose development to an 'industrial' level is indisputable, to refer to the controversial example of potters?[2]

Or again, how far is it possible, from the existing information recorded in the tablets, to draw general conclusions about the numbers of craftsmen, their specific relations with the productive process, their social status, and their dependence on the palace? Is it legitimate to speak of some kind of uniform characteristic of the evidence we possess for all categories of craftsmen? This stage of the investigation presupposes that the difficulty of identifying the craftsmen has been overcome; for instance, there are words that, on the basis of linguistic analysis, point to a craftsman's speciality but on some tablets are not directly connected with the corresponding productive process (see below, category 3). It is accordingly not always possible to draw clear

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[1] Χωμενίδης 1993, 145.

[2] See below.

boundaries with regard to the occupations of certain categories of craftsmen. Moreover, craftsmen known to us also by name appear in other tablets without any reference to their speciality, which gives rise to doubt as to whether they are actually a single individual, or different people with the same name. Consequently, in order to identify a term as referring to an occupation, or to assign an individual known only by his name to some category of craftsman, it is necessary also to take into consideration all the factors that constitute a productive process: the raw materials used, the work force that processes them, and the finished products that result from the processing. Is it in fact possible to consider them all together? In other words, are we in a position to form an overall picture of the productive process starting from the point at which the raw materials arrive –how?– in the hands of the craftsmen and ending with the moment when the finished products are delivered (only to the palace?). Study of the tablets suggests that the relevant information may be assigned to the following categories:

1. There are a few cases where the three factors, raw material, craftsman and finished product are identified in the same tablet, or at least in the same series of tablets, or, finally, there is no explicit reference to the craftsman but important details about him can be inferred from the content of the document itself.

2. There are some cases where only two of the factors can be identified in the same tablet or at least in the same series of tablets. That is, the craftsman is recorded either directly or indirectly together with only one of the other two factors: either with the raw material, or with the finished product. In these cases, the real object of the record is not the craftsman but the quantity of raw material received by him or the finished products he delivers.

3. In the majority of instances, however, the craftsmen are recorded without reference to either of the two factors mentioned above: in records of palace personnel (when the only additional details given about them are the region in which they work or their number), in records of allocations received by them, in records of a tax obligation either incumbent on them or from which they are exempt, and, finally, occasionally as owners of land. I turn now to an analysis of these three categories.

1. Raw Material + Craftsman + Finished Product

The first category of evidence includes the productive process of w e a v i n g, to a lesser extent t h e p r o d u c t i o n o f a r o m a t i c o i l s, and also the obscure, but extremely interesting cases of l e a t h e r - w o r k i n g and t h e m a n u f a c t u r e o f c h a r i o t s.

Weaving

This was the most highly flourishing industry, one of the props of the Mycenaean economy.[3] The palace took a great interest in weaving, for which there is much information in the tablets. We can be sure of the overall process, since it is described almost in full on various occasions: the basic materials used in weaving,[4] wool (**145-LANA*) and flax (**31-SA*), were converted into

[3] Ruipérez & Melena 1996, 169.

[4] Silk may also have been used. For an interpretation of the ideogram **168+SE* as silk, see Duhoux 1975, 120; for further discussion and other interpretations, see Vandenabeele & Olivier 1979, 281-282. The iconography, in which some textiles are depicted as very thin, recalling the quality of silk (Hood 1971, 94) may be regarded as, if not proof, at least supporting evidence in this direction. See also Panagiotakopulu *et al.* 1997 for evidence for silk in the Aegean Bronze Age.

textiles (**159-TELA*)[5] of various types and colours, through processing by specialised –mainly but not exclusively female[6]– personnel. It was a closely supervised industry production[7] carried out in stages, according to Nordquist, in each of which specialists were involved (chain model).[8] The terms for the workers in the process are derived from the specialised[9] labour that each group was called upon to carry out. In this way, the words for craftswomen and craftsmen are connected with: a) various stages of the preparation of the raw materials before the weaving process: *ri-ne-ja* (*λίνειαι*: flax-workers)[10] and possibly *pa-ke-te-ja* (involving work similar to that of the *ri-ne-ja*?),[11] *we-we-si-je-ja* (wool-workers?),[12] *pe-ki-ti-ra*$_2$ (*πέκτριαι*: shearers), *a-ra-ka-te-ja* (*ἠλακατεῖαι*: spindle-workers) and *ne-we-wi-ja* (involving work similar to that of the *a-ra-ka-te-ja*?); b) the weaving and the production of a particular kind of textile: *ko-u-re-ja*, *e-ne-re-ja*, *o-nu-ke-ja*, *te-pe-ja*; c) the finishing process carried out after the weaving: *a-ke-ti-ra*$_2$*/a-ke-ti-ri-ja/a-ze-ti-ri-ja*,[13] *a-pu-ko-wo-ko* (ribbon-makers?),[14] *ra-pi-ti-ra*$_2$, *ra-pte-re*,[15] *e-pi-we-ti-ri-jo*; d) the production of sails: *i-te-ja-o* (*ἱστίαι*), *i-te-we* (*ἱστεῖς*) and nets: *de-ku-tu-wo-ko* (*δικτυουργοί*); e) working within the cycle of weaving production, but with duties that cannot be determined with accuracy on account of etymological difficulties: *da-te-we-ja*, *ko-ru-we-ja*, *ne-ki-ri-de*, *no-ri-wo-ko*, *to-te-ja*, *e-ro-pa-ke-ja*; f) the art of fulling (*γναφική*), in which only men were occupied: *ka-na-pe-we* (*κναφεῖς* or *γναφεῖς*).

All the groups of women, to whom rations of wheat and figs were provided, were workers directly dependent on the palace. The male *i-te-we* and *de-ku-tu-wo-ko*, who appear together

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[5] See Tzachili in this volume, chapter on counting and recording textiles.

[6] Men seem to have been involved in the final phase of preparation of textiles (Killen 1988, 173, note 10).

[7] At Knossos, the groups of the *to-te-ja*, *da-te-we-ja*, *e-ne-re-ja*, *ko-u-re-ja*, *ne-ki-ri-de*, *a-ra-ka-te-ja*, and *a-ke-ti-ri-ja*, who are recorded in the **Ak** series as palace staff, are the same as the groups who are expected in **Lc** series to deliver specific quantities of textiles based on the quantity of wool provided to them (Killen 1988, 167-168).

[8] Nordquist 1997, 533-534.

[9] A number of problems arise, however, with regard to this absolute division of labour. For example, the number of *a-ra-ka-te-ja* is very small and they cannot be considered to have been responsible for spinning all the thread needed by the palace (Τζαχίλη 1997, 130-131, for a discussion of the problem and alternative interpretations of the duties of these women).

[10] Τζαχίλη 1997, 74, where it is suggested that the term applied not to weavers but to women involved in processing the flax in the countryside, prior to weaving.

[11] Τζαχίλη 1997, 74.

[12] The derivation from the word *εἶρος* (= wool) is rejected by Τζαχίλη (1997, 61, note 29).

[13] Various meanings have been assigned to the term. Killen argues that they were occupied in the decoration of textiles (Killen 1979, 165), and Ruipérez & Melena, that they were occupied in shaving the nap of the textiles (Ruipérez & Melena 1996, 241). At Thebes, a group of *a-ke-ti-ra*$_2$ are described as *wa-na-ka-te-ra* (**TH Of 36**).

[14] The term is read **ἀμπυκοFοργοί* and is derived from the word *ἄμπυξ*. The interpretation of this is not clear, however, and various views have been advanced: a) women who made cloth ribbons used to strengthen and adorn the fringes of textiles (Τζαχίλη 1997, 250, note 11), b) makers of headbands worn by humans, or c) makers of headbands worn by horses (or mules?). For the last two views, see Lindgren 1973, II, 22-23. The group of craftswomen known by the name *ka-ru-ti-je-ja-o* [derived from the word *κόρυς* (helmet), Lindgren 1973, II, 74] has also been associated with the manufacture of bands. Another view associates the term with the word *ka-ra-to*, and interprets it as *καλάθιον* (basket), suggesting that these women were basket-makers (Τζαχίλη 1997, 14).

[15] For objections to the idea that the *ra-pte-re* worked in weaving, see Lindgren 1973, II, 133-134, and esp. Hiller 1988, 59, who regards them as leather workers.

hapax in **PY Un 1322**, also received rations,[16] in the context of the *o-no* economic process, which has given rise to much debate.[17] The numbers of sail-makers and net-makers are not given. It may be considered certain, however, that the *i-te-we* were a group of workers, since they receive a large quantity of wheat *GRA* 12. We may recall here that the monthly ration of wheat per person distributed to groups of women has been reckoned at *GRA T* 2 (about 11 kg.), and that the leader of the group, who is called *DA*, receives *GRA T* 5 (about 27.5 kg.). The ration system was not consistently followed in the case of male craftsmen,[18] and the monthly ration they would have received cannot be calculated in the same way that it can for women. The needs of the male workers would certainly be expected to be greater than those for the women, but the quantity of 1,152 (96 x 12)[19] litres of wheat, is probably too large (especially when compared with the rations received by other craftsmen e.g. perfume-makers, see below). One conceivable interpretation is that this is an annual wage; this is unusual, however, and account should also be taken of the fact that in the same tablet the net-maker/s (*de-ku-tu-wo-ko*) receive a distinctly smaller quantity of wheat –*GRA* 2, that is 192 (96 x 2) litres= and *NI* 2, that is 192 litres of figs. If it is assumed that this is an annual wage, it must also be assumed that the term *de-ku-tu-wo-ko* in the tablet refers to only a single net-maker who received rations; this cannot be the case,[20] especially since his wage is smaller than that given to women. (The size of the annual rations given to women, based on the above, would have been approximately 230 litres). The problem thus remains unsolved, and is further complicated by the fact that the object of the exchange is not clear.[21]

Matters are equally complicated in the case of the wages of the *ra-pte-re*. Whereas at Knossos (**KN Fh 1056**) some of these –the precise number is not stated in the tablet– receive rations of olives (*OLIV V* 3), at Pylos, where they are scattered over various parts of the kingdom (**PY An 207 [+] 360**; **An 298**; **An 424**), they appear, like the *e-pi-we-ti-ri-jo*, as the owners of small plots of land (**PY Ea 29**; **Ea 56**; **Ea 325**; **Ea 460**; **Ea 754**; **Ea 813**).

Two of the three *ka-na-pe-we* (*κναφεῖς*: fullers) known by name are also owners of land at Pylos, while the third offers a goat or its hide (**PY Cn 1287**). The case of the fullers, however, is problematic. Their work was of great importance during the final stage of the preparation of textiles, yet they are completely absent from the archives of the highly productive palace at Knossos. At Pylos, too, where one of the three is described as *wa-na-ka-te-ro*, there are too few of them to have catered for all the needs of the palace. If Palaima's hypothesis is correct, that the palace fuller, like, probably, the palace potter and armaments-maker (see below), was responsible solely for making the goods required by the king,[22] the problem is increased, since there are then even fewer fullers to cater for the more general palace requirements. In the

[16] The term 'rations' will be used in this article for the distribution of wheat, barley, figs or olives to all categories of workers. I note, however, the meaning given to the term by R. Palmer: 'Rations are used for dependent workers who have no other major source of food; the ration is intended to give them enough energy to do their work but it is not a payment for their labor. On the other hand, handouts are small amounts of grain given to people because of their status, or affiliation with a religious group; these handouts are probably a minor source of food for these people' (Palmer 1992, 481).

[17] There are many different interpretations of it: Chadwick 1964, 21; Gallagher 1988; Killen 1995, 223; Ruipérez & Melena 1996, 180.

[18] Bech-Gregersen 1997.

[19] All the values of the units mentioned follow the system proposed by Ruipérez & Melena (1996, 90-91, 152).

[20] Lindgren 1973, II, 33.

[21] It has been argued that the *ri-no re-po-to *146* mentioned in lines 4 and 5 of the tablet is the object of the exchange (Chadwick 1964, 25).

[22] Palaima 1997, 411. The view is also advanced by him that the products in question would have been used by the king for ceremonial purposes.

Mycenae archive the term occurs three times in the plural on all three occasions, though the number of individuals is not given in each case. In the tablet **MY Oe 129**, indeed, the *ka-na-pe-we* are recorded along with new (*ne-wo*) wool, which is delivered to them. We do not know whether we are dealing with three groups of *κναφεῖς* or whether these are the same individuals recorded on three occasions. In two tablets (**MY Oi 701**; **Oi 704**), however, they received amounts of the product (?) **190*[23] as in the case of other categories of craftsmen (*ku-wa-no-wo-ko-i*) and also the deities *po-ti-ni-ja* and *si-to-po-ti-ni-ja* in the same tablets.

Perfume-making

In the case of the other highly important Mycenaean industry, the production of aromatic oils, most of our evidence is owed to the good fortune of the preservation of two tablets of the Pylian archive: **PY Un 267** and **PY Un 249**. It should be stressed, however, that the available evidence for oil in general comes mainly from the palace at Knossos, though the purpose for which it was used is not clearly defined there.[24]

PY Un 267 records the raw material, the craftsman and the final product all together: the **ἀλειφαζόος*, unguent-boiler (*a-re-pa-zo-o/a-re-po-zo-o*), whose name is *Θυέστης* (*tu-we-ta*) receives aromatic substances (*tu-we-a*) with which to make an ointment (*a-re-pa-te*), to be produced by boiling (*ze-so-me-no*). The ingredients to be boiled are also defined precisely, and can therefore be identified as ingredients for aromatic oils, in some cases where the purpose of the record is not stated (e.g. in the **Ge** series from Mycenae, where quantities of similar aromatic substances are recorded). The ingredients in question are *ko-ri-a₂-da-na* (*κορίανδρος*: coriander), *ku-pa-ro₂* (*κύπειρον*: cyperus), *KAPO* ('fruit' or cinnamon),[25] *VIN* (wine), and *ME* (honey).

Similar aromatic substances are received by the **ἀλειφαζόος Φίλαιος* (*pi-ra-jo*), who works in the service of the Potnia (*po-ti-ni-ja-we-jo*) in the tablet **PY Un 249**. Two further **ἀλειφαζόοι*, in addition to *Θυέστης* and *Φίλαιος*, are known by name from the Pylos archive –*Εὐμήδης* (*e-u-me-de-i*) and *Κώκαλος* (*ko-ka-ro*). One interesting feature is that in the tablet **PY Fr 1184** *Κώκαλος* delivers about 518 (28.8 x 18) lt./kg.[26] of oil (*e-ra₃-wo*) to *Εὐμήδης*, with no reference being made to their profession as perfume-makers. In the same tablet, he apparently delivers 38 stirrup jars (*ka-ra-re-we*), possibly containing aromatic oil, to the 'workshop' of *Ἰψέως* (*pa-ro i-pe-se-wa*),[27] who may also be included amongst the **ἀλειφαζόοι* if our interpretation of the tablet is correct. There are thus four, or at most five, perfume-makers in the Pylos archive –a number smaller than to be expected. It should also be noted that the term *a-re-pa-zo-o* is not found in any other palace archive. What is more, the different kinds of aromatic oils, *pa-ko-we* (*σφακόεν*), *ku-pa-ro-we* (*κυπαιρόεν*), *wo-do-we* (*ῥοδόεν*), and *e-ti-we*, are also known exclusively from records in the Pylos archive (**Fr** series). At Knossos, where large quantities of oil are frequently recorded, as

[23] Killen is of the opinion that the ideogram **190* represents a kind of foodstuff (Killen 1992, 366, 376).

[24] There is a view that the records of large quantities of oil distributed to various recipients in the **Fh** series from Knossos might indicate that they were intended for craft-industrial use or for aromatic oils (Μπουλώτης 1996, 26).

[25] The interpretation of this ligature offered by M.S. Ruipérez and J.L. Melena is that it might indicate 'solids in general' (Ruipérez & Melena 1996, 264). A. Sacconi has suggested that it refers to cinnamon (Sacconi 1972).

[26] For the equivalence of litre and kilogram of oil, see Ruipérez & Melena 1996, 90.

[27] For the interpretation of an expression with *pa-ro* + the dative of a personal name as meaning 'in the place of' the professional worker, see Hooker 1994, 158. An alternative view is that is means 'in the house of Ipseus' (Ruipérez & Melena 1996, 242, where the average capacity of the stirrup jars is reckoned to be 13.5 litres).

we have seen, these types are unattested. Similarly, at Mycenae (**MY Fo 101**) there is only one tablet, recording a quantity of about 69 lt./kg. (*OLE+WE* 2 *S* 1 *V* 1) of aromatic oil (*OLE+WE*)[28] which is delivered to a group of women. In this case it has been suggested that the oil was used as an industrial product in the process of cleaning and oiling fibres.[29] To what is this lack of direct reference to perfume-makers and their products in the archives of Knossos and Mycenae to be attributed? In the Pylian archive the recording of **ἀλειφαζόοι* with no designation of locality probably means that they worked in the area of Pylos (*pu-ro*) itself, where it has been established that there was a perfume-factory in the area of the palace courtyard.[30] At Mycenae, oil was certainly processed in the house of the oil-merchant, which, while apparently integrated into the system of the palace economy, was so incorporated under special circumstances.[31] In Crete, on the other hand, some buildings associated with the functioning of perfume-workshops have been found, both inside and outside the palace complexes.[32] Can it be conjectured, then, that the system for producing aromatic oils at Pylos was different from that at Knossos and Mycenae? The fact that the palace supervised the distribution of oil is undisputed in all three cases. What perhaps varies is the extent to which the craftsmen depended on the palace. (Is it a coincidence that Kokalos is being given rations?) This is, of course, purely hypothetical, and the lack of evidence may simply be due to the destruction of the relevant tablets.

There does not appear to have been any fixed method of paying the **ἀλειφαζόοι*. Kokalos, as we have noted, was paid in rations (*GRA* 1 *NI* 1) (**PY Fg 374**). On the other hand, Eumedes is reported as the owner of a plot of land in the tablet **PY Ea 812**, and is also recorded (**PY Ea 820**) as an owner of land who stood in a relationship of *o-na-to* to the *me-ri-te-wo* (bee-keeper). There is no evidence for the types of payment that would have been received by the other perfume-makers.

Leather-working

The evidence at our disposal for the productive process of leather-working comes from the **Ub** series of tablets from Pylos. These record information about the raw materials, along with specific finished products and also the craftsmen, though the last are cited only by their personal name, with no reference to their occupation. This is an unfortunate circumstance, since it makes it impossible to be certain of the meaning of the terms that, it has been argued, render the occupation of leather worker: *di-pte-ra-po-ro*,[33] *ku-re-we*[34] and *wi-ri-ne-we*.[35] Before turning to

[28] Shelmerdine interprets the determinative *WE* of the ideogram for oil (*OLE*) as meaning a product of the oil industry for use in weaving (Shelmerdine 1997, 389-390). Another view is that *WE* = *wealeiphes* = *ἀλειμματώδης*, unctuous (Ruipérez & Melena 1996, 242).

[29] Shelmerdine 1997, 389-390.

[30] Shelmerdine 1985, 58-62.

[31] Μπουλώτης 1996, 36.

[32] Μπουλώτης 1996, 37.

[33] The many interpretations offered for this term are based on the meaning of the term *διφθέρα* (prepared hide), from which it is derived. In addition to 'treater of hides' (Ruipérez & Melena 1996, 242, 262), it has been thought to mean 'wearer of a *διφθέρα*' (connected with a priestly office), 'seller of a *διφθέρα*' (but see Olivier 1959, 165-166), and 'scribe'. For all these interpretations, with comments, see Lindgren 1973, II, 34. The interesting possibility that it means scribe is to be associated with the view held by many scholars that the Minoans used 'leather documents' (Shelmerdine 1998, 293, note 13), and this is not impossible in the case of the Mycenaeans, too.

[34] Lindgren 1973, II, 90.

[35] Morpurgo-Davies 1979, 101, note 53; Ruipérez & Melena 1996, 243.

the question of whether or not these terms in fact denote Mycenaean leather workers,[36] let us examine what kinds of hides are recorded, how they are processed, and what kinds of goods are produced. The raw materials are divided into *di-pte-ra*$_3$ or **247-DIPTE* (worked leather?), *wi-ri-no* (unworked leather? ox-hide?), *e-ra-pe-ja* or *E* (deer-skin), *we-e-wi-ja* (pig-skin?) and *a*$_3$*-za* (goat-skin?).[37] All these kinds of hide are listed in the tablet **PY Ub 1318**, where they are delivered to *Αὐγειατέα (au-ke-i-ja-te-we)*, *Μεστιάτορα (me-ti-ja-no)* and *Μυρτέα (mu-te-we)*, who it seems logical to assume were leather workers, since, using the hides, they are apparently to deliver the following finished products: *o-pi-de-so-mo* (bandages?), *ka-tu-ro*$_2$ (*κανθύλια*: pack-saddles?),[38] *wo-ro-ma-ta*, *ru-de-a*$_2$, *a-re-se-si*, *pe-di-ra*, *e-ma-ta* and *e-pi-u-ru-te-we*. This particular tablet, that is to say, provides a complete record of leather-working.

We are also in a position to know of other products deriving from the processing of hides and recorded in the tablets, such as reins (*a-ni-ja*) and blinkers (*o-po-qo wi-ri-ni-jo/wi-ri-ne-o*), which are attested in the tablets from Knossos relating to armour (**Sd**, **Sf** series). But who were the craftsmen who delivered these products? The interpretation of *wi-ri-ne-we* as leather workers is supported by an indirect but important piece of evidence: in the tablets **KN Fh 5428 + 5500** and **KN Fh 5435 + 7987** + *frr.* a group of *wi-ri-ne-we* is included amongst the recipients of oil (in the former case of a quantity of *OLE* 12 *S* 1 while in the latter case the quantity of oil is not preserved); and oil, as we know, was indispensable to the processing of leather. The number of *wi-ri-ne-we* is not preserved, and there are no other details relating to them. In the case of the *ku-re-we* found at Pylos and Knossos, there are strong supporting arguments other than the etymology of the word. Their numbers are large, both at Pylos (**PY An 519**; **An 654**) (110 individuals), where they are included amongst the groups of *o-ka*,[39] and are exempt from tax obligations along with the coppersmiths (**PY Ma 90**), and at Knossos (143 individuals), where they are found in lists of workers (**KN B(4) 164 + 5666 + 7136 + 7544 + 8120** + *frr.* (3)). It might be asserted that the large numbers argue in favour of the view that these were leather workers, given the great demand by the palace for leather products. There is equally little evidence for the *di-pte-ra-po-ro*, other than its etymological derivation, which, as we have seen, has been the subject of a large number of interpretations (note 33). It is of significance that the term is recorded both in the Pylos archives and in those of Knossos and Tiryns; in one case at Pylos (**PY Fn 50**) and in the single case at Tiryns (**TI Uh 12**) the *di-pte-ra-po-ro* probably receive rations (at Pylos *HORD V* 2, while at Tiryns they were probably given figs). In another tablet from Pylos (**PY Ea 814**), which refers to a *di-ra-po-ro* (possibly an error for *di-pte-ra-po-ro*), the individual in question was apparently an owner of land. At Knossos, they were presumably provided with one or more goats or their skins (**KN C 954 + <1632> + 5016**).

Manufacture of chariots

The palaces would naturally have showed an interest in this industry, which probably employed a good number of craftsmen, and their interest is attested by the fairly large number of

[36] See note 15 for Hiller's view that the term *ra-pte-re* is used to mean leather workers.

[37] It should be noted that the following ideograms may also be included amongst the raw materials used in tanning: **150* (skin of an animal), **152* (rinos) and **142* (goat tendons, see Melena 1972, 52 and note 71, and for more on the subject, Melena 1988). For the kinds of hide, see also Trantalidou in this volume.

[38] For the interpretations offered for these terms and an analysis of the full text of the tablet, see Ruipérez & Melena 1996, 262.

[39] An alternative interpretation is that these were the groups of a 'collective', recorded in the context of the preparation of the defense of Pylos against a likely war (Ruipérez & Melena 1996, 232-233). However, the fact that they are dealt with in the same way as the *ka-ke-we* in tablet **PY Ma 90**, and that they are included amongst the lists of workers at Knossos rules out an explanation of this kind.

tablets relating to it both at Pylos and especially at Knossos. It should be stressed, however, that the terms that are generally agreed to be the names of chariot-makers (*a-mo-te-wo*, *a-mo-te-re*)[40] do not occur in the series of tablets relating to chariots. On the other hand, some very important information is provided by tablet **PY Vn 10** from Pylos, which records a group of craftsmen that delivers material to the chariot workshop (*a-mo-te-jo-na-de*). These are the *du-ru-to-mo* (*δρυτόμοι*: woodcutters), who deliver 50 axles (*a-ko-so-ne*) and 150 *e-pi-pu-ta* (young trees or saplings)[41] to the workshop in question. This tablet enables us to confirm two things: a) the obvious etymological derivation of the *du-ru-to-mo* craftsmen. These occur on only one occasion, by great good fortune together with the raw material[42] after which they are named, and also with some of the craftsmen they work with; b) the interpretation of the term *a-mo-to-je-na-de* as a chariot workshop, recorded together with the raw material that it would have used.

Three kinds of wood are known to have been used in the manufacture of wheels in the **So** series from Knossos: elm (*pe-te-re-wa/pte-re-wa*), willow (*e-ri-ka*) and the wood named *ki-da-pa*. One tablet from Pylos (**PY Sa 488**), moreover, records wheels made of cypress (*ku-pa-ri-se-ja*). Many other materials were used in the decoration of chariots and their fittings, as is clear from the **Sd**, **Se** and **So** series from Knossos and the **Sa** series from Pylos; they include ivory (*i-qi-jo a-ja-me-no e-re-pa-te*, **KN Sd 4401 + 8718** + *fr.*), horn (*ke-ra-ja-pi o-pi-i-ja-pi*, **KN Sd 4405 + 4410** + *fr.*), bronze (*ka-ko-de-ta ROTA*, **KN So 894**) and even silver (*a-ku-ro de-de-me-no ROTA*, **PY Sa 287**). The question that arises here is whether the manufacturers of chariots were in a position to make the complete item without the assistance of other specialist craftsmen.

Two individuals are recorded in the Knossos archives, *Ἀλέξιθος* (*a-re-ki-si-to*), and *Κογχίδης* or *Γολγίδης* (*ko-ki-da*) who, although not accompanied by the occupational designation *a-mo-te-wo*, may be regarded as chariot-makers.[43] This conclusion is supported by two considerations: a) the two personal names are followed by the term *o-pa*.[44] b) *Ἀλέξιθος* appears in three tablets (**Sf(2) 4420**, **So 1053** + **5171**, **So(2) 4433** + **4444**); in the first of these he delivers the body or skeleton (**242-CAPS*) of 80 chariots while in the other two he delivers wheels. *Κογχίδης* or *Γολγίδης* appears in two tablets; in one (**Sd 4403** + **5114** + *frr.*) he delivers a chariot without the wheels (**241-CUR*), with fittings made of ivory (*e-re-pa-te-jo*) and horn (*ke-ra-ja-pi*), and in the other a large quantity of wheels (at least 22 pairs).

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[40] The etymological connection of the two names with the word *a-mo*, meaning wheel (and by extension the entire chariot) is undisputed. Other terms that have been associated with the construction of chariots are *i-za-a-to-mo-i*, *e-qe-o a-to-mo*, and the groups recorded together in the tablet **PY An 1281**: *a-mo-si*, *a-qi-ja-i*, *do-ka-ma-i*, *ki-u-ro-i* and *po-qe-wi-ja-i*.

[41] For the interpretation of this term, see Duhoux 1976, 122, note 314, and Ruipérez & Melena 1996, 263.

[42] In Homer, trees are cut not only by *δρυτόμοι* (*Iliad*, XI 86-88, XVI 633-634), but also by *τέκτονες* (*Iliad*, XVI 483-485) and by the *ἁρματοπηγός* himself (*Iliad*, IV 485-487). It may be noted, however, that certain kinds of wood, such as ebony, which, as we shall see, was used in the manufacture of furniture, were imported. A trunk of ebony was found in the Ulu-Burun shipwreck (Bass 1998, 188).

[43] Killen suggests that *a-re-ki-si-to* and *ko-ki-da* were responsible for carrying out finishing or refurbishment work on chariots and wheels and that they were not manufactures of them (Killen, 1999, 331).

[44] It has been suggested that the term means 'workshop' or 'paid work' (Lejeune 1958, 39; *Documents*, 169; Palmer 1963, 129; Sourvinou 1968, 185; Duhoux 1976, 125). Melena interprets it as 'work to be performed' (Melena 1983, 285). The most recent interpretation of the word given by Killen: '...while some doubts over details and the precise interpretation of the records which contain it must inevitably remain, there would seem to be at least a reasonable case that *o-pa* is /ho-pa/ and that it refers to work on a completed manufactured item or a unit of livestock' (Killen 1999, 338).

2. CRAFTSMAN + RAW MATERIAL OR CRAFTSMAN + FINISHED PRODUCT

In the second category the craftsman is recorded in the context of his connection with the raw material that he will be processing or the final product that he will be delivering. Often, however, matters are very complicated here: we know, for example, that the craftsmen *ka-ke-we* receive the raw material *ka-ko*.[45] We also know from various records in the tablets, which make not the slightest reference to bronze, of a series of products made of bronze. The items in question are mainly weapons (offensive and defensive) and vases.[46] Are these, however, the finished products of the work of the *ka-ke-we* mentioned in the **Jn** series? The question cannot be answered in the affirmative with complete certainty on account of the lack of tablets recording the delivery of the finished products by the *ka-ke-we*, and also because there were more highly specialised craftsmen (e.g. weapons-makers or decorators) judging by their occupational name, involved in metal-working. We cannot know, therefore, who made each product. Furthermore, the existence of other categories of metal-workers, to none of whom copper is distributed by the palace or at least is not recorded as being so distributed, gives rise to many more questions relating to the origin and kinds of metals involved, and by extension, to their owners. If the trade in metals from the regions in which they were mined, and their distribution for internal consumption, took place exclusively within the context of palace control, one would expect them to be distributed not just to the *ka-ke-we*, but to all metal-workers, who would otherwise have no *raison d'être*. If, on the other hand, metal-working was not so closely dependent on the palace economy[47] it is difficult to account for the allocations of copper to the *ka-ke-we*.[48]

More than 300 craftsmen,[49] distributed in groups in various areas of the kingdom, are described as coppersmiths in the **Jn** series from the Pylos archive. This number represents the largest group of individuals recorded in the tablets, after the group of women directly dependent on the palace. Curiously, the references are confined exclusively to the Pylos archive. Does their absence from the much larger archive of Knossos[50] therefore have some significance, or is it another coincidence, and how is it related to the equally rare occurrence of the ideogram for bronze at Knossos?

The *ka-ke-we* of Pylos are divided into two large categories, the *ta-ra-si-ja e-ko-te* (*ταλασία ἔχοντες*) and the *a-ta-ra-si-jo* (*ἀταλάσιοι*). In some of the tablets the *ta-ra-si-ja e-ko-te* are further divided into sub-groups, the *a-ke-te-re*, *pa-ra-ke-te-e-we* and *po-ti-ni-ja-we-jo*. This is not

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45 For copper and other metals, and their presence in or absence from the tablets as raw materials, see Michailidou in this volume, chapter on recording quantities of metal in Bronze Age societies in the Aegean and the Near East.

46 See Dialismas in this volume.

47 Gillis 1997, 511-512, where it is asserted that this independence is due to the fact that the trading system for metals came into being before the rise of the Mycenaean palaces.

48 The theory that this involves not the distribution of raw material by the palace, but the delivery of quantities of finished products to the palace by the *ka-ke-we* (Gillis 1997, 511-512) is interesting. It should be emphasised, however, that where finished products of metal are recorded, they are followed by a number, not a statement of their weight. In the case of **Jn** series, therefore, we are probably dealing with the raw material rather than the finished product.

49 Lindgren 1973, II, 61-65. According to Lejeune's calculations, however, their number is in excess of 400 (Lejeune 1958, 178). These numbers were considered too high by Smith: 'In the **Jn** series the number of smiths in the Pylian kingdom seems always to have exceeded the current demand from the palace for metalworking' (Smith 1992-93, 180).

50 It may be noted that the term *me-ta-ri-ko-wo* (**μεταλλιχόος*) is attested in the Knossos archive (**KN Vc(1) 291**), and possibly refers to metalworker (Lindgren 1973, II, 207).

the appropriate place to embark upon a detailed account of the arguments supporting one or another of the interpretations that have been offered of the roles played by these groups of coppersmiths. What should be emphasised, however, is that the coppersmiths who belong to the *ta-ra-si-ja e-ko-te* are recorded as recipients of copper from the palace, while in the case of the *a-ta-ri-si-jo*, the scribe simply notes the number of them next to the occupational designation, making no reference to any quantity of copper. This circumstance has been variously interpreted, principally in terms of groups of coppersmiths being occupied full- or part-time in metalworking, and also of copper being distributed periodically to the coppersmiths recorded in the various geographical regions of the kingdom.

In addition to the **Jn** series, coppersmiths are also recorded in the **Ma** and **Na** series from Pylos. In both these series they are exempted from some kind of obligation: in the **Ma** series tablets the exemption is connected with the non-delivery of products (*ka-ke-we o-u-di-do-si* 'coppersmiths do not deliver'). In the **Na** series tablets, it is not certain whether the coppersmiths are exempted from delivering a specific quantity of flax or from the tax payable on an area of land to the value of the flax produced.[51] The term used to indicate the exemption is the adjective *e-re-u-te-ro* (free).[52] According to one view, this exemption is due to the 'strategic importance' of the occupation of smith to the defense of the kingdom.[53]

Another group of craftsmen may be assigned to the second category, this time by virtue of the fact that they are recorded together with the finished products that they make (?). These are the *ka-si-ko-no* and *pi-ri-je-te* craftsmen, who are recorded in the **Ra** series from Knossos along with daggers (*pa-ka-na*: *φάσγανα*, **233-PUG*), their relationship with which, it seems logical to assume, was connected with their manufacture. The nature of the relationship is not absolutely clear: if we assume that they were the only craftsmen involved in the manufacture of daggers, then why are they registered under two different names in the same series of tablets (**KN Ra**)? If, on the other hand, they were craftsmen involved in the final phase of manufacture[54] since it was they who delivered them, then what craftsmen were involved in the process before the phase involving the *ka-si-ko-no* and *pi-ri-je-te*?[55] The etymological approach to the interpretation of the two terms is of no help in this case.[56]

[51] See Killen 1979, 133-134. If Killen's views about land holdings are accepted, we have to agree with the theory that these were 'part time smiths who spend part of their time working on (palace allocated?) land holdings? Are perhaps the **Jn** tablets records of temporary encampments of smiths gathered together for limited periods each year for work on behalf of the palaces?'.

[52] Duhoux 1976, 166-167.

[53] Ruipérez & Melena 1996, 252.

[54] According to Ruipérez & Melena (1996, 207) *pi-ri-je-te* were probably associated with the processing of ivory and *ka-si-ko-no* with the finishing of metal. For the possibility that the *ka-si-ko-no* craftsmen were involved in the making of horn handles for daggers, on analogy with the *pi-ri-je-te*, if the latter are assumed to have made ivory handles, see Hiller 1992, 305.

[55] Hiller suggests that the term *za-mi-jo* (**KN As(2) 1517**) refers to craftsmen who might have preceded the *ka-si-ko-no* and *pi-ri-je-te* in the process of making daggers (Hiller 1992, 306, note 17).

[56] *ka-si-ko-no*: the etymological interpretations *κασίγνητος*, **κασίγονος* or *διάκονος* are completely at variance with the content of the tablets in which the term appears. Stella's interpretation (Stella 1965, 196) that it means a worker of tin is interesting, but presupposes the existence of the word *ka-so* meaning tin for the first component of the term (for other etymological interpretations see Lindgren 1973, II, 74).

pi-ri-je-te: 1) etymologically associated with the term *pi-ri-je*: a) saw (Palmer 1963, 335; Hiller 1992, 309, note 32). The *pi-ri-je-te* are interpreted as 'sawyers' or 'makers of saws'. It is interesting to note, as a pointer in the direction of their interpretation as 'sawyers', that in two of the three tablets in which they are mentioned at Pylos, they are recorded together with the *to-ko-do-mo*; b) comb, usually made of

The occurrence of these two terms not only at Knossos but also at Pylos is interesting, since a variety of information can be derived for them from each archive. We have already seen that our knowledge of the nature of their occupation is owed to the **Ra** series from Knossos, in which the number of *ka-si-ko-no* is at least 7 individuals and that of the *pi-ri-je-te* at least 4. At Pylos, the group of 5 *ka-si-ko-no* recorded in a tablet of personnel (**PY An 128**) are further qualified by the term *ke-re-te*, which has been interpreted as meaning Cretans. The number of *pi-ri-je-te* in the Pylos archive is not stated. We do know, however, that in one case (**PY An 7**) a group of these craftsmen receives monthly (*o-pi-me-ne*) rations, probably of olives (*OLIV T* 4), while in tablet **PY Fn 1427** (recently joined by J.L. Melena to **PY An 7**) they appear to receive rations of barley (the quantities are not preserved).

3. CRAFTSMAN

The third category includes the majority of the craftsmen, who are known by their occupational name. The fact that the tablets in which they are recorded apparently, at least, have no direct connection with the corresponding productive process makes it difficult to interpret the range of their activities. Etymological derivation of the occupational terms plays the most important role in these cases, though at the same time it gives rise to a large number of problems. There can be no doubt, for example, that behind the term *ku-ru-so-wo-ko* should be seen the *χρυσουργός*, goldsmith –that is, the individual concerned with making objects from gold. The occurrence of the term, however, is confined exclusively to the Pylos archive, in which only 4 individuals are mentioned, all together, on a single tablet (**PY An 207 [+] 360**) that is part of an inventory of the palace personnel (more specifically, of various categories of craftsmen); there is also one reference to the region in which they probably worked, *a-nu-wa*. The Pylos archive is also the source of the only reference we have to the use of gold as a raw material (**PY Jo 438**).[57] The precedent of the distribution of copper to the smiths was not followed in the case of gold. We do not know how goldsmiths procured the gold they worked with and, as in the case of the coppersmiths, we cannot be certain of the kind of artefacts they delivered. A few finished products made of gold are known from other tablets. These are mainly vases (**PY Tn 316**; **Tn 996**, **KN K(1) 872**) and decorative attachments for furniture (**PY Ta 707**; **Ta 714**), and also the items *pa-sa-ro* and *wa-o*.[58]

On the same tablet as the goldsmiths 5 *to-ko-so-wo-ko*, bow-makers (the full number is probably not preserved) are recorded; the region in which they worked is not preserved either. The bow (*τόξο*) itself is not mentioned in the tablet archives[59] though metal arrow-heads are

ivory (Melena 1987, 423; Ruipérez & Melena 1996, 248). In this case the *pi-ri-je-te* are interpreted as 'comb-makers'. 2) Hooker interpreting the tablet **KN Ra(1) 1540** points out that it is not possible that the term *pi-ri-je-te* derives from the verb *πρίω* (Hooker 1994, 153).

[57] There is another reference to gold in **PY Ae 303**. In this case the view has been advanced that it is a reference to the 14 servants of the priestess at Pylos responsible for the temple gold (Ruipérez & Melena 1996, 228). If this is so, one would expect the mention of gold to refer not to the metal as a raw material but to finished products owned by the sanctuary.

[58] For the interpretation of these as a chain and a double axe respectively, see *Documents*, 502.

[59] We may note the view that the ideogram **256* probably stands for bow (Ruipérez & Melena 1996, 207). For the view that the **KN Mc** series tablets are lists of raw materials to make bows of horn and wood (composite bows), see Hiller 1992, 310, note 24. For these bows, see Chadwick 1976, 131. For the tablets in the **Mc** series, see also Melena 1972, 28-54.

recorded.[60] The processing of bone or wood –probably used as the raw materials[61]– to make bows clearly required expert knowledge. It is not known, however, whether the supply and therefore the total output of bows took place exclusively within the context of the palace economy, given the relative ease with which the raw material could be procured.

Other categories of craftsmen involved in working with wood are also known. These are the *te-ko-to-ne* (*τέκτονες*: masons) and the *to-ro-no-wo-ko* (*θρονουργοί*: throne-makers), whom it seems reasonable to regard as carpenters and cabinet-makers respectively. The references to the former are exclusively from tablets recording personnel. Five *τέκτονες* are recorded at Knossos (**KN Am(2) 826**). At Pylos, in addition to the five known by name (**PY An 5**), groups of *τέκτονες* are recorded on two tablets (**PY An 18**; **An 852**), and are described as absent (*te-ko-to-na-pe*).[62] If Lindgren's interpretation of the tablet **PY An 18** is correct, their total number is in excess of 254. I believe that this large number, the fact that they are recorded along with the category of *to-ko-do-mo*, which is examined below, and the circumstance that they were probably sent a long way[63] from their regular place of work, all consistent with the hypothesis that they were responsible for making the fixtures in interior rooms.[64] If so, the hypothesis could be taken further and they could be associated with the construction of the interior features known from the tablet **PY Vn 46**. These are, *inter alia*, columns (*ki-wo-qe*, *ta-to-mo*), pilasters (*pi-ri-ja-o*), beams or benches (*ta-ra-nu-we*), parts of the chimney (*ka-pi-ni-ja*) and parts of decorative (?)[65] wall-fixtures (*e-to-ki-ja*).[66] In the case of the *θρονουργοί*, our knowledge comes from the archive at Knossos, where a tablet from the series listing personnel (**KN As(2) 1517**) records three individuals, known only by their names, who apparently worked for the workshop of the *θρονουργός* (*to-ro-no-wo-ko*), who is also cited by name (*o-pi e-sa-re-we to-ro-no-wo-ko*). According to Hiller, there are probably other *to-ro-no-wo-ko* amongst the individuals known only by their name in the tablet **KN As(2) 1520**.[67] The finished products made by them, however, are known not only from Knossos, but also from the well-known **Ta** series from Pylos, listing household equipment, in which there are records of chairs (*to-no*), tables (*to-pe-za*) and footstools (*ta-ra-nu*) made not only of wood, but also of other precious materials such as ivory (*ta-ra-nu ku-te-so a-ja-me-no e-re-pa-te-jo*, **PY Ta 707**), gold (*a-ja-me-na ku-ru-so*, **PY Ta 714**), lapis lazuli (?) (*ta-ra-nu a-ja-me-no ku-wa-no*, **PY Ta 714**), glass (?) (*to-pe-za we-a-re-ja*, **PY Ta 642**),

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[60] A total of 8,640 arrow-heads is recorded in the Knossos archive (**KN R 4482**).

[61] Cf. the expression *κεραξόος ... τέκτων* used in the *Iliad* (IV 110) for maker of bows.

[62] The term is controversial and it is also thought to be a place name. For a recent support of this hypothesis see Killen 1998.

[63] According to Papadopoulos (1997, 459), the recording of absent workers is evidence for the movement of craftsmen, and along with them of ideas and artistic trends, both within the borders of the kingdom and outside them, paralleling the mobility of craftsmen in the East (Zaccagnini 1983). Note also the movements of building workers in Classical Greece (Hellmann 2000, 265).

[64] Support for this hypothesis might be sought in the Homeric expression *τέκτων δούρων* (*Odyssey*, xvii 384). The Homeric craftsman of this name makes wooden windows for houses (*Odyssey*, xvii 340, xxi 43-45). Moreover, craftsmen described as *τέκτονες ἄριστοι* had already constructed the palace of Paris (*Iliad*, VI 313-315). Palmer (1963, 456) suggests that the term was applied to craftsman in general.

[65] It has been suggested that the terms *a-ro-po* (**PY An 199**) and *ki-ri-se-we* (**PY An 298**) are connected with the decoration of the interior rooms of buildings, more specifically with the execution of wall-paintings; they are connected etymologically with the verbs *ἀλείφω* and *χρίω* respectively, and might designate wall-painters. Three male *a-ro-po* are known, of whom Bech-Gregersen regards it as probable that, along with the *pe-re-ke-we*, they are the only craftsmen who were regularly included in the system of rations distributions, like the dependent female staff (Bech-Gregersen 1997, 400).

[66] For the interpretation of the terms in the tablet **PY Vn 46**, see *Documents*, 504.

[67] Hiller 1992, 308.

precious stones (*to-pe-za ra-e-ja*, **PY Ta 642**), and with sophisticated decorative elements (human figures, lion's-heads, running spirals, shells, phoenixes, polypods, etc.).[68] The kinds of wood used are *κύτισος* (*ku-te-so*), which was probably ebony,[69] *mi-ra₂* (a kind of pine?) and *pu-ko-so* (box-wood?). As in the case of the chariot-makers, the problem arises here, too, whether the *to-ro-no-wo-ko* made the complete items, irrespective of the material; or, accepting Chadwick's view that all raw materials other than wood were used solely for decoration,[70] whether they were also responsible for the decoration. In other words, did the furniture workshop (and perhaps also the chariot workshop, see above) function in such a way that each individual was responsible for a different phase of the furniture-making process, and also received and used raw materials other than wood? This is an interesting theory, but gives rise to problems in interpreting the occupation of craftsmen who have been regarded as decorators –namely the *a₃-te-re* (**αἰτῆρες*)[71]– who are found in a tablet in the personnel series (**KN B(4) 101**) from Knossos. The record of a craftsman of this kind at Pylos is followed by his payment (?) in wheat, the quantity of which is not preserved (**PY Un 1321**). What kind of items did the *a₃-te-re* decorate? Did they work as highly specialised experts in the service of the craftsmen who delivered the finished products? The problem assumes a broader dimension in the light of the existence of other categories of craftsmen involved with decoration, such as the *ku-wa-no-wo-ko* or the *ko-wi-ro-wo-ko*. The interpretation of the term *ku-wa-no-wo-ko* as **κυανουργός* may be regarded as certain, on the basis of references in Homer to *κύανος*,[72] a material also attested in the Pylos archive, as we have seen, in the **Ta** series. The craftsmen who worked with this material however, are attested only in the archive at Mycenae, where, as we have already noted (see above, p. 149), they received quantities of the product (?) **190*. Quite apart from the nature of the material concealed behind the term *ku-wa-no*[73] it is significant that another category of craftsmen who specialised in working a raw material used exclusively for decoration is recorded here without any statement of their relationship to the craftsmen who apparently delivered the final product. As for the *ko-wi-ro-wo-ko*, the only record of whom is in the tablet **KN B(4) 101**, where they are associated with the *a₃-te-re*, our knowledge is essentially confined to their occupational name. The etymological interpretation of the term *ko-wi-ro-wo-ko* as **κοιλουργός*, that is, 'maker of hollow objects', does not shed much light on their speciality, and they have been regarded as carpenters, stone-workers, or even specialists in the art of embossing.[74]

Similar problems, involving several interpretations, arise in the case of the craftsmen known by the name *pe-re-ke-we*, who are found at Pylos and Mycenae. Two groups of 13 individuals (or, according to Lindgren, the same group recorded twice),[75] are known in the Pylos archive

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68 For the interpretation of the terms used to indicate the decorative elements in the **Ta** series from Pylos, see *Documents*, 332-348.

69 See note 42.

70 Chadwick 1976, 148: 'The basic material of the furniture is apparently not mentioned; the officials no doubt thought it superfluous to mention it was made of wood, and perhaps they didn't know what wood it was. ...The epithets of material must refer to decoration rather than basic substance...'.

71 For the etymological connection of the term with the words *a-ja-me-no, a-ja-me-na*, see *Documents*, 180; Chadwick 1992, 170 (where, however, the opposite view is expressed: 'An agent (noun) in *–τήρ* could be conceivable, derived from the verb of the participle *a-ja-me-no*, possibly meaning "inlaid". But this does not fit the context of the **Aq** set, which appears to list men of importance').

72 *Iliad*, XI 24, 35; *Odyssey*, xii 87.

73 It has been suggested that this was azurite, lapis lazuli, or glass-paste (Halleux 1969).

74 For these three interpretations, see Κατζούρος 1955, 7, Hiller 1988, 7 and note 6, and Palmer 1963, 431, respectively.

75 Lindgren 1973, II, 115.

(**PY Ae 574**; **Ae 765**). In another tablet from Pylos (**PY Cn 1287**) a craftsman of this category named *da-u-da-ro* apparently delivers a goat or goatskin, like other craftsmen (*ka-na-pe-u*, *ke-ra-me-u*) and slaves. At Mycenae (**MY Oe 130 + 133**) a group of *pe-re-ke-we*, whose number is unknown, delivers or receives a quantity of wool equal to 12 kg. (*LANA* 4). This evidence is clearly insufficient for us to choose between the two most likely interpretations, which suggest that the *pe-re-ke-we* were manufacturers or users of axes[76] or basket-makers.[77] The latter of these, however, conflicts with Promponas's view that regards the craftsmen known as *ma-ra-te-we* as basket-makers;[78] *ma-ra-te-we* are known from the Pylos archive, where they are described in the tablet **PY Na 245** as *ra-wa-ke-si-jo* –that is, having some kind of dependence on the *ra-wa-ke-ta*– and are exempted from the obligation to deliver flax. The term is found also in the singular (*ma-ra-te-u*) in three tablets from the same archive, where it appears to be a personal name. Of the many interpretations advanced, based exclusively on etymological grounds[79] in the absence of any other information, we may note that of Tzachili,[80] who suggests that they were *καλαφάτες* (caulkers), who sealed up the gaps between the timbers of ships with oakum. This is an ingenious proposition since it accounts for the connection of the *ma-ra-te-we* with the flax used for oakum, which '...consists of the residual, poor quality fibres remaining after the flax has been processed'.[81]

Shipbuilding seems, however, to have been the job of the *na-u-do-mo* craftsmen, who are recorded in just a single tablet in the Knossos archive (**KN U 736**) and in two tablets and one sealing from Pylos. Their number at Knossos is not known, while in the tablet **PY Vn 865** from the Pylos archive, the names of a group consisting of twelve individuals are preserved. It is not known whether this is the same group that in **PY Na 568** is exempted, like the group of *ma-ra-te-we*, from the obligation to pay tax in the form of flax. The suggestion that they were *ναϜοδόμοι* –that is temple-builders– should be regarded as erroneous, not only due to the absence of certainly identified religious structures at this period, but also on account of the presence in the tablets of the term *to-ko-do-mo*, which is interpreted as *τοιχοδόμος/τειχοδόμος*. The *to-ko-do-mo*, who are found exclusively at Pylos, are recorded in four tablets, each one of which furnishes interesting information about them. **PY An 35** records 12 *τοιχοδόμοι* 'who are to build' (*to-ko-do-mo de-me-o-te*)[82] in four regions of the kingdom (*pu-ro*, *me-te-to-de*, *sa-ma-ra-de*, *re-u-ko-to-ro*). In **PY An 18**, which refers to absent masons (see note 63), there is also reference to an absent *τοιχοδόμος* (*to-ko-do-mo a-pe-o*) in the region of *te-re-ne-we*. It is not clear whether these are the same people that receive a monthly (*o-pi-me-ne*) ration, probably of olives (*OLIV*) in tablet **PY An 7**, or those that deliver or receive an unknown quantity of barley (*HORD*) in tablet **Fn 1427**. (In both these tablets the *pi-ri-je-te* receive the same treatment as the *to-ko-do-mo*, see note 56).

[76] For the possibility that the term *wa-o* means double axe, see note 58.

[77] Lindgren 1973, II, 115.

[78] Support for this view is to be found in the lecture entitled 'Basket-weaving and mat-weaving in the economy of Akrotiri', given by M. Beloyianni to the conference 'Akrotiri, Thirty Years of Investigation (1967-1997)', Athens, 19-20 December 1997, the proceedings of which have not yet been published. Beloyianni reads the term as *μαλαθῆϐες* and connects it etymologically with *μαλάθες*, a type of basket (Προμπονάς 1993, 28-32). See also the interpretation of the female *ka-ru-ti-je-ja-o* (note 14).

[79] Lindgren 1973, II, 93.

[80] Τζαχίλη 1997, 71.

[81] Τζαχίλη 1997, 71.

[82] The verb *δέμω* is found in Homer with the meaning of build (Πανταζίδης, *s.v.* *δέμω*) (*Iliad*, VII 337; IX 349; VI 245, 249).

We have already encountered manufacturers of specific types of weapons, such as the *ka-si-ko-no*, the *pi-ri-je-te* and the *to-ko-so-wo-ko*. To these should also be added the *e-ko-so-wo-ko* craftsmen –that is, makers of spears– who occur on only one occasion in the Knossos archive, with no further information given about them, on a tablet, moreover, that is now lost (**KN Xd <299>**). The term is most probably to be connected etymologically with the word *ἔγχεα*, which is also recorded in the Knossos archive (**KN R 1815** + *fr.*), relating to 12 bronze spears (*e-ke-a ka-ka-re-a*). The meaning weapon-makers has been advanced for two other terms –*e-te-do-mo* and *e-to-wo-ko*. The etymological association of these with weapons (*ἔντεα*), however, is not the only one possible.[83] In Homer, the word *ἔντεα* means not only weapons but also vessels.[84] Moreover, why would the Pylos archive, in which both terms occur, use two different names for the same craftsman? Only one of the words is found at Knossos, where it is a *hapax legomenon*: in the tablet **KN Fh 462 + 2008 + 5470**, an *e-to-wo-ko* is recorded as one of the recipients of a quantity of oil of 4.8 kg. At Pylos there are 9 *e-to-wo-ko* craftsmen, recorded in two groups in the tablet **PY An 39**. It is not clear whether these include the *e-to-wo-ko* who receives barley (*HORD T* 5 *V* 1) in the tablet **PY Fn 79**. Our evidence for the term *e-te-do-mo* comes only from the Pylos archive, where two craftsmen with this designation are known, with their personal names *ka-ra-pi* and *a-tu-ko* also recorded. The former is found once in tablet **PY Ea 808** as the tenant of public land (*e-ke o-na-to pa-ro da-mo GRA* 1). The latter is recorded in three tablets: as a tenant of public land (*o-na-to e-ke pa-ro da-mo ke-ke-me-na ko-to-na*) in the tablet **PY Ep 301**, as a sub-tenant (*e-ke-qe o-na-to pa-ro wa-na-ta-jo*) in **PY Eo 211**, but the most interesting information relating to him is that in **PY En 609**, in which he also appears as a lessee of land (*o-na-to e-ke de pe-mo*), he is further qualified as *ἀνακτορικός* –that is, drafted in the service of the king (*wa-na-ka-te-ro*). The direct connection between *wa-na-ka* and weapons can be seen, according to Palaima, in the tablets from the Room of the Chariot Tablets, while the personal armourer of the *wa-na-ka* is probably associated with him by some kind of ritual relationship.[85]

In addition to the armourer and the fuller, the adjective *wa-na-ka-te-ro* is applied to one of the total of four *ke-ra-me-we* (*κεραμεῖς*) of the kingdom of Pylos. The potter in question is *pi-ri-ta-wo*, who is recorded as an owner of land (*ko-to-na ki-ti-me-na*) in two tablets (**PY En 467; Eo 371 [+] 1160**). Another potter is known by name –*qe-ta-ko*, who seems, like the fuller by the name *te-re-do*, to have delivered a goat or its skin (**PY Cn 1287**). The other two potters are recorded in the region *re-ka-ta-ne* in a tablet recording personnel (**PY An 207 [+] 360**). The term also occurs in the dative plural in a tablet from Mycenae (**MY Oe 125**), with no further details as to their number. At Knossos, by contrast, there is an indirect reference to the term in the form of the feminine personal name *ke-ra-me-ja*. The probability that proper names are derived from or related to occupations, as in modern times, has been discussed by Ilievski.[86] The eventuality that women worked in vase-making should not be ruled out, despite the lack of relevant evidence from the Classical period. The manufacture of indispensable items of household equipment seems to have been a female concern in many primitive societies, mainly because it did not require any great physical effort. In the case of the traditional pottery produced in early modern Greece, moreover, the master-craftsman-father who was the head of the workshop producing household pottery was always assisted by his wife, who was responsible for the decoration and

[83] For the other etymological interpretations and comments on them, see Lindgren 1973, II, 52-53.

[84] Πανταζίδης *s.v.* *ἔντεα*. Muhlestein bases his interpretation of the term *e-to-wo-ko* as 'Geschirrsattler' on this meaning of the word *ἔντεα* (Muhlestein 1955, 124).

[85] Palaima 1997, 411 (see also note 22).

[86] Ilievski 1987, 155-156.

for teaching the art to the children. The view that women were probably involved in pottery production has been discussed by Olivier, Åstrom and Sjoquist.[87]

The explanation usually offered for the fact that there are far fewer references than one would expect to pottery products,[88] and particularly to potters, is that the pottery 'industry' did not come under the direct control of the palace. This limitation on the power of the central authority may have been accounted for by various reasons: a) Ease of access to the raw material, which rendered palace intervention, and control in the case of loss, unnecessary.[89] b) The fact that the roots of pottery went back to very ancient practices probably enabled it to function without state control,[90] based on traditional mechanisms of a different kind. It might, for example, have been subject to direct control by the community itself in the form of the *da-mo*.[91] The lack of references to potters, however, is probably due to the very nature of pottery-manufacture. Speaking of pottery workshops in Old Palace Crete, McGillivray[92] suggests that for practical reasons they functioned on a seasonal basis, only during the summer months. The Mycenaean year began at the winter solstice.[93] Since the Pylos tablets correspond with archives covering three months, and since the destruction of the palace is placed in spring –the modern months of March and April[94]– the 'main' period of pottery-making activity would not yet have commenced. In this case, of course, we would expect there to be more evidence from the archive at Knossos, where the destruction of the palace is reckoned to have taken place after the end of July.

COMMENTS

Having now completed our exposition of the evidence for craftsmen, we find ourselves, as stated in the introduction, confronted with a 'labyrinth', though unfortunately not viewed from its centre. Nonetheless, a number of general observations can be made, with regard to:

1) The proportion of craft-specialisations by palace archive. Of the 52 craft specialisations, both male and female, to which reference is made, 35 are found in the Pylos archive (19 of these exclusively in this archive), 29 in the Knossos archive (9 of them exclusively here), 6 in the Mycenae archive (the *κυανουργοί* exclusively here), 3 in the Thebes archive (all three in connection with weaving), and only 1 in the Tiryns archive.

2) The numbers of craftsmen. Some information may be derived from the Pylos archive on the numbers of individuals occupied in particular specialisations. Weaving, for example, employed

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87 'Olivier, Åstrom and Sjoquist discuss in two letters exchanged in 1995 the eventuality of elder potters, male and even female, being ultimately employed as tablet kneaders in the Mycenaean palaces. The women potters could have worked along with their children, as is possibly suggested by the **KN Ap 639** tablet' (Kopaka 1997, 528, note 44.) See also the possibility that the term *ku-te-re-u-pi* (**PY An 607**; **Na 296**), if it is indeed an occupational name rather than an *ethnikon* or a place name (Lindgren 1973, II, 92), is connected etymologically with the word *χυτρεύς* found in Plato (*Republic*, 421 D) and therefore refers to women potters in tablet **PY An 607**.

88 The record of 180 stirrup jars in the tablet **KN K 778**, for example, is normally considered as intended to register their contents and not the vases themselves.

89 Tegyey 1988, 6.

90 Palaima 1997, 411.

91 Tegyey 1988, 7.

92 McGillivray 1987, 277.

93 Ruipérez & Melena 1996, 212-213.

94 Ruipérez & Melena 1996, 212-213.

a large number of craftswomen, in excess of 300 individuals. This number increases, moreover, when account is also taken of the 473 children who worked alongside them and were given half the adult ration.[95] Generally speaking, the various craftsmen recorded in the Pylos archive exceed 850 individuals on the most moderate of calculations, about 300 of whom, as we have seen, are *ka-ke-we*.[96] The corresponding calculations for the Knossos archive are more difficult, since numbers are rarely recorded or preserved after the name of the craftsmen. Nevertheless, in the case of weaving, a number of about 500 craftswomen may be calculated on the basis of the **Ak** series, to which may be added the individuals under training[97] included in this series.

3) The distinction between the participation of the two sexes in the productive process. What needs to be established here, of course, are the probably causes and above all the social consequences of this participation.[98] Craftswomen are known certainly to have taken part in weaving.[99] The view has been expressed, however, that the eventuality of women working in other sectors, such as pottery, cannot be ruled out.

4) The choice of occupational terms –that is, in the language of linguistics, the choice of an expression to determine a concept.[100] What rationale is followed in this selection? Accepting that 'there exists a conceptual material, a store of general concepts that form the raw material of which the content of every language is made up',[101] we find ourselves confronted with a notable phenomenon. The terms of the Greek craftsmen of the Late Bronze Age are derived etymologically: a) from the raw material with which they work, b) from the finished product they produce, c) from the process carried out or the tool used by the craftsmen during their work:

a) From the raw material with which they work. Table 1 includes the occupational terms that are derived from raw materials which are also recorded in the archives, whether or not in direct association with the craftsmen. We may also note that the terms *we-we-si-je-ja* and *du-ru-to-mo* are also connected etymologically with raw materials, though these are not known from the tablets.

Despite the high degree of specialisation of the Mycenaean economy, it is interesting to note that not all the raw materials mentioned in the tablets are matched by corresponding occupational terms. I refer by way of example to the use of metals whose processing and use are attested beyond doubt in the archaeological record. Three metals are certainly recorded as raw materials in the tablets –copper (*ka-ko - *140-AES*), gold (*ku-ru-so - *141-AUR*), and lead (*mo-ri-wo-do*). Silver (*a-ku-ro*) is also known, though only as a decorative material, unless we assume that the term *pa-ra-ke-we/pa-ra-ku-we* represents silver as a raw material. Finally, tin (*ka-te-ro*) is also probably attested.[102] This epigraphic and archaeological evidence for the above five metals is matched by two corresponding categories of craftsmen *–ka-ke-u/ka-ke-we* and *ku-ru-so-wo-ko*,

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[95] Ruipérez & Melena 1996, 152.

[96] Calculations of all the workers –not only craftsmen– who depended directly or indirectly on the palace of Pylos have been made by S. Hiller (1988).

[97] For the calculation of the number of women in the **Ak** series, and an analysis of the evidence relating to the teaching of weaving in the Knossos archive, see Τζαχίλη 1997, 272-280.

[98] 'Viable human populations need a division of labour according to age, sex and/or status differences, social ideas and prohibitions and of course their interaction' (Kopaka 1997, 525).

[99] See also the model that associates women's work with industry production, and men's with the presence of a chief master-craftsman and a craft hierarchy (Nordquist 1997, 525).

[100] Μπαμπινιώτης 1980, 126.

[101] Μπαμπινιώτης 1980, 126.

[102] See also note 56 for the term *ka-so*.

only the former of which are recorded together with the raw material *ka-ko*, while the latter are not found in association with gold as a raw material. Did these craftsmen work exclusively with copper and gold respectively? If so, to what level of the manufacturing process, compared with craftsmen who took their names from finished metal products (such as *e-te-do-mo* and *e-ko-so-wo-ko*)? Which craftsmen were responsible for working with the other metals? Comparison with the information to be derived from Homer is of interest at this point: in the Homeric poems no clear distinction is drawn between the coppersmith and the goldsmith,[103] and the god Hephaistos works with the equal ease with gold, silver, tin, bronze and even *κύανος*[104] in making the famous shield for Achilles. Should we therefore anticipate that the *ka-ke-we* of the tablets would be able to work with other metals as well as bronze? If so, how is the existence of the term *ku-ru-so-wo-ko* to be explained?[105] Answers to questions of this kind, relating not only to metalworking but to almost every sector of craftsmanship, might solve many problems connected with the degree of specialisation of the craftsmen of the period and, by extension, the issue of whether they were occupied full- or part-time, and the extent to which they were dependent on the palace.[106] The limited, uneven evidence available for the 'payment' of craftsmen makes no effective contribution in this direction.

Table 1. Occupational terms deriving etymologically from raw materials.

PRODUCTIVE PROCESS	OCCUPATIONAL TERM	RAW MATERIAL
Weaving	ri-ne-ja	ri-no
Tanning/Leather-working	di-pte-ra-po-ro	di-pte-ra
	wi-ri-ne-we	wi-ri-no
Decorative arts	ku-wa-no-wo-ko	ku-wa-no
Metal-working	ka-ke-we	ka-ko
	ku-ru-so-wo-ko	ku-ru-so

b) From the finished product they produce. Table 2 includes occupational terms derived etymologically from finished products that are also mentioned in the archives, whether or not in direct association with the craftsmen. There are, of course, many other occupational terms derived from finished products such as the terms *a-pu-ko-wo-ko*, *ka-ru-ti-je-ja-o*, *de-ku-tu-wo-ko*, *i-te-ja-o* and *i-te-we*, *to-ko-so-wo-ko*, *na-u-do-mo*, *ma-ra-te-we*, *ko-wi-ro-wo-ko*, *e-te-do-mo* and *e-to-wo-ko*, however, there is no corresponding record for these products in the surviving tablets.

[103] The goldsmith Laerkes (*Odyssey*, iii 425) is referred to a few lines later as a coppersmith (*Odyssey*, iii 432).

[104] Hephaistos was, of course, a god who was able to manufacture objects beyond the abilities of mortals (shield of Achilles, automatic tripods, metal serving-maids, and gold dogs), but in his person are encapsulated characteristics of the metalworkers of the period.

[105] For a probable answer to this question based on evidence drawn from the oriental sources, see Μιχαηλίδου 1997.

[106] On this subject, see Morpurgo-Davies 1979, who contrasts the greater degree of specialisation in the Mycenaean period with that of Homeric times.

Table 2. Occupational terms deriving etymologically from finished products.

PRODUCTIVE PROCESS	OCCUPATIONAL TERM	FINISHED PRODUCT
Weaving	ko-u-re-ja	pa-we-a ko-u-ra
	e-ne-re-ja	e-ne-ro
	o-nu-ke-ja	o-nu-ke
	te-pe-ja	te-pa
Perfume-making	a-re-pa-zo-o	a-re-pa-te
Manufacture of chariots	a-mo-te-wo	a-mo
	a-mo-te-re	a-mo
Cabinet-making	to-ro-no-wo-ko	to-no
Metal-working	e-ko-so-wo-ko	e-ke-a
	pi-ri-je-te	pi-ri-je
Decorative arts	a_3-te-re	a-ja-me-na

c) From the process carried out (*ra-pi-ti-ra*$_2$ and *ra-pte-re*) or the tool used by the craftsmen during their work (e.g. *a-ra-ka-te-ja*, *a-ke-ti-ra*$_2$, *e-pi-we-ti-ri-jo*).

All these craftsmen found in the tablets, with a greater or lesser degree of specialisation, dependent directly or indirectly on the palace, and accompanied exclusively or occasionally by a statement of their occupation, were not merely the motive power of the Mycenaean economy but at the same time the creators of the artistic tradition of Mycenaean civilisation. Who knows whether Mycenaean poets did not sing the praises of some of them, or whether their fame did not travel along with their frequently exported products?

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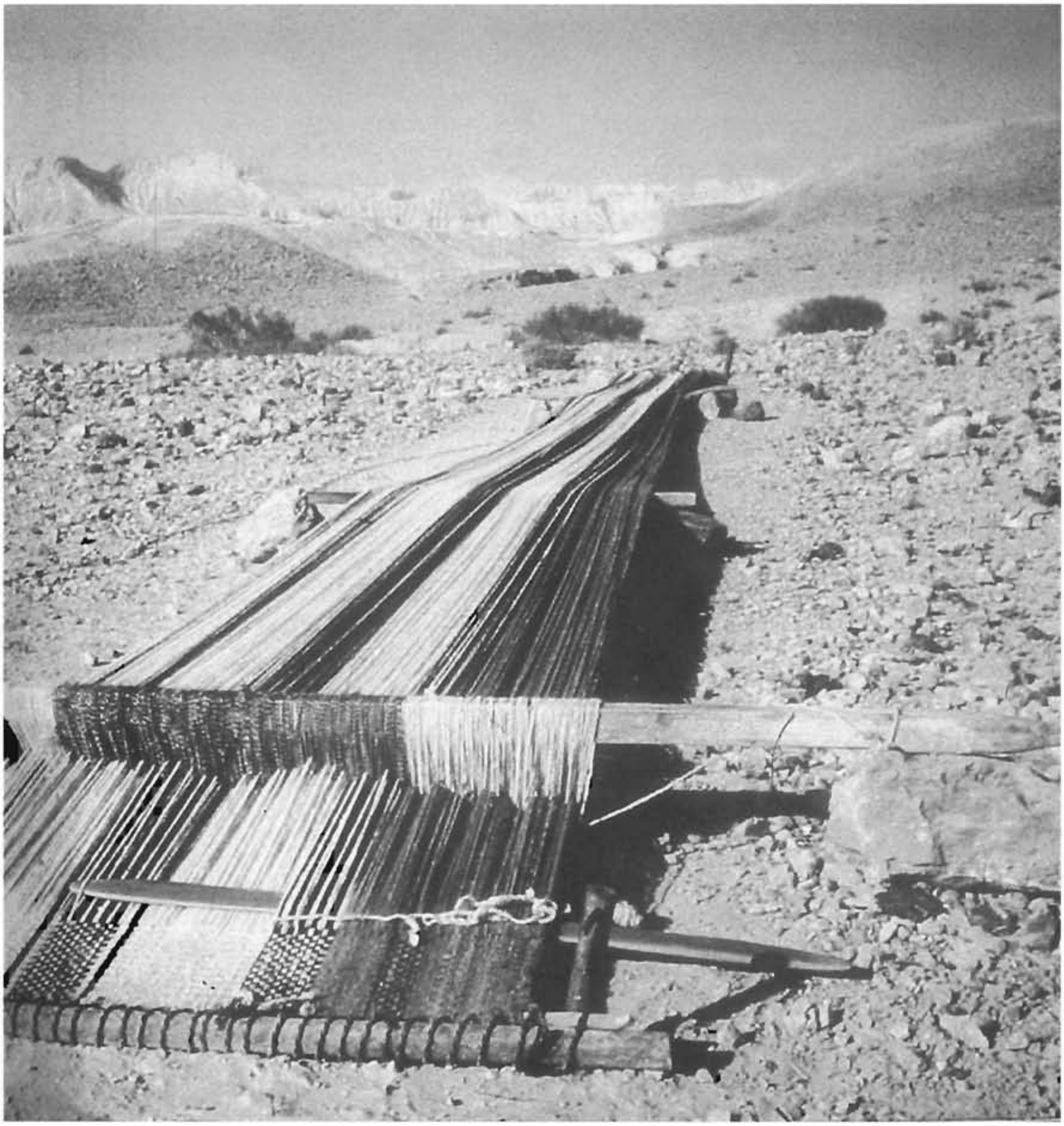

A horizontal loom still used by the Bedouins in the desert (after I. Τζαχίλη, *Υφαντική και Υφάντρες στο προϊστορικό Αιγαίο*, 1997, fig. 1). This was the earliest type of loom, also depicted in the wall-paintings of Middle Kingdom Egyptian tombs.

CIRCULATION OF TEXTILES IN THE LATE BRONZE AGE AEGEAN*

Iris Tzachili

From the very beginning I adopt a pessimistic view: that trade in textiles, or at least the greater part of it, lies on the invisible side of history, lost forever along with the overwhelming bulk of commercial exchanges that went unrecorded. Either because textiles, unlike metals or pottery, leave hardly any traces behind them, or because the little evidence that can be gleaned and that may be associated with the trading of textiles is susceptible of many different interpretations. Moreover, precisely because the form and manner in which this trading was conducted is unknown, the very concept of trade requires clarification and continuous confirmation.[1]

Trade in the Aegean and eastern Mediterranean has been at the centre of interest in recent years. Generally speaking, commercial exchanges, which were due to a variety of causes –the search for rare or essential raw materials, and contacts between the islands and the mainland, necessary to survival– have been thought to have created or at least significantly intensified the need to produce a surplus. This had the effect of strengthening the group that managed the surplus, thereby promoting and consolidating social differentiation and possibly leading to the emergence of the earliest forms of state. Commercial exchanges and trade are thus seen not simply as consequences of the production of a surplus, but as factors in the creation of the surplus. Social conditions, that is, play a role of decisive importance in all exchanges, in the transfer of goods from the producer to the consumer, and the exchanges may serve either as a means of attaining social equality, or as precisely the opposite –a means of consolidating social inequality.[2]

Attempts have been made recently to identify the place of origin of artefacts regarded as imports, to construct models on the basis of specific known examples (bronze, pottery), to measure the exchanges in quantitative terms, to use statistical principles in order to arrive at the original quantities from the evidence at our disposal, and to correlate these with distance from the place of origin.[3] The aim of these endeavours is to approximate the original quantity/volume not simply of one good, but of trade as a whole, for exchanges were made on the basis of barter, without using a coinage, and no one category of merchandise can therefore be considered in isolation from the rest. It is against this general background that exchanges involving textiles

* The present article was read at the 6th International Conference on the Prehistoric Aegean (1987), never published. A few essential additions have been made to the bibliography for the needs of the present volume. (For the translation of the Greek text I express my thanks to Dr D. Hardy).

[1] The definition of the content of the concept 'trade' and theoretical approaches to it have formed the subject of several collective works in recent years. See, e.g., Gale 1991 and Gillis *et al.* 1995, where the theoretical approaches are expounded and doubts expressed as to the concepts used.

[2] The most important of the studies I have consulted on the question of the mutual influences between social change and commercial exchanges are: Renfrew 1969, 151-159; Knapp 1985 and Earle 1985; Archi 1984, Rowlands 1973, and Lepore 1986.

[3] See, e.g., the study by Portugali & Knapp 1985; see also Cherry & Knapp 1991. For a criticism of these views see Catling 1991, and also Snodgrass 1991.

should be seen, since this is the only way in which it is possible to establish their extent and importance. However, surviving remains are to all intents and purposes non-existent in the case of textiles; all that we have to fill the gap are a number of indications that point to their existence and significance, but which certainly do not enable us to assess their quantity or the position they occupied in the overall trade cycle. Things become even less clear when account is taken of the fact that throughout the entire Classical period textiles were produced and consumed mainly domestically, with the possible exception of a few that belong to the category of luxury goods; this implies that the line between exchanges and domestic consumption is not always clearly distinguishable, like that between local and overseas trade.

In the Mycenaean period, moreover, to which our interest is confined since the scanty evidence at our disposal dates from it, the processes of social differentiation were quite advanced, state-forms had taken shape and, to complicate matters, weaving activity, probably with commercial implications, is apparent both in regions in which palace societies had evolved and in cities that fell outside the scope of such formations.

I now turn to an examination of the evidence available for the well-known palace centres of the Mycenaean world. The terms 'palace' and 'palatial' are used conventionally to mean the centralised administration.

For about the last fifty years, on the basis of the evidence of the Knossos archives, the production of wool and textiles has been regarded as a source of wealth for Crete and the Mycenaean palaces that was fairly certainly attested. The Knossos palace was apparently the centre of a huge flock-rearing enterprise. It assembled wool, made a detailed record of it, and distributed it to dependent workers, who returned it in the form of finished textiles. The mere numbers associated with wool-production are impressive: 1/5 of the total number of tablets found at Knossos refer to the rearing of flocks (**Dg** and **Dn** series). The number of sheep involved is about 100,000, and 30 tonnes of wool were delivered, with another 20 tonnes still expected.[4]

Efforts to interpret the evidence normally concentrate on the structural details of the system and the connections between the various stages in the processing of the wool. Occasionally, however, attention has also been paid to the likely recipients of the product. For whom were the textiles assembled by the palace intended? In order to answer this, we need first to answer another, preliminary question: whether or not the wool constituted a production surplus. That is, did the flocks and the production of textiles controlled by the palace constitute a surplus? Were they the part left over after the basic needs of the producers themselves had been met –the part taken by the palace either in the form of raw materials or in the form of labour? Or were they the total product? The usual view is that a necessary precondition for any form of trade is the existence of a surplus, or, if we accept that there is a mutual influence between the two, at least the objective capacity to produce a surplus. On the model of similar state formations in Mesopotamia, the interpretation usually offered is that the central authority, having assembled the surplus, itself assumes responsibility for various forms of exchange (redistribution of goods, gifts, mutual exchanges) in the context of a marketless economy, without the use of a coinage.[5]

[4] Killen 1964; Olivier 1967; Godart 1977. For a detailed bibliography on the subject, see Προμπονάς 1983, 95.

[5] The main proponents of these views are Polanyi (Polanyi *et al.* 1957), who based them mainly on Weber's work. A few years later, the corresponding Marxist theory was advanced by Diakonoff: he proposed the existence of two economic spheres –the collective sphere of the palace and sanctuaries, and the independent, free communities who controlled the communally owned land. This theory is in turn based on the much-debated concept of the Asian production mode. See mainly Diakonoff 1969. For a summary of more recent views and criticisms, see Archi 1984. See also Sjoberg 1995, 19-30, where Polanyi's views are applied to the Aegean.

If the wool and textiles of the Mycenaean palaces in fact formed a surplus, this would be consistent with the organisation of other sectors, the assembling of grains, for example, where we are clearly dealing with surplus production. If, however, the wool and textiles represent not a surplus but the total production, then the palace assumes responsibility not only for gathering the goods but also for their redistribution. In the case of the flocks of Knossos in particular, the number of 100,000 sheep for the area controlled by Knossos has been considered too large to be simply a surplus, especially when compared with the 400,000 sheep that were recently reckoned to be the total for Crete.[6] This huge number has been considered a regulatory reserve in case of emergencies.[7] If this is the case, trade in textiles is not out of the question.

Whether the wool and textiles assembled by the palaces represented a surplus or the entire output, the same question remains to be answered: for what were the palace textiles intended? The explanation advanced almost automatically to account for any surplus, is the desire to acquire goods of which there is a shortage –that is, for commercial exchanges.

At this point we should open a parenthesis. Textiles are not goods of the same order as wool or other raw materials. They are manufactured products in which have been invested, in addition to the raw material, many hours of labour, technical expertise, and specialisation. The exploitation of textiles is literally the exploitation of accumulated, specialised labour. Moreover, textiles are goods that endure over time for several generations and may be regarded as luxury items bearing a direct relationship to the social status of the person using them.

Let us now examine to what use the central authority might have put them. Some were redistributed to special groups living and working outside the household or the community, which were the primary units of production and consumption. Examples of such groups might be the army, or people who worked on boats, or specialist labourers, for whom the palace provided a livelihood in return for services. One group who received textiles in the palace of Knossos were the *e-qe-ta*, who were attendants on the king, possibly army officers. The textiles called *e-qe-si-ja*, after the name of their recipients, were possibly goods provided against services, or perhaps their uniforms.[8] This example is typical of the palace system of redistribution.

In the same **Ld** series from Knossos other textiles are described by the adjective *ke-se-nu-wi-ja (ξένιϜα)* –that is, textiles intended for foreigners. This is another use of palace textiles, at a different level, in the context of what are known to ethnologists as gift exchanges. In Homer, such a gift was a necessary and obvious consequence of any act of hospitality, and invariably entailed an obligation on the recipient to reciprocate the gift. Odysseus leaves the island of the Phaeacians with his ship loaded with goods –*ξεινήια* as Alkinoos calls them (*Odyssey*, viii 389)– amongst which are textiles. When he arrives on Ithaca he assumes the form of a stranger and tells his father about Odysseus' visit and the gifts he had given him many years before (*Odyssey*, xxiv 273):

'And I gave him gifts of friendship, such as are meet.
Of well-wrought gold I gave him seven talents,
and a mixing-bowl and all of silver, embossed with flowers,
and twelve cloaks of single fold, and as many coverlets,
and as many fair mantles, and as many tunics besides,
and further more women, skilled in good handiwork,
four comely women, whom he himself was minded to choose'.[9]

[6] Killen 1963, 50; Hiller & Panagl 1976, 129.

[7] Halstead & O'Shea 1982, 96-98.

[8] Deger & Jalkotzy 1978; see also Killen 1985, 264. For an interpretation of the adjective *e-qe-si-ja* as a type of textile, see Ruipérez & Melena 1996, 136.

[9] Homer, *The Odyssey*, with an English translation by A.T. Murray, vol. II, The Loeb Classical Library, Harvard University Press, 1966.

We know from the classic work on gifts by M. Mauss,[10] about the functional relationship between gifts and commercial exchanges in so-called archaic communities, and this relationship was identified and expounded in the case of Homeric society by M. Finley.[11] The relationship is treated more specifically and extensively in E. Benveniste's study on its linguistic forms.[12] The use of the word *ξένια* to describe palace textiles suggests the existence of similar exchanges in the circuits controlled by the palace; further support for this is provided by the fact that at Pylos, the same adjective, *ke-se-ni-wi-jo*, is used of certain quantities of olive oil.[13]

Or, finally, it might be assumed that the textiles assembled by the palace were exported to some distant, unknown, region outside the territory of the palace and that this accounts in part for the wealth of the Mycenaean palaces. In this case, exchanges based on textiles were not isolated but will have involved other goods and their price, or rather their exchange value, will have been determined with reference to all the goods that formed part of the specific transaction. A letter from Amarna, sent from Alasia to the Pharaoh of Egypt[14] lists the cargo of a ship heading from Egypt to Cyprus, which included ebony, various vessels, a chariot with gold decoration, horses, linen textiles, oil, silver, an ox, and aromatic oils. Similarly, evidence from the area of modern Boğazköy alludes to textiles along with various other products sent from the Middle East to Cyprus.[15] The Aegean and Crete are not mentioned anywhere in these cases. The value of this evidence for the subject under discussion lies in the comparison of textiles with the other goods exchanged.

One piece of evidence normally adduced in support of these supposed Minoan exports of weaving products[16] to which, however, a value *exempli causa* is atttributed, is that of the well-known Egyptian wall-paintings in tombs of officials of the 18th Dynasty depicting the Keftiu bringing gifts, mostly of vases but also including folded lengths of cloth.[17] These depictions have given rise to much debate as to their relationship with the Aegean and possible Mycenaean or Minoan influence, and doubt has recently been cast once more on whether they were Cretans.[18] What is not in doubt, is that the wall-paintings depict some form of exchange of textiles (gifts or trade) between Crete and Egypt. There was, however, an obstacle in the way of these exchanges: the nature of the textiles. Crete was primarily a wool-producing land, as is evident from the Linear B archives, and therefore inevitably exported wool. In Egypt, wool was surrounded by certain taboos: it was considered polluted, as is apparent from the unequivocal testimony of Herodotus, who tells us: «*Οὐ μέντοι ἔς γε τὰ ἱρὰ ἐσφέρεται εἰρίνεα οὐδὲ συγκαθάπτεταί σφι· οὐ γὰρ ὅσιον*» ('But nothing of wool is brought into temples, or buried with them; that is forbidden') (Herodotus II.81).[19] All the evidence suggests, moreover, that linen-production was widespread in Egypt and formed a major agricultural activity, as is also apparent from the wall-paintings.[20] We also have actual finds, of which the most famous is the balls of thread found at

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[10] Mauss 1923-24. See comments on later interpretations and criticisms by Sahlins 1972, chapters IV and V.

[11] Finley 1965, chapter III.

[12] Benveniste 1983, 315-326.

[13] Killen 1984, note 7, 264 and note 67.

[14] Knudtzon 1915, 278-299, letter no. 34.

[15] Knapp 1980.

[16] See, e.g., Renfrew 1972, 212.

[17] For the problem of the Keftiu and their identity, see mainly Vercoutter 1954, and Sakellarakis & Sakellarakis 1984; also Barber 1991, 330-357, Warren 1995, Shaw 2000, and Τζαχίλη 2000.

[18] See Strange 1980 and the criticism of it in Vincentelli 1984.

[19] *Herodotus*, with an English translation by A.D. Godley, vol. 1, The Loeb Classical Library, Harvard University Press, 1966.

[20] Vandier 1978, 58-80, 242-244.

Tell el-Amarna.[21] Woollen textiles did exist, then, but only for limited uses.[22] The woollen garments worn in Crete would probably have been useless in Egypt, therefore, and if textiles were in fact imported from Crete, it seems more probable that they will have been put to different kinds of use, perhaps covering walls and floors as tapestries or decorative screens, which were quite possibly made of wool.[23]

Whatever the case, the idea that Egypt was a recipient of Cretan surpluses is far from convincing and all efforts to identify evidence in Mesopotamia, where references to the Aegean occur before the 2nd millennium BC, have proved equally fruitless. In any case, wool was produced in abundance in the whole of what was called the fertile crescent, and it seems unlikely that there was a need for significant exports from so far afield.[24]

Where, then, did Cretan wool and textiles go? This issue must, I believe, be examined in connection with the form taken by trade at that period. Commercial practices depended on social relations in general, and this has been the principle underlying the main attempts at interpretation. The most important of these attempts has already been mentioned: exchanges were carried out by the central authority which assembled the surplus; they involved, that is, a kind of state monopoly. The debate usually revolves around how far the market could exist and function in a pre-monetary economy, and on an investigation of the role of the private merchant alongside palace-controlled trade. The great majority of commercial exchanges, however, took place in a context that differed from trade in the modern sense (involving profit, concurrence, etc.), on the basis of the redistribution of goods, mutual exchanges, etc. –that is, of the simple management of the surplus by the central authority.[25]

The second direction in which an interpretation is sought is not incompatible with the previous one. This is that alongside the central authority there was a category of private individuals working on their own behalf, who conducted long-distance trade, probably on the principle of the profit motive. This view seems to be the most widely held, particularly with reference to commercial exchanges between the Aegean and the Middle East.[26] Braudel's model is invoked, involving independent merchants conducting the carrying trade in the Mediterranean[27] mainly over short distances, and support for this is sought in the interpretation of archaeological sites as small trading posts for redistribution (Kea)[28] or prosperous towns that contracted for the right to conduct the trade of Crete (Akrotiri on Santorini).[29]

Very little evidence has been identified in the archives of Mycenaean Greece for the conduct of trade (and not, of course, simply of textiles), either by private individuals or by the palaces. Indications of trade with remote areas range from minimal to insignificant, at least as far as direct evidence is concerned. The subject has been treated at some length by Killen,[30] who sets out the possible reasons for this lack of evidence (trade is a marginal, seasonal activity and was therefore not recorded, or the record is not identifiable in the archives, or the tablets recording it have not survived), though he concludes that none of these explanations seems adequate or reliable.

[21] Lucas 1948, 146-147.
[22] Hall 1986, 10.
[23] Helck 1979, 23; Shaw 2000, 60-61; Barber 1991, 331-351; Cline 1995, 275.
[24] Klengel 1984, 12.
[25] Klengel 1984.
[26] Knapp 1985, 3-5; Renfrew 1972, 468-470; Kemp & Merrillees 1980, 276-278.
[27] Braudel 1972, 574-576.
[28] Davis & Lewis 1985.
[29] Doumas 1982.
[30] Killen 1985.

Exchanges, and not only commercial exchanges, were conducted on the basis of barter; they involved, that is, goods whose exchange value had been previously calculated. A possible example is furnished by tablet **Un 1322** from Pylos, where a specific quantity of wheat is exchanged for textiles –that is, a quantity of wheat is supplied as wages to craftsmen, one of whom is a weaver.[31] Exchanges that may reasonably be described as commercial and that include textiles are possibly recorded in the Pylos tablets **An 35** and **Un 443 + 998**, in which a quantity of alum (*tu-ru-pte-ri-ja*, *στυπτηρία*) is exchanged, again for specified quantities of wheat, wool and finished textiles. This is the first reference to commercial exchanges involving textiles. The interesting feature of the Pylos tablet **Un 443 + 998** is that the person with whom the exchange is made is described by the ethnic *Κύπριος (ku-pi-ri-jo)*. The same adjective also occurs in three tablets in the **KN Fh** series, **347**, **361 + 9069 + 9096 +** *fr.*, **371 + 5448**. It may therefore be assumed that these exchanges were conducted with someone from Cyprus, who will naturally have been a different person at Knossos and at Pylos but who will have come from the same island in both cases, and that on at least one occasion textiles, *inter alia*, were the object of the exchange. Textiles, of a specified kind moreover (*pu-ka-ta-ri-ja*), were sent from Mycenae to Thebes (**MY X 508**). The person who conducted the exchange, or assumed responsibility for it, or on whose behalf it was conducted, who is called *ma-ri-ne-u* in **MY X 508**, is also found at Thebes in tablets relating to textiles.[32]

There is also some evidence from the coast of Syria and Palestine: Crete is mentioned in a list from Mari recording deliveries of tin to various people, one of whom is from Crete. The exchange took place at Ugarit. Unfortunately, we do not know the item for which the tin was exchanged.[33]

The evidence from the Mycenaean archives relates to exchanges centred on the palace. The palace system, however, did not cover the whole of the Aegean, and the most common archaeological evidence for weaving activities –loomweights and spindlewhorls– is usually found in ports in regions outside the immediate control of the palaces, on Kea,[34] Melos,[35] Thera,[36] Kos,[37] and Kythera.[38] There is similar evidence, albeit in smaller quantities, from mainland Greece (e.g. Nichoria)[39] and from Crete, where again it is found in ports as well as at the palaces themselves (Knossos, Malia), though in this case at ports controlled by the palaces, such as Zakros,[40] Amnisos[41] and Kydonia.

This fact is not particularly remarkable. It could very easily be attributed to the chance element in excavations or to the interests of the excavators. It acquires interest, however, in my opinion, when combined with other evidence. It may not be fortuitous that the women recorded at Pylos (**As**, **Ab** and **Ad** series), who were probably occupied in weaving occupations, are invariably natives of ports, coming from Knidos, Chios, Miletos, Lemnos, Asia (Lydia) and Zephyria (Halikarnassos).[42] Whatever their status, whether slaves or simply paid dependent

[31] Chadwick 1964; Duhoux 1976, 130-134.
[32] Killen 1985, 269. For a different interpretation, see Ruipérez & Melena 1996, 190.
[33] Klengel 1984.
[34] Cummer & Schofield 1984, chapter VII.
[35] Atkinson *et al.* 1904, 213ff., pl. XXXVIII; Renfrew 1985, 330-332.
[36] Marinatos 1969, pl. 39; 1971, pl. 50; Doumas 1983, 117, pl. 81; Τζαχίλη 1997, 183-193.
[37] Morricone 1975, 279, fig. 240.
[38] Coldstream & Huxley 1972, pl. 59, 11-16.
[39] Carington-Smith 1992.
[40] Πλάτων 1982, pl. 150.
[41] Αλεξίου 1955. For weaving activities at Amnisos in the Mycenaean documents, see Hiller 1982, 59.
[42] Killen 1984, 55-57.

workers, whether they came as prisoners of war or in some other way, we know with certainty that they were specialised weavers, that they were born in ports, and that it was in these ports that they learned and practised their art.

Roughly the same picture emerges from the Homeric poems. Here, too, the women who worked on the loom live in or come from ports: they include the women of Sidonia, captives at Troy, who wove the 'highly decorated peplos' offered to Athena by the Trojan women (*Iliad*, VI 289-295), the women of Phaeacia, who were as expert at weaving as their menfolk were at sailing (*Odyssey*, vii 108-111), and the women of Lesbos (*Iliad*, XI 270-272). Though it cannot be claimed to constitute proof, this evidence, when taken together, points to the main places for exchanges in the Aegean, the ports. Weaving production seems to have been concentrated here, where goods were loaded and agreements concluded. The products that served either as merchandise or as an exchange unit for other luxury goods or much-needed raw materials were made on the spot, without the need for transportation costs.

How far were these exchanges part of the trade carried on by the palaces? For it is reasonable to assume that the palace would have attempted to control them. My impression is of two circuits which, while overlapping were nevertheless distinct. In all probability, the trade in textiles was associated with other goods, since in the absence of coinage, the only way in which trade can have been practised is through barter in goods and –why not?– services. In this situation, it could have been conducted in parallel with and independently of the palace system of collection and concentration. The monopoly in wool production exercised by the palace of Knossos, the corresponding training programme in the art of the loom recorded in the **Ak** series, and the attempts of the palace of Pylos to procure, perhaps by violent means, the specialist women weavers it needed from distant places and organise the production of textiles, all seem to me to reflect the efforts of the palaces of the Mycenaean period to intervene in sectors that had previously functioned autonomously and independently of them.

As for the geographical destination of the goods, this should be imagined as being within the Aegean. It may be no coincidence that the only tablet mentioning commercial exchanges of textiles mentions exchanges of this nature that took place between Thebes and Mycenae. Long-distance trade in textiles seems improbable, at least on a large scale. The exchanges that did take place were of luxury goods and similar items, which were exchanged for items such as ivory, precious stones, etc.

Finally, it should be recalled that we are dealing with a period of intense social differentiation, in which clothing, above all else, served to make social differentiation visible and functioned as a signifier of individual status, as can be seen from the wall-paintings. Textiles, the most obvious of the visible elements emphasising social differences, were possibly one of the consequences of social stratification in the New Palace period, and in turn contributed to further differentiation and the intensification of these differences.

Despite the fact that weaving was never on the cutting edge of technological advance, capable of influencing social change, the undisputed exchange value of the textiles and their symbolical charge, which seems to have been of some importance given their significance in various rituals, assisted in the process by which textiles, as merchandise with added value and as signal/token/signifier of the privileged status of their owners, contributed to the consolidation of the inequality of social relations.[43]

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[43] Τζαχίλη 1997, 22-25.

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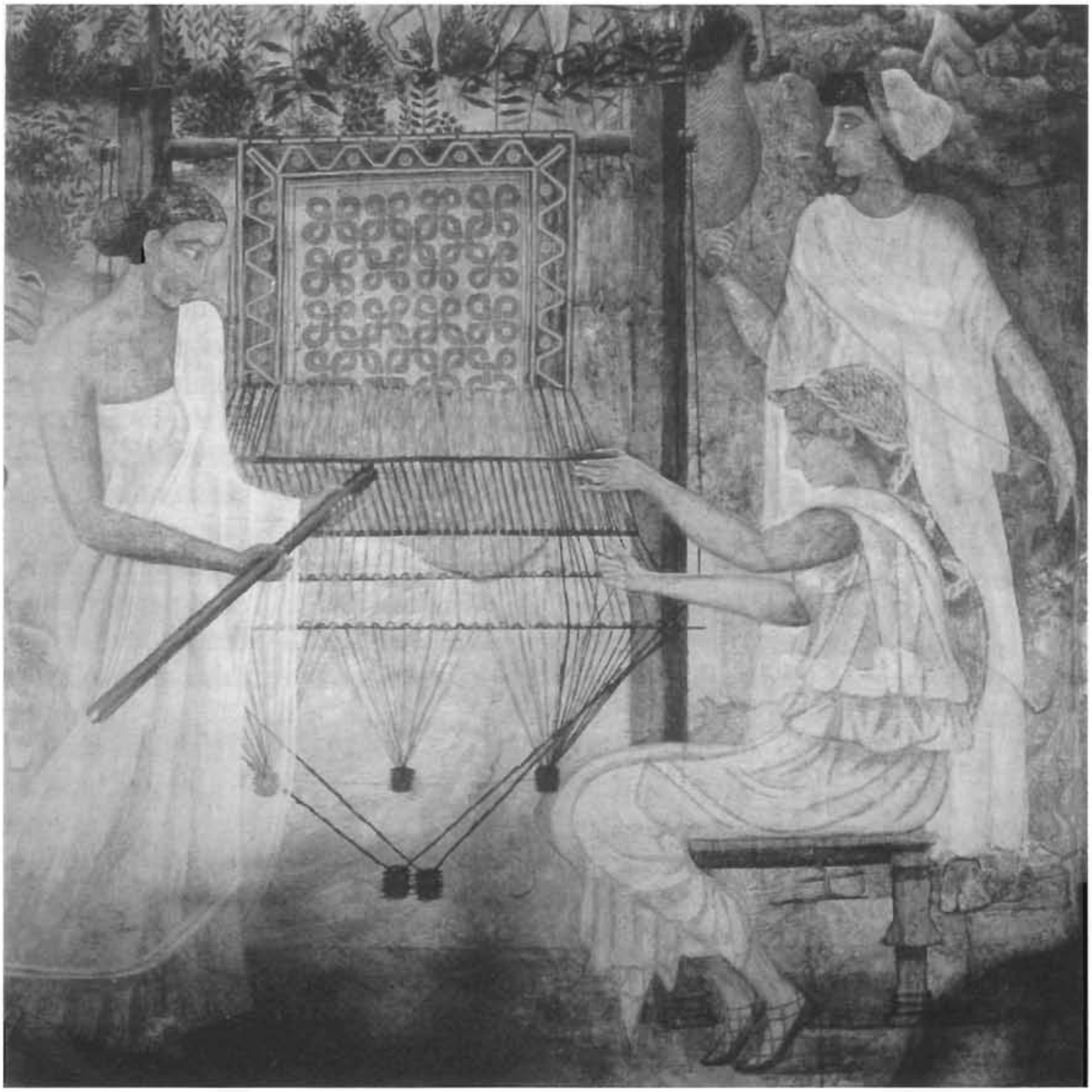

Wall-painting with women weaving and spinning in Alexandria (restored); Museum of the Diaspora in Tel-Aviv (after J. Mélèze-Modrzejewski, 'Une judaisme d'expression grecque', *Le Monde de la Bible* no. 111, 1998, 62).

COUNTING AND RECORDING TEXTILES IN THE MYCENAEAN ARCHIVES OF KNOSSOS*

Iris Tzachili

The purpose of this article is to attempt to study the quantities of textiles recorded in the archives of Knossos and assess them in their historical context. The major obstacle to this endeavour is the fragmentary condition of the archives, to which I shall return below. Before turning to a consideration of the evidence, however, I would like to enumerate a number of factors and preconditions that are inherent in any assemblage of objects, and may therefore be regarded as given in the present case. Recollection of these considerations at this point may perhaps help us to arrive at a better evaluation of the quantitative data.

The concept of quantity, or rather quantification, which is the subject of this volume, is associated with a number of concepts.

A. The nature of the product. In itself, quantity is a neutral, abstract concept. It does not mean very much in isolation, but gains significance from the product that is accumulated, and which is totalled and quantified. The fact and practice of accumulation, which is not the same for every kind of product, the way in which this act is perceived and expressed, and the nature of the inevitable abstraction of this practice as a concept so that it is valid for many similar instances, all depend entirely on the kind of product accumulated. Quantities of wheat or oil or other agricultural produce differ radically from quantities of textiles, which have already undergone a manufacturing process. Everything –the entire fact and practice of accumulation– is different. The goods are calculated differently, measured differently, and stored and transported differently. The act of accumulation, different for each product, is carried out in a different manner, involving different steps, different vessels, and a different rationale. This is why quantity is expressed in so many different ways.

B. The principles of accumulation, that is, the criteria by which different categories are differentiated. The act of accumulation is based on principles of similarity and difference. That is, some products are considered to be similar and are added together, while others are different and are counted and measured in different categories. The act of grouping has a number of interesting aspects. There are, of course, some obvious distinctions: weapons, textiles, vessels. Even with similar products, such as textiles, categories are established that reflect quality, and also specialisation, commercial relations, division of labour, geographical distinctions, and ways in which the textiles are handled (see below). The criteria used in grouping products together reflect the social reality, the material requirement of the product in question, and the demands of processing.

C. The purpose. The existence of a quantity of similar products implies that they were gathered together for some purpose. Two such purposes commonly apply. One is to achieve the aim of self-sufficiency, to create a stock, either at the individual level, or at the collective level of

* I wish to express my thanks to Dr David Hardy for the translation of the Greek text.

the community (through taxation, for example).[1] The other is for purposes of exchange, whether conducted within the community or areas under its control, or further afield, possibly involving middlemen who shouldered the financial risk and can therefore be called merchants.[2]

D. The place. Any accumulation presupposes provision for a place in which the products can be accumulated –that there are storerooms and the appropriate storage vessels. Storage of products involves a sequence of related activities: the steps that need to be taken, such as measures to preserve the products (ventilation, temperature, removal of insects and bugs) and to secure them (sealing systems). All these are normally visible to the archaeologist and constitute the aspect of accumulation that leaves most trace, in the form of vessels for transportation and storage, special storerooms in and outside the house, cupboards, sealings, etc.

E. Time. This is a very important factor that tends to be overlooked. Quantity is ephemeral. It continually changes. It increases with the new harvest or new deliveries, is subject to consumption on a daily basis, is exchanged, and never remains the same. Measurement is therefore also ephemeral and must constantly be repeated.

F. The act of measuring presupposes exchanges. In itself, it is a strong indication that the producer is not the same as the consumer or user. People rarely count goods if they produce them for their own consumption. They can normally tell at a glance if they have enough or need more. The fact that they measure them means that they have to calculate correspondences and the goods are therefore intended for exchange. These exchanges can be of all kinds. Either equal and freely entered into, like those that take place on a daily basis through barter, sometimes in the context of a small community though more often in larger villages of towns. Or unequal and obligatory, as in centralised communities, where the exchanges may take the form of taxation or *corvées*. Why should a count be made of how many textiles there are in the palace storerooms, if commercial transactions have not already taken place or are anticipated? Or if a record is not to be made of an allocation, a delivery, or the payment of some debt? Goods that are exchanged or taxẹd include services and the work of weaving itself, as is evident from the **Lc** series of tablets (see below). There is no reason for counting or measuring except as proof that exchanges have been properly carried out.

G. Measuring requires a numeral system. This in turn presupposes the attainment of abstract thinking, a fully developed number system, and means of measuring. The way in which the Linear B number system was recorded resembles that of Linear A. In all scripts, digits are formed and evolve independently of the phonetic system that determines the written version of the spoken word, but which does not influence the recording of numbers in the form of digits.

I. It follows from the above that quantities are of interest even when they are not exhaustive, and our interest is not confined exclusively to such cases. In any event, whether absolute or relative, it is invariably in the context of their relation to something else that their interest lies. The purpose of historical research is usually to determine what this something else is. The quantities of textiles in the Mycenaean archives, for example, are only interesting if they can be compared with something else, such as the output of another region. It is also only through comparison that it becomes clear whether the products quantified represent a surplus, and whether we can discern social relations from comparison of the numbers. Only in this way do they acquire historical interest. Even in the case of the **Lc** and **L** series, for which Killen[3]

[1] The question of the importance of a reserve stock to meet emergency needs as a significant factor in the development of the accumulation of goods by palaces has been dealt with by Halstead & O'Shea (1982), and by Halstead (1992).

[2] See previous chapter by Tzachili in the present volume, with the relevant bibliography.

[3] Killen 1966.

successfully identified absolute values for certain pieces, which are repeatedly recorded in both series, the interest of the exercise lies not in the absolute numbers but in the fact that the same lot is registered in two different records, which sheds light on the manner in which production was organised. That is, the numbers serve here not to define the quantity in absolute terms, but as an element of identification.

Comparison with quantities of another product with which the given product is exchanged can be even more important, since this reveals its economic value, a historically defined magnitude. Sometimes the numbers reveal differences in production between workshops or areas, or differences in quality, kind, and the amount of raw material required. Difference may also emerge in the output from year to year, or in comparison with other periods. All these are subjects whose interest lies in quantitative comparisons; accordingly, even if the surviving evidence relating to quantities is incomplete, it can still be considered strongly indicative because of its comparative nature. As we have already noted, the measuring of quantities provides us with numbers which have no special properties in themselves, but acquire them only in combination with other numbers.

I now turn to the specific difficulties surrounding the subject of this article. The assessment of the quantities of textiles recorded in the Knossos tablets is faced with two basic difficulties, two unknown factors.

1. The fundamental question whether all the tablets have survived. Probably not. Unfortunately, we do not even know the approximate proportion of the archives preserved, or whether this was uniform in all cases. In other words, is the proportion of the surviving tablets relating to sheep in the **D** series the same as that relating to textiles in the **L** series? Again, probably not, but it is any case difficult to decide. This holds good for the entire cloth-making process. Moreover, the surviving tablets are themselves not complete, but are preserved in fragments, often with some of the words missing along with numbers or parts of numbers. For these two reasons, it is difficult to come close to the original quantity. Various efforts have been made to investigate the internal structure of the archives and the internal logic of the recording system that reflects the way in which products were accumulated. In the case of the **L** series with which we are concerned, Killen has attempted to identify the internal relationship between the various records relating to textiles on the basis of the quantities and the scribes.[4] Fortunately the sample is a fairly large one and there are grounds for asserting that even if we cannot approximate the original quantities, the numbers preserved may be regarded as representative of the proportions.

2. The unavoidable question is what proportion of the total output is recorded in the archives. Was this the entire output or only the surplus that was accumulated by the central administration through some kind of exploitation? The matter has been considered in connection with less fragmentary series of tablets, such as **Da** and **Dg**, which record flocks of sheep and goats. The number of animals recorded in the tablets is about 100,000. Killen considers the number too large to be only a proportion of the output accumulated by the palace, as suggested by Ventris and Chadwick.[5] One argument he adduces is that in the 1927 census, 400,000 sheep were recorded in Crete as the total flock of the island. How can a number as large as 100,000 –that is, one quarter of this figure– represent the palace flocks?[6] Whatever view one takes of this, what is valid for one product is not automatically the same for another. Factors differentiating between products come into play, such as their economic value, their exchange possibility, the way in which production is organised, the domestic needs of different communities, and so on.

[4] Killen 1966.
[5] *Documents*, 179.
[6] Killen 1963; Hiller & Panagl 1976, 129.

3. Even if we had full knowledge of these two factors, our conclusions would still be uncertain, since account has also to be taken of geographical area and time. Various hypotheses have been advanced with regard to the geographical area that came under the administration of the palace at Knossos,[7] but it is my opinion that the area covered by the output of the textiles recorded remains an open question, in the same way that we cannot know the size of the flocks. Time is a more secure factor, since it is generally considered, on the basis of the frequent repetition of the adjective *pe-ru-si-nwa* –that is, 'of the previous year' (**Dp 7742, So 4442** + *frr.*), that the archives reflect a stock-taking for one year, that is, the year in which the product is recorded.

It is evident from the above that absolute numbers are difficult to calculate, and are in any case of little interest if they are not seen within the context of other historical factors. In the case of the **Lc** and **Ld** series, absolute numbers have been established[8] through calculation and have been used as a basis on which to demonstrate that the same textiles are recorded in different ways at different stages of their processing; even here, however, interest focuses not so much on the numbers but on the demonstration of the fact that the same lot is recorded twice. For this reason, we shall concentrate on the numerical proportions between different kinds of textiles and the manner in which they are recorded, hoping that they may shed light on some of the basic questions posed above.

The grouping of the textiles counted is made on the basis of their ideograms (Table 2).[9] These consist of vertical rectangular shapes with different numbers of vertical lines at their bottom edge and a distinguishing sign, usually a syllabogram, set within the rectangular surface. We therefore have good grounds to conclude that the ideograms represented rectangular pieces of unknown dimensions, and are of the same shape as the textile when it came off the loom. The lines at the bottom probably indicate the warps hanging from the textile before they were cut and the piece finished. Their number is possibly connected with the density of the fabric,[10] but might also indicate its width, which would be of great importance for the textile's value and therefore of great interest for the record. Minoan textiles were woven on a vertical warp-weighted loom, and their length will have ranged between about 2 and 3 metres.[11] They can easily be counted by the piece.

In the catalogues that follow, all the textiles have been counted, including those recorded in recapitulatory tablets.[12] Not included are records of textiles for which, though the ideograms are recorded, the accompanying number is missing, since this would destroy the ratio of number of entries to number of textiles.

Lc Series

A characteristic feature of this series is the combination of reference to textiles and wool (ideograms *TELA* and *LANA*). The records relate to a decentralised production of textiles. In addition to Knossos, weavers were active at various sites, producing textiles that were delivered in finished form to the central authority. The series was described and analysed by Killen,[13] who

[7] Chadwick 1976, 48-60; Ruipérez & Melena 1990, 106-113; Bennet 1988, 1990.
[8] Killen 1966, 1979.
[9] Palmer 1969, 8-17; *Documents*, 48-53.
[10] Melena 1975, 79-81.
[11] Τζαχίλη 1997, chapters IV and V; Barber 1991, 91-115.
[12] I had some reservations about this method, since it is quite likely that I counted the same textiles twice. I thought, however, that it was the best method for statistical purposes, since I would in any case be unable to attain absolute numbers. A similar method is used by Killen (1963).
[13] Killen 1966, 1974.

made the necessary correlations with tablets in other series. The combination of the records for wool and textiles on the same tablets has been interpreted in two different ways. Either these were simultaneous deliveries of wool and textiles to the central authority and were recorded on the same tablets, possibly because they came from the same region. Or the administration provided weighed wool to the weavers, which the latter then processed and delivered when finished in the form of various kinds of textile.[14] This would account for the recording of both wool and textiles in the same tablets. An element that supports the latter view is the word *ta-ra-si-ja*, *talasia* in the recapitulatory tablets **Lc(1) 536 [+] 7383 + 7731** and **Lc(1) 535 + 538**. The word *talasia* means the practice just described: the delivery of a weighed quantity of raw material to workers, who return it in the form of finished products.[15] The **Lc** series in particular sheds light on the function of *talasia*. Given that the quantities measured were for a single year, and given the quantities of wool and textiles, which are rather limited, it appears that the weavers working within the *talasia* system did not come exclusively under the palace administration and did not work solely for it. They were merely obliged to weave a given quantity of wool each year. *Talasia* was a kind of compulsory labour, a kind of tax payment in the form of work, possibly rather like the obligatory labour or *corvée* attested for Near Eastern civilisations. The scribes of the series are: the scribe 103, who specialised in the recording of textiles,[16] and the scribe 113 in combination with the scribe 115, who frequently completed, on the *verso*, entries started by 103.

The numbers of the textiles are grouped by ideograms (shown in Table 2). The *TELA* ideograms are rendered specific by various words or abbreviations that preceded them. The order in which they are discussed here begins with the simplest entries, that is, plain ideograms, and moves on to the more complex ones, which have a greater number of determinatives. The number of vertical lines beneath the rectangle of the ideogram is also noted. See also the final table giving the number of pieces and entries (Table 1).

1. *TELA*, with no further qualification and with differing numbers of lines beneath the rectangle.[17] The total quantity of textiles defined in this way is 145 pieces, distributed amongst 7 entries. To these should be added the recapitulatory **Lc(1) 536 [+] 7383 + 7731**, which refers to 200 pieces accumulated through the *talasia* system.[18] The total number of pieces is thus 345, which is quite large, especially in proportion to the number of entries. The lines at the bottom vary in number, so the textiles are of differing densities or widths.

2. *pa-we-a TELA*. The ideogram *TELA* is made specific by the addition of *pa-we-a*, which precedes it and is thought to be the Homeric word *φάρος* (cloth, cloak).[19] The number of pieces is at least 82, though there are only three entries. It is thus large in proportion to the number of entries. The distinctive feature of the group is the presence of more than one line at the bottom edge of the ideogram –three on two occasions and four on one. These textiles were therefore

[14] *Documents*, 315.

[15] Duhoux 1976, 69-115.

[16] For scribe 103 and his methods of working, see Landenius-Enegren 1995.

[17] Tablets **Lc(2) 483** + *fr. TELA* with three vertical lines and recording 26 pieces, **Lc(1) 552** *TELA* with one vertical line and the number 1 piece, **Lc(1) 557** *TELA* with one vertical line and recording 80 pieces, and in the same tablet, second line *TELA* with one vertical line and recording 7 pieces, **Lc(1) 582** *TELA* with no clear indication of vertical lines, and the number 30, **Lc 7394 + 8684** *TELA* with two vertical lines and recording 1 piece.

[18] According to Olivier, this was the recapitulatory tablet for all the entries for which the collector was not responsible (Olivier 1967, 91).

[19] Tablets **Lc(2) 481** *TELA* with three vertical lines and 30 pieces, **Lc(2) 581** *TELA* with four vertical lines and 40 pieces, **Lc(2) 7377 + 7385 + 8016** ideogram *TELA* with three vertical lines and 12 pieces.

either densely woven or very wide or both. There is an apparent tendency to count in tens. The word *φάρος* does not render the general idea of textile or garment, but means a specific kind.[20]

3. *pa-we-a ko-u-ra TELA*. The words *pa-we-a ko-u-ra* precede the ideogram *TELA*. The meaning of *ko-u-ra* is unknown, but the term *ko-u-re-ja*, which occurs in the same series, indicates an occupation, a person who produces *ko-u-ra* textiles. One interpretation suggested is that it is the word *κουλα*, a variant of *κοῖλα* meaning 'short'.[21] A feature of these ideograms is that they all have only one vertical line. I believe that this is possibly associated with the interpretation offered for the term. *ko-u-ra* textiles are possibly *κοῖλα* in the sense of delicately woven, a textile that may be draped, for which the warps, possibly indicated by the single line, are widely set. There is reference to 459 textiles, the largest number in the series, in 6 entries.[22] The number of textiles in tablet **Lc(1) 7392 + 7398** is enormous. The same tablet records the name of a collector *we-we-si-jo* and the large number of textiles is an indication of the importance of his office.[23] The usual ratio of textiles to wool in this category is 3:5; they were, that is, much lighter than the textiles described as *tu-na-no*, or with the ideogram *TELA+TE*. This, too, is consistent with the interpretation of the term *ko-u-ra* as *κοῖλα*, light, needing only a small quantity of wool.

4. *pa-we-a ko-u-ra *161 TELA*. This very small category of entries for textiles has all the features of the previous group and is further distinguished by the addition of the second ideogram **161*, which precedes the *TELA* ideogram. The precise significance of **161* is unknown, but it is probably associated with coloured textiles. It occurs three times. In the two instances where the number is recorded, there are 15 pieces in one case (**Lc(1) 531 + 542**) and 10 in the other (**Lc(1) 534 + 7647 + 7818**) –both of them numbers divisible by five. A total of 25 pieces is thus recorded. On both occasions there is just a single vertical line at the bottom of the *TELA* ideogram, as in the previous category which is qualified by the term *ko-u-ra*. An attempt is made below to interpret the meaning of the ideogram **161*.

5. *tu-na-no TELA*. This is the most homogeneous category. The ideograms in all the entries[24] have a single line, with the exception of **Lc (1) 558**, which has two. The recapitulatory tablet **Lc(1) 536 [+] 7383 + 7731** records 48 pieces. The total is 88 textiles in 17 entries. The features of this group are the constant ratio of 1:3 for textiles to wool[25] and the fact that the *TELA* ideogram invariably has a single vertical line. The numbers of pieces are all low –1, 2, 3 and on one occasion 6. An exception is formed by **7392 + 7398**, which records 10 pieces and possibly even more, for the tablet is broken immediately after the number. This is the tablet associated with the collector *we-we-si-jo* in which the large number of 240 *pa-we-a TELA* is recorded, a feature that argues in favour of the great importance of the collectors in the administration of Mycenaean palaces. The final shared feature of this group is that the entries for *tu-na-no TELA* are invariably in the second line. All these characteristics led Palmer to suppose that this may

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[20] Killen 1979, 153; Melena 1975, 43.

[21] Ruijgh 1967, 251.

[22] **Lc(1) 530 + 7384** with 40 pieces, **Lc(1) 532 + 554** with 16 pieces, **Lc(1) 540 + 8075** with three pieces, **Lc(1) 551 + 5507 + 7397** with 110 pieces, **Lc(1) 553 + 7379** with 50 pieces, **Lc(1) 7392 + 7398** with 240 pieces.

[23] For the importance of the collectors, see Bennet 1992, who summarises earlier views. See also Killen 1995.

[24] **Lc(1) 525** with 3 pieces, **Lc(1) 526** with 3 pieces, **Lc(1) 527 + 7143 + 7331** with 2 pieces, **Lc(1) 528** with 1 piece, **Lc(1) 530 + 7384** with 3 pieces, **Lc(1) 532 + 554** with 1 piece, **Lc(1) 534 + 7647 + 7818** with 1 piece, **Lc(1) 551 + 5507 + 7397** with 3 pieces, **Lc(1) 553 + 7379** with 2 pieces, **Lc(1) 558** with 1 piece, **Lc(1) 582** with 6 pieces, **Lc(1) 646 + 662 + 6015 + 8517** + *frr.* [+] **5875** with 1 piece, **Lc(1) 5746** with 2 pieces, **Lc(1) 7289 + 7395** with 1 piece, **Lc(1) 7392 + 7398** with 10 pieces.

[25] Killen 1966, 106.

have referred to fabric that the worker was allowed to weave for herself,[26] presumably from the wool provided by the palace. This, of course, conflicts with the entire *talasia* system as set out above. Moreover, Killen notes that on a label from Knossos (**Wb 8711**) the word *tu-na-no* occurs together with the term]*o-a-pu*-[(= *ἀπόδοσις*?), which implies that the textile *tu-na-no* was delivered somewhere.[27]

6. *TELA+TE*. The textiles recorded by this ideogram form the largest category of the series and have the largest number of entries. A total of 222 pieces is registered in 17 entries. Special reference should be made to **Lc(1) 525** which has three vertical lines beneath the ideogram and 40 pieces, the largest number in the category with the *TELA+TE* ideogram. The large number of pieces on this tablet is probably connected with the description of them as *wa-na-ka-te-ra*, which has been interpreted as meaning those that belong to the king, the *ἄναξ*. The ideograms for the other entries have two vertical lines[28] or only one,[29] and in two cases the ideogram has no vertical lines at all.[30] Finally, it is worth noting that in one case (**Lc(1) 646 + 662 + 6015 + 8517 +** *frr.* **[+] 5875**) the abbreviation *re*, with 1 piece, is added before the *TELA+TE* ideogram. The recapitulatory tablet **Lc(1) 536 [+] 7383 + 7731** refers to 267 pieces, and the ideogram has two vertical lines. The number 222, added to the 267 of this last tablet, gives a total of 489. One interesting feature is that the ratio of finished textiles to wool is 1:7, implying that they are textiles requiring a lot of wool, either because they are large, or more probably because they are thick. Killen believes that the syllabogram *TE* in the centre of the rectangle of the ideogram *TELA* is an acrophonic abbreviation for the term *te-pa*,[31] and that these textiles are therefore produced by weavers described as *te-pe-ja*. Duhoux suggests the reading **σ(τ)έρφα*,[32] a fabric with the texture or appearance of sheepskin. Similar textiles with projecting loops are called *φλοκιαστά* in modern Greece and require a great deal of wool. Fabrics of this kind are depicted in Mycenaean wall-paintings.[33] The same ideogram also occurs in the **Le** series, and twice in the **L** series (see below).

7. *pe-ko-to TELA+TE*. This occurs twice (**Lc(1) 526** with 10 pieces and one vertical line and **Lc(1) 527 + 7143 + 7331** with 2 pieces and, again, one vertical line). To these should be added **Lc(1) 551 + 5507 + 7397**, in which the acrophonic *pe*, probably for *pe-ko-to*, is added before the *TELA+TE* ideogram. The total number of pieces is 14. The word *pe-ko-to*, *πεκτόν*, is associated with the verb *πέκειν*, to comb.[34] If the interpretation offered above of the *TELA+TE* textiles is correct, that it renders textiles with loops, the addition of *pe-ko-to* means additionally that these *pe-ko-to* textiles were further processed and were 'combed', that is, they were given a smoother, downy texture, rather like modern towels, or possibly velvet. They will certainly have been more valuable, which may account for their being fewer in number.

8. *TELA+ZO*. This occurs only once and refers to only 1 piece of textile (**Lc 5612 + 5885**). There are four lines beneath the rectangle of the ideogram, which implies a densely woven fabric. (The same ideogram occurs on only one other occasion, in tablet **L 433 + 7880**).

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[26] Palmer 1969, 291.

[27] Killen 1979, 153, note 7.

[28] **Lc(1) 529 + 545** with 30 pieces, **Lc(1) 558** with 20 pieces, **Lc(1) 5746** with 10 pieces, **Lc(1) 526** with 14 pieces, **Lc(1) 527 + 7143 + 7331** with 19 pieces.

[29] **Lc(1) 5746** with 4 pieces, **Lc(1) 541 + 5055 + 7104 + 8045** with 22 pieces, **Lc(1) 543** with 11 pieces, **Lc(1) 551 + 5507 + 7397** with 10 pieces, **Lc(1) 561** with 1 piece, **Lc(1) 553 + 7379** with 10 pieces.

[30] **Lc(1) 530 + 7384** with 7 pieces and **Lc(1) 532 + 554** with 4 pieces.

[31] Killen 1966, 109.

[32] Duhoux 1976, 71, note 185.

[33] Τζαχίλη 1997, 239-244.

[34] *Documents*, 315-316.

Le SERIES

The smaller **Le** series is connected with **Lc** and includes tablets in which deliveries of textiles are recorded with the same ideograms and often with reference to the same sites. The series is from the same scribe, 103, as the previous series, and probably records receipts of textiles from the same workshops mentioned by this scribe in the **Lc** series. In **Le 641** + *frr.*, for example, the word *de-ka-sa-to* indicates a receipt and the same thing is attested in **Le 5903 + 5937** + *frr.* and **Le 5629 + 5867 + 8446 + 8522 + 8559** + *frr.* [+] **8512** by the word *a-pu-do-si.*[35]

The main ideogram is *TELA+TE*. Essentially the same ideogram is repeated throughout the entire series. Another consistent feature is that there is invariably either a single vertical line beneath the rectangle of the ideogram or no line at all. The ideograms in **Le 641** + *frr.* and **Le 5930 + 6003** are supplemented by the abbreviations *pe* and *mi*, normally expanded as *pe-ko-to*, as in the **L** series, and *mi-ja-ro* respectively. The number recorded is small in comparison with the entries –56 pieces for 14 entries. It was thus only a small delivery. I believe that since the word *talasia* occurs in **Le 642 + 5950**, this deals with the provision of services in kind, as we have seen, which will not have involved large numbers.

Ld SERIES

This series has been more studied than the others connected with textiles, and several of the terms contained in it have been analysed. Its characteristic features are the large number of terms referring to colours, and the fact that some of the ideograms –**158* and **161*– are unexplained.[36] Killen classifies these tablets as storage records, in which the source is not stated, and records of deliveries, in which the source is mentioned. He divides the latter into two groups, on the basis of the presence of particular terms. The main ideogram is again *TELA* but in this case *TELA+PA* also occurs. *PA* is probably an abbreviation for *pa-we-a*. Killen draws attention to the absence of *TELA+TE*: only *TELA* alone and *TELA+PA* are found. He believes that the **Ld** series records the receipt of *pa-we-a ko-u-ra*, of which fixed quantities are recorded in **Lc**, while the **Le** series, in contrast, records receipts of *TELA+TE*. According to Killen the distinction is due to the fact that some of the textiles in **Ld** underwent some process, or were dyed. The same series also contains two more much-debated terms, *e-qe-si-ja* (**Ld(1) 571, Ld(1) 572, Ld(1) 575 + 580, Ld(1) 583 + 6024**) and *ke-se-nu-wi-ja* (**Ld(1) 573, Ld(1) 574, Ld(1) 585** + *fr.*). The former of these is related to the *e-qe-ta*, a category of military officers.[37] It has been interpreted as referring to textiles intended for these officers (uniforms?) or provided for them by the central authority. *ke-se-nu-wi-ja* has been interpreted as *ξένια*, possibly textiles intended for foreigners, as gifts, or for commercial exchanges, or even for export. These terms are mutually exclusive. Textiles that are *e-qe-si-ja* are not *ke-se-nu-wi-ja*. According to another interpretation, advanced by Knapp, these qualifications relate to the quality of the textiles.[38] This is consistent with the internal structure of the records and preserves a certain homogeneity. In this, as in the previous series, the special importance of the collector is apparent. Here, again, the largest numbers of textiles occur in tablets that bear the name of a collector. According to Killen, the rest of the textiles belong to the *wanax.*[39]

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[35] Killen 1966, 152-153.
[36] Palmer 1969, 292; *Documents*, 317-319; Killen 1979.
[37] Deger-Jalkotzy 1978, 98-105.
[38] Knapp 1991, 42.
[39] Killen 1979, 155-156.

Since coloured textiles appear to be the main characteristic of this series, I have used this as a basis for counting, following the recapitulatory tablet (**Ld(1) 587 + 589 + 596 + 8262**). After the coloured textiles, I shall turn to the plain *TELA* and thereafter to the other ideograms.

1. *re-u-ko-nu-ka TELA*. This is the largest number of textiles for which the colour is given, with a total of 527 pieces. If we accept Killen's division,[40] 105 textiles are recorded on tablets listing the textiles to be found in the storerooms.[41] The number is invariably divisible by five, and it follows that the textiles recorded on tablets were already divided into categories. In the latter case, of deliveries, greater numbers of textiles are recorded in the receipt tablets. The number is 422 pieces.[42] The number of lines beneath the ideogram varies, but is most commonly two. There are only three tablets recording receipts, one of which (**Ld(1) 587 + 589 + 596 + 8262**)[43] is a recapitulatory tablet, while another records deliveries to the collector (**Ld(1) 598 + 661**). This perhaps accounts for the numbers being so large. There are appreciably more textiles described as *re-u-ko-nu-ka* than all the other coloured textiles together. The term is translated as *λευκώνυχα* –that is, textiles with white *o-nu-ke* (see below).

2. *po-ki-ro-nu-ka TELA*. There are only 29 textiles in four entries, two of which are on the recapitulatory tablet **Ld(1) 587 + 589 + 596 + 8262**, with 24 pieces, and the collector's tablet **Ld(1) 598 + 661**, which has 1 piece. On one occasion there is the further qualification *o-pi-qi-na*, when 4 pieces are recorded (**Ld(1) 584**). There are perceptibly fewer pieces, that is, than in the previous category. The term is translated as *ποικιλώνυχα*, textiles with *o-nu-ke* of different colour.[44]

3. *ko-ro-ta*$_2$ *TELA*. There are 16 textiles in two entries, on the recapitulatory tablet **Ld(1) 587 + 589 + 596 + 8262** which records 14 pieces, and on the collector's tablet **Ld(1) 598 + 661**, with 2 pieces. In both cases there are two vertical lines beneath the rectangle of the ideogram. The term *ko-ro-ta*$_2$ probably means dyed textiles, or textiles dyed the colour of saffron (*κρόκος*) –that is, pinkish yellow.[45]

4. *pa-ra-ku-ja TELA* or **56-ra-ku-ja TELA*. According to Killen, these are probably the same word.[46] 72 pieces are recorded in two entries. One is a tablet recording stored textiles (**Ld(1) 575 + 580**), which mentions 30 pieces. This is consistent with the constant feature of this group that all the numbers are divisible by 5. The other is the recapitulatory tablet **Ld(1) 587 + 589 + 596 + 8262**, with 42 pieces. The meaning of the term is unknown.

5. *TELA*. There are 10 other cases in which the *TELA* ideogram is accompanied by a number, and the total number of pieces recorded is 278. This includes the recapitulatory and storage tablets, which accounts for the number being so large. The textiles in question are never plain, however. All the ideograms are accompanied either by qualifying words such as *o-nu-ke* (**Ld(1) 5615 + 5873 + 8248** + *fr.*) or *pa-ro e-ta-wo-ne* (**Ld(1) 5607 + 8247**) or occur on recapitulatory tablets, with the addition of the word *to-sa*. Next to the ideogram they probably all had a

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40 Killen 1979, 151.

41 **Ld(1) 571** and **Ld(1) 572**, with 25 pieces each, **Ld(1) 573** with 35 pieces, and **Ld(1) 585** + *fr.* with 25 pieces. This last tablet is included here despite the fact that the ideogram is qualified by other words in addition to *re-u-ko-nu-ka*.

42 **Ld(1) 587 + 589 + 596 + 8262** with 372 pieces, **Ld(1) 598 + 661** with 37 pieces, **Ld(1) 5615 + 5873 + 8248** + *fr.* with 13 pieces.

43 For the restoration of this tablet and comments on the tablets which it probably recapitulates, see Killen & Olivier 1968, 119.

44 For the meaning of this term and the second component *o-nu-ke*, see Killen 1979, 162-164. For a different interpretation, Τζαχίλη 1982.

45 *Documents*, 319.

46 Killen 1979.

qualifying word related to colour. They are also followed by the ideogram **161* (**Ld(2) 785, Ld(2) 786, Ld(2) 787 + 1009 + 7378**).

6. **158*. This ideogram is found on tablets recording textiles already stored[47] (Table 2). Palmer, on the basis of the sign, interpreted it as a bag, pile or heap.[48] It occurs six times and is invariably accompanied by the number 1. The number of textiles recorded before it is always divisible by 5. The same ideogram also occurs on one occasion in the **L** series, on tablet **L 578**, where it is accompanied by the number 2. In every case, the scribe is 116.

161*. This occurs once before *TELA* on **Ld(2) 785, with 3 pieces. In two other entries (**Ld(2) 786, Ld(2) 787 + 1009 + 7378**) it is followed by the term *ki-to-pi*, and the quantities are not preserved. In both these cases the *TELA+PA* ideogram occurs in the first line. Its sign is different from those of the rest of the *TELA*, and it does not consist of a rectangular textile (Table 2). For the interpretation of it, see the following, **L** series.

7. *TELA+PA*. This occurs only twice (**Ld(2) 786, Ld(2) 787 + 1009 + 7378**), and in the only case where the number is preserved, it is 1. In both cases there are three lines beneath the rectangle.

8. *TUN+KI*. According to the sign (Table 2) this is a sleeved overgarment; it is certainly a garment and not a textile. *ki* is an abbreviation for *ki-to*, *χιτών*. It occurs on one tablet (**Ld(1) 595**) with two acrophonic abbreviations, *o* and *pe*, the former probably for *o-pe-ro* (*ὄφελος*, owing) and the latter for *pe-ko-to* (see above). The same ideogram also occurs in the **L** series. 8 pieces are recorded and one is owed, giving a total of 9.

L Series

This series is characterised by the presence of the ideograms *TELA*, *TELA+PU*, *TELA+PA*, **161*, *TELA+KU*, **164*, *TELA+ZO*, *TELA+TE*, *TUN+KI*, and *TUN+RI*.

1. *TELA*, with 1, 2 or 3 vertical lines. The total number of pieces is large: 538 in forty entries.

2. **161 TELA*. The ideogram **161* invariably precedes the *TELA* ideogram. The total number of pieces is 46 in three entries, representing a fairly high proportion of pieces to entries.[49] In another three cases the number is not preserved (**L 590, L(2) 5108, L 7389**). One feature is the repetition before the ideogram of weaving terms of unknown meaning (*e-ni-qe*, *nu-wa-i-ja*), or terms relating to colour (*po-ki-ro-nu-ka*, *e-ru-ta-ra-pi*), as in the **Ld** series. When account is taken of the evidence from the previous series, where **161* is invariably found next to terms indicating colour, it may be assumed that it was in some way related to coloured textiles.

3. *TELA+PA*. This occurs twice. On one occasion (**L 7387**) it is connected with a record of 1 piece, and on the other (**L 178 + 281**) it is preceded by the ideogram **161* and is associated with a record of 6 pieces. The total number of pieces is thus 7. In both cases there are three vertical lines at the bottom, and the textile is therefore a densely woven one. As the previous series, the textiles with which it is associated are not frequently found, and were therefore either rare or not of great interest to the central administration.

4. *TELA+PU*. This is the most common ideogram of the series. It has two main features. First the huge quantities recorded, which are much larger than those of any other entry in the entire

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[47] The ideogram **158* occurs on tablets **Ld(1) 571, Ld(1) 572, Ld(1) 573, Ld(1) 575 + 580, Ld(1) 576,** and **Ld(1) 577** (also on **L 5647**, but with no number, since the tablet is in a very fragmentary condition).

[48] Palmer 1969, 293.

[49] **L(7) 592 + 663 + 8310** + *frr.* with 30 pieces, **L(2) 593 + 5992 + 8587** with 4 pieces, **L(2) 5910 + 5920** with 12 pieces.

series relating to textiles. Numbers as large as 980 are recorded for a single entry (**L 5561**). Second, a clear tendency is apparent to record in tens, and there is also a large number of lines beneath the rectangle. The number of lines is not constant, but may be 3 or 4, and the textiles are therefore wide and densely woven (Table 2). A total of 2,528 pieces is recorded in twenty-nine entries. The smaller numbers probably refer to textiles that are 'owed', as in **L(3) 869**. The ideogram is accompanied either by adjectives relating to quality and colour (*pu-ka-ta-ri-ja*, *re-u-ka* in **L(7) 471**) or by geographical terms (*pa-i-to*, *do-ti-ja*). The qualification *o-pe-ro* is twice accompanied by the acrophonic abbreviation *pe* and occurs on one occasion without it, in **L(3) 455 [+] 1616**.

5. *TELA+KU*. There are few occurrences of this ideogram and the numbers cited are low. There is a total of 41 pieces in eight entries.[50] In four of the entries *TELA+KU* is accompanied by the previous ideogram, *TELA+PU*.

6. **164*. This occurs only twice, in **L 520**, which has three entries on three lines with 3, 2 and 4 pieces, and in **L 698**, where the number is not preserved, but where it is accompanied by the qualification *pe-ko-to*. The total number of pieces is thus 9. In **L 520**[51] quantities of wool are given along with the ideogram, and in the first line these are associated with the term *pe-re-ke*, which could be either the third person singular of the verb *περιέχω* (contain) (though there are grammatical difficulties involved in this interpretation), or a proper name. The ideogram consists of the familiar rectangle for textile, with four blobs inside it touching the sides (Table 2). This is an iconographic convention indicating a patchy textile or possibly leather or some material like leather. Since the quantities of wool are large and the number of textiles small, they may have been very heavy fabrics, possibly a kind of carpet. The ratio is 6 units of wool to 1. Cf. *TELA+TE*.

7. *TELA+ZO*. This occurs once in **L 433 + 7880** and is accompanied by the number 1. There are three lines beneath the rectangle. There are only two occurrences, the other being in **Lc 5612 + 5885**, where, again, 1 piece is recorded. This was a rare textile, or one of little interest to the administration.

8. *TELA+TE*. This occurs twice in this series, both times involving the scribe 103. In the first case, **L 5660**, the number is not preserved, and in the second, **L 8160**, 1 piece is recorded.

9. *TUN+KI*. It is evident from the sign that this is a garment and not a textile. It is possibly not fortuitous that the word *e-ra-pe-me-na* (*ἐρραμμένα*, 'sewn') occurs in the second line of **L(2) 647 + 2012 + 5943 + 5974**. 10 pieces are recorded in five entries.[52] In three of the five entries it is found in association with the term *e-ni-qe*, the meaning of which is not known, though it is certainly connected with textiles. It is worth noting that the number of garments known is very small in comparison with the number of textiles.

10. *TUN+RI*. This is a variant of the previous ideogram and occurs only once, on **L 178 + 281**, listing 2 pieces.

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[50] **L 514** with 14 pieces and 2 lines, **L(4) 515 + 7412 + 7611 + 9534**, with 2 pieces and no lines, **L(4) 516** with 2 pieces and 2 lines, **L(8) 1647** with 5 pieces and no lines, **L 5757**, on which there are two occurrences, one with 3 pieces and 3 lines, and one with 4 pieces and an indeterminate number of lines, and **L(8) 7404** with 10 pieces.

[51] *Documents*, 321, 488.

[52] The ideogram occurs twice in **L(2) 593 + 5992 + 8587**, once with 2 pieces and once with no number preserved, in **L(1) 594** with 1 piece, in **L(2) 647 + 2012 + 5943 + 5974** with 3 pieces, in **L 870** + *fr.* with 1 piece, in **L 5917**, where the number is not preserved, and in **L(2) 5961** with 3 pieces.

CONCLUSIONS

Let us now see what evidence emerges from this compilation of the figures.

I. Methods of accumulation and related terms

The evidence relating to this subject is perhaps the most interesting. The various ways in which textiles are classified show that they were grouped on the basis of kind, quality, and colour, and they also shed light on the methods and aims of production. The relative quantities also provide evidence for the use, economic importance, and rarity of each category recorded. There are perhaps good grounds for believing that the greater the interest shown by the administration in a particular kind of textile, the larger the number of qualifying terms associated with it.

1. Basically, textiles are classified according to the various ideograms (Table 2). The use of these ideograms gives rise to some questions in my mind. Their presence is obviously due to their function as a supplementary recording system within the context of the script. However, the ideograms are also accompanied by a large number of qualifying words and there are grounds for suspecting that in many cases they overlap (see the case of *TELA+TE* and *TELA+PA*). It is my view that the presence of both is due not only to recording methods or the habits of scribes, but also to some desired standardisation –and this may imply the actual standardisation of weaving output. Or at least that this was the aim. When the large numbers are also taken into account, I believe we may conclude that at this period this kind of standardisation would have assisted commercial exchanges –we are speaking, that is, of standardisation with regard to quality, kind, and dimensions. Nor should it be forgotten that standardisation becomes necessary when dealing with large quantities. Further support for this argument is provided by the fact that those textiles qualified by words as well as by ideograms are fewer in number than those indicated only by ideograms, which implies that standardisation was the rule and special features the exception.[53]

2. The various qualifying words that accompany the ideograms relate to:

a) Colours, special kinds of textile, or quality. As a general rule, it might be said that textiles indicated by ideograms are classified first by kind, and second by determinatives referring to colours or quality, or even to a special kind of textile (*po-ki-ro-nu-ka*: *ποικιλώνυχα*, *a-ro*$_2$*-a*: fine quality, *e-ni-qe* or *pa-we-a ko-u-ra*: textiles with *e-ni-qe* or *pharea ko-u-ra*). A comparison of quantities reveals that the majority of the textiles for which the colour is given are white.[54]

b) Again according to the determinatives, there are two categories of accumulation. The first involves those textiles whose origins must be declared –presumably because the interest of the recording official is in checking that some obligation has been discharged, such as the delivery of a corresponding quantity of finished textiles in return for wool provided. In these cases we have a detailed record of where the textiles come from and they are named according to their kind and origins (*se-to-i-ja*, *pa-i-ti-ja*, *ko-no-so*). In contrast, textiles in the second category are recorded when they are already stored, and only their kind, and possibly their purpose, is given.

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[53] This is not without exceptions: the textiles indicated by two ideograms, *TELA+PA* and *TELA+ZO*, are very few in number. They were possibly textiles which, while being indicated by an ideogram, and therefore having a tradition in the place they were made so that there was already an ideogram for them, were nonetheless of little interest to the palace administration. Or this was possibly a stage of recording at which this kind of textile had not yet been accumulated. Whatever the case, we are dealing with exceptions.

[54] White textiles are not those that have not been dyed. They are not naturally white. Neither wool, nor linen textiles and threads are white by nature. They are specially treated with sulphur to whiten them.

In this case the numbers are rounded off, and are all divisible by 5. In other words, the numbers reveal the way in which they were arranged. Here, too, the numbers themselves provide important evidence. Entries relating to receipts are much greater in number than those connected with stored items, as, too, are their quantities. There are probably two reasons for this: either the central administration was not interested in recording all stored textiles, or they were rapidly distributed (commercial exchanges, redistribution) and there was no time to store them. We have no evidence on this matter. Most of the tablets record receipts or calculations of anticipated receipts. Not despatches. It should perhaps be assumed, therefore, that of the stored textiles, the only ones recorded were those that had some special purpose, or a specific quality that was standard (*ke-se-nu-wi-ja*: foreign textiles, *e-qe-si-ja*: textiles for the *e-qe-ta*).

II. Organisation of production

1. Quantities of textiles form part of the discussion of the role of the collector. This is not the focus of the present article, but it is immediately obvious that the quantities given in tablets associated with collectors are huge in proportion to the total number of recorded textiles. **Lc(1) 7392 + 7398**, for example, alludes to 240 *pa-we-a ko-u-ra* textiles for the collector *we-we-si-jo*, out of a total number of 449 textiles in this category –that is, it represents about half. In some cases, these quantities are greater than those of products recorded as belonging to the palace. Various conjectures have therefore been made as to the independent role played by the collectors, and various functions have been attributed to them, along with a distinctive social status (senior officials, land-owning class). In a recent article, Killen maintains that whatever their status, their activities were of interest to the central administration, which is why they were recorded.[55] In my opinion, the real question lies elsewhere, in how far the central administration that supervised the recording is to be identified with the *wa-na-ka*.

2. Quantities of textiles also shed light on the function of the *talasia* system (see above for bibliography). The evidence here comes mainly from series **Lc** and **Le**. The most important feature is that the quantities are relatively small. They therefore represent the provision of services, work owed, though this was only supplementary work and of fairly short duration, so that it occupied only part of the time and energy of the worker. It follows that the workers subject to the *talasia* system were independent of the palace. The system may have been rather similar to the *corvée* of Mesopotamia. The administration provided wool and expected finished textiles in return, though in relatively small quantities: it was, that is, a mild form of taxation.[56]

3. Small quantities are also involved in the case of the textiles described as *wa-na-ka-te-ra*, belonging to the *wa-na-ka*. Unless all the other products recorded –apart from those delivered to the collectors– also belonged to the *wa-na-ka* but, if this was the case, why are some explicitly qualified as such while others are not? The question is, as we saw above, whether the centralised authority responsible for the records is identical with the king.

III. Purpose

Some of the textiles recorded in the **Ld** series are stored. They are qualified in a variety of ways, normally with reference to colour. Some of them probably refer to the recipients, since they are qualified by adjectives that perhaps allude to them. We are dealing, that is, with temporary storage of the textiles until they were redistributed and came into the hands of those

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[55] Killen 1995.

[56] Duhoux 1976, 80-81. See also Nosh, 1998.

entitled to and expecting them, or the potential recipients. This is mainly the case with textiles described as *ke-se-nu-wi-ja* and *e-qe-si-ja*. If these terms really indicate the purpose of the textiles in question (*ξένια*, gifts for foreigners, or textiles for the *e-qe-ta*), they provide us with some important evidence –namely that provision was made for exchanges, or that in cases where the textiles were intended for the *e-qe-ta*, there was some system in operation for redistributing goods in return for services. This is true, of course, only if the interpretation of these terms offered is correct, and they do not simply mean some particular kind of textile.

IV. Numeral system

A general tendency can be observed for the textiles that are accumulated to be recorded in numbers divisible by 10 (mainly the *TELA+PU*). That is, the recorded quantities of textiles reveal a tendency to collect in tens, in accordance with the decimal system, or in fives, as can be seen in the tablets with the ideogram **158*, mainly of the **Ld** series.

V. Textiles delivered in larger quantities to the central administration

Comparison of the arithmetical data reveals which textiles were delivered to the central administration in the greatest quantities (see Table 1). The largest group are the textiles described as *TELA+PU* of which there were 2,528 pieces. These are followed by plain *TELA* with a number of 1,161, and then by three roughly equal categories: *pa-we-a ko-u-ra*, with 459 pieces, *TELA+TE* with 490, and *re-u-ko-nu-ka* with 527. The grand total is somewhat fewer than 5,700 pieces. It should not be forgotten that these numbers are not absolute, but that their value is purely proportional; in reality they will have been considerably greater. In any event, it is worth noting that the recorders were interested in and recorded all quantities from the largest (about 1,000 pieces) to the smallest (just a single piece). Control of the movement of textiles took account of the smallest detail.

Epilogue

Finally, I would like to return, if I may, to absolute numbers, because their exclusion from the study of the relative numerical data is itself not definitive. The connection between them is always latent.

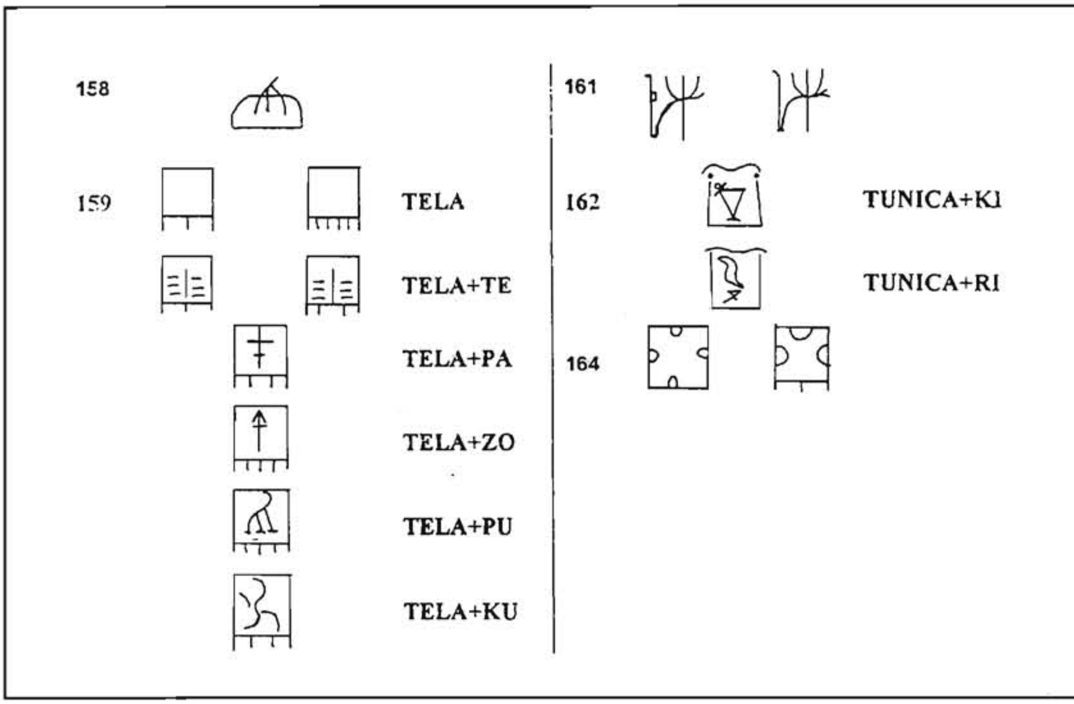
From Table 1, it can be seen that a total of about 5,700 textiles are involved. When I had completed my calculations, I found myself faced with a very simple question, to which I am unable to supply an answer because it involves the sphere of absolute numbers and their relation to general historical evidence: is 5,700 textiles a large or a small number? Although to some extent a rhetorical question, it nevertheless has a substantive aspect. To what extent was society simply covering its living needs? What part did the production of prestige goods play? (See the arguments in the introduction). Whether the quantities of textiles are given in absolute or relative numbers, the basic question of the scale of output must remain unanswered, since the other relevant factors are unknown.

Despite the lack of certainty, however, the detailed evidence emerging from the relative numerical quantities proved to be by no means negligible. Taken together with the other evidence cited, it helps us form a picture of the administration that in turn reflects the operational structures of the Mycenaean centres of power.

Table 1. Types of textiles and quantities.

IDEOGRAMS AND DETERMINATIVES	QUANTITIES	ENTRIES
Ld series		
re-u-ko-nu-ka TELA	527	9
po-ki-ro-nu-ka TELA	29	4
ko-ro-ta_2 TELA	16	2
pa-ra-ku-ja or *56-ra-ku-ja	72	2
TELA	278	10
TELA *161	3	1
TELA+PA	1	2
TUN+KI	9	1
Lc series		
TELA	345	7
pa-we-a TELA	82	3
pa-we-a ko-u-ra TELA	459	6
pa-we-a ko-u-ra *161 TELA	25	2
tu-na-no TELA	40	16
TELA+TE	489	18
pe-ko-to TELA+TE	14	2
TELA+ZO	1	1
Le series		
TELA+TE	56	14
L series		
TELA	538	40
*161 TELA	46	3
TELA+PA	7	2
TELA+PU	2,528	29
TELA+KU	41	8
*164	9	3
TELA+ZO	2	2
TELA+TE	1	2
TUN+KI	10	5
TUN+RI	2	1

Table 2. Linear B ideograms mentioned in this chapter.



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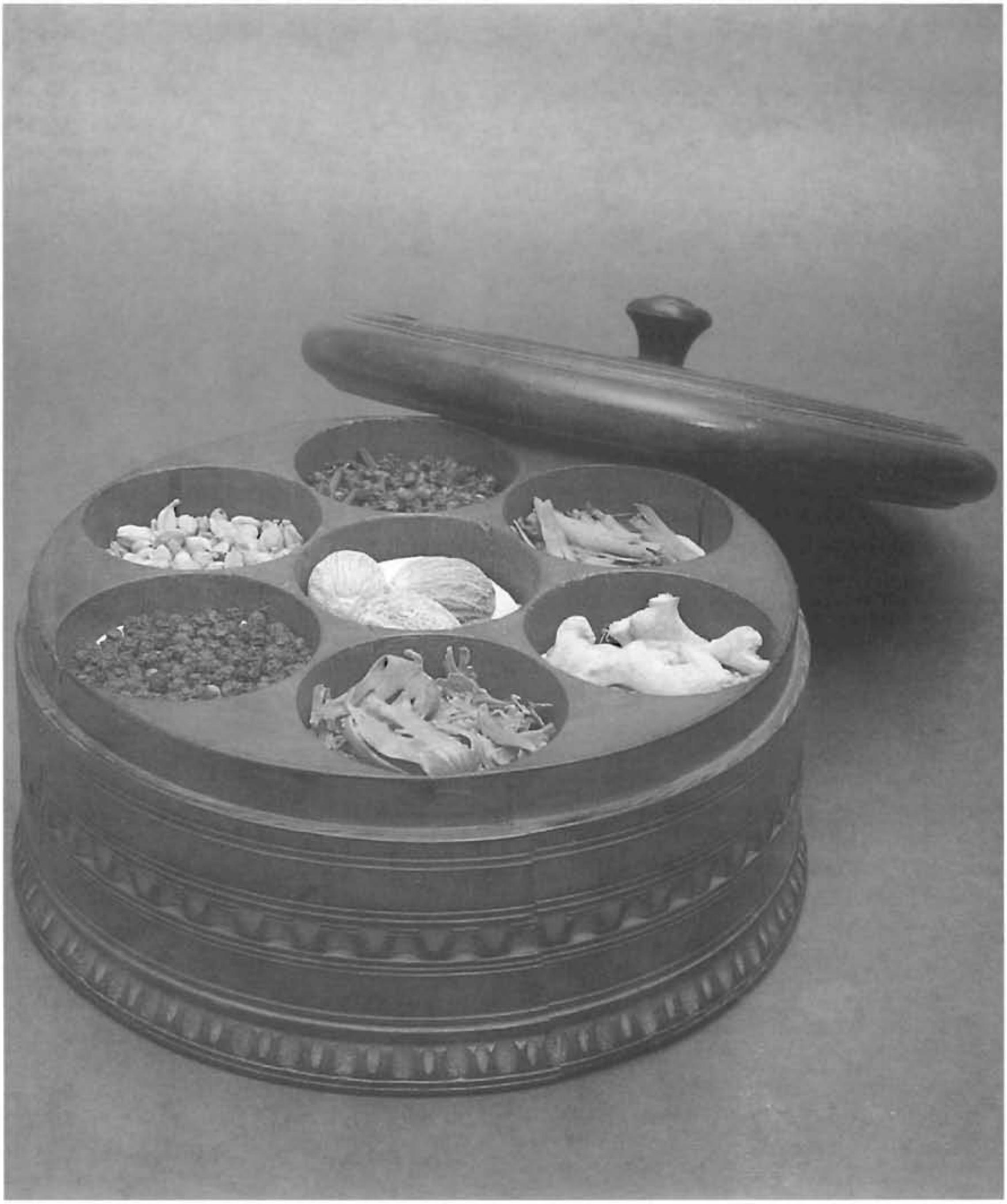

Spice box, 17th century, containing nutmeg, cinnamon bark, coriander and ginger, pimento and pepper. As late as the 19th century, pharmacists traded not only in medicines but also in spices and sweets (after W.-H. Hein & W.-D. Müller-Jancke, *Kostbarkeiten aus dem Deutschen Apotheken-Museum Heidelberg*, 1993, 62-63).

CONDIMENTS, PERFUME AND DYE PLANTS IN LINEAR B: A LOOK AT THE TEXTUAL AND ARCHAEOBOTANICAL EVIDENCE*

Anaya Sarpaki

INTRODUCTION

The aim of this chapter is to re-examine the condiments, perfume and dye plants mentioned in the Linear B archives in order to readdress problems of identification. Moreover, the available textual, archaeobotanical, botanical and ethnobotanical evidence has been collected in order to try to tackle issues which touch upon social, political and economic explanations of the Mycenaean world.

There has been a temptation, so far, to see the Mycenaean world as an undifferentiated whole, in both cultural and chronological terms. Culturally it covers or influences the whole of the geographical area of Greece but with greater emphasis on the south of Greece, and chronologically it spans the period 1450 to 1200 BC. This, at least, is the period when Linear B was the accepted administrative script. This simplistic view has stopped us from evaluating the subtle geographical/cultural differences, which could have immense repercussions on agricultural practices, population needs for goods, and evaluation of priorities in administrative concerns. Dissenting from a simplistic view of the Mycenaean world, and comparing with what Rothman[1] has said about the Greater Mesopotamian area, it would be a mistake to see it as totally uniform or homogeneous. He claims that from the very beginning, differing groups drew selectively from the great pool of cultural traditions and organisational structures in the region to create unique, local cultural and possibly organisational arrangements. As much as the commonalities in the region, these local arrangements determined the organisational dynamics of complexity in Greater Mesopotamia. This, it is believed, explains, very well –although it refers chronologically to earlier periods– what must have taken place in the Mycenaean world.[2] The clay tablets are just one source of data mirroring this complexity and are just pieces –nevertheless, very important ones– in the puzzle leading to our understanding of this complex society. It is not just the general economic information which is important, but the local differences within the Mycenaean world, which, we hope, will become clearer as research progresses in all fields of epigraphical, archaeological, and archaeological science studies.

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* I would like to thank my colleague and friend Anna Michailidou for inviting me to participate in the programme 'Prehistoric Technology and Exchange: Counting, Weighing and Recording the Raw Material and the Product', of the Research Centre of Greek and Roman Antiquity; also for challenging me with a more intimate acquaintance of Linear B. In the preparation of the tables I greatly tapped into the Linear B database, which has been created at this centre, and was assisted by Alkis Dialismas, Dimitra Kriga and Katerina Voutsa, whom I wholeheartedly thank. George Landers and David Hardy have provided a good English shake-up and I thank them warmly for it.

[1] Rothman 1994, 7.

[2] Sjöberg 1995; Shelmerdine 1999, 555, 564, 565 (for scribes), 567, 573: 'the Mycenaean kingdoms are different in a number of ways'.

Little is known of Mycenaean economic transactions in comparison with the details that other economic systems in the Near East have offered through the decipherment of their written documents. The little we know comes from a 'slanted' view, through the few ephemeral documents which happened, temporarily, to record economic transactions before they were copied on to more durable material, probably, papyrus, wood and/or parchment. The Linear B tablets, as we know, refer only to the economic year during which the tablets were destroyed. As the discovery of these written clay documents is just a mere accident of fate, the picture that is drawn is, as a result, quite distorted. Even so, there is no way of even evaluating the degree of misrepresentation. Tablets were preserved only where conflagration occurred in the palaces. We would need an evaluation of the degree of destruction such as a knowledge of which area(s) were subjected to fires, in order to be able to evaluate the likelihood of the preservation of the relevant tablets, and in order to be surer of what we are missing in each case. Therefore, areas, which were not exposed to burning did not produce equivalent evidence, but, nevertheless, probably held very important economic documents of the same or other activities. What is interesting is that products of the same category often tend to be recorded in the same area(s), and, therefore, we could claim that, for certain products, we have much of the concurrent evidence for the specific part of the year.

1. The Plants in the Tablets: Indirect Observations

It is interesting to note that some plants, which are mentioned in some archives, are not referred to at other sites.[3] The interpretation of such phenomena is obscure and there may be many explanations. First, it may be a quirk of chance, whereby the preserved tablets do not mention the products, which might have been annotated in other archives –now lost– due to the accident of preservation. A second explanation is that plants considered of economic importance in one area of study, cannot necessarily be thought of as being of the same economic stature in another geographical region. For example in areas where the saffron crocus does not grow, this plant would have been either of very high value due to its rarity, or of no use, as needs, in the first instance, develop by exploring the local availability of species. It is very probable that similar local differences could have been greater in prehistory than one can presently imagine. The palace 'centres' might have annotated different crops for a multitude of reasons. The appearance of certain crops only in certain 'centres' (Table 1) does not demonstrate conclusively that these were not cultivated in other areas as well, but might indicate that 'transactions' involving them did not interest the palace, for some reasons not yet understood.

One reason might be related to the type of land where these crops would have grown: in certain areas, that is, some crops might have been 'palace related' in that the land on which the crops would have grown, might either have been state owned or connected to the palace under some system of taxation.[4] Another reason might have been the control that the palace might have wished to exercise over certain 'crafts'. For example one can detect a rather diversified interest of Mycenae, perhaps, in dyeing with safflower (Table 2) where there is a recording of seed as well as of harvest –florets.[5] Mycenae, also, seems to have 'controlled' some condiments, such as

[3] Of course, we should also take into account the fact that all the tablets are not chronologically synchronous.

[4] Duhoux 1976.

[5] A discussion of this point is presented below under *ka-na-ko*.

celery (Table 2), cumin,[6] mint,[7] sesamum,[8] *ko-no*[9] and cardamon.[10] On the one hand, Mycenae seems to have favoured annotating imported plants (such as ginger grass (?) and cumin), to a much greater extent –from the evidence at hand– than Knossos, which, to my mind seems more involved in local production. Pylos is nearer to the inclination/policy of Mycenae, with its mention of cinnamon,[11] henna[12] and aromatised oils.[13] From the fragmentary evidence at hand, we could say that Mycenae and Pylos provide an image of 'higher'-level 'trade'[14] with other centres abroad than does Knossos. Mycenae together with Pylos, in present parlance, could be identified as the more 'urban' centres of the Mycenaean period –as seen from the tablets– compared with Knossos, which fell behind in terms of 'status' products such as condiments. In this respect, the impression formed, is that Mycenae and Pylos were more centres of consumption,[15] whereas Knossos was a centre of production[16] of 'higher level' goods. Does this mean that the palate of the Knossians was less extravagant and, therefore, more provincial, or that external 'trade' was no longer in the hands of Knossos but went via the intermediary and/or control of the Peloponnesian centres? Another sign of the 'urbanity' of Mycenae is the mention of mint and celery, two plants which could well have been grown in gardens, near the towns, but, obviously, its inhabitants, either did not have the garden space or were involved in more 'urbanised'[17] endeavours rather than engaging in the pursuit of 'humble' row-gardening. This, for whatever reason, is an indirect indication of 'heavy' urbanism. Due to the unavailability (or difficulty of access) of such produce, the palace administration was forced to annotate its possession, which is seen from their mention in their archives.

Knossos, on the other hand, seemed to deal far less with exotics, and more with products, which were implicated in industrial uses such as dyeing,[18] and resins, which would have been useful as unguents and for different purposes often connected with industrial endeavours. The textile industry must have been of great importance for Knossos, as is clear from the several very thorough studies of Killen,[19] but also seems to be verified by the evidence arising from the

[6] See Table 8.

[7] See Table 9.

[8] See section under *sa-sa-ma* where it is suggested that sesamum does not refer to sesame but to an oil. For sesamum see Table 10.

[9] See Table 11 and catalogue of plants (Section 4).

[10] See Table 3.

[11] See Table 12.

[12] See Table 3.

[13] See rose and sage in Tables 3 and 17.

[14] By 'higher'-level 'trade' I mean that it is not exactly staple goods, nor does it refer, necessarily, to luxury items, such as precious commodities, but to goods which would be more in demand by an urban and opulent community, rather than by an urbanised but more farmer-based society (Godart 1981).

[15] A very interesting article by Stein (1994) refers to these chiefdom economies for the Ubaid period in Mesopotamia as having strategies of wealth finance –which in our case would suit the Mycenae and Pylos archives– versus a polity of staple finance, which would suit the Knossos model. One can assume that 'wealth finance' embodies the consumer mentality, whereby valued materials are of primary interest and importance.

[16] The terms 'consumption' and 'production' are generally referred to agricultural communities but here they are used in the context of complex societies, and therefore produce a divide, at a higher level, of urban societies.

[17] Surely, there is a hierarchy within urbanism (Sjöberg 1995, 27). Could we be seeing a difference between redistributive 'exchange' and the beginning of a 'market' economy?

[18] See crocus, and *po-ni-ki-jo* (alkanet?).

[19] Killen 1984 *inter alia*.

Table 1. Linear B archives, which mention the relevant plants.[20]

PLANT SP.	LINEAR B
ka-na-ko, e-ru-ta-ra, re-u-ka	MY Ge
mi-ta, mi-ta-qe, ka-ra-ko	MY Ge
sa-sa-ma, SA	MY Ge
ko-no, ko-i-no	MY Ge
ku-mi-no, KU	MY Ge; Ui
po-ni-ki-jo	KN Bg; Ga; Sd; X
wo-do-we	PY Fr
CROC, ko-ro-ki-no	KN Np; X
KAPO	PY An; Un, KN F
CYP, PYC, ku-pa-ro	MY Fu; Ue, PY An; Fa; Fr; Ua; Un, TH Wu, KN E; F; G; Ga; Uc
ma-ra-tu-wo, MA	MY Ge, KN Ga;
ko-ri-ja-do-no,[21] KO	MY Ge; Ue, PY An; Un, KN Ce; F; G; Ga; V
ki-ta-no, AROM (*123) (?)	KN Ga, PY An[22]

botanical listings.[23] What seems to occur is that the control of the palace ran through all of the stages of this industry, from the ownership/control of flocks to the dyeing of the fibre and to the weaving of the various types of cloth.[24]

In the field of perfumery, Knossos does not seem to lag behind. Iris root (?)[25] is controlled, together with fennel oil (?), coriander, saffron,[26] and cyperus. The production of drinks, such as wines, must have also been an important source of income and socio-economic control for the ruler(s) of Knossos. The resins[27] would have helped to aromatise drinks (?) such as wine or other, made them more appealing to the senses, and also helped preserve them during their long voyages.

Stein[28] in his stimulating article on Ubaid economy, ritual and power, argues that the 'chiefly strategy of locally-based, ritually generated staple finance resulted in the peaceful spread and

[20] For a discussion for each and every one see the catalogue of plants (Section 4).

[21] For several other forms of the term see Table 7.

[22] **PY An** is included if *AROM* (**123*) is *ki-ta-no*. It is perhaps not a coincidence that the *AROM* (**123*) (Table 4) is also in **KN Ga** series.

[23] The mention of dyes such as *po-ni-ki-jo* and saffron.

[24] Varieties of cloth are mentioned in the Knossos tablets. See Tzachili's relevant chapter in the present volume.

[25] We have used a question mark as the question is still disputed. I personally incline in the direction of the iris. Here we would also need to mention the results of the analysis of the organic content of a tripod jar, found at the site of Chamalevri, Crete, which was identified as *Iris sp.* (*Minoan and Mycenaean Flavours*, 50, 51). However, the scientific article related to this find is still awaited so as to evaluate the level of probability of this chemical compound. See Table 3.

[26] Saffron could be used to both aromatise and colour perfumery.

[27] *re-di-na-to-mo* (André 1964, 88) is the collector of resin? The new reading is *re-qo-na-to-mo* (Aura Jorro & Adrados 1993, Vol. II, 236, 241). Refer to the term *ki-ta-no* (**123*), which is not yet accepted by all as equated to **123*.

[28] Although Stein (1994, 44) refers to much earlier societies, the Ubaid (*ca.* 5th millennium), and comparisons cannot be strictly justified, yet, the degree of complexity of those eastern societies, provides material for thought, when interpreting the Mycenaean world.

long-term stability of small scale chiefly polities throughout greater Mesopotamia', a description which would suit the Knossian economy, as we see it from the present archives and especially the agricultural resources. Knossos seems to mobilise indigenous resources as staple finance, whereas Mycenae and Pylos seem to have economies depending more, perhaps, on wealth distribution from exotic trade goods. These are very important and subtle matters whose impact is felt not only on the economy but the repercussions affect aspects of social organisation and aspiration, which need much further investigation for the Aegean of the Mycenaean period.

The plants listed in the tablets[29] surely demonstrate the minimum number of the plants, either imported or existing in the then 'markets', whose importance was considered worth annotating in the tablets, for we can assume that not all produce was recorded.[30] The administrative centres registered all that was of interest to the palace for (a) redistributive or (b) other 'trade' purposes, and (c) purposes which still evade us but must have been connected with special categories of land ownership and/or use, e.g. share-cropping state-owned land, cultivation of particular crops which might interest the palace, or tax concessions connected with other rights of cultivation. Certainly, much more research is needed regarding land ownership and all that it entails, although a great deal has already been written.[31] The listed plants cover the entire spectrum, from one end, humble agricultural produce, such as barley, to, at the other end, condiments, perfumes and dye plants, which are listed as luxury goods. This study concentrates only on plant material, which belongs to the group classified as 'higher'[32] status crops, namely aromatic plants, condiments, and dyes, which are 'transacted' in measures of volume, are weighed and/or counted in various sorts of unknown ways.[33]

Interestingly we notice that some aromatics occur, time and again, at different centres, such as *Coriandrum sativum* (coriander)[34] at Knossos, Mycenae and Pylos and *Foeniculum vulgare* (fennel)[35] at Knossos, and Mycenae. *Cyperus spp.*[36] is also mentioned in several centres (Mycenae, Pylos, Knossos but also at Thebes). Some plants, such as *Carthamus tinctorius* (safflower), *Mentha spp.* (mint), *Sesamum indicum* (sesame), *Pistacia lentiscus* (*σχῖνος*)/ *Cymbopogon schoenanthus*[37] and *Cuminum cyminum L.* (cumin),[38] appear only in the Mycenaean archive. Others, such as *Alkanna tinctoria* (alkannet), *Pistacia terebinthus* (terebinth resin), and *Crocus spp.* (including cartwrightianus and sativus) (saffron), are mentioned only at Knossos. The explanation of such a phenomenon is complex, as mentioned above, as it could be due to a combination of factors. The mere presence of and haphazard cultivation by private farmers would not have required the central authority to keep official records. Assuming they were reflections of real economic structures, it might be that these portray records of areas of influence, a type of 'economic catchment area', whereby, the administration of any area registered what was

[29] See Tables 1 and 2.

[30] An example is the total absence of recording of pulses in Linear B, although we find them, time and again, in the archaeobotanical samples.

[31] See Duhoux 1976 *inter alia*.

[32] Here 'higher' level is used instead of 'luxury' plants as this last term, I believe, is better used for products of extravagance.

[33] For example bunches, baskets, 'primary units' (see note under Table 3), which tend to be different for each plant/plant-substance, where it is not always clear to us as to what is meant.

[34] See Tables 1 and 7.

[35] See Table 6.

[36] See Table 14.

[37] See discussion of *ko-no* in the catalogue of plants. See Table 11.

[38] See Table 8.

within its catchment area: *Crocus spp.* for example, is only mentioned at Knossos. This could be a reflection of a real situation in that saffron crocus exists in the wild in Crete and the Cyclades,[39] and *Crocus cartwrightianus*, *C. tournefortii*,[40] *C. cancellatus* may have been intensively collected only in those areas.[41] It would make sense for Knossos to have been a registry centre of this aromatic plant, as the crocuses which produce saffron are mainly found in Crete, and, if the Cyclades were incorporated in the politico-economic sphere of the Knossos palace administration, due to their geographical proximity,[42] they too could have provided some produce.[43]

2. Quantities of Aromatic Plants: Possible Interpretations

Most of the above mentioned aromatic plants were measured by volume, and/or some were weighed and a few were counted in primary unit measures, which might have been different for each plant/plant-product. Only one of the identified plants, mint[44] was counted in 'bunches' (*PE*).[45] However, the size of these 'bunches' is unknown: could it have been the size of today's batches of onion/garlic, or smaller, in the way parsley and even mint is traded? Probably, one should envisage larger quantities, for example the quantity that an equine (donkey, mule, horse) can carry as one load.[46] One plant in particular, *ki-ta-no*, is annotated in fairly large quantities of *ca.* 16,500 litres (1.65 tons)[47] and its listing is centred on Knossos. The highest value was 5,568 litres and no transaction fell below 960 litres.[48] On the other hand, plants/plant-material such as *ka-na-ko* (safflower) (mostly weighed, but the white variety measured by volume), *ma-ra-tu-wo* (fennel), *ku-mi-no* (cumin), as well as *sa-sa-ma* (sesame), were all measured by volume, which is commonly done for measuring materials which are in seed form. All are also referred to in rather small quantities, which do not greatly exceed a few litres. Others are referred to with even the smallest values, in units as small as 3 gr., such as the crocus (measured by weight) (Table 16). *po-ni-ki-jo* (weighed) also has rather small quantities (*ca.* 1-4 kg. and only occasionally more) (Table 13). The commodity *ko-ri-ja-do-no* (coriander) is rather variable, as there is mention of fairly small quantities (9.6 litres) and very large ones (12,480 litres) (Table 7). Could it also be possible that we are dealing with oils aromatised by –or even coming from– these plants, instead of the seeds alone? Or else could it have been seeds of these plants coated with oil and/or even taking the form of an aromatic paste, in order to prolong their preservation and their aroma? All of these aromatic plants could have grown in Greece, but most have not been found archaeobotanically to date, for reasons which touch upon the problem of preservation on Greek

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[39] They also exist in Attica but obviously they are beyond the catchment area of Mycenae, Pylos and Thebes.

[40] This species and the previous one are found in Crete, whereas, the next, *C. cancellatus* has edible bulbs and is found all around Greece. *C. oreocreticus* is an endemic species in central and east Crete, and I have to thank Don Evely (oral communication) for the information that it was also collected, in modern times, as saffron. However, this needs more verification.

[41] See Sarpaki 2000.

[42] It is interesting to note that *Crocus cartwrightianus* is found, today, only in the west of Crete, but its distribution might have been greater in the past.

[43] It is worth mentioning the high importance of this plant in the LM IA/LC I period (Sarpaki 2000).

[44] See Table 9.

[45] See also *ko-no* calculated in 'bundles' –annotated as *E*– (cf. Table 11).

[46] It would be *ca.* 70-100 kg., which would be the average weight of a person. Horses and mules would have been able to carry more than donkeys.

[47] See Table 15.

[48] Some 28,000 litres are added (see Table 4) especially if one includes **123*.

sites, but are, also, due to behavioural tendencies involving aspects of the harvesting, processing and disposal of these plants.

On the whole, we are dealing with fairly small quantities of these plants/plant-substances,[49] even though these figures relate to one season's harvest, and more would definitely have been expected for the palatial 'machinery'; the more so as the cultivation of most could well have been implemented, in Greece, at this early date. This phenomenon is difficult to explain. Have we lost most of the tablets and are these a mere window to the past, representing a bare shadow of the Mycenaean economic system? The small quantities continue to puzzle us. Plants such as fennel (Table 6), rose (Table 3), cumin (Table 8), and sage (Table 17) would have been expected to be annotated in larger quantities.[50] As the quantities are rather small, and their 'transaction' could have been effected in some form of liquid measure[51] (liquid volume), this induces me to suggest that there is some reason to believe that these quantities could refer to the product of the processed plant, i.e. concentrated aromatic water and/or oil, or even seed crop. The terms, *pa-ko-we* (aromatised with sage), and *wo-do-we* (aromatised with roses) are probably simply examples of a substance (oil?/water?) perfumed with sage, and rose. This may, of course, be only one of the explanations for their archaeobotanical absence, but others need to be explored.

For Mesopotamia, Levey[52] suggests that some specialised apparatus, dating back to 3500 BC. has been found at Tepe Gawra (Fig. 1)[53] which 'indicates that ancient Sumer knew extraction, sublimation and a proto "distillation"'. These vessels are described as having a large trough formed by their double rim. In the inner lip are drainage holes leading back to the container. For extraction, botanical or faunal material would be placed in the trough or channel. The solvent, water or oil, would be volatilised, strike the cover and run down over the material in the channel and then back again into the pot, thus forming a continuous extraction process. Variants of this vessel have been found at Tepe Gawra, others where there are no holes leading back to the boiling solvent in the pot. 'The sublimate/distillate is then retained in the circular channel formed by the two rims'.[54] This process could, one assumes, also have been carried out with simple cookware pottery, whereby the botanical material would be imbibed in the water or oil, depending on the medium used. These would be heated and a fragment of absorbent cloth would be used, either under the lid or instead of one, and would occasionally be squeezed and replaced.[55] In this manner, volatile oils would be procured. If a simple kind of distillation was

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[49] Taking into consideration that an approximate equal weight of rhizomes is needed to the quantity of material to be dyed.

[50] The reason, I believe, we qualify them as small quantities is when we have in mind the accepted model of the palace as a re-distribution centre. If they were used as a condiment for the population of a whole palatial complex, unless used very sparingly, the quantities should be seen as fairly small. On the other hand, if this model only refers to staple products, and condiments were not included in this re-distribution system, then those seasonings which were in current use for the palace might not have been annotated, and only seed crop for next year's planting would have been archived. If this explanation is correct, the small quantities of seed make sense.

[51] Unfortunately, for fennel and cumin we only have the *V* and *Z* denominations and not the *S* and *T* which would differentiate between dry and liquid measure. Therefore, we cannot argue in favour of either, but, at this stage, we cannot exclude their 'transaction' in liquid form.

[52] Levey 1956, 145.

[53] From stratum VI (beginning of the 3rd millennium) (Speiser 1935, pl. LXXIV); also from stratum XI-A, where social stratification seems to have reached an apogee (Tobler 1950, 158, pl. CXLII and CXLVI).

[54] Levey 1956, 146.

[55] Athanasia Kanta (1999) has made certain observations on 'primitive' methods of distillation, which are used at the modern village of Monastiraki in the Amari area of Crete.

possible why not make 'cumin water', 'fennel water', 'coriander water', just as orange-flower water or rose water is made today? In that case, sesame could be reduced to paste form, or even an oil. Coriander, on the one hand, just like the aromatics mentioned above, could have circulated as oil and/or some kind of coriander water (**MY Ge** series where quantities are rather smaller), or even in paste form, but, of course, these figures could also refer to seed crop. On the other hand, at Pylos and Knossos, large quantities were listed, and refer, rather, to the fruits. For coriander, perhaps four kinds of transactions would have been possible: aromatic oil of coriander or 'distilled coriander water', processed seeds reduced to paste or powder, the greens, and whole seeds. However, it is curious that the quantities referred to at Mycenae are so regular. It is as if a certain set amount is handed in as seed crop for the next year's planting. Could it be that section **MY Ge** also had responsibility for collecting and allocating good quality seed crop?

3. Perfume, Condiments and Dye Plants: Some Thoughts on Their Social Role

Perfumes, condiments and dye plants are not only tied to economic factors, but are potent with cultural, social and symbolic meanings.[56] Preferences for certain 'flavours' are bound by taboos, and to cultural 'areas' where the fondness for 'smell' (odours), 'taste', and 'sight' are not free from the bondage of social memory –in other words, of culture. We, generally, like the smell, taste and sight of what we are brought up with, and, generally speaking, people keep to these, particularly at times when geographical and social mobility were far more restricted than at present.

Greece being what it is, a country with a large number of aromatic herbs growing in all areas, one cannot believe that condiments would not have been used to preserve,[57] season and diversify people's otherwise bland diet. Yet, these herbs grew in the wild and were found practically everywhere, so what would have been the reason for keeping an inventory of items so widely available? It is, therefore, easy to understand that in Prehistory, the use of condiments was in some cases more of a necessity than a luxury, especially when it concerned preservation of foodstuffs.[58] Consequently, it could be claimed that in the Mediterranean or where the climate is hot, condiments used in food are an absolute necessity and belong to the population at large.

Perfumes, on the other hand, cannot be classified on the basis of the same needs. Perfumes are more of a luxury reserved for social elites, as they cannot be classified under items of necessity. However, we do know that perfumes did actually protect people from certain diseases, especially illnesses transmitted by, for example, fleas or other body bugs. We now know that perfumes can keep these insects at bay. One could classify them as proto-disinfectants.

Some dye plants would have fallen under the same logic as condiments in that they must have been widely available from very early times. One might assume the choice of colour and plant to have been strongly adapted to the local availability of plants, just as folk costumes of an area have a certain stereotype of colour and decoration, adapted to the local curation/tending of plants, but other 'exclusive' colour(s) must have been potent with cultural, symbolic meaning(s)

[56] Sherratt & Sherratt, in their very important paper (1991, 354), state that 'perfumes are not just luxuries but embody concepts of value and purity which have a power which is more than just a consequence of their relative scarcity'. The same can be said for the burning of incense or the use of particular colours.

[57] It is believed that herbs (McGee 1998, 649) such as oregano help preserve foods from pathogens and would have been important for their longevity and, therefore, of paramount importance in the storage of foods in the prehistoric period.

[58] It has been observed that condiments such as salt, pepper (not in Prehistory) and other herbs such as thyme, oregano, and so forth, can retard the oxidation of foods and thus extend their preservation.

and related to religion, status, sex, probably age and/or wealth. The problem of dyes and colour is a very intricate one and is potent with semiotic meanings. Fabrics, beyond the necessity of dress, are a feature of display, and their function is to help differentiate the wearer from others (whether clans, tribes, and/or cultures). These are social signals, related to personal and communal identity, which differentiate a society at large from another society, belonging to another cultural *entourage*. They provide a point of reference of culture, of identity, of social order, and therefore, of survival *vis-à-vis* others. Perfumes belong to a much more subtle level of social stratification, and cultural identity. One might suggest that people would be much more prone to wearing the same perfume, even if they belong to different cultures, rather than to wearing the same type of clothes. Perfume, as being a luxury item which circulated widely, must have superseded cultural differences, and contributed towards uniting social classes intra-culturally. One might therefore claim that perfume –amongst other luxury items, which we shall not deal with here– existed to form some '*koine*', in social-identity terms, of wealth and symbol, transcending culture differences.[59]

4. Catalogue of the Perfume, Condiments and Dye Plants Referred to In Linear B: The Archaeobotanical and Ethnobotanical Data

CROC:[60] *crocus spp*. (*C. cartwrightianus* and *C. sativus*), the saffron crocus (Table 16). On the Theran frescoes, where crocus collecting is depicted *par excellence*, they have been identified as *Crocus cartwrightianus* for reasons explained.[61] However, we cannot exclude its cultivation in parallel with the collection of the wild species, for it seems to have been a very important plant of high economic value and religious symbolism. The saffron crocuses might have been used for dyeing,[62] in perfumery, as a condiment and also as a medicinal plant.

All we can say is that *C. cartwrightianus* seems to have been the progenitor of *C. sativus*, but this 'domestication' must have occurred very early on, as *C. sativus* has lost its ability to propagate by seed.[63] It only propagates by bulb, in other words vegetative propagation, which is a sign of a long period of domestication. Nowadays bulbs of *C. sativus* are planted in July, in well-tended fields, and the first harvest takes place more than a year later, in the autumn. For one

[59] This justifies the wide circulation of perfumes and incense in the Mediterranean at this period, which transcended cultural frontiers.

[60] Strangely crocus is referred to in three ways, **33* (Lejeune 1971, 155, note 50; *Documents*, 51), **144* and *ko-ro-ki-no*.

[61] Sarpaki 2000; Σαρπάκη 2001.

[62] The styles (orange) contain a pigment (yellow) that is soluble in water with a very high colouring potential as it colours 100,000 times its volume in water. However, the author is intending to carry out some dyeing experiments with Mrs Sophia Kana using various natural fibres. On the other hand stamens (yellow) today are excluded from best-quality saffron and are only left as inclusions in second-quality produce. At Akrotiri, however, both styles and stamens are nowadays kept and used together. We still do not know whether they were separated in Mycenaean times. However, it is interesting to note that in the wall-painting depicting a woman (priestess?) in the passage between room 4 and 5 of the West House, she is holding an incense burner in which are coals and a yellow substance, placed on top of the coals, which seems to resemble the yellow stamens in that they are like 'threads'. Morgan (1988, 29) also believes the priestess in Room 4 (West House) has stigmas of saffron over the brazier and it has been also observed by the present author that their colour is yellow and not dark orange. She is also wearing a yellow, crocus-colour, robe. Is this a coincidence or does it symbolise the fact that crocus stamens used to be burned as incense? Crocus smell, as I, personally, noted, resembles very much the sweet odour of honey. Would this be intensified with burning? It will be worthwhile to carry out the experiment.

[63] Zohary & Hopf 2000, 207.

stremma[64] 114,000 bulbs are needed.[65] It is said that 100,000 flowers[66] produce *ca.* 5 kg. of styles, which is reduced to 1 kg. after drying.[67] The styles contain a pigment (yellow-crocin) that is soluble in water with a very high colouring ability, as it colours 100,000 times its volume in water.[68]

No archaeobotanical traces of either crocus have been found and the chances of preservation are extremely low. The harvest of this plant does not permit archaeobotanical preservation, as only the flowers are picked in order to separate the styles (3 orange) and stamens (3 yellow) from the petals. This is done piecemeal, every day or whenever picking is conducted within the flowering period.[69] Theran crocus-picking as well as modern ethnographic observations from the Akrotiri area, Santorini have been recently recorded.[70] What is important to note is that all of the cleaning is nowadays conducted in the open air, generally in a shady place, near the harvesting area, as the styles and stamens need to be separated before the flower withers. These are the only botanical parts taken back to base/settlement, but they leave no visible potential archaeological evidence behind. Our only chance would be that, in areas where *C. sativus* is cultivated, we

[64] The stremma, a measure of land used in present-day Greece, is equal to 1,000 sq.m.

[65] Ορφανίδης 1873, II, 312.

[66] Baumann (1993) claims that 100,000 to 140,000 flowers make 1 kg. of dried saffron. One presumes the number of flowers depend on their degree of maturity, as well as whether they are the product of the cultivated or the wild species.

[67] Cardon & du Chatenet 1990, 125.

[68] Cardon & du Chatenet 1990, 125.

[69] Nowadays at Akrotiri, Santorini the flowers are picked either very early before sunrise or late at sunset, yet Orphanides (Ορφανίδης 1873, II, 312) claims that they should be collected at *ca.* 10-11 a.m. after the dew has evaporated. Flowers hardly last for more than two days, on the plant itself. These are collected in containers and then poured into larger baskets (*κοφίνια*) and are transported immediately to where the styles and stamens are separated. He also stresses that on no occasion should the flowers (styles) of one day be left to be separated the next (Ορφανίδης 1873, II, 314). If the flowers remain unseparated for one-two days, then one should consider the product lost. The time needed to clean the styles is one hour for 20 dramia (where a dramion = 3.203 gr. in Greece; 1 kg. = 312 dramia) of 'fresh' crocus, so that in four hours each worker can separate 240 gr. of 'undried' crocus. In order to dry them, he remarked that they should be placed in a shady and draughty area and turned two-three times a day. When dry, the styles are five times lighter in weight. In order to store or transport them, they are transferred into wooden boxes of odourless wood and they should not be compacted as they can develop mould if they are still slightly humid, or, if totally dry, compaction can reduce them to dust! However, crocus can be falsified with *Carthamus tinctorius*, or *Calendula, Scolymus*. The production of crocus in its first year of planting is *ca.* 2/3 less than the second and third years. Generally, the plantation, after the first year produces *ca.* 2.58 kg. of crocus per stremma (Ορφανίδης 1873, II, 318). Another very important part of the plant which has economic value are its leaves, which should not be cut before the end of March/beginning of April, but afterwards and before they turn yellow, they can be used as fodder (Ορφανίδης 1873, II, 344), whereby 10 stremmata can produce *ca.* 700 kg. of leaves in the first year but more than 1,024 kg. in later years. After the collection of the leaves, the farmer needs to rake the soil, and this should be done again around the end of August and September, to weed the field. He should not dig deeper than 6-7 cm. for fields, which have two or three year crocuses but, if they are older, they should be weeded with the utmost of care as the bulbs are even closer to the surface. It is said that Pliny mentioned a renewal of the crocus plantation every eight years. This renewal of the crocuses should take place in June or July. Orphanides claims that saffron was sold *ca.* 60-65 francs per gram (*ca.* 1872) and could go as high as 300 francs. He calculated that crocus plantations could provide 180-250 drachmas for the Greek farmer per stremma per year and occupy a workforce for only a few weeks per year, which he considers a good return that would keep women and children occupied, for several months of the year.

[70] Τζαχίλη 1994; Sarpaki 2000.

might conceivably find a reserve of corms stored for the next planting in a jar or the like. As for the wild variety, it is archaeologically/archaeobotanically invisible.

Turning to the crocus mentioned in the Knossos tablets, we realise the huge collective effort needed to produce the quantity mentioned (*ca.* 3,726 gr.) which would have represented an area of *ca.* 2 stremmata of intensively cultivated *Crocus sativus*. This, in itself, is, I believe, another piece of evidence proving that wild crocus was collected. As it is fairly dispersed in the wild, one would expect that the area of collection must have been huge. However, an added problem occurs and that is its area of natural existence, which in Crete is today confined to the west of the island, especially to the Akrotiri peninsula of Chania.[71] Was the habitat of the saffron crocus (*C. cartwrightianus* and *C. sativus*) more extensive and did it cover much of central Crete? Were the Knossos archives also referring to the other two or three species (*C. tournefortii*, *C. cancellatus* and perhaps *oreocreticus*)? The first and third would probably have existed in Crete, in the east and the central parts respectively, but the second is absent today from the island. Was it the case then, too? There are many implications attached to each probable explanation, but none we could prove, at present. If the distribution of *C. cartwriaghtianus* was the same as today, the ramifications are enormous, as it would imply that the Knossos 'catchment area' extended to the west of the island, and, perhaps, as far as Thera to the north.

e-ti-we: henna (?), *ἔρτις, κρημνός, κύπρος* in Greek (Table 3). It has been argued, that the term is an adjective, describing an aromatic plant used in the oil;[72] in other words, it describes an odour. On the other hand, Shelmerdine[73] argues that it is rather a description of colour, and not of scent. In that case, *e-ti-we* could be a dye. It has been considered from a fairly early time that *κρῆμνος* was probably *Lawsonia inermis*, henna.[74] Henna is not a plant native to Greece, but existed in North Africa (Egypt), Arabia and India.

There are two varieties, *Lawsonia inermis L.* and the variety *L. inermis var. alba.* with white flowers. They are connected with cosmetics, dyeing and perfumery. The flowers are exceptionally odoriferous and are used to perfume unguents in Egypt. The flowers, though, need to be freshly picked and not dried in order to impart the scent, plus they would need to be imported in very large quantities; two reasons why Shelmerdine believes that it was impossible to import them for perfumery (fragrance). Dioscurides mentions that some 1,000 flowers would be needed for a recipe. On the other hand dried leaves of the plant could have been imported, as these are the source of an orange-red dye. A paste was made in ancient Egypt –and this is still used nowadays in Egypt– with which they dyed, and still do, the palms of their feet and hands, their nails, hair, and sometimes eyelashes. This decoction of the leaves was occasionally used to dye cloths.[75] Perhaps women depicted with red ears, on the wall paintings at Akrotiri, could have used henna. In Egypt several mummies have been found with henna on their hands, feet, and hair. An orange-red mummy wrapping from the 21st Dynasty was found to have been dyed with henna, probably mixed with a red colour, *Carthamus tinctorius*.[76] A perfume of unknown date was analysed and henna was found to be one of the several substances present. However most findings are dated to the Graeco-Roman period in Egypt.[77]

[71] Mainly the Stavros area of the Akrotiri peninsula.
[72] See Duhoux 1993, 103.
[73] Shelmerdine 1985, 30.
[74] Shelmerdine 1985, 27.
[75] See Lucas & Harris 1999, 310.
[76] See Lucas & Harris 1999, 153.
[77] See de Vartavan & Amoros 1997, 151.

ka-da-mi-ja: *Cardamomum ssp.*, cardamom (Table 3). It was identified as *Lepidium sativum*, garden cress, by Duhoux[78] (**MY Ge 604**), who does not mention the possibility of it being cardamom at all. Although neither has been identified archaeobotanically in Greece, *Lepidium cf. sativum* has been found in Egypt from 3800-3500 BC.[79] *Καρδάμωμον* was mentioned by Theophrastus and Xenophon. The root of the name is said not to have an eastern origin,[80] although this annual plant seems to have had a Near Eastern derivation,[81] but could well have grown in Greece. It could have been used as a salad or a green vegetable, but its mention in the tablets is puzzling to us, as one would think it too humble a plant, economically, to warrant such mention. However, one could suggest that it would, rather, refer to *καρδάμωμον* (see Theophrastus) (cardamoms), which is *Cardamomum vulgare* or *Elettaria cardamomum*. In Egypt an ointment was prepared where, amongst other substances, cardamom was included,[82] but its area of origin is India and Ceylon. It is the seeds, which retain the delicate spicy essence but they retain it better if they remain enclosed in their capsule. These capsules are, therefore, harvested very carefully so that they do not spill the seeds; they are cut off with scissors before they are fully ripe and then dried slowly with the aim of preventing them from splitting open. The seeds are used as a condiment, for medicinal purposes, for chewing to sweeten the breath and in confectionery. Nowadays, they provide the flavour of certain liqueurs, and the oil can be used in perfumery. It is considered expensive and is second only to crocus[83] (see cinnamon and cassia, which were very expensive in Roman times).

ka-na-ko: *Carthamus tinctorius*, safflower, *ζαφαράνα*, *ψευτοζαφορά*, or otherwise 'false saffron' (Table 5). Shelmerdine[84] does not classify it under perfume crops but it might have been used as a condiment, dyes for foods, oil, dye (for textiles) and ointment. Kohl[85] is also extracted from its charred soot, but its use as dye for textiles is best attested.

The earliest finds to date –3rd millennium BC– come from the Syrian sites of Atij, Raqa'ι and Kerma (modern Syria). All of the three sites yielded a few whole seeds, named achenes and achene fragments but it is still difficult to assign them to species, although the archaeological specimens resemble, on morphological grounds, *C. tinctorius L.*[86] Nevertheless, at least one specimen from Tell 'Atij resembles *Carthamus tenuis (Boiss. & Bl.) Bornm*,[87] wild species of

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[78] Duhoux 1993, 104, and *Documents*, 549. However, Palmer (1999, 476, 485), quoting Varias Garcia (1993, 198-201), refers to it as *Nasturtium officinale L.* (watercress). This last plant might have grown wild in Greece but has not been detected yet archaeobotanically.

[79] El Hadidi *et al.* 1996. For other sites see de Vartavan & Amoros 1997, 156.

[80] Hoffner 1974, 110.

[81] de Rougemont 1989, 231.

[82] Lucas & Harris 1999, 87.

[83] See Pliny for the prices of some spices, of his time.

[84] Shelmerdine 1985, 171-172.

[85] Present day Egyptian kohl is made of soot from the burning of the safflower plant (Lucas & Harris 1999, 82). This could also have been used in the Mycenaean period. Another important soot comes from oliban which is the frankincense of the *Boswellia ssp.* and *Commophora ssp.* (Lucas & Harris 1999, 91); Baum (1994, 28) claims it is made into an ink and is also used for cosmetics, for blackening the eyelashes and eyelids.

[86] McCorriston 1997.

[87] McCorriston (1997, 44) claims that the origins of safflower are unknown, whereas Zohary & Hopf (2000, 211) insist that the wild stock of safflower is 'well identified' and that the domesticant is interfertile with *C. persicus Willd.*, and *C. oxyacanthus M. Bieb* and, could, therefore, derive from them. Genetic research also points to the Euphrates basin as a possible place of origin for the crop and the closest modern genetic relatives grow today in the Syro-Palestine area. These are *Carthamus flavescens*, *C. oxyacanthus* and *C. palaestinus* (McCorriston 1997, 44). Kroll (1990, 41) identified *C. lanatus* in the Early Bronze Age at Feudvar.

safflower growing in Jordan today. This in itself indicates that there are still possibilities of finding other species of safflower in archaeological assemblages. From Syria too, other very early finds have been found in Early Bronze Age levels from Tell Hammam et-Turkman, dated to 2400-2000 BC,[88] where charred remains of *ca.* 65 flower heads from Tell Hammam et-Turkman were uncovered. This is, therefore, strong evidence that safflower was cultivated for its florets at this date. Archaeobotanical finds were also noted at Selenkahiye of the same period. Of course, this does not exclude its cultivation for its achenes as well, which are valued for their oil.

From Egypt, safflower achenes were found in Tutankhamun's tomb (*ca.* 1325 BC) and garlands of this plant were found adorning 18th Dynasty (*ca.* 1500 BC) mummies.[89] Other more recent finds come from Amarna[90] but there is as yet no evidence for their use there.[91] Evidence for its use as a textile dye in Egypt comes as early as the 12th Dynasty (*ca.* 1900-1700 BC). From the archaeobotanical findings in Egypt and Syria, as well as from the analyses of textiles, we can say that there is evidence for the growing of safflower for its dye.

Two types of dye can be extracted from the yellow-red florets. One can only be used as a condiment, as it is water-soluble. This is used instead of saffron for colouring foods yellow, and is, therefore, sometimes confused with saffron and named 'false saffron'. The other dye, carmine, is water insoluble[92] and was widely used to colour textiles orange, pink to red –depending on the preparation of the dye and the type of the textile– before the production of synthetic dyes. Today, in Egypt, the dried red florets are sold to tourists as 'saffron'.[93] Hence, it earned the name of 'false saffron', which may have been a falsification that started early in history, and may have been a falsifying product for the uninitiated, either sold alone or perhaps mixed with true saffron. These dried florets are also sold today in the '*souks*' (markets), as a source of dye in Egypt, but the quantities needed are great,[94] and the harvest is done piecemeal throughout the flowering period, which takes place in July and August, that is if the harvest is for the dye; otherwise, if it is for the oil, the plants are left to mature further after the withering of the flowers and until the seeds are fully grown. The flower heads are generally harvested when nearly withered, either in the very early morning and/or before sunset.[95] For a bright red, the quantity of dye needed was in the ratio of 1 to 1. However, it is unstable in light.

In Europe, the earliest finds are a single achene of safflower found in the Early Bronze Age levels at Feudvar (Vojvodina, Yugoslavia).[96] The importance of safflower for the Mediterranean is that it can grow in drought[97] conditions, but it favours and exploits humidity in the soil, as its root system goes quite deep (*ca.* more than 2 m. depth).[98] It favours marginal dry-farming

[88] van Zeist & Waterbolk van Rooijen 1992.
[89] Zohary & Hopf 2000, 211.
[90] Samuel 1989, 281.
[91] de Vartavan & Amoros 1997.
[92] It becomes soluble in dilute solutions of alkali, such as natron, and has been employed recently for dyeing silk and for colouring starch to make rouge for toilet purposes (Lucas & Harris 1999, 153) (natron = GK nitron = sodium carbonate $Na_2CO_3.10H_2O$). Other mordants are chalk or kaolin, and, where available, potash alum was used. Potash alum could be produced by reducing plant matter into ash. It would be interesting to know whether the safflower plant, when and if burnt after harvest, would produce ash with a high potash content.
[93] de Rougemont 1989, 273.
[94] Cardon & du Chatenet 1990, 28.
[95] Cardon & du Chatenet 1990, 28.
[96] Kroll 1990.
[97] It can grow even with as little as 250 mm. of rain.
[98] Knowles 1955, 277, 280.

regions and does not fare well under irrigation or rainfall at maturation, although it would favour some rainfall in the spring and early summer, in the first stages of its growth.

Its achenes are white and, under dry land conditions, yield some 40-175 kg. per 1,000 sq.m. These produce 24-36% oil.[99] This explains the description of white for the achenes and red for the florets (Table 5). It makes sense that all the whites are measured in dry volume, which would be a practical way of noting the quantity of seed, but if oil was extracted from the safflower, larger quantities would definitely have been expected than the 1 and 2 litres as mentioned. It seems more likely that we are dealing with the seed kept for planting the next year's crop, especially as we know that safflower is an annual. Therefore, the standardised achene quantity might refer to the seed needed to grow safflower in a given size of field. The red, on the other hand, could well be the florets, dried and ready to be used as dye. They are then pressed into cakes. When they are thoroughly dried, they are packed into bales weighing *ca.* 45-90 kg. each.[100]

As has been noted, safflower is a summer crop and seems to clash with the typical Mediterranean agriculture whereby the traditional winter cereals and legumes would still be maturing at the planting time of the safflower –unless it was grown in fields, which were periodically left fallow and were rotated with cereals and legumes. In this manner, safflower would help control weeds and not deplete the soil as much as cereals. Deliberate planting of safflower would fit into a winter-crop/fallow/summer-crop rotation, which could have been implemented in Greece in the Bronze Age. This agricultural policy would have been ideal for Greece, especially in areas which are affected by the *meltemia* summer (July/August) winds where uncultivated ground, which is left fallow, would be exposed to undue erosion by the *meltemia*. This could have been avoided by planting summer crops on fallow fields, hence, the importance of safflower, which could be a further indication of even greater agricultural intensification at the end of the Late Bronze Age of Greece.

There seems to be something of a discrepancy between the seed produced[101] and the florets. Of course, the florets would have been very bulky but light when dry, so this amount seems to have been reasonable. However, the achene is more of a mystery. As it is mentioned in small quantities, could we be seeing the achene (best quality) provided for the next year's crop? For the quantity does not justify the oil explanation. In this case, we can perhaps claim that the administration controlled the base (the seed crop, and either planted it themselves or provided the rights to some farmer to do so and thus created a form of subordination to production) and the produce (red florets).

KAPO: This is a very controversial term (ideogram **127*) (Table 12), which has been interpreted in various ways. The original decipherers, Ventris and Chadwick, interpreted it as *καρπός*, fruit, and equated the *ka-po* to the monogram *KAPO*, with which Sacconi[102] disagrees. Another researcher, Gallavotti,[103] interpreted the monogram *KAPO* as the Greek *σκάφος*, which

[99] Gill & Vear 1980; but compare Καββάδας, 1805-1806, where he mentions that 50-54% of oil is extracted.
[100] Forbes 1953, 121.
[101] According to Knowles (1955, 286) under dry conditions the seed yielded in the range of 40 to 170 kg. per stremma, whereas the dried florets ranged between 5 to 19 kg. per stremma (Knowles 1955, 294). What seems important is that Knowles (1955, 294) claims that an achene crop can be obtained in addition to the flowers. I do not know how this would affect the dye, but I believe it would probably reduce the dye quality, as the florets would be dried/partly dried in the sun.
[102] Sacconi 1972.
[103] Referred to in Sacconi 1972, 23.

is a rare form of *σφάκος*, sage, *ἀλιφασκιά* in Cretan. Theophrastus refers to it as *φάσκον*. Shelmerdine,[104] however, does not accept Sacconi's interpretation for cinnamon. Bennett, instead, has interpreted *pa-ko-we*[105] as deriving from the Greek *σφάκος*. However, the objection of Sacconi rests on the fact that sage was not used as an ingredient in perfumery in Classical times and, therefore, she believes it would not have been used in the Mycenaean period either.[106] This, it is believed, is a dangerous assumption, as tastes in perfumes, much as in other things, would sometimes change through time and from culture to culture. Shelmerdine,[107] moreover, accepts sage as a perfume fragrance in Mycenaean perfumery. On the other hand, if, for the sake of argument, one accepts Sacconi's cinnamon interpretation, we should consider the long distance of the countries producing cinnamon, from the Mediterranean.

Cinnamomum zeylanicum, cinnamon, originates in South India and Ceylon. A tree of the same genus *C. cassia* (originating in China) is perhaps the *κασσίαν* mentioned by Theophrastus, and several species of cassia (probably *C. camphora*, *C. tamala*, *C. obtusifolium*, *C. pendunculatum*[108] were mentioned by Dioscurides. These exist in the Far East, which is the same general area where *Elettaria cardamomum* grows.

Cinnamon was used in making aromatics in Egypt,[109] but so far it is not possible to say which cinnamon species. *C. tamala* is said to be the base of malobathrum oil, which was the raw material extracted from the leaves of the cinnamon tree.[110] In Egypt, plant remains have been found of *Cassia absus* (seeds) and *C. senna* (wood charcoal and pollen).[111] As it was found in areas adjacent to Greece, there are great possibilities to find it as charcoal. Archaeologists working on sites in Greece, although they collect it to some extent, rarely give it to specialists to examine. This is the reason, it is believed, that many hidden treasures amongst the charcoal, which would provide great surprises in the field of imported materials, await discovery.

If *KAPO* is a product of the cinnamon genus of trees, we could be dealing with, broadly speaking, three products: cinnamon wood (*ca.* 10 denarii[112] per pound), cinnamon for which it is not clarified whether it is in stick or powder form (1,500 denarii per pound), and which seems to be the most expensive of the condiments, or cassia, which varied enormously and ranged between 5 to 50 denarii per pound. If we consider that myrrh –depending on the quality– was between 3 and 50 denarii per pound, and frankincense between 3 and 6, it is obvious that cinnamon must have been the most expensive of all, but what we do not know is whether this price hierarchy was the same for the Late Bronze Age. At Pylos, as *KAPO* is mentioned as 'transacted' in two ways, we could well be dealing with either the sticks (bark) or the wood which is calculated in primary units, and perhaps cinnamon powder as transacted in the measure of volume. However, the fairly large quantity (*ca.* 140 litres + units 9) from Pylos conflicts with

[104] Shelmerdine 1985, 18.

[105] Sacconi 1972, 24.

[106] See Killen (1964, 172), who claims it is used in unguent preparations, but also see Killen 1987, where *ka-po* in **KN F(2) 841 + 867** refers to *κῆπος*, garden, a garden orchard (Palmer 1999, 479, note 63).

[107] Shelmerdine 1985, 38.

[108] Καββάδας, 1924-1925; Sacconi 1972, 26.

[109] Lucas & Harris 1999, 87, 333.

[110] Darby *et al.* 1977, 798.

[111] de Vartavan & Amoros 1997, 65-66, although from experience we know that for a charcoal and pollen specialist, it is, most of the time, impossible to put a species to a genus, in which case we would only be able to identify *Cassia sp.*

[112] These are the prices quoted by Pliny for his time (Groom 1981, 154).

its high price –if its status was the same in Prehistory– and, as *KAPO* is always mentioned together with substances used in perfumery, it must have had some connection with it. Are we, therefore, dealing with an oil perfumed with cinnamon and circulated as aromatic oil to enrich perfumes? Shelmerdine,[113] nevertheless, does not include it in her list of perfume plants. As a conclusion, we might say that *KAPO* needs to be reinvestigated and perhaps redefined, if and when new tablets are found with this product.

ki-ta-no: Melena[114] identifies it with turpentine, *Pistacia terebinthus L.*, *κρίτανος*, but it is believed, by the present writer, to represent another plant, the rockrose, *Cistus creticus L.* (Tables 4 and 15) The latter is mentioned as *κίσθος* by Theophrastus, which produces the ladanum or labdanum[115] (*λήδανον*[116] mentioned by Herodotus and Dioscurides, whereas ladano by Pliny), and *ladanu* in Assyrian. In Crete, the plant is commonly called *αλάδανος*, *λαδανιά*.[117] The ending, *δα-νος*, could well have changed from a dental stop to its middle[118] and transformed it to *ta-no* in *ki-ta-no*. However, as we do not know how the Mycenaeans pronounced certain letters, the transformation of *λη/λα* in *λάδανο/λήδανο* to *ki-* in *ki-ta-no* is still difficult to explain. Therefore, *ki-ta-no* might not refer to the plant, but mainly to its product, ladanum (*λαούντανο* in Greek), for reasons expanded more below.

Cistus creticus L.: This perennial bush grows abundantly in phrygana and maquis zones, especially on Crete, and the view that it is a product found in profusion in the Knossos archives[119] makes great sense, as this bush is widely found in Crete.[120] A true resin,[121] the

[113] Shelmerdine 1985, 171-172.

[114] Melena 1974a, 1976a; *inter alia* Duhoux 1993, 106.

[115] This should not be confused with laudanum, called *λαούντανο*, which is a tincture of opium.

[116] Liddell & Scott, *s.v. λῆδον*.

[117] Φραγκάκι 1969, 32-35 for Crete of the 20th century.

[118] I would like to thank Dr Y. Tzifopoulos, Department of Philology of the University of Crete, for providing me with this information.

[119] The earliest literary mention of ladanum in Egypt is in the Bible, where it is stated that merchants carried it from the area of Gilead (Transjordan) into Egypt and that Jacob sent ladanum to Egypt as a present for his son Joseph (dated to *ca.* 10th century BC). The sending of ladanum from Palestine to Egypt, is indicative of the fact that this was a product in demand and not produced in Egypt (Lucas & Harris 1999, 94). It is interesting to note that *ki-ta-no* was the resin that Tuthmosis III imported from Syria-Palestine in annual quantities averaging 9,250 litres. Indirectly, it is an indication of the need of the Egyptians for this product, as it has been noted that indigenous sources of aromatic resins are virtually absent from this country (Serpico & White 2000, 884). However, only in Coptic times was evidence of ladanum detected (Lucas & Harris 1999, 95). The resin beads (Fig. 4) found in the tomb of Tutankhamun, as has been checked from the bibliography have not been analysed in order to detect the source of the resin, but could also be ladanum. A possibility is that ladanum, being cheaper than frankincense and myrrh, could have been used for daily use and for ordinary purposes, not connected to funeral occasions, and that most probably the material that has been studied so far is the one found in wealthy tombs. Lucas & Harris (1999, 97) claim that a brown resin (it is the right colour for ladanum) is found in all graves of all periods, and of all ranks. It is believed that not all the mysteries found in Egyptian tombs and excavations have been totally disclosed, and more information is yet to be expected, especially as regards the analysis of materials.

[120] The present author is researching together with Manolis Flouris the ethnobotany of this plant and collection of this resin.

[121] Gum (*κόμμι*, *γόμμα*) is the term used for any of numerous colloidal polysaccharide substances of plant origin that are gelatinous when moist (soluble in water) but harden on drying, whereas resins (*ρητίνη*) are solid or semi-solid organic substances that are either translucent/transparent or yellow to brown, and form

ladanum (Fig. 2), is collected from its fruits and leaves during the hottest days and the warmest hours of the day in July, and is still collected in Crete, though in very small quantities, nowadays. It was used for medicinal purposes and as incense, while it is presently used in aromatics and soap manufacture. Baumann[122] describes traditional ways of collecting ladanum in Crete,[123] Cyprus and Arabia.

In the 18th century, this resin was exported from the port of Larnaka, in Cyprus, in containers of 50 and 100 okades (64 and 128 kg.).[124] In both countries it is collected with a sort of 'flexible' comb-like implement, but the purest ladanum is collected from the beard and hair of browsing goats, which is also 'harvested'. This is placed in boiling water in order to make it melt.[125]

The usefulness of the resin is manifold. Its medicinal properties are said to guard against pestilence, diarrhoea, rheumatism, colds, and the evil eye (Fig. 4). Frangaki[126] claims that the plant was used in dyeing and gives a bordeaux red when dyeing cotton. However, its most common use must have been its use as ladanum (medicine) and as incense.

The quantities mentioned are fairly large and if **123*[127] (Table 3) is *ki-ta-no* (Table 15) we are dealing with amounts reaching over 45 tons. This would have meant that Knossos was recruiting

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especially in plant secretions and are not soluble in water, but only in ether or other organic solvents. The Mycenaean term *re-di-na-to-mo* (*ῥηδινατόμος*), André (1964, 88) believes, is indicative of a profession and must have been used to denote those that collected resins and also gums. However, the term could not be traced in *Index Généraux* but Aura Jorro & Adrados (1993) include it in their terms.

122 Baumann 1993, 89-92.

123 M. Pitton de Tournefort (1727, 86), the traveller, describes and includes a drawing of the instrument with which the Cretans of his time collected ladanum at the village of Melidoni. Pliny (XXXVII.73-76) also describes vividly the collection of the resin from the hair of the goats.

124 Every oka has a special weight value; for example the Turkish oka is 1,282 grams, the Hellenic oka is 1,280 grams, and the Egyptian oka is 1,237 grams (*Εγκυκλοπαίδεια Πυρσός, s.v. οκά*). Therefore, 64 and 128 kg. are involved (Γεννάδιος 1914, 513).

125 When it was heated on a low flame in water and was subsequently sieved in order to separate it from inclusions, a product was obtained called *poix de Bourgogne* (André 1964, 95). When it cools, the resin hardens and floats on the surface of the water. This 'automatic' separation makes it easy to process. If it was left to heat for a long time, the volatile oils were eliminated and were collected on fleece. The remainder was the vegetable tar, *πίσσα υγρά*, or *κώνα* (André 1964, 95). This was thickened with vinegar and was used to 'tar' pottery jars and in boat building, to 'tar' the wood. When this was re-heated it lost all the volatile oils and was reduced to real tar, *ξηρά πίσσα*, which is the product of the liquid tar, *υγρά πίσσα*. André (1964, 96) has a list of all the terms used in Greek and Latin for those substances. We need to note that tar (*πίσσα*) refers to (a) gum and (b) tar; *πίσσα ωμή* is the gum. However, from analysis of the Kyrenia wreck (4th century BC) (Beck & Borromeo 1990) it is evident that ancient pitch was made from resinous wood and not by the alternative method of heating pine resin alone. This pyrolysis of wood was conducted either specifically to manufacture pitch or was a by-product of charcoal manufacture. In addition, petroleum products were added to the pine pitch. A Late Bronze Age tin-covered conical cup from Chamber Tomb 1, Asine, provided evidence for rosin (colophony), made from pine resin for binding tin on vessels (Gillis 1994, 61). Colophony is also produced from the 'mastic' tree.

126 Φραγκάκι 1969, 33.

127 For **123* see Sacconi 1971; she argues that (a) *ko-ri-ja-do-no* is influenced by **123* and is measured in the same manner, (b) when **123* is mentioned together with coriander, the quantities are double those when it is mentioned alone. However **123* is also a substance that is transacted in large quantities alone. On p. 28 she claims that it is a substance, which is also transported as seeds. Having seen the way ladanum can be rolled into small 'balls', I believe, it is possible to 'trade' it in volume measure and it could, figuratively, be treated as a seed.

a work force from all areas of central and perhaps eastern Crete, and these people would have brought the produce in exchange for some other benefits, of which we have no evidence as yet. As we see from the above, Egypt imported *ca.* 10,000 litres of ladanum resin from Syro-Palestine, which, it is believed, could have been imported from the Mycenaean world, and especially from Crete. Melena[128] has drawn an interesting plan of the sites that are referred to as producing *ki-ta-no* in Crete and, interestingly enough, they are confined to the central part of the island, which is basically the area where this resin is collected nowadays.

ko-no or *ko-i-no* (Table 11): This has been variously interpreted, and has been a matter of debate. Some[129] believe it to be *Cymbopogon schoenanthus* (ginger grass) and others claim it could be *Acorus calamus L.*,[130] or the terebinth trees and equate *ko-no* to *ki-ta-no*.[131] If it is ginger grass, it would have been an imported plant from Arabia, India and Africa. Its importance is its oil, the oil of ginger grass, which would have been very valuable and expected to be transacted in small quantities and measured by volume. Kavvadas[132] believes that it might be the *σχῖνος* mentioned by Dioscurides and Theophrastus, but this does not automatically mean that the *σχῖνος* of their time would be the same plant, and the term today refers to the *Pistacia* tree.[133] It is, of course, possible that it could have referred to the same plant, which might have had a different name at Knossos (*ki-ta-no*) from the one used at Mycenae (*ko-no*), but *ko-no* is measured in primary units and *ki-ta-no* is mentioned in fairly large quantities (cf. Tables 11 and 15), but measured by volume. These points, I believe, argue against *ki-ta-no* being the same product as *ko-no*. Secondly, ginger grass, as producing oil, would have been very valuable and, therefore, expected to be transacted in much smaller quantities.

It is also believed to be turpentine, *Pistacia terebinthus* by Melena,[134] who thought it to be the *κρίτανος* of the ancients. Resin from *P. terebinthus*, *P. atlantica*, and *P. lentiscus* are noted as having been found at various sites in Egypt.[135] However, the finds from *P. atlantica* should be considered dubious, as the tree is native to the Canary Islands and is of no commercial use.[136] Yet, Zohary & Hopf[137] claim that nuts have been repeatedly found in Neolithic and Bronze Age levels of the Near East, and that today they are an arboreal constituent of the oak-park forests of the Near East arc. It has been claimed to be present at Sesklo, in the Aceramic/Early Neolithic (frequent), in the Proto- and pre-Sesklo phases (rare), and the Sesklo phase (5th millennium) (rare)[138] but this is a disputed identification.[139]

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[128] Melena 1974a, 52.

[129] Amongst others Maddoli 1967; *Documents*, 555.

[130] Wylock (1972) believes we could include *Acorus calamus L.* in the contested plants, but the present author thinks not, as it is a plant, which did not originally exist in Greece (*Flora Europaea* V, 268-269); it is presently only naturalized.

[131] See above for a different explanation for *ki-ta-no*.

[132] Καββάδας, 429.

[133] The term *σχοῖνος* refers to *Juncus sp.* or a type of reed.

[134] Melena 1974a, 1976a.

[135] de Vartavan & Amoros 1997, 206-207; Serpico & White 2000.

[136] De Rougemont 1989, 113. Contrary to this, Zohary & Hopf (1993, 197) claim that the nuts of *P. atlantica*, wild pistachio, are sold in the old-type markets and are therefore edible and they refer to the archaeological sites of Iran, Iraq and Turkey where it has been found (Zohary & Hopf 1993, 202-206).

[137] Zohary & Hopf 2000, 223.

[138] Zohary & Hopf 2000, 223.

[139] This has been identified by archaeobotanists (J. Renfrew and J. Hansen) as *Pistacia atlantica* at Sesklo and Franchthi (referred to by Zohary & Hopf 2000, 223) but identifications must be dubious and these

Pistacia terebinthus L., turpentine tree, *τερμινθίνη*[140] (Theophrastus and Dioscurides) in Greek, is a common plant in the maquis of Greece and the Mediterranean. It provides a true resin[141] from the sap of the wood, which is sold as amorphous crystals. Its fruits, named *τσίκουδα* in Greek, salted and baked are said to be quite palatable.[142] Gennadios mentions that they could also be eaten raw or in brine. If crushed and pressed, they produce an edible oil, the oil of terebinthus, mentioned by Dioscurides, but also used for lighting in the East. Galls, long and horn-like are formed in spring, on the leaves,[143] by aphids,[144] and are used for tanning.[145] The young shoots named *τσίκουδα* and *τσιτσιράφα* by the inhabitants of Pelio in Thessaly, Euboea, the northern Sporades and Skyros are prepared in brine and made into preserves.

The *Pistacia* tree produces fruit eight years after planting. An adult tree about twenty years old produces up to 30 okades (38.4 kg.) of fruit per year and is productive for over 100 years. This fruit matures at the end of August or beginning of September and is harvested by beating with a stick (a reed). The crop is then dried in the sun and stored. It was sold in Athens for 1½-2 drachmas per oka (1.28 kg.) at the beginning of the 20th century.[146]

Lucas & Harris[147] state that the true botanical source of the resin has not been identified and the question is how secure identifications of these resins could be possible nearly four decades after having been excavated. However, it has been identified as *Pistacia terebinthus L.*[148] and was found in *ca.* 100 jars of the Ulu Burun wreck.[149] This resin is semi-liquid but if boiled in water it rejects its oils, and turns milky colour and shiny. It is then sold in this solid form, in the shape of *μαγίδων*[150] which in Cyprus are called white tar or tar of Paphos.

remains need to be re-studied. All references to Sesklo by Kroll (1991, 172-174) are referred to as *Pistacia sp.* This shows his understated dilemma in treating these finds at a species level. As for Franchthi, Hansen (1991, 43) has re-identified the material and claims that the archaeobotanical material is more likely to be *P. lentiscus* and not *P. atlantica.*

140 Turpentine oil (*τερεβινθέλαιο*) is produced from various trees but in Greece it is nowadays produced mainly from *Pinus halepensis*, the Aleppo pine.

141 Hepper (1992, 195) believes that it provides an insignificant yield of resin and that it would be useful to have field notes as to its productivity.

142 Καββάδας, 3144; Γεννάδιος 1914, 785.

143 Cardon & du Chatenet 1990, 276.

144 Two species of aphids, *Pemphigus* and *Aplonema*, produce galls which contain a very rich source of tannin, especially for black dye (Cardon & du Chatenet 1990, 276). Some say they produce a red dye (Καββάδας, 3144) and others a yellow dye (Baumann 1984, 157, 159). Presumably it depends on the mordant and the chosen cloth.

145 Gall nuts served a two-fold purpose, providing both a dye and a mordant (Faber 1938, 287). They contain some 50-60% of the same tannin as the leaves (Cardon & du Chatenet 1990, 276).

146 Γεννάδιος 1914.

147 Lucas & Harris 1999, 321.

148 Identified by Hairfield & Hairfield (1990).

149 It is believed that approximately a ton of terebinth resin was transported in these jars (Pulak 1998, 201). More evidence comes from the New Kingdom where many vessels from Amarna seem to have contained *Pistacia sp.* resin (Serpico & White 2000).

150 *Μαγίς (-ίδος)* (commonly named *καντάρι*) is an ancient utensil, which is in the shape of a portable, round, table. Note, as an alternative, that in the tomb of Tutankhamun, what was identified, as 'frankincense', is believed (Lucas & Harris 1999, 92) to have been powdered incense made into balls. It is also interesting to note that resin lumps, large resin beads and ear studs were made from resin and thus could have circulated in these forms. Moreover a whole necklace made of resin was found in the tomb (Hepper 1990, 20) (Fig. 4).

I would, therefore, conclude that *ko-no* is not *ki-ta-no*. They both refer to large quantities and are probably products extracted from local plants. They could certainly have been products of resinous plants/trees. The **MY Ge** tablets refer to plants which are condiments (such as mint), dye plants (such as *ka-na-ko*) and 'exotic' products such as sesame but which could have been planted in Greece at that time (see *sa-sa-ma*), so we might have to revert to different plant identifications for *ko-no* as well.

P. lentiscus L., the lentisk tree, is also widely present in the Mediterranean maquis, and known as *σχῖνος* today, but is also known since Theophrastus' and Dioscurides' time. It also provides a good quality resin.[151] If the fruit (*σχινόκοκκα*) is pressed, 18-20% edible oil (*σχινέλαιον*) is extracted, which could also be used for lighting.[152] It also has other uses, as the wood is very good quality, often used to make charcoal,[153] and the year old twigs are often used for basketry. Its leaves (*σχινόφυλλον*), bark and galls are used for tanning and dyeing. One would expect the resin to have been used as incense too.

P. lentiscus var. chia, the mastic tree, produces the resin named *μαστίχα* in Greece. *P. atlantica* will not be dealt with as it grows in North Africa and the Canary Islands.[154] Today, the mastic tree grows in the south of the island of Chios, Greece. Orphanides[155] stated that he had successfully produced the same Chian mastic at Antiparos and Amorgos, and the same occurred in Attica. The same mastic was grown at the village of Komi tou Yialou in Cyprus where the children collected and chewed resin from the scarred branches.[156] This is an indication of a possible wider distribution for this plant in the past.

The 'mastic' tree grows and produces more in coastal, hot and airy places. The trunk is scarred in several places to let the resin flow and drop to be collected. This practice starts in July and continues until the end of September/beginning of October. Its characteristic is that the natural resin coalesces in teardrop form (*δακρυόμορφος*). Perikos[157] explains, in great detail, all the process of cleaning the tree and preparing for the scarring, as it takes place, traditionally, nowadays. The product is divided into 7 grades of mastic from large and clean drops to dust,[158] showing that nothing is wasted. Its price in 1939 was 222 drachmas per 1.28 kg., whereas today it is 2,500 drachmas per kilo. In the old days mastic was measured by weight[159] and calculated in staters (*στατήρας*), with 1 stater[160] corresponding to 44 okades (56.32 kg.). Could the Mycenaean *sa-pi-de* (Table 3) be some kind of measure, too, like *AROM*, stater, and *μαγίς*, in modern Greece?

In conclusion, I would say that *ko-no*, *ki-ta-no* and even *sa-pi-de* might refer to different resins, some in more semi-liquid or malleable form such as *ki-ta-no*, and others in a more solid state. Mastic is another ingredient, which, scarce as it is today, would have circulated in some quantity, as it is heavy, and would have been in great demand in neighbouring countries. Had the

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[151] All mastic is light coloured if freshly harvested and crystalline when broken and comes as a contrast to its 'dusty' surface (Baum 1994, 23).

[152] Baum 1994, 22.

[153] Γεννάδιος 1914, 783.

[154] de Rougemont 1989, 113; and does not grow in Greece (see among others Βαλαμώτη 2001, 32; Browicz 1987).

[155] Ορφανίδης 1873.

[156] Γεννάδιος 1914, 784.

[157] Περίκος 1990, 21-23.

[158] Περίκος 1990, 34.

[159] Περίκος 1990, 46.

[160] The stater (*στατήρας*) is also commonly known as *καντάρι*, and these figures are quoted from Perikos (1993, 45), although elsewhere the stater is calculated at 100 kg. (*Μεγάλη Ελληνική Εγκυκλοπαίδεια*, s.v. *στατήρ*).

mastic grown only in a limited area, as it does today, we would have expected the Mycenaeans to have controlled the monopoly of its circulation.

ko-ri-ja-do-no: Coriander, *κορίαννον* in Greek and identified as *Coriandrum sativum*. In Mycenaean it is referred to as *ko-ri-a₂-da-na/KO* (**MY**, **PY**), *ko-ri-ja-da-na* (**MY**) (plural), *ko-ri-ja-do-no* (**KN**)[161] (Table 7).

It is an annual umbellifer, cultivated for its dried seeds and fresh leaves. It is sown early in the autumn or in spring and harvested in July.[162] Every stremma needs some 2 okades of seeds (2.56 kg.).[163] These have a variety of uses such as for cooking, as a condiment,[164] and for medicinal purposes. The Egyptians refer to several recipes for a multitude of ailments[165] and from Linear B information one can assume that it was used as an aromatic in perfumery.

Its area of origin seems to be the Near East and the Mediterranean basin, as it grows wild in oak scrub and adjacent steppe-like niches. The earliest archaeobotanical finds[166] of coriander seeds come from Pre-Pottery Neolithic B (6500-6200 BC) Nahal Hemar cave, Israel.[167] In Syria, seeds were found in 2nd millennium Tell ed-Dar.[168] In Egypt, half a fruit has been found in Predynastic levels[169] but from the 18th Dynasty, fruits (*ca.* ½ litre) have been found from the tomb of Tutankhamun,[170] Deir el Medineh, and Amarna.

In Greece, the earliest appearance is from the Neolithic levels of the Franchthi Cave.[171] At Early Bronze Age Sitagroi seeds were also found.[172] In the Late Bronze Age, the site of Akrotiri on Thera has presented us with 46 seeds of coriander,[173] which were present, either as a contaminant of a *Lathyrus clymenum* (spanish vetchling) crop, or as a natural plant insecticide/ repellent.[174] In any case, it must be considered to have been a cultivated plant, even though, in the *Lathyrus clymenum* crop, it was merely a contaminant.

It is worth mentioning that three tablets recording coriander from Pylos (Table 7) produced 998.4 litres of coriander, whereas five tablets from Mycenae provided two-thirds of the quantity, namely *ca.* 624 litres. Knossos, on the other hand, with thirty-three tablets records some 23,040 litres (23 tons). It is obvious that coriander circulated in at least two forms, one in primary units which might represent containers (?), and the other in large measures of volume (Knossos,

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161 Duhoux 1993, 105.

162 Melena (1974b, 134) describes how the whole umbels are harvested in July by cutting. They are put in the sun for *ca.* 48 hours and when they dry they are then beaten to extract the seeds. In cultivation an average of 1,000 kg. per hectare is obtained.

163 Γεννάδιος 1914, 538.

164 As incense perhaps (Georgiou 1986, 8), as coriander was found in an incense burner.

165 Manniche 1989, 94.

166 A reservation as to whether they are archaeological is expressed by Zohary & Hopf (1993, 188) because these 15 fruits –all found in one stratum, strata 3 & 4– are not charred but desiccated. Kislev (1988, 80) also suggests that a C^{14} date is necessary.

167 Kislev 1988, 77.

168 Zohary & Hopf 1993, 188.

169 de Vartavan & Amoros 1997, 85.

170 Renfrew 1973, 171.

171 Only four seeds were found (Renfrew 1973, 171).

172 Renfrew 1973, 171.

173 Sarpaki 1992, 225.

174 Panagiotakopulu *et al.* 1995, 708. If Melena's assumption (1974b, 141) is correct –that is if shepherds were involved in the growing of coriander– perhaps it could be accepted as an indication of its use in the curing and the aromatising of meats and dairy products?

Mycenae and Pylos); the major unit might possibly have been *AROM T* 1 = 105.6 litres and was probably a third way which represented very much smaller quantities, still measured by volume (Mycenae and Knossos).[175]

Melena[176] discusses thoroughly all the problems related to the coriander tablets and develops theories about the incoming and outgoing quantities of this product in the Knossos tablets. On the basis of his calculations, the incoming would be calculated at *ca.* 10,000 litres and the outgoing *ca.* 3,000 kg. These figures clearly suggest the importance of the cultivation of coriander for economic purposes (perfumery), but it is also used for monthly rations[177] which gives it a 'monetary' value and is an indication of its wider use and importance, probably for culinary and preservative purposes as well.

ku-mi-no: Cumin is widely accepted as *Cuminum cyminum*, which points to a Semitic origin,[178] as it is called *ka-mu-nu* by the Babylonians and Sumerians (Table 8). The Hittite word is *kappani.*[179] Cumin has two varieties, the lighter coloured seeds and the darker seeds that are termed 'black cumin',[180] and it is sometimes confused with caraway (*Carum carvi*), which is said not to be cultivated in the Mediterranean.[181] Interestingly, Shelmerdine[182] does not include it in her list of perfume plants and, assuming she accepts the cumin identification, we should rather view it as a condiment, due to its slightly pungent smell. The Hittites sprinkled it on bread, in order to make use of its characteristic colour for analogic/sympathetic magic.[183] We cannot be totally sure, yet, that 'black cumin' was not *Nigella sativa*, which could also be grown in Greece.[184]

C. cyminum is an annual plant whose natural range covers an area from Turkestan to, probably, the eastern Mediterranean. However, it seems so far not to have been found archaeobotanically in Greece but this could well reflect inadequacies in our sampling strategies and the fact that these seeds would be stored in small pots/containers, which are, to date, rarely sampled for archaeobotanical data.

Cumin seeds have been found at some sites in the Mediterranean, such as Tell ed-Dar (2nd millennium BC Syria) and Deir el Medineh (New Kingdom, Egypt),[185] while 'black cumin' (*Nigella sativa*), an annual plant as well, has been found in Tutankhamun's tomb (1325 BC, Egypt) and several other sites mentioned by Germer.[186] These two plants could have been naturalised very early in Greece, although we have not yet found any tangible evidence.

175 These would represent seed crop, possibly recorded for planting set fields; or could it have been coriander oil (oil perfumed with coriander)?

176 Melena 1974b.

177 Melena 1974b, 159.

178 Shelmerdine 1985, 136.

179 Hoffner 1974, 103.

180 de Rougemont 1989, 261.

181 de Rougemont 1989, 260 and yet considered naturalised by Γεννάδιος 1914, 467 and Καββάδας, 1812-1814.

182 Shelmerdine 1985, 171-172.

183 Hoffner 1974, 104.

184 Wylock (1972, 110, 113-114) believes it might be *Lagoecia cuminoides L.* or even *Pimpinella anisum L. anise*. The former has the taste and smell of cumin and does grow around the Mediterranean, whereas the latter does also grow in Greece. The question, though, is whether such plants would have been mentioned in archives whose prime purpose was economic. The only presence of anise (though this needs to be confirmed) was detected in an MM IA pottery vessel from Chamalevri (*Minoan and Mycenean Flavours*, 40) but the scholar (Beck) still needs to provide the degree of confidence of this find.

185 de Vartavan & Amoros 1997, 89-90; Zohary & Hopf 2000, 206.

186 Germer 1989, 61; Darby *et al.* 1977, 807.

Cumin seeds are used as a condiment in foods and drinks but also have medicinal properties. The plant is grown in spring and harvested in the autumn only for its seeds. At Mycenae, which is the only site we know where cumin is mentioned, it is obviously a 'transacted' good. The six tablets that mention cumin from Mycenae have very small quantities recorded, which could either mean that they refer to seed crop that would be allocated to the next year's farmers, or else could also be cumin oil and/or paste of cumin.[187] However, the evidence is still not conclusive and one could also argue that the term refers to another plant, caraway, *Carum carvi*. This latter plant would have been more likely to be mentioned amongst aromatic substances (**MY Ge** tablets) as it could be used for both perfumery and aromatising drinks. The chances of *ku-mi-no*[188] representing caraway are quite high but still hypothetical.

ku-pa-ro: Cyperus (Table 14). This must be a pre-Hellenic name, as *suadu* is the Assyrian name for the cyperus plants. It is also mentioned by Homer[189] and this author seems to differentiate between *Cyperus papyrus L.* (*βίβλινος*) and *Cyperus* (?) *longus/C. esculentus L.* (*κύπειρος*).[190] Wylock, Melena and Palmer[191] discuss extensively the cyperus plant and, unhesitatingly, include it in the list of plants used in perfumery.[192] An interesting insight for those studying the site of Akrotiri, Thera, is that Pliny[193] considers the island to be an area of cultivation/harvest of this plant, and perhaps gives an insight into the fact that Thera might have had some marshy areas in the sandy soil, as the *Cyperus* plants are all hydrophilous.

The edible species of cyperus is *Cyperus esculentus*,[194] (chufa / tiger nut) and the edible parts are the corms,[195] which can be eaten in a variety of ways. These can be eaten raw, as a vegetable, or roasted or even used as a source of starch for flour and of edible oil. In Spain, a well-known drink is made from it, called *horchata*.

Cyperus esculentus, chufa,[196] is a native of southern and central Europe, and is marketed as tiger nut in Britain. In Greece it is very little known, as *αμύγδαλο εδάφους* (ground almond)[197] or *μάννα του ουρανού* (manna of heaven).[198] It has been cultivated in the Mediterranean since very early times, but no archaeobotanical finds of this plant have been found, so far, in Greece. In Egypt it was considered a very important food plant[199] since predynastic and throughout dynastic times,

[187] It could also be evidence for its importing rather than its local cultivation. At present the problem does not seem finally resolved.

[188] Could it be a coincidence that the Turkish word for caraway is *kiminion* (Γεννάδιος 1914, 468)?

[189] Moazzo 1983, 109.

[190] See Duhoux 1993, 107 for references.

[191] Wylock 1970, 128-133; Melena 1974c; Palmer 1999, 470-472.

[192] See also Shelmerdine 1985.

[193] Pliny, *Natural History*, XXI.117-118.

[194] For details about the plant see de Vries 1991.

[195] A wall painting in the tomb of Visir Rekhmire in Thebes, Egypt (18th Dynasty - 15th century BC) depicts the preparation of tiger nut, where it was ground, sifted, and then was made into a dough, after which honey was added to it. Subsequently, it was placed in a pan with fat and 'fried'. This must have been a type of biscuit and/or cake. In the same tomb, another wall painting depicts the measurement of the tiger nut crop with a type of container which looks like a *χόννος* (Negbi 1992, 65; Manniche 1989, 42, 98; see also Maddoli 1967 for *χόννος*).

[196] Palmer (1999, 485) identifies the edible cyperus (*C. esculentus L.*) as referred by *CYP+O/PYC+O*, *CYP+PA* (?), whereas other names (*ku-pa-ro*, *ku-pa-ro-we*, *CYP/PYC*, *AROM+PYC*, *CYP+KU*, *PYC+QA*) (Palmer 1999, 470) refer to aromatic cyperus.

[197] de Rougemont 1989, 331.

[198] Καββάδας, 2207.

[199] Zohary & Hopf 2000, 198.

and has even been found as early as the 5th millennium BC and into predynastic contexts, and, generally, throughout prehistory.[200] Its cultivation seems to have remained completely in Egyptian hands, as it has not been found elsewhere. There is a very long list of finds of chufa from archaeological contexts in Egypt.[201]

The other possible plant is *Cyperus rotundus L.* (Fig. 5), the nut grass, which is believed by Gennadios[202] to be the *κύπειρος* of Theophrastus. It is commonly known as *γαρούφαλλα του Άργους* and its odoriferous root is chewed, just like the mastic of Chios, in order to refresh the breath.[203] In Late Palaeolithic Egypt, *ca.* 16,000-15,000 BC tubers of this plant were found at Wadi Kubbaniya[204] and are present from the Old Kingdom onwards.[205] It would have played the role of carbohydrate staple in their diet, but later on, in Mycenaean times, it seems to have been used as an astringent,[206] as mentioned by Dioscurides. However, others believe that it was 'well known as a perfume ingredient throughout antiquity'.[207]

Cyperus longus L. is a common plant in the marshes and along the rivers in Greece. This plant, too, has rhizomes, which have a taste resembling walnuts and could be consumed dry and raw, as one would eat dried fruit.[208] In Egypt it has been identified since the 5th Dynasty.[209]

Cyperus spp. are known to have been used for making basketry, and ropes of various kinds, as well as, often, used for tying various crops. In Greece, the rhizomes of these plants might probably be found archaeobotanically, in charcoal samples, especially as Hather[210] has closely studied their rhizome anatomy, but charcoal studies are still not applied universally.

In the tablets, cyperus is mentioned in two ways, which, it is believed, refer to at least two species of cyperus.[211] One is a perfume ingredient and a second is as a food. A third commodity, **171* is connected with cyperus and it is believed perhaps to have been cyperus stem (see notes of Table 3 for discussion). The ideograms *PYC/CYP* also appear with different ligatures: *AROM+PYC*, *CYP+KU*, *PYC+QA*, *CYP+O/PYC+O*, *CYP+PA*. Of these, the ideograms and the first three ligatures are found on tablets from Knossos and Pylos listed together with aromatic plants used for perfumery. In this case, *C. rotundus* is most probably understood. On the other hand, the two last ligatures appear at Knossos, Pylos, Mycenae and Thebes 'on mixed commodity tablets and nodules which may be assessment or collection records, or inventories of foods for festivals'.[212] In this case, the species referred to would probably be the edible cyperus, *Cyperus esculentus L.*[213] but one cannot totally exclude *C. longus L.*

It is interesting to note that *C. rotundus* seems to be listed in larger amounts than *C. esculentus*. This is an interesting observation[214] that indirectly proves the bias of the palatial administration.

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[200] Darby *et al.* 1977, 649-650.
[201] See de Vartavan & Amoros 1997, 94-96.
[202] Γεννάδιος 1914, 587.
[203] Καββάδας, 2208.
[204] Hillman 1989.
[205] de Vartavan & Amoros 1997, 100.
[206] Shelmerdine 1985, contrary to Melena (1974c, 306) who believes that it was a perfume and food additive too.
[207] Melena 1974c; Palmer 1999, 471.
[208] Καββάδας, 2207.
[209] de Vartavan & Amoros 1997, 96.
[210] Hather 1993,116-123.
[211] Melena 1974c; Palmer 1999, 470.
[212] Palmer 1999, 470.
[213] *C. rotundus* also has edible rhizomes.
[214] Melena 1974c; Palmer 1999.

As one could easily guess, the administrative 'machine' was more interested in luxury items (perfumery ingredients) than in the staples which the *C. esculentus* or the *C. longus L.*[215] would have been.[216] This does strongly indicate that the staples which most probably existed in large quantities, too, were not referred to as the palace had a low interest in these, whereas the control of *C. rotundus*, an important ingredient in perfume manufacture, was of paramount importance. As all three are hydrophilous plants, one would expect to find them more or less in the same ecological zones, especially as Greece was an area with still many marshes in the Pre Second World War period.

A question, which occurs to us, is whether these *Cyperus spp.* were collected or deliberately cultivated. The large numbers, more than 10 tons at Knossos, induced Melena[217] to consider deliberate cultivation but Hillman[218] has reasons to believe that, if dug up carefully, it would be possible both to collect large amounts and to avoid destroying the swards. What we do know is that *C. rotundus* together with *C. papyrus* were deliberately planted in Egyptian gardens,[219] but it is reasonable to conclude that ecological zones needed for cyperus cultivation would have abounded in several parts of Greece, in the areas known as marshy ground.

ma-ra-tu-wo: Fennel, *μάραθο*, *Foeniculum vulgare*,[220] is the wild variety, and the cultivated one is *F. vulgare var. sativum* (Table 6). It is a biennial/perennial plant,[221] which is very easy to grow, and is cultivated for all of its parts –roots, stacks, seeds, leaves–, as it flourishes in stony and dry areas. Moreover, it can be planted from autumn to June, and would have been very well adapted to many areas of Greece. Its production has been calculated to 100-150 okades (128-192 kg.) per stremma. This product –it is not stated whether plant or seed– was sold at 60-80 lepta (0.6-0.8 of a drachma) per oka in the early years of the 20th century, prior to 1914.[222]

Its mention in rather small quantities of volume at Mycenae and Knossos is puzzling. It either refers to the seeds of fennel, which would have been used as a condiment, and for medicinal purposes;[223] or might we also infer a kind of 'primitive' distillation process[224] for the seeds (they contain *ca.* 5% of volatile oil)?

mi-ta: Mint, Greek *μίνθη* (Table 9). These are plants, which have a multiplicity of uses such as medicinal, aromatic (volatile oils), and as a condiment. In cultivation, mint can produce 2,500-3,000 kg., in fresh form, per stremma, whereas dry it is reduced by 1/2 to 1/3. The volatile oils produced are in the range of 0.2-0.3% of the dry weight.[225] The species that would have

[215] One would tend to agree that *C. esculentus L.* is the most likely candidate because its production could be controlled by cultivation and not just collection.

[216] This could have circulated as potatoes do today and not as flour, I believe, due to the lower viability of flour compared to the whole rhizomes.

[217] Melena 1974c.

[218] Hillman 1989.

[219] Wilkinson 1998, 164.

[220] Duhoux 1993, 108.

[221] It is biennial but as the seeds fall from the umbels into the ground, the plant becomes established in the same spot and, consequently, can be considered a sort of perennial.

[222] Γεννάδιος 1914, 639.

[223] It is considered to be good for the production of milk in nursing mothers (Φραγκάκι 1969, 139), for the stomach, as a diuretic, for eye ailments, and it was used in several ancient civilizations as an antidote for snake bite (Manniche 1989, 106).

[224] Yet at this stage there is no way of knowing whether it is dry or liquid volume.

[225] Καββάδας, 2563-2566.

occurred in Mycenaean Greece are *Mentha pubescens*,[226] *M. aquatica L.*, *M. suaveolens*,[227] *M. microphylla*,[228] *M. longifolia*,[229] *M. spicata*,[230] *M. pulegium L.*[231] *ka-ra-ko*, now read *ka-]ra-to*,[232] pennyroyal,[233] is considered to be *Mentha pulegium*, for reasons not explained. Chadwick[234] seems to agree with this identification by Warren. The quantities, however, are puzzling, as they seem to be very small for such a common plant. The ideogram **154* (Table 3) is also believed by Palmer[235] to refer to pennyroyal,[236] which is now known as *Mentha pulegium*.

MU: It is an ingredient only found at Knossos and perhaps refers to myrrh[237] (see *murru* in Assyrian) (Table 3). Myrrh is derived from various species of *Balsamodendron* and *Commiphora* and occurs in yellowish-brown masses of gum resin,[238] whereas frankincense is yielded by the genus *Boswellia* and from *Commiphora pedunculata*. These trees still grow in southern Arabia, Somalia and parts of Ethiopia. Frankincense is a very good incense and myrrh is of particular value as a base for perfumes and unguents –hence, perhaps, its reference in Mycenaean texts. It is interesting to note the prices quoted by Pliny for these and other commodities, and the relative cheapness, weight for weight, of frankincense and myrrh in comparison with other luxury items is striking.[239] For example, various types of myrrh were sold at 11-16 denarii per pound and frankincense was even cheaper, at 3-6 denarii per pound, which should be compared with cinnamon,[240] sold at 1,500 denarii per pound, or balsam at 1,000 denarii per pint.[241]

pa-ko-we: Sage-scented, *σφακόεν* (Table 17). Although sage is not thought to have been used for perfumery in Classical times, we cannot exclude its use for this purpose in the Mycenaean period.[242] The oil of sage, as well as the tea (leaves) is produced by several species of *Salvia* such as *S. officinalis*, *S. triloba L.*, or *S. pomifera L.* However, these are plants that are also used for medicinal purposes, and in the villages of the Messara (Crete)[243] sage was said to be smoked, just

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[226] It exists in Thessaly.
[227] It exists in the whole of Greece and Crete.
[228] It exists in the whole of Greece and in Crete too.
[229] It is present in Crete.
[230] Warren (1970, 373) refers to *M. puperta* as mint, *mi-ta* (*μίνθη*) but so far as I could trace in botanical references, no such mint grows in the Mediterranean, unless he means *M. spicata*, which is the spearmint and is grown widely. *M. pulegium*, pennyroyal, is considered to be *ka-na-ko* for reasons which are not made clear. Chadwick (*Documents*, 561) mentions *M. viridis*, which is an older botanical name for *M. spicata*. *M. spicata* is presently grown in gardens –probably the *μίνθη* or *ἡδύοσμον* of Theophrastus.
[231] It is probably the *γλήχων/βλήχων* of Theophrastus.
[232] Baumbach 1986: **MY Ge 605 + 607 +** *fr.* **[+] 605a +** *fr.* **[+] 605b +** *frr.*
[233] Warren 1970.
[234] *Documents*, 550.
[235] Palmer 1999, 485.
[236] *Documents*, 226; Warren 1970.
[237] Sacconi 1969.
[238] Lucas & Harris 1999, 92.
[239] Groom 1981, 154-155.
[240] Cinnamon and cassia, which come from plants from the Far East, seem to have been among the most expensive commodities, at least, in Roman times.
[241] It is not clear, though, whether he is referring to the dry measure pint, the liquid measure or the British imperial.
[242] Duhoux 1993, 111.
[243] Φραγκάκι 1969, 202.

as tobacco, in the old days. Small, sweet, apple-like galls are produced at the tips of the young branches of the plant and are collected, unsystematically and eaten in parts of Crete (in the East of Crete, around the Palaikastro area).[244]

po-ni-ki-jo: It has been a much disputed term, judging from the many references to it in the bibliography (Table 13). If we trace its various interpretations through time, we see that Ventris & Chadwick[245] refer to it as a Phoenician spice[246] (red colour or Phoenician origin)[247] but did the Mycenaeans know Phoenicia by this name? Melena[248] disagrees that it had any connection with later Phoenicia. It is referred to as possibly deriving from *φοινίκη* palm-tree, 'palmette'[249] or referring to red.[250] Melena[251] believed that the palm-date interpretation was likely, as he thought it to be a food, drink additive, and provided as a ration to certain groups of workmen,[252] but it is not measured by volume as seed crops were, therefore, according to Melena it might be a processed matter. Dates do provide food (dried dates) and also a sort of wine, which was made in Egypt.[253] Date wine has even been mentioned from Crete, in an archaic inscription from Gortyn and it has been tentatively identified in Linear A by Best.[254] The date-palms (*Phoenix dactylifera*) could and would, most probably, have been present on Crete and in other parts of Greece, but it would have been growing just as an ornamental tree and would have been used only for industrial (e.g. fuel) and craft (e.g. woodworking)[255] purposes. The date palm requires a warmer and drier climate than Greece could provide. The high temperatures and the low humidity are particularly important for fruit setting and, mainly, ripening,[256] and these conditions do not seem to be provided in Greece. This is apparent as palm trees do grow, but they produce fruit, which never reaches maturity. This must have been the same in antiquity, where people seem to have been familiar with palm trees (see iconography), and we might therefore assume that they had an intimate knowledge of the tree but no actual remains of date stones have so far been found in Greece. The invisibility of the date (no stones found) is indicative of the similarity of the climate then and at present. Therefore, Melena's[257] interpretation stands only if they imported palm date pulp, which, in that case, would have been measured by weight and not by volume, like other seeds. This is the case for *po-ni-ki-jo* but the quantities are rather small and

[244] Personal communication from farmers of Angathia village.
[245] *Documents*, 222.
[246] Murray & Warren (1976, 44) believe that it 'need not be an aromatic, but some other substance used in unguent production, or even something not unguent at all'. However, it is agreed that *po-ni-ki-jo* is either a plant or a plant product.
[247] Maddoli 1967.
[248] Melena 1973, 82.
[249] Duhoux 1993, 112.
[250] Murray & Warren 1976, 57-59; Foster 1977b.
[251] Melena 1973, 83.
[252] Melena 1973, 80; Erard-Cerceau 1990, 265, whereas Foster (1977b, 56) does not believe it to be a foodstuff.
[253] Darby *et al.* 1977, 614-615, 728-729.
[254] Best 1972, 32.
[255] Charred wood (unpublished by the author) has been found at the site of Palaikastro (East Crete) (LM III) and another find has come from Pseira (unpublished). The use of the date-palm for building material has been mentioned by Orlandos (Ορλάνδος 1955, 18, 28). He asserted that it is a soft but strong wood. Strabo (XVI.1.5) mentioned that it was used for beams and columns.
[256] Zohary & Hopf 1993, 157.
[257] Melena 1973, 84.

mostly in the range of 1-5 kg., which is minimal, if it referred to dates. This would not have been worthwhile even recording. Its common occurrence, though, with coriander and the common references to it in the tablets, would rather suggest a product that is produced/harvested locally but not a foodstuff.[258]

Murray & Warren[259] believe that it was rather a substance 'producing or consisting of red colour'.[260] One of their suggestions is cochineal, red dye from *Kermococcus vermilio*, an aphid which parasites on *Quercus coccifera L.*, kermes oak, but they believe it was unlikely to have been measured by weight as the insect has the size of a seed and was believed to have been the same in antiquity.[261] However, I believe the desiccated product could have been measured by weight, as very expensive products are (cf. saffron) but in rather smaller quantities perhaps.

Another relevant tree is *Pistacia terebinthus L.* on whose leaves an aphid is parasitic. These insects form horn-like galls that were used to produce a red dye, but if *ki-ta-no*[262] is this tree, as suggested by Melena,[263] this could not be equated to *po-ni-ki-jo*. Yet, another suggestion was the red dye from the Murex shells (*Murex trunculus L., M. brandaris, Thais haemastoma L.*) but Murray & Warren believe, rightly so, that it would be most incongruous for this to be mentioned in juxtaposition with a spice (coriander).[264] However, *po-ni-ki-jo* is measured by weight, so it must have been something fairly valuable (a powder, an incense, a dye) and perhaps we could turn to the finds of Ulu Burun for some suggestions. The thousands of *Murex opercula*[265] neatly stacked on the boat suggest that they must have been used as incense, when ground to powder. This is still used today, in many parts of the Arab world. In that case, the 'camouflaged' powdered form would not have been out of place when mentioned together with other aromatic plants, and would have been transacted by weight due to its –expected– high price.

A fourth suggestion by Murray & Warren is orchil, which is a red, violet or purple dye obtained from various lichens, such as *Roccella tinctoria, Lecanora tartarea, Roccella fucoides* and *Rytiphloea tinctoria*.[266] They were common on rocks on Eastern Mediterranean coastlines, and perhaps this fact alone discourages one from believing that a common product would have been so meticulously annotated and, therefore, of high enough price.

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[258] Foster (1977b, 53) also believes that it is not a foodstuff, nor a spice, but rather a plant product, which is used for industrial purposes. See Murray & Warren (1976, 43-44, 47) for a very detailed discussion of where –geographically– *po-ni-ki-jo* would have been produced; according to them, it was produced in northern Crete, at no great distance from Knossos. Later Melena (1983, 93) changed his earlier interpretation and suggested that it was dyer's madder. Whatever it was, it must have been expensive, but not as much as saffron, where the quantities transacted were much lower.

[259] Murray & Warren 1976, 47-54.

[260] See also Sinastra 1982 interpreting it as colouring material.

[261] Referred to as 'grains' (*Granum tinctorium*) (Forbes 1953, IV, 104). It is a dye used from very early times, as textile fibres were found at the Neolithic cave of Adaouste (Bouches-du Rhône, France) (Forbes 1953, IV, 102). It is more expensive (Forbes 1953, IV, 107) than *Rubia tinctorum*, so it is logical that the dyers would switch to a good steadfast dye and one that would not be overpriced. However, cochineal is unsurpassable in the bright red it can produce, which was described to me by Sophia Kana (a dyer who lives and works at Katsikia, near Hagios Nikolaos, Crete) as a bright, fiery and aggressive red.

[262] See *ki-ta-no* where it is suggested by the present author that it is *Cistus creticus L.*, the rockrose.

[263] Melena 1974a.

[264] Another reason, we believe, is that the dye from the *Murex* shells cannot be preserved for any great length of time, and therefore cannot be stored nor 'circulated', as the material rots. The dyeing process goes hand in hand with the dye extraction, so *po-ni-ki-jo* could not be the dye, but, of course, could be threads and/or cloth dyed with *Murex spp*. However, in that case should this product not have been mentioned with cloth?

[265] Bass 1997, 163.

[266] Abundant on the island of Amorgos.

Another two possibilities are *Alkanna tinctoria*[267] (*Anchusa tinctoria L.*) dyer's alkanet, *βαφόρριζα*, *βοϊδόγλωσσο*, and *Rubia tinctorum*, madder, *ριζάρι*. Both are common throughout Crete and both have roots that produce a red dye. Moreover, the roots of either plant would not be incompatible, as Murray & Warren[268] claim, with the weights recorded, and it makes more sense for roots to be weighed than to have their capacity measured.[269] The localities of collection of *po-ni-ki-jo* around the area of Knossos, and the existence of these plants in the same geographical zone, renders this possibility as effective, but for reasons such as the proximity of the produce and the bulky nature of the roots, one would have expected these products to have circulated in larger quantities, and moreover to have circulated outside the palace bureaucracy and not to have been mentioned in the tablets, as being highly available and therefore of not very high economic value. As a consequence, the hypothesis of the *Murex* opercula still remains the most likely of those discussed.

Alkanna tinctoria is a small plant, which does not grow higher than 10-30 cm. It flowers in April to June but the part used is its root (*αρμπαρρόριζα* in Greek) and specifically its epidermis, which is harvested in the spring and the autumn.

The epidermis contains, amongst other things, several pigments but the main one is alkannine, which provides the violet-red colour. However, this is insoluble in water and, nowadays, it is extracted by immersing the material (wool, cotton or silk) in a warm bath (*ca.* 40° C.) of alcohol (at *ca.* 35°), in which 65 gr. of dyer's alkanet is dissolved in 1 litre of water.[270] In an hour the fibres are dyed. It is, however, soluble in oil and fats.[271] The fabrics are rinsed and left to dry in the shade. The colour produced depends on the mordants. For example, if alum is used, the colours produced are violets and lilacs. If iron ore is used, the colours are grey and grey-violets. Unfortunately, the dye is fugitive, and unless they had invented a way to stabilize it, its price –unless, of course of symbolic value– should not have been very high, when account is also taken of the reasons mentioned above for the root.

Rubia tinctorum, madder, *ἐρυθρόδανο*[272] or *ριζάρι*, *αλιζάρι* is one of the most appreciated dye plants of south-west Asia and Europe as it was extensively grown for its rhizomes from which a brilliant red pigment (alizarin) was extracted.[273] It was widely cultivated in Greece.[274] Alizarin was widely used to colour linen, wool, and leather and, perhaps, even wood.[275] The dye gets

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[267] This is also regarded as a possibility by Foster (1977b, 64, 66) and Melena (1983, 93).

[268] Murray & Warren 1976; Foster 1977b, 66.

[269] There is strong evidence suggesting that it could have been a root/rhizome product due to its registration in weight. As we have said, roots decrease enormously in weight when dried. Sophia Kana claims that the weight is reduced to 1/3 when dry, but she also claims that root/rhizome products dye as a 1 to 1 solution, that is to say that the amount of dye needed is of equal weight to the textile to be dyed. Therefore, we could claim that the amounts referred to are rather small for the needs of administrations such as Knossos. This is difficult to explain at the moment.

[270] It would be worthwhile discussing the quantities of dye material used for dyeing, as this quantity of 65 gr. of dye to 1 litre of water seems to be very high, and would, therefore, have meant that the quantities in the tablets are very small compared to what they could dye.

[271] Cardon & du Chatenet 1990, 30.

[272] Mentioned as such by Dioscurides, though Herodotus (IV.189) named it *ἐρευθέδανον*. Dioscurides mentions that it is planted between olive trees. The Romans seemed to do the same (Forbes 1953, IV, 107).

[273] Zohary & Hopf 1993, 192.

[274] Ορφανίδης 1873, III, 317.

[275] *po-ni-ki-ja* on **KN Sd 4409 + 4481** + *frr.* (3).b, and *mi-to-we-sa* on **KN Sd 4415 + 4417 + 4469** + *frr.* suggest two distinct shades of red colour in the decoration of chariots (Murray & Warren 1976, 48).

fixed to the textile fibres, only after their treatment with a mordant (alum salts). Aluminium alum induces dark red coloration, iron alum results in a brown-red colour, and chromium alum produces red-violet colours. Pliny's description of dyeing in Egypt asserts that after mordanting the textile, it is plunged in a cauldron of boiling dye[276] and taken out the next minute fully coloured. It is remarkable too that, although the cauldron contains a uniform dye, the material extracted is of various colours –depending on the mordant used for a specified textile– and most important of all, these colours are never washed out.

Madder is a perennial herb, which grows in winter when the temperature is *ca.* 10-12° C., and flowers in June/July. The seeds are ripe in August. Its wild forms are native to south-west Asia and central Asia, but spontaneous populations thrive in the Mediterranean basin on waste ground, the margins of cultivated fields and hedgerows. Rhizomes or seeds propagate it in March or early April. In May or June the plants are thinned out and the soil covered with 2-3 cm. of soil. In November 5-8 cm. of soil covers the plants even more. The following May, the plants are weeded and in September they are harvested. The green part is cut to a height of 12-15 cm. from the ground and this is considered excellent fodder. In November, they are again covered to 5-8 cm. (always with soil from the area). These successive alluviations aim at fortifying and multiplying the rhizomes. If water is available in the summer, they are irrigated 3-4 times. The rhizomes are usually harvested the third year,[277] in October (in the previous September, the green parts of the plants, as before, up to a height of 12-15 cm. from the ground, are harvested for fodder). As for the rhizomes, they are collected and left in small piles to dry in a shady and airy spot,[278] without being cleaned. The production, of course, depends on the quality of the soil[279] but one stremma produces *ca.* 1,280 kg. of rhizomes,[280] which, after drying, are reduced to 1/3 of their weight and, therefore, *ca.* 400-450 kg. of dried rhizomes. Some plants are left for seeding and they are always harvested, after the third year, in October. This is how Gennadios[281] described the cultivation on Hellenic land.

After drying, a rather complicated treatment takes place whereby the roots are beaten, in order to remove the dirt and the outer skin, and then they are pulverised.[282] The rhizome contains the dye in the form of glucosides, in a red layer between the outer rind and the core of the woody particles.[283] The price of this dry root has changed a great deal depending on its demand. In the early 1800's in France (Avignon) it was sold at an astronomical price. 100 kg. were sold for 300 French francs, but in 1837 it went down to 45-75 French francs for the same weight. Its seed too can be sold at 1-3 francs per kg.[284]

The earliest evidence of the dye is said to come from samples of cotton from Mohenjo-Daro dating to the 3rd millennium BC.[285] From Egypt there is evidence found at Tell el Amarna

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276 Apostolaki (Αποστολάκη 1952, 103) claims that ¼ of the weight of the dyed material is needed in powder form, for dyeing, but the quantity depends also on the desired hue of red. See Κερασσιώτη 1941, 30 where it is noted that ¼ of a *mna* of madder, which is roasted and cut into small pieces, is needed for 1 *mna* of wool.

277 They are harvested from the age of 18-30 months.

278 In Greece they are dried in the open air.

279 It is cultivated in marshland, where there is a high percentage of clay, but it depletes the soil.

280 It is also mentioned that 1 stremma can produce 350-500 kg. of roots (Ορφανίδης 1873, III, 376).

281 Γεννάδιος 1914, 311.

282 Apostolaki (Αποστολάκη 1952, 104) claims that in Crete, after drying the roots, they are cut into small pieces and reduced to powder with a rotary mill. They are then sieved through a fine mesh.

283 Forbes 1953, IV, 106.

284 Ορφανίδης 1873, III, 317.

285 Barber 1991, 232.

(18th Dynasty - 1370 BC), from a red-coloured flax textile.[286] From Tutankhamun's tomb,[287] a dyed fabric was found to have been dyed with madder and *Carthamus tinctorius*.[288]

Other vegetable dyes which colour various hues of red are:[289] *Onosma echioides L.* (Greek *αμπελοφράχτης*), whose rhizome could be processed in the same manner as *Alkanna tinctoria*, and was used by the mountain tribes of the North of Greece;[290] *Rubia peregrina*, *Asperula tinctoria L.*, *Asperula odorata L.* (rare though in the Mediterranean), *Galium verum L.*, *Gallium mollugo L.*, *Galium aparine L.*, *G. saxatile L.*,[291] *R. patientia L.*, *R. crispus L.*, *R. obtusifolius L.*, *Rhamnus catharticus L.* (bark and fruits are used), *Rhamnus alaternus L.* (bark and green fruits are used), *Scorodorma foetidum*,[292] and *Hypericum perforatum L.* (flowers used). All the above plants could produce reds with the right mordanting.[293]

As a consequence of all this discussion, which leaves us more perplexed, I would still mention the strongest candidates which to my mind are *Murex* dye and/or opercula,[294] and not madder which would have been produced in larger quantities and does not justify its mention in quantities as small as those noted in the *po-ni-ki-jo* tablets. Moreover, *Carthamus tinctorius* is excluded as it has been considered to be *ka-na-ko*. However, it would be expected that *Murex* dye extraction would have existed hand-in-hand with leather craft as wèll as a textile-dyeing craft industry, due to the rapid rotting of the *Murex* gland material, and the fact that it would not travel far.[295] Due to the small quantities of *po-ni-ki-jo* and, therefore, its high value, one would expect that whatever substance it is, its weight would not have been increased by the addition of salt and so forth. As *Murex* dye, as far as we presently know, could not travel far on its own, due to its rapid rotting, it would lead us to conclude that *po-ni-ki-jo* could refer to thread dyed with *Murex*, if not the powdered opercula. This red thread could have been made from light material, which does not weigh much,[296] and a possibility worth investigating is silk thread from the saturniid, *Pachypasa otus*,[297] whose cocoon has been found in Late Bronze Age Akrotiri, Thera. This thread, dyed red with porphyra, might have been a product of two industries, silk and purple-dye production. Furthermore, this species produced silk in some parts of the Levant until last century, in the same geographical areas that porphyra dye was also extracted. Could this be just a coincidence?

[286] de Vartavan & Amoros 1997, 226.
[287] Hepper 1990.
[288] Barber 1991, 227.
[289] Red-brown to yellow-brown hues are produced by soaking cloth in solutions of tannin, available from a wide range of leaves and bark (Barber 1991, 232).
[290] Cardon & du Chatenet 1990, 30.
[291] The *Galiums* serve to dye the Scottish tartans and are very steadfast colours (Cardon & du Chtenet 1990, 40). All plants whose parts are not specified as being used, have their rhizomes/roots used for dyes.
[292] Barber 1991, 232.
[293] Cardon & du Chtenet 1990, chapter III.
[294] We have seen that it is a traded product, not just locally but overseas. Every *Murex* produces one operculum, which could be reduced to powder and, therefore, conveniently sold by weight measure.
[295] Sophia Kana, herself a textile dyer using organic dyes (animal and vegetal), claims that *Murex* dye would not have travelled at all well due to fact that the material would have rotted away. Its length of life according to her would have been a matter of days, but this needs further verification, as its length of life could possibly have been extended through other means, such as by salting, drying in the sun etc. Experiments need to be carried out on the effect of these on the colour of the dye.
[296] We know that silk is exceptionally light, though strong compared to its bulk.
[297] Panagiotakopulu *et al.* 1997.

As has been seen, this substance still eludes us and we can just make hypotheses. However, it was thought to be a need to discuss all the possibilities, which have been suggested in the past, and give reasons why some seem more plausible than others, but none renders us totally satisfied. The silk thread dyed with porphyra seemed a wild but possible guess but the mention of *po-ni-ki-jo* together with other condiments negates this hypothesis. Another strong possibility is madder, especially the final product, such as the pulverized and sieved rhizome, which would justify the transactions in weight value. Could madder have been used to colour perfumes as well as used for dyeing? It is proposed instead of *Alkanna tinctoria*, as this plant has a fugitive dye.

sa-sa-ma: Sesame, *σήσαμον*, *Sesamum indicum L.* (Table 10). Sesame does not belong to the crops of the Near East and Mediterranean (no wild progenitors exist in these areas), but rather arrived from further east, south of the Sahara in Africa, and India.[298] Claims for its early introduction into Mesopotamia come from texts (Akkadian and Sumerian). The word *sa-ma-ma* (Hittite) was thought to mean sesame[299] but this is now in doubt. However, researchers have claimed[300] that the term denotes 'oil plant' in general and that it does not provide clear evidence for its cultivation in the 2nd millennium BC. Sesame is, therefore, excluded, and it is probably the word *sapsama* (Hittite), which refers to it.

The proposed progenitor of sesame has, recently, been thought to be *S. orientalis L. var. malabaricum Nar.*,[301] which has close morphological, genetic and phytochemical affinities with cultivated sesame. If this were the case, cultivation would have started in India. The oldest record of the cultivated sesame comes from Harappa in the Indus Valley and is dated to some time between 2250 and 1750 BC.

Sesame has two possible growing seasons,[302] one in April to June and harvested in late summer, which is the normal one, and another in mid-March (early planted) and harvested in mid-July. This second is the most likely to have taken place in the southern parts of Greece. It is imperative to have the harvest exactly on time, because if left for too long, the seed could fall out of the pods and become lost. As to processing the oil, there is still a need to observe traditional methods of extraction. Two methods have been shown to be used. One is pounding the sesame seeds in a mortar and the oil dripping from the resulting cake. This oil is thought to be the best. The second method is crushing the warmed seeds in a mill and extracting the sesame from the pulp. The oil cake is the residual substances after the oil has been pressed out, and this by-product is given as feed to cattle.

In Egypt pollen has been identified in Predynastic times, but a secure presence seems to date to the 18th Dynasty, when actual seeds were found.[303] From Bronze Age Greece, we have no actual archaeobotanical remains.

The quantities referred to in the tablets are fairly small, repetitive, and measured by volume. This, in some way, induces us to believe that, in Linear B, just as in other Near Eastern scripts, *sasama* has fallen into the trap explained for the other scripts, and that it does not refer to sesame at all but to an 'oil' –sesame oil perhaps, but not necessarily. In that case we would expect it to have been imported as a finished product and not as agricultural produce. Another

[298] Zohary & Hopf 2000, 140-141.
[299] Hoffner 1974, 126.
[300] Güterbock 1968.
[301] Bedigian & Harlan 1986.
[302] Stol 1985, 119.
[303] de Vartavan & Amoros 1997, 238.

point worth mentioning is that white safflower (Table 5) which is the achene from which safflower oil can be extracted, is also mentioned in the same manner, measure of volume and the same quantities or fractions of it.[304] So, if *sa-sa-ma* meant 'oil', could it also have referred to safflower oil, amongst others?

se-ri-no: Celery, *σέλινον*, *Apium graveolens* (Table 3). This is a biennial plant, which needs moist and rich soils, and it can therefore be assumed that it grew in row gardens in early summer (planted in March-April). It is a plant, which is most probably of Mediterranean origin, but does not like the scorching sun, and is therefore grown densely planted. Just like today, it must have been harvested both for its leaves and its root, which is also used as a condiment and for pharmaceutical purposes.

In Egypt, it has often been found adorning mummies,[305] hence its associations with death. Fruits, leaves and wreaths have been identified since Early Dynastic times.[306] In Greece there is mention by Pindar[307] of wreaths made from celery,[308] which suggests that the scent was also appreciated, although there is no mention of its use in perfumery, but it must have been consumed as a condiment in foods. Its medicinal and diuretic properties must have been appreciated since early times.

wi-ri-za: Iris root (?), Greek *ἴϱιδα* (Table 3). It seems to have been used for perfume manufacture in Mycenaean times.[309] Several irises grow in Greece but a few are of economic importance, such as *I. germanica* (yellow flowers, medicinal purposes, given to teething babies to alleviate pain), *I. florentina*, *I. pallida* (volatile oil) and *Iris illyrica*. *I. germanica subsp. floretina* (*I. florentina*) (aromatic rhizome, produces the so-called Orris root) were cultivated until recently in Tuscany and near Verona.[310] They are cultivated there in the same field for three years without any tending. However, in July roots are harvested and only one is left to grow. These are thoroughly washed and then left to soak for a few hours, before their skin is peeled off and they are washed again before they are laid to dry on wicker mats, in the shade in a well-ventilated place. From *ca.* 100 okades (128 kg.) of harvested roots, some 35-40 okades (*ca.* 45 kg.) is retained when cleaned and dried. These were sold locally for the equivalent of 1-1½ drachma for every 1.28 kg.[311] Kavvadas[312] referred to different cultivation methods, which, most probably, were applied in Greece, although he did not state it. He claimed

[304] Compare the volumes of *ka-na-ko*, *ma-ra-tu-wo*, *ku-mi-no*, *sa-sa-ma* and some of *pa-ko-we* where measures of 1.6 litres are often noted. Since we know that the last is a liquid measure, could it be assumed that the others are too? So could it be oils or pastes aromatised with these condiments/herbs?

[305] Darby *et al.* 1977, 670.

[306] de Vartavan & Amoros 1997, 41.

[307] Wreaths were awarded to the winners of the games at Nemea, which were conducted in memory of the death of the king's son. He was bitten by a snake when he sat beside a celery. Therefore, one can say that, even in victory, it indirectly symbolised death. Celery needs to grow on soil, which is fertile (well-manured) and its stem is kept softer and whiter when covered by soil. This ability, to remain 'fresh' when buried, is probably what the celery symbolised and was probably the reason why mourners wore wreaths of celery and planted celery plants to decorate graves (Καββάδας, 501).

[308] Dalby 1997, 222.

[309] Shelmerdine 1985, 14.

[310] de Rougemont 1989, 303.

[311] Γεννάδιος 1914, 439.

[312] Καββάδας, 1699.

that the harvest was conducted in the second half of July, in the third year after planting, whereby rhizomes were collected but a few were left *in situ* for propagation purposes. After they were washed and dried, preferably in the sun –not in an oven as it damaged their quality– for eight days, they were stored in a dry place until they were sold. Their weight was reduced by 1/3 of their freshly dug weight. Their cultivation was fairly effortless, and *I. germanica* grows in the least fertile ground.

Iris pseudacorus (yellow flower) has tannins, and is used as a dye.[313] If mixed with alum, it produces strong yellows. Although it is sometimes used medicinally, its rhizome is poisonous.

Irises have been depicted in Aegean art (wall-paintings) but not in Egyptian art, whereas the only archaeobotanical evidence comes from Egypt and is dated to the Graeco-Roman period (a wreath found). It has been re-identified by Tächholm as *I. albicans L.*[314] Recently chemical analyses by Beck and Evans[315] have identified oil of iris from three MM IA pottery vessels from the site of Chamalevri, western Crete.

The issue whether *wi-ri-za* is iris, is still not decided and it is still a debated issue. Another interpretation is that it might be the lanolin at the root of the animals' hair.[316] The production of perfume and oils used for perfumery seems, however, to be a logical explanation, as Greece is within the environmental range where aromatics could be produced at their best, not too dry but hot enough to produce concentrated oily substances. However, it is interesting to see that this plant material –root– is calculated in primary units, and it is even more important to note that *wi-ri-za* is, if not the same plant as **157*, a product which circulated in the same manner and was calculated in the same primary unit, even in areas so far removed as Pylos and Knossos. This means that it was a product, which circulated internally and was probably important enough to propagate for external circulation as well.

wo-do-we: Rose, *ῥοδόεν*[317] (Table 3). It seems to have been very similar to the one described for Classical times. The same weight (1:1) in oil and in petals is needed[318] and these would be steeped in oil for several days.[319] In the meantime, they would be returned to each vat to stir the oil, strain out the spent botanical parts in order to use fresh batches of the aromatic source. It is difficult to say which roses the Mycenaeans used for their perfumery. It could have been several subspecies of the *Rosa* genus, such as *Rosa canina*, the dog rose,[320] and/or *R. gallica subsp., centifolia*,[321] cabbage rose, *μαγιανή* in modern Greek: just as in Mycenaean times this denotes a month, which would refer to the time of its harvest, being May. Both could be found in Greece but we have, so far, no tangible archaeobotanical data of this plant.

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313 Cardon & du Chatenet 1990, 290.

314 de Vartavan & Amoros 1997, 139.

315 Pending full publication, it is impossible to verify the degree of confidence of these findings (*Minoan and Mycenaean Flavours*, 50-51).

316 Chadwick & Baumbach 1963, or wool used to strain perfumes (Beck & Beck 1978).

317 For the preparation of rose perfume see, *inter alia*, Wylock 1970, 128-129; Erard-Cerceau 1990, 269-270.

318 Wylock 1970, 1972.

319 Shelmerdine 1985, 46.

320 *R. canina* was named the dog rose, after the belief that it cured rabies.

321 Hurst (1967, 62) believes it is *R. gallica* or *R. sancta*; Goor (1981, 10) adds the qualification that there were four zones of growth and diversity of wild roses, one of which is the southern European zone, comprising the Balkans, Greece, Italy and central Europe. The chief species in this zone are *R. canina L.*, *R. gallica L.*, *R. rubra*, *A. alba L.*, and *R. centifolia L.*

Its use was not only to make perfume but the rose hip is used to make jams and syrups as well. As the seeds would be extracted from these preparations, the chance of finding *rosa spp.* is meagre. The flowers would have been harvested at dawn, when the coolness of the morning was still present, so as to collect the petals at their best.[322] Petals, of course, do not leave any evidence of their presence. The chances of the hips being caught in a charring environment would be greater, and in that case, it might be possible to identify their presence, if that occurred. However, art[323] and Linear B have given us proof of its existence in the Aegean, in contrast with ancient Egypt where no mention or depiction of it is made. It is, therefore, possible, and very probable, that the Mycenaeans exported this ingredient in perfume form to Egypt,[324] and it could well have been considered a luxury item.

The rose has many uses and many parts of it are useful, such as the flower (petals), the fruit, the leaves, the bezoar (galls), its water and oil. It was used as a medicine, in cosmetics, and as a perfume. Goor[325] claims that the petals can be pounded[326] and then strained through a 'linen cloth into a bronze vessel'; the juice is then heated on a slow fire until it is reduced to thick syrup, like honey. This rose juice is used for a multitude of ailments such as for the ears, mouth (tonsils, gums, sores), stomach, womb, headache, and rectal trouble and when used by itself or mixed with vinegar, it induces sleep and dispels nausea. On the other hand the burned petals are used as a cosmetic for the eyebrows and eyelashes.[327] The little galls or blisters[328] of the rose, it is believed, mixed with bear's grease, are a remedy for mange.[329] Hippocrates is also known to have prescribed rose-tinctured honey.[330] In ancient Greece and Rome rose water was added to wine, to flavour and colour it. In that case, it could not have been imbibed in olive oil or any other oil for that matter.

Goor[331] describes a method of preparing rose water[332] from the Talmud, which is extremely interesting and could very well refer to similar methods applied in the Bronze Age in Greece. It is said that in Persia petals were placed in water in a clean wooden vessel, which was left uncovered in the sunlight for several days. The drops of oil emerging from the flowers bubbled up to the surface and were sponged off with pads of cotton wool.[333] These were squeezed out and the resultant rose water was allowed to drip into a flask and then hermetically sealed until

[322] Though this is contradicted by Goor (1981, 90), who claims that the best time to pluck petals is in the midday warmth, when the petals are most highly scented.

[323] Namely wall paintings.

[324] All the finds of roses in Egypt, however, are dated much later, to the Roman period (de Vartavan & Amoros 1997, 225).

[325] Goor 1981, 78-79.

[326] He believes that, in the beginning, oil and essential perfumes were 'milled' out of a variety of plants and herbs.

[327] The leaves were burned into powder-form and were used as a mascara for women's eyelashes and as an emulsion for inflamed eyes (Goor 1981, 90). This powder, if sprinkled on the body, prevented sweating.

[328] The bezoar or bedaguar –in French *bedegar*.

[329] This is a contagious skin ailment which is marked by eczematous inflammation and loss of hair. It affects both animals and humans, and is caused by a minute parasitic mite.

[330] Goor 1981, 83.

[331] Goor 1981, 89-91.

[332] Goor (1981, 91-93) claims that in Israel rose water is made from *R. damascena Mill*, the damask, *R. alba*, the white and *R. centifolia*, the cabbage rose, and claims that the earliest method of extracting the oil was by 'milling'. He claims that 1 kg. of oil was extracted from 500 kg. of roses.

[333] These, of course, could have been replaced by linen cloth or better still material made from goat's hair as this does not absorb the oil within its fibres.

needed. This process is thought to have been introduced by the Persians. Pliny on the other hand presented three ways of handling petals. One method is to plunge petals in oil or wine in glass vessels set in the sun,[334] with salt and/or aromatic herbs. Another method was to express the juice by crumbling the petals and collect the juice in receptacles of bronze and heat it on a slow fire until it thickened to the texture of honey. A third method was to lay a thin layer of animal fat and spread the freshly picked petals with the slightest imperceptible contact. The lard quickly absorbed the perfume of the petals and, after a day, the spent petals were swept away and a fresh harvest of petals was arranged. This took place day after day until the full aroma was soaked up. This product was moulded into little pellets or pins for ladies' use. However, in modern Iraq, sesame oil is mixed with rose petals with the same result. The present Arabic way of making rose perfume is to blend sesame oil with fresh rose petals, let the mixture stand for a few months and then drain off the sesame oil.

The commonest edible form of the rose was its jam and this could be sealed with wax. Stacking layers of petals with honey in between and warming the mixture so that rose oil would seep into the honey also made rose honey. After a time span of approximately one week, the petals were sifted out of the emulsion. However, in older times, rose water was included in several sweets, fruits and drinks, and was much more extensively used than at present.

5. Other Plants Of Economic Use Not Identified In Linear B But Important In Bronze Age Societies (Table 18)

Isatis tinctoria: Woad, *ἰσάτις* (Theophrastus, Dioscurides). Barber[335] refers to the Cottes, where it is claimed that woad was identified on some of the bast fibres from Neolithic Adaouste, while the inhabitants of one or more Neolithic sites are believed to have reportedly stored woad seeds,[336] though no details are given. However, woad is native to south-eastern Europe. The evidence of 'blues' which come from Egypt (5th Dynasty) and from Palestine, as well as the blue dyes in Egyptian texts are subject to question, and it is still not certain whether their source is woad or indigo (*Indigofera tintoria*), whose area of origin is India. Even more confusing, though, making analysis even harder, is the fact that more than fifty plants also contain the chemical indican.[337]

The pigment is extracted from the leaves, which are dried, powdered and fermented, a tedious and 'smelly' process,[338] but its positive point is that the colour is very permanent. From Greece to date we have found no archaeobotanical evidence.

Juniperus spp.: Junipers, *κεδραία*,[339] could have been trees whose products (resins) might have had a substance mentioned in the Linear B tablets but which has not been identified to date. *Juniperus oxycedrus subsp. macrocarpa*, *J. oxycedrus subsp. oxycedrus*, and *J. phoenicea sensu lato* are found in several areas of Crete, including the island of Gavdos. *J. oxycedrus* and

[334] It would have been a type of proto-maceration as maceration itself demands that blossoms are seethed in oil at temperatures of 65° C.
[335] Barber 1991, 227, 234.
[336] Barber 1991, 234.
[337] Barber 1991, 234.
[338] Zohary & Hopf 2000, 208-209.
[339] It is the *άρκευθος* of Crete.

phoenicea are also widespread in mainland Greece, and they could well have been imported, from both areas, to Egypt.[340] Was Asia Minor or Greece the exporter? Its usefulness is manifold. The wood is used in carpentry but would impart a delicate aroma to grilled food and could also have been used as fumigant. The berries had multiple uses in medicine,[341] as incense and as a condiment. After all, they have been identified in a tripod at Malia.[342] Their resinous flavour is used in foods and the distilled oil (found mainly in the little cones, the so-called in Greek *κεντρόμηλα*) is used today to flavour Dutch genever.

Juniper is also said, in an Egyptian text, to have been used for dyeing.[343] It is mentioned that 'fresh juniper' was used to dye a strip of linen in the cult at the temple of Dendara (Upper Egypt). When mordanted with alum, juniper berries produce a pale creamy-brown dye. In Egypt there is archaeobotanical evidence of *Juniperus spp.*, which is common. *J. drupacea*, first appeared in the Middle Kingdom, *J. oxycedrus*, in Predynastic times and up to the Coptic period, whereas *J. phoenice* is found from the 3rd Dynasty.[344] *J. oxycedrus* is a very good wood, which is not attacked by insects and can be polished and made into very fine objects, used for a multitude of things, such as flasks. It also has very fine oil, which is used for medicinal purposes, both for humans and animals, and can also be used for lighting. *J. macrocarpus* is a more xerophilic plant.[345]

Papaver somniferum: This is believed to be the *μήκων* of Homer and is now the cultivated poppy. The setigerum poppy is the progenitor (*P. somniferum ssp. setigerum*), because this diploid is interfertile with the somniferum cultivars.[346] The distribution of the wild poppy is in the western Mediterranean, all along the coast from Italy to Tunisia. Together with the early archaeobotanical finds from the 4th millennium BC lakeshore settlements in Switzerland, and contemporary sites in Germany, Late Neolithic Lagozza in north Italy, and Final Neolithic (*ca.* 3000 BC) Cueva de los Murciélagos, Spain,[347] these all suggest a western Mediterranean domestication.[348] In Greece, the earliest archaeobotanical find (*P. somniferum*) is dated to the Early Bronze Age, from the sites of Kastanas,[349] and Mandalo,[350] but another find of the same date was found at Thermi,[351] although the author did not mention that it was *P. somniferum*. For the

[340] There is a relief, though, of the picking of juniper berries in the tomb of Niankhmum and Khnumhotep at Saqqara dating to the Old Kingdom (Manniche 1989, 111).

[341] It is an antiseptic, diuretic, and carminative.

[342] Georgiou (1986, 8) stated that the vessel was an incense burner. It is important to note that the pottery use was assumed from the organic remains alone, where juniper berries were found (species not identified) together with coriander and *Ferulago nodosa*.

[343] Manniche 1989, 112.

[344] de Vartavan & Amoros 1997, 143-146.

[345] Καββάδας, 1138, 1140.

[346] Zohary & Hopf 1993, 128-131.

[347] A fairly comprehensive catalogue of poppy finds is enumerated in Zohary & Hopf 1993. At Cueva de los Murciélagos, many opium capsules and a large quantity of seeds were found (Merlin 1984, 171).

[348] For detailed discussion of poppy finds in the western Mediterranean see van Zeist 1980; Bakels 1982; Merlin 1984, 176.

[349] Kroll 1991, 175.

[350] Βαλαμώτη 2001, 30.

[351] Lamb (1936, 27) published the Thermi find. This if proven correct would refute Merlin's (1984, 180) thesis that opium was only introduced to the eastern Mediterranean in the Late Bronze Age via the trade contacts between East and West and *vice versa*. However, this find needs to be restudied archaeobotanically.

Late Bronze Age the archaeobotanical data (seeds) come from Akrotiri, Thera,[352] Kastanas, Tiryns[353] and Assiros.[354] However, it is said[355] that a Sumerian clay tablet dated to *ca.* 2100 BC mentioned poppy. It is a fact, though, that opium (*ὀπός*,[356] *μήκων ὁ ὀπώδης* of Theophrastus) has not been recognised in Linear B, although it could, very probably, lurk under the unidentified spices/condiments/aromatics.[357] Hoffner[358] noted that in Hittite records, there is mention that pomegranate juice was combined with other ingredients to produce a substance, which congeals. Merlin[359] wonders whether one of the other substances was the sap of the opium poppy. This could produce a medicine, a hallucinogen or an 'alcoholic' drink, which would also have had intoxicating effects. The poppy is, therefore, both a remarkably beneficial crop, as well as a socially dangerous drug.

Although, surprisingly, textual evidence of poppy is lacking,[360] another source is profuse with data –the Mycenaean artistic records. Merlin, Kritikos, Kritikos & Papadaki[361] enumerate the artifacts and artistic records which are profuse with indicative evidence, but surely by now even more evidence would be available. A detailed discussion, however –and up to finds of the early 1960s in this category of data– (statuettes, pins, smoking paraphernalia, seal rings) is conducted by Kritikos & Papadaki for the Prehistoric and the Classical periods. The evidence points to the fact that in the Late Bronze Age the scarring[362] (Fig. 6) of the opium capsule[363] was known (pins with notches dated to LM III)[364] (Fig. 7) and that the sap was heated indicating that the opium

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352 Sarpaki 1992.

353 Kroll 1991.

354 Jones *et al.* 1986.

355 Merlin 1984, 155.

356 *Ὀπός* is the latex which is expressed from the capsule, and *μήκων* is pressed from the leaves and the seeds and is less effective than the former.

357 The interesting discussion, exchanged in the correspondence between Chadwick and Merlin, was provided, by the latter, in his book (Merlin 1984, 197-198).

358 Hoffner 1974, 120.

359 Merlin 1984, 201.

360 No word for either poppy or opium has been identified in Sumerian, Akkadian, or Assyrian (Krikorian 1975, 103). Chadwick & Ventris (*Documents*, 130) claim that the identification by Sundwall as 'poppy-seed' is very improbable, 'especially in view of the large quantities involved'.

361 Merlin 1984; Kritikos 1960; Κρητικός & Παπαδάκη 1963.

362 Kritikos (1960, 72; Κρητικός & Παπαδάκη 1963, 141) claims that at first the capsule was scratched perpendicularly (see idol from Gazi, Crete). Also see several Mycenaean pins with notches.

363 When the petals are fully mature they fall, and the capsule is, then, ready to be scarred while still on the plant. The multiple scarring is done vertically or horizontally (Γεννάδιος 1914, 656) and the sap (milky latex), which is air-dried, is emitted and the opium is collected in this tear-form the next day (Moazzo 1985, 63). This is then scraped by instruments and made into balls. They are left to dry, under the sun, for two-three days until the colour turns a yellow-brown. The person who collects this matter can fall into a deep sleep if he does not use an antidote, which consists of slices of onion on his forehead, as the smell neutralises the soporific action of the latex (Moazzo 1985, 63).

364 The large terracotta 'goddess' idol from Gazi, Crete is dated to the LM III period, and as the notches are evident on the opium capsules, it is an indication that this method of extracting opium was known at least since that period. An interesting find from Egypt was an LM IB jug (Merrillees & Winter 1972) which had blackish-brown stains in the lower body and this material was submitted to Dr J. Winter for analysis (Merrillees & Winter 1972, Appendix, 128-130). He concluded that it was an aqueous material (beer or wine, rather than an oil) with the presence of small plant fragments. One hypothesis was that some species of plant seed, with a high lipid content (saturated fatty acids), such as grape seed, linseed, poppy seed and

was taken by inhalation of the vapours.[365] Before it was ready to be smoked, the opium, after collection, had to be submitted to a series of transformations. The material (opium) is made into *πλακούντες*, which are put in wooden boxes.[366] If these are kept in poppy petals, they develop a very special aroma. These baked 'cakes' are the 'brut' opium. In order to be prepared for smoking, it is submitted to a series of operations in special craft centres, some of which were well known in modern times, such as in Saigon and Batavia. These 'cakes' are sliced, put in water and left to macerate in bronze vessels and then heated until the substance acquires a syrupy consistency. This matter is made to concentrate until it turns into a brown molasse, the so-called *tshandou* or opium for smoking. However, before being traded it is submitted to beating so that it mixes with oxygen and it is also mixed with a moss, *Aspergillus niger*.[367]

Two types of 'pipes' for smoking are possible, (a) open 'pipes' (without bottoms) and (b) closed 'pipes' (these always have holes in the lower lateral section).[368]

The poppy[369] is a very useful, annual plant, which is extremely productive and grows in most climates and marginal lands. It can even be grown in areas where animals graze and does not need to be protected, as the animals do not graze upon it.[370] Several parts of it are also useful. Opium[371] is the sap of the poppy capsules. The leaves are also planted as a potherb or used as fodder. Its seeds can be pressed to produce comestible oil[372] or ground to make poppy flour and

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sesame could be considered a candidate. Olive oil and palm oil cannot be ruled out, but would be present more as the expressed oil rather than as ground plant material. However, it is likely that the material was Egyptian and (re)-using a Minoan pot, rather than Cretan material (Merrillees & Winter 1972, 107). It is an agreed fact that the Late Minoan pottery imports in Egypt are remarkably poor. The perishable ingredients, which would have been in demand in Egypt were saffron, a 'bean from Keftiu land' (imported perhaps from the Aegean) (Merrillees & Winter 1972, 110), *Lathyrus clymenum*, might have been an import from the Aegean to Tel Nami, Levant (Kislev *et al.* 1993, 151) (*Papyrus Ebers*, dated to the early 18th Dynasty). Other products could have been an aromatic lichen (*Parmelia furfuracea*), which did not grow in Pharaonic Egypt, and purple dye. Another exported legume/bean could have been the lupin, *Lupinus albus spp. graecus*, which is the progenitor of the domesticated *L. albus* and is native to the Aegean (Zohary & Hopf 2000, 122-123), although strangely enough, legumes are not mentioned in Linear B (*inter alia* Erard-Cerceau 1988). It would be important to examine all Minoan and Mycenaean pottery found in Egypt for their contents, as preservation would allow organic remains to be preserved.

365 Evans (1964, IV, 145ff.) interpreted the tubular vessels (without bottoms) as water pipes whereas Kritikos & Papadaki (Κρητικός & Παπαδάκη 1963, 143) refer to them as 'pipes'. They explain the way the opium was smoked and show the utensils. Karageorghis (1976, 126) found a 'pipe' at Kition, Cyprus (*ca.* 1200 BC), which is believed to have been used for smoking opium.

366 Their weight was *ca.* 70-80 kg. (*Μεγάλη Ελληνική Εγκυκλοπαίδεια, s.v. πλακούς*). It averaged 40-60% of good quality opium, 30-40% of medium quality and 3-10% of very average quality.

367 Moazzo 1985, 63.

368 See Κρητικός & Παπαδάκη 1963, 7; Merlin 1984, 243-244 for ways of inhaling vapours.

369 The is the *P. somniferum L.*, the so-called 'black poppy' but there is also a white variety *var. album D.C.* These are named after the colour of their seeds and this distinction was recognised in Ptolemaic Egypt where reference is made to *μήκων μέλαινα* (the black poppy) and *μήκων λευκή* (the white poppy) (Crawford 1973, 232); here the black variety is more common, but the white is richer in morphine opium (Καββάδας, 3022).

370 Καββάδας, 3022.

371 Opium is the air-dried milky latex, which exudes from the incisions in the seedpod of the living plant, and meconium is obtained by infusing the whole of the cut plant. Opium seems to have been the most common substance, though both are referred to in the medical papyri (Crawford 1973, 231).

372 Knapp 1991, 26 where he refers that cold-pressed oil is white, whereas it is reddish when hot-pressed.

sprinkled over dough for flavour. Even what is left after the pressing, makes excellent cattle cake.[373] Interestingly, 45%[374] of the weight of the seed is oil,[375] and this can be used for cooking and in lamps. It is said to burn for much longer than olive oil.[376] Ground, it is made into porridge or cake filling, as is still done in some countries such as Austria and Germany. Even the dried stalks form straw may also be used for fuel.

Large-scale cultivation requires intensive care in weeding, and was done by young boys in Egypt,[377] and thinning the young plants but the yield is good and it is a profitable crop in many parts of the world. The seeds can be sown in November but sowing has been reported also in February.[378] One needs *ca.* 0.340 kg. of seed to plant 1,000 square metres[379] (1 stremma) and the yields are in the order of 0.8-1.4 kg. of opium per stremma and 45 kg. of seed.[380] The harvest was in May-June[381] and when the capsules were beginning to turn yellow, these were harvested and left to dry in the hot sun for two-three days until they were completely dry. Then the capsule was beaten in order to collect the seed. If these were collected, in order to be used for oil, they were sifted, cleaned and, in Egypt, stored in the granary. In some places, after the harvest of the capsules, the stalks were collected and tied in bunches to be used as fuel.[382] Strangely enough, there is no mention of opium collection[383] but we must not disregard the fact that it was a crop primarily cultivated for oil.[384]

Rhus ssp.: One of the species is *Rhus cotinus*, *κοκκυγέα* (Theophrastus), and its wood is used in dye; the leaves contain tannins, whereas its sap is poisonous. The other species, sumach, *Rhus coriaria*, *ῥοῦς* (Dioscourides),[385] is used as a dye (black, brown and yellow) and the colour depends on which part of the plant is used, such as the leaves, the fruit, the root or the young plant. It is also used for mordanting leather, and for medicinal purposes.

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[373] Crawford 1973, 230.

[374] Cf. Crawford 1973, 230.

[375] Some 30% of clean white oil on a first cold pressing could be produced, which can be increased up to 50-60% on subsequent heated pressings.

[376] Merlin 1984, 91.

[377] All information on the poppy from Egypt comes from the 3rd century Zenon papyri and is preserved from the North Fayum area. It is questionable whether opium existed before that time in Egypt but Merrillees & Winter (1972, 127) argue that honey, in which opium would had been dissolved, may have been carried in base-ring juglets from Cyprus to Egypt, during the 18th Dynasty.

[378] This refers to Egypt, whereas, for Greece, Gennadios (Γεννάδιος 1914, 657) notes that the crop is planted after the first rains of autumn and not later.

[379] Gennadios (Γεννάδιος 1914, 657) notes that *ca.* 600 gr. of seed are needed for 1 stremma.

[380] From the Zenon archive, it is clear that poppy seed is recorded, measured in baskets, containers or *choinikes* (Crawford 1973, 234), just like the saffron crocus. However Gennadios (Γεννάδιος 1914, 657) claims that 1 stremma can produce as much as 250 kg. of seed, and the price is ½ drachma per 1.280 kg. Crawford 1973, 230.

[381] Or July-August, depending on the latitude.

[382] Γεννάδιος 1914, 657.

[383] Crawford 1973, 233.

[384] The contents of an LM IB jug (the Abbott vase) found in Lower Egypt were analysed (Merrillees & Winter 1972, 130) and it was suggested that an oil-rich plant seed was the source, one of the proposed plants being the poppy seed.

[385] In Akkadian *ṣipru* is a cognate of the Arabic *ṣafara*, 'be yellow'. Note how close it is to the term *safran*. Sumac was found in the Ulu Burun wreck (Bass 1997, 164) and is believed to have dyed the wax on which they wrote in the diptych, found in the wreck.

Styrax officinalis: storax, *στύραξ*, is a tree that emits a resin, the storax,[386] when incisions are made in the branches, and it is widely used in medicine, as incense and in perfumery. Its pounded fruit is also a narcotic and used for catching fish.[387] Today, it is used in the Roman Catholic Church for incense.[388] This tree is probably the Biblical stacte and the sweet storax.

This product circulated in three forms up to the beginning of the 19th century, that is (a) in solid tear-form, (b) in semi-solid form in a piece of cane, when it was called *στύραξ καλαμίτης* or (c) in small pieces (plain storax) in which form it was still found at the beginning of the 20th century.[389] In Cyprus, in the area of Karpasia, storax is still found in form (b).

EPILOGUE

We have tried to tie together textual, archaeobotanical and ethnobotanical information. Of course the textual and archaeobotanical information needs to be enriched, on the one hand, with more tablets, which might throw light on certain terms and uses, especially for the ideograms, which cannot be translated. On the other hand, more soil samples need to be examined for environmental data, and in our case, for enriching our present knowledge of plant use, preparation, and plant circulation. More ethnobotanical knowledge needs to be gathered, specifically to answer archaeological/archaeobotanical problems. This needs to be conducted as soon as possible, due to the massive loss of information, day by day.

As for plants in Linear B, we either accepted previous identifications, or else, if there were more than one, we set out our suggestions and excluded the ones which could be rejected due to botanical information. We have ventured four new suggestions for interpreting plants/plant material. One is the term *sa-sa-ma*, which has so far been translated as sesame. Yet, we might have to redirect linguistic research to this term and see all the new linguistic suggestions for the Hittite word *sa-ma-ma*. More recent research does not agree that it refers to sesame but applies it rather to oil. Which oil though? It is definitely not the oils which are referred to in Linear B, and as existing in the Mycenaean period, i.e. olive and, possibly, safflower oil (see *ka-na-ko* for discussions). The actual absence of sesame archaeobotanical finds in Greek archaeology, if not accidental, needs to be accepted as a *sine qua non*. This means that until we find it we should consider that sesame did not exist in the Mycenaean world but its presence in oil form cannot be excluded. However, if the term refers to 'oil', this does not deny the possibility of the word referring to sesame oil, but not excluding poppy oil and other oils such as *Juniperus spp.* as well.

The other term, which has been disputed, is *ki-ta-no* (see term) which, it is suggested here, belongs to the rockrose, and particularly, to its product, ladanum. So far, it has been identified with turpentine (*P. terebinthus L.*) but we suggest that *ko-no* is the term that refers more probably to the *Pistacia spp.* of plants. The third suggestion is for *sa-pi-de* (see under *sa-pi-de* in Table 3), which might refer to wooden boxes/cabinets filled with opium. Another term, which has been greatly studied, is *po-ni-ki-jo*, with a plethora of suggestions, some of which are more

386 This should not be confused with the liquid styrax (balsam) which is produced from *Liquidambar orientalis*. This tree is found in Asia Minor and some Aegean islands (e.g. Rhodes) and the liquid resin is produced by boiling and pressing the bark (Baum 1994, 39). However, the term 'olibanum' is used for many genera and species of plants, such as *L. orientalis*, and frankincense (*Boswellias*, *Commiphoras*).

387 Γεννάδιος 1914, 924.

388 Polunin & Huxley 1972, 143-144.

389 Γεννάδιος 1914, 924.

plausible than others. They have been discussed in the relevant section. However, new suggestions have been proposed here, which is silk thread, dyed red with purple dye or *Murex* opercula powder.

Some interesting points emerge from this study, especially as all condiments, aromatics and dye plants were viewed as a whole, from all sites providing us with a Linear B archive. Our aim was to 'touch upon' social and economic information. We were able, we believe, to perceive some specialisation in the centres of Pylos and Mycenae, on the one hand, and Knossos, on the other. The first two have a certain emphasis on condiments and aromatics which are imported from areas further afield than the Aegean (henna, cardamom, cinnamon?, sesamum?), implying that we are dealing most probably with a 'consumption' site which has an 'urbanised' population, eager to consume such exotic goods. This urbanisation is stressed even more with the recording of common (for the Aegean) plants such as celery and mint, emphasizing even further the 'urban nature' of Mycenae, where either there was not enough space even to grow garden plants, or the occupation of the inhabitants in other industrial pursuits did not permit their involvement in farming activities.

Knossos, at the other end of the scale, seems more of a 'production' centre, where aromatic plants, resinous plants and dye plants are of special interest to its centre of control. Plainly put, it is as if Knossos exported, while Mycenae and Pylos imported. The implications of this statement for the Mycenaean world, if verified by archaeological research, are enormous. Does this mean that even imports found at Knossos, on the whole, were first deposited at the other centres before reaching the Cretan metropolis? This would give an insight into the possible different organisation of secular and religious power inter-regionally and intra-regionally. Unfortunately, here we were only able to raise questions to which research in the forthcoming years might, we hope, provide answers.

Another area of interest is the dyes that the centres control, i.e. safflower (red-orange depending on the mordant used), henna (dark orange-red) (Mycenae), Alkanna tinctoria (red)/*Murex* dye[390] and/or opercula, and saffran (yellow) (Knossos). In other words, these two colours, red and yellow, seem to have a special symbolic *semeiosis*, probably of power, and most probably are also connected to religion.[391] A stimulating article by Edens[392] was written about the 'symbolic capital' of power, the legitimation found in colour, which was implemented in Kassite,[393] Babylonia, and which, I believe, is of immediate relevance to our case. There the king 'expressed divine approval for his rule by displays of colour, and in the hands of others, the political power of colour appealed to the symbolic figure of the king'.[394] He claims, therefore, that 'colour operated as a hierarchical structure of reference, the pivotal element of which was the just king'. The king symbolised all that was ordered and just and divinely approved. Hence, we assume that red must have symbolised social order, just as in Mesopotamia. Perhaps, the red colour on the plaster of the throne room at Knossos was a display of such order and sovereignty. On the other hand, yellow is connected to divinity, so it might have been reserved for those who

[390] The fact that *po-ni-ki-jo* is an exclusively Knossian product, if our proposal is correct, fits well within the framework of Knossos being an important industrial centre for textiles and dye.

[391] We cannot doubt the power of colour in either secular or religious functions. It is a well-known fact that Roman emperors wore purple-red cloaks and that the blue, indigo blue, worn by the Virgin Mary is an explicit expression of the power of colour in religious symbolism.

[392] Edens 1994.

[393] Kassites refer chronologically to the Late Bronze Age.

[394] Edens 1994, 219.

came into contact with the divine. We should remember that the saffron collector at Xeste 3, Akrotiri, Thera, namely the one emptying the basket full of crocuses in front of the blue monkey was wearing a saffron-yellow coloured top. The same holds true for the so-called priestess drawn on the east doorjamb of the door leading from room 4 to room 5 of the West House, Akrotiri, Thera. Again, divinity or proximity to divinity is marked by yellow, perhaps symbolising the power and the light of the sun, the source of life (light, warmth), of stability, and of eternity.

Table 2. Plant products from the Linear B archives[1] which are weighed, measured by volume, and/or counted.[2]

PLANTS	COMMON NAME AND GREEK NAME	MYCENAEAN NAME/SIGN	ARCHIVE
Carthamus tinctorius L.	Safflower/κνῆκος	ka-na-ko e-ru-ta-ra: red, re-u-ka: white[3]	MY (6 tablets)
Foeniculum vulgare Miller	Fennel/μάραθο[4]	ma-ra-tu-wo, MA	MY (5 tablets), KN (3 tablets)
Coriandrum sativum L.	Coriander/κορίανδρος	ko-ri-ja-do-no, ko-ri-ja-da-na, ko-ri-a_2-da-na, KO, AROM+KO	MY (5 tablets), PY (3 tablets), KN (29 tablets)[5]
Mentha spp.	Mint/μίνθος	mi-ta, MI[6]	MY (4 tablets)
Sesamum indicum (?)	Sesame/σουσάμι	sa-sa-ma, SA/*31	MY (5 tablets)
Pistacia lentiscus/ Cymbopogon cf. schoenanthus	Terebinth/ginger grass/ σχίνος (?)	ko-no,[7] ko-i-no, e-ne-me-na (abbrev. to E)[8]	MY (4 tablets) KN (1 tablet)
Salvia spp. cinnamomum (?) cf. cassia	Sage (?) cinnamon/ κανέλλα, rush (?)	KAPO[9]/*127	PY (4 tablets), KN (1 tablet)

[1] The plants mentioned are those which demonstrate that they are not treated as agricultural products *per se* (e.g. grain) but have a 'higher' transactional status.

[2] All the tablets from Tiryns, Thebes and Mycenae have been checked in *TITHEMY*. Knossos have been checked in *CoMIK*, Pylos in *PTT*.

[3] Discussion about *ka-na-ko* and *po-ni-ki-jo* as referring to the same plant is conducted by Murray & Warren 1976, 54-55, and they conclude that this is not possible. They explain the reasons thoroughly.

[4] *MA* (Lejeune 1971, 163).

[5] Cf. Palmer 1999, 484 mentions only 12 citings.

[6] *Documents*, 105.

[7] *ko-no* is a controversial term whose translation has not been decided yet. On the one hand, it is recognised as *σχῖνος* (look at Olivier 1969, 51ff. for two species of *σχῖνος*–not to mistake with *σχοῖνος*– and Wylock 1972 recognises it as *Acorus calamus L.*) and, on the other, it is thought to be a *χόννος* = *δοχείο* (Maddoli 1967); cf. *ko-i-no* (**MY Ge 606** + *fr.*). Palmer (1999, 485) prefers the *Acorus calamus L.* identification, and mentions terms *DE*, and *e-ne-me-na E*. However, it is important to say that *A. calamus L.* does not seem to be present in Greece, for it is not mentioned in *Flora Europaea* and other floras for Greece. Only Sibthorp referred to its existence (Καββάδας, 183) and its presence is therefore disputed, whereas Gennadios (Γεννάδιος 1914, 36) believes it had been mentioned by Dioscurides as 'acorus wine', which was wine scented by *Acorus sp.*

[8] *Documents*, 226, 545.

[9] **127* = cinnamon (Sacconi 1972); see term *KAPO* under plants for discussion.

Table 2. (Continued).

PLANTS	COMMON NAME AND GREEK NAME	MYCENAEAN NAME/SIGN	ARCHIVE
Cyperus[10] spp. (cf. C. rotundus, C. esculenta and C. longus L.)	Chufa/tiger nut grass, galingale/κύπειρος	CYP+O, CYP+PA (?), PYC+QA, CYP+KU, AROM+PYC, ku-pa-ro, ku-pa-ro_2, ku-pa-ro-we, PYC+O; CYP+O	MY (2 tablets), PY (7 tablets), TH (1 tablet), KN (23 tablets)
Cuminum cyminum L.	Cumin/κύμινο	ku-mi-no, KU[11]	MY (6 tablets)[12]
Alkanna tinctoria/ Anchusa tinctoria	Alkannet/φοινίκιο, βαφόρριζα	po-ni-ki-jo	KN (25 tablets)[13]
Cistus creticus L.	Rock-rose/κρίτανος	ki-ta-no/*123[14]	KN (2 tablets)
Crosus spp. (C. cartwrightianus & C. sativus)	Saffron/κρόκος[15]	CROC/*144, *33, ko-ro-ki-no	KN (43 tablets)
Salvia spp.	Sage species	pa-ko-we, PA/OLE+PA	PY (19 tablets)
Rosa spp.	Rose	wo-do-we	PY (6 tablets)

[10] In Assyrian cyperus is mentioned as *suadu*, so *ku-pa-ro* might be a pre-Hellenic name. Palmer (1999, 485) separates the edible cyperus (*C. esculentus L.*) as referred to by *CYP+O/PYC+O, CYP+PA* (?).

[11] *KU*, I believe, refers more to *ku-mi-no* because it is more with the condiments, which one expects to find *ku-mi-no* with (i.e. *ma-ra-tu-wo, sa-sa-ma, re-u-ka*, etc.). The quantities, as well, are within the range expected for *ku-mi-no*.

[12] Palmer (1999) refers to 5 citings.

[13] Palmer (1999) refers to 20 citings.

[14] **123* = condiment; Lejeune 1971, 161 (Table: 160) and also p. 162: '*coriandre et d'autres épices!*'; see Sacconi (1971, 27, 29) who identifies it as a spice, namely *ki-ta-no*.

[15] **33* = safran (Lejeune 1971, 155, note 50).

Table 3. Quantities of condiments, perfume and dye plants of the Mycenaean period, which are debated and/or unknown as to their identification in the Linear B tablets.

PLANT	COMMON NAME	MYCENAEAN NAME/SIGN	TYPE OF TRANSACTION (C), (M), (W)[1]	TABLET	MYCENAEAN QUANTITIES
Rosa spp.[2]	rose	wo-do-we[3]	(Ml)	PY Fr 1203[4]	S 1 V 2
		wo-do-we	(Ml)	PY Fr 1204	Z 1
		wo-do-we	(Ml)	PY Fr 1207	V 1[
		wo-]do-we	(Ml)	PY Fr 1208[5]	S 2 V 4
		]wo-do-we-qe	(Ml)	PY Fr 1223	S 2
		wo-do-we	(Ml)	PY Fr 1238	S 1
Lawsonia inermis L.[6]	henna	e-ti-we[7]	-----[8]	PY Fr 343	-----
		e-ti-we	(M)	PY Fr 1209 [+] 1211	V[
		e-ti-we	(M)	PY Fr 1224	Z 2
Several plants[9]	myrrh	MU[10]	(C)	KN Og(1) 8038	units 46
Cardamomum ssp.	κάρδαμο	ka-da-mi-ja	-----	MY Ge 604	-----
Apium graveolens	celery	se-ri-no	(W)	MY Ge 604	M 2

[1] (C) = count; (M) = measure –as in volume for dry or liquid measure, a capacity measure; (W) = weight as in balance (σταθμά); measured by weight; (BA) = basket, (Cu) = cup; (BUN) = (?) bundle/δεμάτι (*E* in *ko-no*); (BU) = bunch/δέσμη (Mycenaean *PE*); μονάδα αγαθού = primary unit, whereas it is mentioned as 'whole numbers' by Chadwick & Ventris (*Documents*, 55).

[2] Among the roses, which could have existed, are *R. gallica, R. sancta* (Hurst 1967, 63), *R. canina* (Baumann 1993), also, perhaps, *R. centifolia* (Warren 1970, 373). Probably rose-oil, or any other volatile oil produced from plants could have been extracted in a simple *bain marie*, if a metal container was used or else even pottery could have been employed (see Kanta 1999).

[3] It is interesting to note that *wo-do-we* is always mentioned together with *OLE* (olive).

[4] It is preceded by *PO* 1, which is ligatured with oil (*Documents*, 572). For this commodity we can be sure that it was quantified in liquid measure (see Hooker 1994, 86), and, of course, the (*S*) measure qualifies liquids.

[5] *PO* 3 precedes it.

[6] If identification is correct (Duhoux 1993, 103), it would have been an imported plant (see *e-ti-we*); see also ideogram **23*.

[7] Shelmerdine (1985, 136) refers to **ertis* as henna (?), where she presents some interesting references for the reasons she equates ertis with henna; also see Duhoux (1993, 103).

[8] When the type of transaction for the particular commodity is unreadable, and/or destroyed, the equivalent Mycenaean quantities are left blank and the dotted line denote this. Asterisks mean that we do not know the quantity of the primary unit. This convention is going to be used in all tables.

[9] It could refer to Frankincense and myrrh, which are gum resins. Frankincense comes from trees of the genus *Boswellia* (such as *B. sacra, B. carteri, B. papyrifera* etc.) (Groom 1981, 232) and myrrh comes from different species of *Commiphora*. In Rome myrrh, which was used as a base for perfumes and unguents, was two-three times more expensive than frankincense (an incense) (Groom 1981, 154).

[10] Dots under *MU*. *MU* could stand for *murru* (Assyrian for myrrh) (Shelmerdine 1985, 23).

Table 3. (Continued).

PLANT	COMMON NAME	MYCENAEAN NAME/SIGN	TYPE OF TRANSACTION (C), (M), (W)	TABLET	MYCENAEAN QUANTITIES
Unknown plant/ plant-material		sa-pi-de[11]	(C)	MY Ge 602	units 6[13]
		sa-pi-de	(C)	MY Ge 602	units 6
		sa[-pi-de	-----	MY Ge 605 + 607 +[12]	-----
		]sa-pi-de	(C)	MY Ge 605 + 607 +	units 12
		sa-pi-de[	-----	PY Vn 19	-----
		sa-pi-de[	-----	PY Vn 19	-----
		sa-pi-de	(C)	PY Vn 19	200[
		sa-pi-de	(C)	PY Vn 19	80[
		sa-pi-]de	(C)	PY Vn 19	60
		]sa-pi-de	(C)	PY Vn 19	40
		sa-pi[-de	-----	PY Vn 19	-----
		]sa[-pi-de	-----	PY Vn 19	-----
		*132[14]	(MI)	PY Un 2	S 2
		*154[15]	(C)	PY Un 592	21 units
		*154	(C)	PY On 300[16]	≥ 46 units
		*154[	----	PY On 375	-----
		*154/ra-ka	(C)	PY Un 592[17]	units 21
		da-ra[ ]	----	MY Ge 603 + frr.	-----

[11] It is believed, by some (*inter alia* Killen 1964, 172; Sacconi 1971, 31) to be a condiment, or an aromatic, as it is mentioned together with them, namely with coriander, cumin, safflower, fennel, mint and sesame. The interpretation of it as being a box (σαρπίδες) (Hooker 1994, 269; Killen 1964, 172) is not very satisfactory, and it could rather be a commodity, which is counted in 'containers' (*Documents*, 227, 581) [cf. 'mastic' which is calculated in 'staters' (στατῆρες)]. However, opium is kept in wooden boxes in set weights (see section below on *Papaver somniferum*).

[12] When a tablet ends in (+) it refers to other fragments not mentioned here.

[13] For all of the *sa-pi-de* I have made no calculations regarding the quantities they represent.

[14] This is thought to be a plant and/or plant produce –transacted in liquid measure– as it is mentioned together with processed products such as flour, honey, wine, dried (?) fig and cyperus, in tablet **PY Un 2**. Of course products such as molasses from the grape and the carob have not been suggested with the exception of Scafa (1995) but the author believes it is a possibility worth examining. Recently, the carob has been detected in pollen just after Minoan times (Bottema & Sarpaki in press), and wood has been found from Late Bronze Age Mochlos (Schoch in press) and Kommos (Shay *et al.* 1995).

[15] Palmer (1999, 485) refers to it as pennyroyal (see *Documents*, 226 and also Warren 1970 who refer to *ka-ra-ko* as pennyroyal).

[16] **PY On 300**.2 (10 units and 6 units); **300**.3 (5 units and 3 units); **300.4** (**154*[and 3 units); **300.5** (**154*] and 3 (?) units); **300.6** (3 units); **300.9** (just **154*); **300.**10 (2[units and 3 units); **300.**11 (units [ ]2 and units 3); **300.**12 (2 (?) 3 units).

[17] Lejeune (1971, 160) mentions for **PY Un 592** [20 units?][*ra-ka*]. In *Documents*, 578 *ra-ka* is said to probably be **154*.

Table 3. (Continued).

PLANT	COMMON NAME	MYCENAEAN NAME/SIGN	TYPE OF TRANSACTION (C), (M), (W)	TABLET	MYCENAEAN QUANTITIES
		*171	(C)	PY Aq 64	30 units[23]
		*171[18]	(C)	PY Un 1414	4 units
		*171	(C)	KN Ga(1) 519	2 units
		*171[19]	(C)	KN Ga(3) 464	4 [units
		*171[20]	(C)	KN Ga(3) 464	4 units
		*171	(C)	MY Ge 606 + fr.	11 units
		*171[21]	----	MY Ge 608a + frr. +	-----
		*171	(C)	TH Wu 46	30 units
		*171	(C)	TH Wu 56	30 units
		*171[22]	(C)	TH Wu 59	36 units
		*171	(C)	TH Wu 76	30 units
Iris ssp.	Iris	wi-ri-za[24]	----	PY Un 249	-----
(cf. illyrica)		]wi-ri-za	(C)	KN Od 2026[26]	-----
		wi-ri-za	(C)	KN Od 8202 + fr.	-----
		wi-ri-[	(C)	KN X 44[27]	-----
	?iris	*157[25]	(C)	PY Un 267	units 16[28]
		*157	(C)	PY An 616	units 28
		*157	(C)	PY Un 249	units 10

[18] Palmer (1999, 467) also mentions it as an aromatic and on p. 470 states that 'this commodity is connected to cyperus by context' and perhaps indicates the cyperus stem, as it had already been claimed by Melena (1974c). The interpretation has been accepted by Palaima (1989).

[19] It is mentioned together with cyperus.

[20] The same also mentioned together with cyperus!

[21] It is also mentioned with cyperus but with a group of other aromatics such as coriander, fennel, sesame, safflower, mint, and an unknown aromatic. **171* has also been mentioned first by Melena (1974a) to have been a fodder plant and has been pursued by Palaima (1989, 112), but Palmer (1999, 474-475) rightly believes that it is most unlikely. One would not expect a transaction of fodder to have been annotated in the records.

[22] On another tablet (**TH Wu 71**), cyperus is mentioned too! This could not, just, be a coincidence, I believe.

[23] **PY Aq 64.2** (3 units); **64.5** (6 units); **64.6** (3 units); **64.7** (12 units); **64.13** (6 units).

[24] *wi-ri-za* = iris root *–Iris illyrica–* (Cardon & du Chatenet 1990). *Iris pseudacorus* = dye. The ideogram **157* consists of an infinity sign surmounted by *WI* (Shelmerdine 1985, 18: *wi-ri-za* = substance measured in units rather than by weight or volume; see also Foster 1974, 117-118). Melena (1983, 115) refers to it as an unknown substance and Lejeune (1971, 161) states that *WI* is understood in the ideogram **157* and, perhaps, refers to *wi(riza)*. Other plants have useful roots such as *Rubia tinctoria* (in modern Greek *ριζάρι*), which could be, yet, another possibility. As it is mentioned together with *LANA*, I would favour the identification of *R. tinctoria*, which is used to dye wool and not *Iris* which would have been a very costly oil reserved only for perfumes. On the other hand, it has been claimed by Palmer (1963) that the ideogram **145b* is the root of the iris but it has been much disputed by Chadwick & Baumbach (1963) that it could refer to the root of the wool, which is rich in natural grease and lanolin and appropriate for unguents. See also Beck & Beck 1978.

[25] See *wi-ri-za* (note above). Dots under **157* and under 16.

[26] Mentioned together with wool.

[27] It most probably refers to *wi-ri-*[(*KT*[5]).

[28] Dots under **157* and under 16.

Table 4. Quantities of plant material (**123*) which has not been identified, but which is believed to be an aromatic/spice.

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)[1]	TABLET	MYCENAEAN QUANTITIES	MODERN EQUIVALENCES
*123 AROM[2]	(M)	KN Ga(1) 680	AROM 1 + T[	> 105.6 lt.
	(M)	KN Ga(1) 680	AROM 10[	960[lt.
	(M)	KN Ga(1) 680	AROM[	> 96 lt.
	(M)	KN Ga(5) 1536 + 5776	AROM 34[	3,264 lt.
	(M)	KN Ga(1) 677 + 7769	AROM 5	480 lt.
	(M)	KN Ga(2) 422	AROM 1	96 lt.
	(M)	KN Ga(2) 416	AROM 9 + T 2	883.2 lt.
	(M)	KN Ga(2) 419 + 5806[3]	AROM 1	96 lt.
	(M)	KN Ga(2) 423 + 7366[4]	AROM 2	192 lt.
	(M)	KN Ga(1) 675	AROM 10[6]	960 lt.
	(M)	KN Ga(5) 1530 + 1531	AROM 58	5,568 lt.
	(M)	KN Ga(5) 1530 + 1531	AROM 31	2,976 lt.
	(M)	KN Ga(5) 1532	AROM 35	3,360 lt.
	(M)	KN Ga(5) 1533	AROM 12	1,152 lt.
	(M)	KN Ga(5) 1534	AROM 5[7]	480 lt.
	(M)	KN Ga(5) 5780	AROM 30	2,880 lt.
	(M)	KN Ga(5) 5020	AROM 4	384 lt.
	(M)	KN Ga(1) 7365	AROM 20	1,920 lt.
	(M)	PY An 616[5]	AROM 21	2,016 lt.
TOTAL				27,868.8 lt.

[1] See Table 3, note 1.

[2] See Table 15. It has also been identified as a unit of measure by Chadwick, E. Bennett and Geiss (see Sacconi 1971, 21 and note 10), who do often identify **123* with *ki-ta-no*, and *ko-ri-ja-do-no* and more rarely with *ku-pa-ro* (see note under Table 1). As mentioned in this paper, I would prefer to identify it with *ki-ta-no*. It is interesting to note that this substance is a solid and, therefore, calculated in dry measure.

[3] Coriander is also mentioned in this tablet.

[4] *po-ni-ki-jo* is mentioned in the same tablet.

[5] It is mentioned together with the name of a liquid (*me-po*) (*Documents*, 560), cinnamon (?) (*KAPO*), and coriander.

[6] It is [[*KO*]] *pe-ma AROM* 10, so could this be coriander, seed *AROM* 10?

[7] Dot under 5.

Table 5. Quantities of condiments, perfume and dye plants of the Mycenaean period, as seen in the Linear B tablets: *Carthamus tinctorius.*

LINEAR B ka-na-ko (e-ru-ta-ra) (re-u-ka) *128[1]	TYPE OF TRANSACTION (C), (M), (W)[2]	TABLET	MYCENAEAN QUANTITIES	MODERN EQUIVALENCES[3]
e-ru-ta-ra[	-----	MY Ge 602	-----	-----
e-ru-ta-ra	-----	MY Ge 602	-----	-----
ka-na-ko[	-----	MY Ge 602	-----	-----
e-ru-ta-ra	-----	MY Ge 602	-----	-----
ka-na-ko	(W)	MY Ge 602	M[	1[kg.
ka-na-ko	(W)(M)	MY Ge 603 + frr.	M 2 + cup 1[5]	2 kg. + ?
ka-na-ko	(W)(M)	MY Ge 603 + frr.	M 1 + cup 1	1 kg. + ?
e-ru-ta-ra	(W)	MY Ge 603 + frr.	M 1	1 kg.
e-ru-ta-ra	(W)	MY Ge 603 + frr.	M 1	1 kg.
re-u-ka[4]	(M)	MY Ge 603 + frr.	V 1	1.6 lt.
e-ru-ta-ra	(W)	MY Ge 604	M 1	1 kg.
ka-na-ko	(W)	MY Ge 604	M 1	1 kg.
e-ru-ta-ra[	-----	MY Ge 604	-----	-----
e-ru-ta-ra	(W)	MY Ge 604	M 3	3 kg.
ka-na-ko	(W)	MY Ge 605 + 607+	M 2	2 kg.
e-ru-ta-ra	(W)	MY Ge 605 + 607+	M 3	3 kg.
re-u-ka	(M)	MY Ge 605 + 607+	V 1	1.6 lt.
e-ru-ta-ra	-----	MY Ge 605 + 607+	-----	-----
re-u-ka	(M)	MY Ge 605 + 607+	Z 2	0.8 lt.
e-ru-ta-ra	(W)	MY Ge 605 + 607+	M 2 + P 1	2 kg. + 20 gr.
re-u[-ka	-----	MY Ge 605 + 607+	-----	-----
re-u-ka	-----	MY Ge 605 + 607+	-----	-----
e-ru-ta-ra	(W)	MY Ge 606 + fr.	M 3	3 kg.
re-u-ka	(M)	MY Ge 606 + fr.	V 1	1.6 lt.
KANAKO	(W)	MY Ge 608a + frr.+	M 3	3 kg.
<u>TOTAL</u>:				
e-ru-ta-ra	(W)			24.2 kg.
re-u-ka	(M)			5.6 lt.

[1] Most probably referred to red florets, whereas white refers to the seeds of the same plants (*Documents*, 58).
[2] See Table 3, note 1.
[3] The weights are approximate as we do not know the exact equivalences: i.e. L = talent = ±30 kg., M = double mina = ±1 kg., N = ±250 gr., P = ±20.8 gr., Q = 3.4 or less. Chadwick (*Documents*, 57, 394) notes that the unit for dry measure is 96 lt. (instead of 120 lt. which was used before) and T = 9.6 lt.; V = 1.6 lt., Z = 0.4 lt.
[4] Where there is no distinction, is it the red type, which is mentioned?
[5] Ideogram *155^{VAS}*. See Fig. 8.

Table 6. Quantities of condiments, perfume and dye plants of the Mycenaean period, as seen in the Linear B tablets: *Foeniculum vulgare*.[1]

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)[2]	TABLET	MYCENAEAN QUANTITIES	MODERN EQUIVALENCES
ma-ra-]tu-wo	(M)	MY Ge 602	V 1	1.6 lt.
ma-ra-tu-wo	(M)	MY Ge 602	Z 1[ ]	0.4[ ] lt.
ma-ra-tu-wo	(M)	MY Ge 602	V 1	1.6 lt.
MA[3]	(M)	MY Ge 603 + frr.	V 1	1.6 lt.
MA	(M)	MY Ge 603 + frr.	V 1	1.6 lt.
MA	(M)	MY Ge 603 + frr.	V 1[ ]	1.6[ ] lt.
MA	(M)	MY Ge 603 + frr.	Z 2	0.8 lt.
MA	(M)	MY Ge 604	V 1	1.6 lt.
MA	(M)	MY Ge 604	Z 2	0.8 lt.
ma-ra[-tu-wo	-----	MY Ge 605 + 607 +	-----	-----
ma-ra-tu-wo	(M)	MY Ge 606 + fr.	V 1	1.6 lt.
MA	(C)	KN Ga 5672	units 2[5]	***
MA	(C)	KN Ga 7496	units 2	***
MA	(C)	KN Ga 7496	unit 1	***
MA	(C)	KN Ga 953 [+] 955	units 3	***
MA	(C)	KN Ga 953 [+] 955	units 2	***
MA[4]	(C)	KN Ga 953 [+] 955	units 2	***
TOTAL				13.2 lt. + units 12

[1] Most probably identified as *Foeniculum vulgare*, fennel, as I disagree with Erard-Cerceau (1990, 262-263) in classifying fennel as *Pimpinella anisum*, which is another condiment, anise. However, an early mention of aniseed in Greece comes from Vickery (1936, 27, 51) and has been noted as found at Therasia, Thera. Renfrew (1973, 178) states this same reference as well. As the material was never identified by an archaeobotanist, we would need more evidence to consider it as belonging to this genus. This organic material, unfortunately, has not yet been located by the present author and it is not known whether it is lost, misplaced or had been wrongly identified.

[2] See Table 3, note 1.

[3] *ma-ra-tu-wo* abbreviated *MA* (*Documents*, 105).

[4] Dots under *M*, which makes it not terribly secure and it has an extra stroke, which distinguishes *LANA*. Probably it is an error (*CoMIK* I, 397).

[5] We do not know whether this is a liquid or dry transaction, and consequently there is no way of knowing whether 1 unit = 96 litres or 28.8 litres (Chadwick 1976, 104-108; *inter alia* Palmer 1999, 471).

Table 7. Quantities of condiments, perfume and dye plants of the Mycenaean period, as seen in the Linear B tablets: *Coriandrum sativum* (*ko-ri-ja-do-no, KO*).

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)	TABLET	MYCENAEAN QUANTITIES	MODERN EQUIVALENCES
ko-ri-a$_2$-da-na	(M)	PY Un 267	AROM 6	576 lt.
ko	(M)	PY Un 592	AROM 4 T 4	384 lt. + 38.4 lt.
ko-ri-jo-da-na[1]	-----	PY An 616	-----	-----
TOTAL				998.4 lt.
KO AROM	(M)	MY Ge 603 + frr.	AROM T 2	96 + 19.2 lt.
KO	(M)	MY Ge 603 + frr.	T 2	19.2 lt.
KO	(M)	MY Ge 603 + frr.	T 2	19.2 lt.
KO	(M)	MY Ge 603 + frr.	T 2	19.2 lt.
KO	(M)	MY Ge 603 + frr.	T 2	19.2 lt.
KO	(M)	MY Ge 603 + frr.	T 2	19.2 lt.
ko-ri-a$_2$-da-na	(M)	MY Ge 605 + 607 +	T 2	19.2 lt.
ko-ri-a$_2$-da-na	(M)	MY Ge 605 + 607 +	T 2	19.2 lt.
ko-ri-ja-da-na	(M)	MY Ge 605 + 607 +	T 2	19.2 lt.
[ ]na[2]	(M)	MY Ge 605 + 607 +	T 2	19.2 lt.
AROM+KO	(M)	MY Ge 606 + fr.[5]	AROM T 2	19.2 lt.
ko AROM	(M)	MY Ge 608a + frr. +	AROM T[	105.6[lt.
ko AROM[3]	(M)	MY Ge 608a + frr. +	AROM T 1	105.6 lt.
ko AROM[[4]	-----	MY Ue 652 + 656	AROM T[	105.6[lt.
TOTAL				≥ 624 lt.
KO	(M)	KN Ga(2) <34>	T 5	48 lt.
ko-ri-ja-do-no[6]	(M)	KN Ga(2) 415	AROM 1 T 6	96 lt. + 57.6 lt.
	(M)	KN Ga(2) 416	AROM 9 T 2	864 lt. + 19.2 lt.
ko-ri-ja-do-no	(M)	KN Ga(2) 417	AROM 1	96 lt.
ko	(M)	KN Ga(2) 417	V 1[	1.6[lt.
ko-ri-ja-do-no	(M)	KN Ga(2) 418[7]	T 5	48 lt.
ko-ri[-ja-do-no	(M)	KN Ga(2) 419 + 5806	AROM 1[8]	96 lt.
ko-ri-ja-do-no	(M)	KN Ga(2) 419 + 5806	AROM 1	96 lt.

[1] Dots under *-ri-jo-da.*

[2] Melena and Olivier (*TITHEMY*, 61) believe it is likely to be *ko-ri-ja-da-na.*

[3] Dots under *ko. ko AROM* taken as *AROM T* 1 = 105.6 lt. perhaps should be assumed to be the largest quantity for that specific product.

[4] Dots under *ko* and *AROM.*

[5] According to this document, coriander would have been planted near Mycenae (Erard-Cerceau 1990, 258).

[6] Melena (1974b, 140) claims that it refers to coriander but coriander is not mentioned.

[7] Could it be the one Erard-Cerceau (1990) mentions as **KN Ga(1) 518**, for it does not seem to refer to coriander? It could be a misprint.

[8] Melena (1974b, 140) refers to *AROM* 1 for **419**.1 and *AROM* 1 again for **419**.2.

Table 7. (Continued).

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)	TABLET	MYCENAEAN QUANTITIES	MODERN EQUIVALENCES
ko-ri-ja-do-no	(M)	KN Ga(2) 421	T 5	48 lt.
ko-ri-ja-do-no	-----	KN Ga(2) 422	-----	-----
ko-ri-ja-do-no	(M)	KN Ga(2) 423 + 7366	AROM 2[13]	192 lt.
ko-ri-ja-do-no[	-----	KN Ga(2) 673	-----	-----
ko-ri-ja-do-no	(M)	KN Ga(1) 674	AROM 10	960 lt.
[[KO]][9]	(M)	KN Ga(1) 675	AROM 10	960 lt.
ko-ri-ja-do-no	(M)	KN Ga(1) 676	AROM 6	576 lt.
]ni-jo[10]	(M)	KN Ga(1) 677 + 7769	AROM 5	480 lt.
ko-ri-ja[11]	(M)	KN Ga(1) 678 + fr.	AROM 5	480 lt.
]-do[12]	(M)	KN Ga(1) 679	AROM 6	576 lt.
]ja-do	(M)	KN Ga(1) 680	AROM 1	96 lt.
ko-ri-ja-do-no	(M)	KN Ga(1) 685	T 2	19.2 lt.
ko	(M)	KN Ga 738	AROM[	≥ 96 lt.
ko	(M)	KN Ga 953 [+] 955	T 1[	≥ 9.6 lt.
ko-ri[	(M)	KN Ġa 953 [+] 955	T 4	38.4 lt.
[14]	-----	KN Ga 5672	-----	-----
]ja	(M)	KN Ga(1) 7365	AROM 20	1,920 lt.
ko-ri-ja-do-no	(M)	KN Ga(2) 7367 + 7368 +	[[T 6]]	[[57.6]] lt.
KO	(M)	KN Ga 7496	T 2[	19.2 [lt.
KO	(M)	KN Ga 7496	T 4	38.4 lt.
]ko[15]	(C)	KN G 7525	unit 1[16]	96 lt.
]ko	(C)	KN V(2) 7527	units 4	384 lt.
KO	(C)	KN F 7542	units 25	2,400 lt.
KO	(C)	KN Ce 8279	units 130[[17]	12,480 lt.
KO	(C)	KN Ce 8346 + 8644 + 9111	units 80[	7,680 lt.
TOTAL[18]				7,988.8 lt. + units 240 = 23,040 lt.

[9] As it is erased it will be mentioned here but will not be included in total sum.

[10] This is stated as coriander in Melena (1974b, 135).

[11] Dots under *ko* and *ri* (*CoMIK* I, 678).

[12] Probably]*ja-do* where dots under *ja*.

[13] Dots under 2 so maybe wrong numeral but, at least, we know it is more than *AROM* 1.

[14] Melena (1974b, 153-154) claims it refers to coriander but the word is probably understood.

[15] *KT*[5], 216: possibly *KO*.

[16] From the Mycenae tablets we assumed that the largest unit is *AROM T* 1 = 105.6 lt. So the problem here is whether we should calculate the same for Knossos or just the 96 lt. It is not improbable for the major unit at Mycenae to have been different from the major unit at Knossos for that particular product. For example in the Mediterranean world grams and dramia represented slightly different measures.

[17] Dots under 130. According to Melena (1974b, 157) this refers to enormous quantities of coriander in the range of 12,480 litres.

[18] Erard-Cerceau (1990, 259) refers to **KN Ga 7307.1** as referring to coriander but I could not see the term mentioned, or could it have been a typing error instead of **KN Od 7307**. The same goes for **KN Sd 4401 + 8718 +** ***fr.*** (Erard-Cerceau 1990, 263), as *po-ni-ki-jo* is referred to, but again the term for coriander could not be traced.

Table 8. Quantities of condiments, perfume and dye plants of the Mycenaean period, as seen in the Linear B tablets: *Cuminum cyminum L.*

LINEAR B[1]	TYPE OF TRANSACTION (C), (M), (W)	TABLET	MYCENAEAN QUANTITIES	MODERN EQUIVALENCES
ku-mi-no-jo[	-----	MY Ge 602	-----	-----
KU	(M)	MY Ge 603 + frr.	V 2	3.2 lt.
KU	(M)	MY Ge 603 + frr.	V 1	1.6 lt.
KU	(M)	MY Ge 603 + frr.	V 2	3.2 lt.
KU	(M)	MY Ge 603 + frr.	V 1	1.6 lt.
KU	(M)	MY Ge 603 + frr.	V 2	3.2 lt.
KU	(M)	MY Ge 603 + frr.	V 1 Z 2	1.6 lt. + 0.8 lt. = 2.4 lt.
KU	(M)	MY Ge 604	V 1	1.6 lt.
ku-mi-na	(M)	MY Ge 605 + 607 +	V 1	1.6 lt.
ku-mi-no	(M)	MY Ge 605 + 607 +	Z [	-----
ku-mi-no	(M)	MY Ge 605 + 607 +	Z 2	0.8 lt.
ku-mi-no	(M)	MY Ge 605 + 607 +	Z [	-----
KU	(M)	MY Ge 606 + fr.[2]	V 1	1.6 lt.
KU	(C)	MY Ui 709	units 900	***
TOTAL				20.8 lt. + units 900[3]

[1] It is not mentioned as a perfume ingredient, neither in Shelmerdine's (1985) book nor in Foster (1977a) and Wylock (1970). It is, also, mentioned only as a condiment in Hoffner 1974, 103, therefore, I would rather favour the condiment use for those reasons but also for the fact that it is mentioned, in Linear B, together with ingredients which would be rather used as condiment i.e. sesame, mint, fennel and so forth. Many medicinal uses, as referred to it in Egypt (Darby *et al.* 1977).

[2] According to the document, cumin was cultivated in the Argolid (Erard-Cerceau 1990, 258).

[3] This is difficult to interpret as the quantities of that commodity are fairly small which makes us unable to be sure whether its circulation is in dry or liquid measure. On the other hand, if it was in liquid 900 x 28.8 = 25,920 lt. and in dry 900 x 96 lt. = 86,400 lt., both calculations provide unusually high figures.

Table 9. Quantities of condiments, perfume and dye plants of the Mycenaean period, as seen in the Linear B tablets: *Mentha spp*.

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)	TABLET	QUANTITIES
mi-ta	(C)	MY Ge 602	PE 2[2]
mi-ta-qe	(C)	MY Ge 603 + frr.	PE 20[3]
[ka-]ra-to[1]	(C)	MY Ge 605 + 607 +	cup 1[4]
mi-]ta	(C)	MY Ge 605 + 607 +	PE 1[5]
mi-ta	(C)	MY Ge 605 + 607 +	PE 1[6]
mi-ta	(C)	MY Ge 606 + fr.	PE 2[7]
TOTAL			PE 26 + 1 cup (?)

Table 10. Quantities of condiments, perfume and dye plants of the Mycenaean period, as seen in the Linear B tablets: *Sesamum indicum* (?).

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)	TABLET	MYCENAEAN QUANTITIES	MODERN EQUIVALENCES
[[sa-sa-ma]]	-----	MY Ge 602	-----	-----
sa-]sa-ma	(M)	MY Ge 602	V 1	1.6 lt.
sa-sa-ma	(M)	MY Ge 602	Z 2	0.8 lt.
SA	(M)	MY Ge 603 + frr.	Z 2	0.8 lt.
SA	(M)	MY Ge 604	V 1	1.6 lt.
SA	(M)	MY Ge 604	Z 2	0.8 lt.
SA	(M)	MY Ge 604	V 1	1.6 lt.
]sa-sa-ma	(M)	MY Ge 605 + 607 +	Z 2	0.8 lt.
sa-sa[-ma	-----	MY Ge 605 + 607 +	-----	-----
sa-sa-ma	(M)	MY Ge 606 + fr.	V 4	6.4 lt.
TOTAL				14.4 lt.

[1] Probably *ka-ra-ko* (*Documents*, 226, where it is related to pennyroyal, *Mentha pulegium*). I believe we cannot be so precise as to give the species name but we could say that it could refer to the *Mentha spp*.

[2] (*BU*) = bunch. In *TITHEMY*, 59, *PE*. Varias Garcia (1993, 218-219) claimed it had a value of 10 units of mint. Palmer (1999, 477, note 54) refers to it as identified by Killen as an abbreviation for the unit of weight known as the *πέλεκυς* with a value of 10 *mina* or *ca*. 5 kg. Would mint, in this case, be fresh or dried as 10 kg. of dried mint would be fairly bulky. Here I will not try to make calculations, as this issue is still not unanimously accepted.

[3] *mi-ta-qe* 20 = *mi-ta ?qe* 20.

[4] Describes it with **155*^{VAS} which is the one-handled cup.

[5] Also described with *PE* (*Documents*, 227).

[6] Same *PE* as previous.

[7] Quantity in *PE* too.

Table 11. Quantities of condiments, perfume and dye plants of the Mycenaean period, as seen in the Linear B tablets: (?) *Pistacia lentiscus*/(?) *Cymbopogon schoenanthus*.

LINEAR B[1]	TYPE OF TRANSACTION (C), (M), (W)	TABLET	QUANTITIES
ko-no-a-po-te-[.][2]	-----	MY Ge 602	-----
ko-no[3]	(C)	MY Ge 603 + frr.	units 10[5]
ko-no	(C)	MY Ge 603 + frr.	units 10[6]
ko-no	(C)	MY Ge 603 + frr.	units 12[7]
no-ko[4]	(C)	MY Ge 603 + frr.	units 10[8]
ko-no	(C)	MY Ge 603 + frr.	units 10[9]
ko-no	(C)	MY Ge 603 + frr.	DE 1
ko-no	(C)	MY Ge 604	units 2[10]
ko-i-no	(C)	MY Ge 606 + fr.	DE 1
ko-no[11]	-----	KN Ga 953 [+] 955	-----
TOTAL			units 44

Table 12. Quantities of condiments, perfume and dye plants of the Mycenaean period, as seen in the Linear B tablets: (?) *Cinnamon*/(?) *Salvia spp*.

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)	TABLET	MYCENAEAN QUANTITIES	MODERN EQUIVALENCES
KAPO	(C)	PY An 616	KAPO 4	***
KAPO[12]	(M)	PY Un 249	T 6	57.6 lt.
KAPO	(M)(C)	PY Un 267	KAPO 2 T 5	48 lt. + ***
KAPO	(M)(C)	PY Un 592	KAPO 3 T 4	38.4 lt. + ***
KAPO	-----	KN F(2) 841 + 867	-----	-----
TOTAL				144 lt. + ***

[1] Check note 7 under Table 2.
[2] Melena and Olivier (*TITHEMY*, 38) claim that it could be divided as *ko-no a-po-te-ra*.
[3] See Table 2, note 7.
[4] *no-ko* is a misspelling of *ko-no*.
[5] After 10 the word *e-ne-me-na* 1 is mentioned, and according to Chadwick (*Documents*, 543, 226) *e-ne-me-na* describes a form of σχῖνος (see *ko-no*) and it is abbreviated to *E*. Also Melena (1974b, 154) states that it is measured in *MA* units (?).
[6] It is followed by *E* 1.
[7] Same as previous!
[8] Followed by *DE* [ ].
[9] Followed also by *E* 1.
[10] Followed by *DE* 1.
[11] Mentioned three times on the same tablet but with no quantities.
[12] Dots under *KAPO* (**127*) treated as cinnamon (Sacconi 1972). It is found with perfume ingredients (Melena 1974b, 160) and estimated in dry weight (*T*) and unit. Could it refer to the powder form in volume and the sticks (bark) when in unit? See also Palmer (1999, 485) who refers to it as rush or a sort of *Cyperus*.

Table 13. Quantities of condiments, perfume and dye plants of the Mycenaean period, as seen in the Linear B tablets: *po-ni-ki-jo*.

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)	TABLET	QUANTITIES	MODERN EQUIVALENCES
po-ni-ki-jo	(W)	KN Ga(2) 425	M 1	1,000 gr.
po-ni-ki-jo	(W)	KN Ga(2) 426	M 4 N 1	4,000 + 250 gr.
po-ni-ki-jo	(W)	KN Ga(2) 427 + 8102	N[ ]	
po-ni-ki-jo	(W)	KN Ga(2) 427 + 8102	M 8 N[ ]	8,000 gr. + [ ]
po-ni-ki-jo	(W)	KN Ga(2) 427 + 8102	M 1 N 1	1,000 + 250 gr.
]-ni-jo[1]	(M)	KN Ga(1) 677 + 7769	AROM 5	480 lt.
po-ni-ki-jo[	(W)	KN Ga(2) 1335	-----	-----
po-ni-ki-jo	(W)	KN Ga(2) 7425	M 2	2,000 gr.
po-ni-]ki-jo	(W)	KN Ga(2) 7426	M 14[	14,000 gr.
po-]ni-ki-jo	(W)	KN Ga(2) 7429	M[	≥ 1,000 gr.
po-]ni-ki[-jo	-----	KN Ga(2) 8439	-----	-----
po-]ni-ki-[jo	-----	KN X 9735	-----	-----
po-ni-ki-jo	-----	KN Bg 1020	-----	-----
po-ni-ki-jo	-----	KN Bg 1021 + 7428	-----	-----
po-ni-ki-jo[	-----	KN Bg 1040 + frr.	-----	-----
po-ni-ki[-jo	-----	KN Sd 4401 + 8718 + fr.	-----	-----
]po-ni-ki-jo[2]	(W)	KN Bg 5584 + 7427 + fr.	M[	≥ 1,000 gr.
po-]ni-ki-jo[	(W)	KN Bg 834[3]	M 34	34,000 gr.
po-]ni-ki-jo[	-----	KN Bg 8438	-----	-----
po-ni-]ki-jo	-----	KN Bg 9297	-----	-----
po-]ni-ki-jo[	-----	KN Bg 9298 + 9388	-----	-----
po-ni-ki-jo	-----	KN Bg 992 + 8582 + frr.	-----	-----
po-ni-ki-jo	(W)	KN Ga(2) 417	M 5	5,000 gr.
po-ni-ki-jo	(W)	KN Ga(2) 418	M 3	3,000 gr.
po-ni-ki-jo [	-----	KN Ga(2) 420 + fr.	-----	-----
po-ni-ki[-jo[4]	-----	KN Ga(2) 423 + 7366	-----	-----
po-ni-ki-jo[5]	(W)	KN Ga(2) 424	M 5	5,000 gr.
TOTAL				79,500 gr. + 480 lt.

[1] Melena 1976b, 135.

[2] Referring to *po-ni-ki-jo* given to 30 men. Dots under the *po* (*CoMIK*, 330), therefore, interpretation not very secure.

[3] This quantity was given to an unknown number of women. Godart (1970, 387) believes that due to the high number it must be a special document (referred as **KN Og 834**).

[4] Dots under *-ki* (*CoMIK*, 155).

[5] Dot under *-ni* (*CoMIK*, 155).

Table 14. Quantities of condiments, perfume and dye plants of the Mycenaean period, as seen in the Linear B tablets: *Cyperus spp.* (cf. *rotundus* and *C. esculentus*).

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)	TABLET	MYCENAEAN QUANTITIES	MODERN EQUIVALENCES
CYP+O[1]	(M)	MY Fu 711	T 1 [[5]]	9.6 lt. [[48]][2]
CYP+O	(C)	MY Ue 652 + 656	units 7	672 lt.
CYP+KU	(C)	MY Ue 652 + 656	units 5	480 lt.
TOTAL				1,161.6 + [[48]] lt.
CYP+O	(M)(C)	PY Fa 16	units 8 T 2 V 1[[ ]]	768 lt. + 19.2/1.6
CYP+O	(C)	PY Ua 434	units 13	1,248 lt.
CYP+PA	(M)	PY Un 2	V 5	8 lt.
CYP+PA	(M)	PY Un 2	T 1 V 3	9.6 lt. + 4.8 lt.
CYP+O	(M)(C)	PY Un 47	units 3 T 4 V 1	288 + 38.4 +1.6 lt.
ku-pa-ro$_2$[3]	(M)	PY Un 249	AROM[5] 2 T 5	192 lt. + 48 lt.
ku-pa-ro$_2$	(M)	PY Un 267	AROM 6	576 lt.
ku-ro-ro$_2$[4]	(M)	PY An 616	AROM 13 T 5	1,248 lt. + 48 lt.
ku-pa-ro-we	-----	PY Fr 1203	-----	-----
TOTAL				4,499.2 lt.
PYC+O	-----	TH Wu 71	-----	-----
PYC+O[6]	-----	TH Wu 81	-----	-----
CYP+KU	(M)(C)	KN F(1) 157 + fr. [+]	5 T 3	480 lt. + 28.8 lt.
CYP [+?]	(C)	KN F(1) 157 + fr. [+]	unit 1	96 lt.
CYP	(C)	KN Uc 160	unit 1[	96[lt.
CYP+O	(C)	KN F(2) 852 + 8071 + fr.	12[[7]	1,152[lt.
CYP+KU	(M)(C)	KN F(2) 5043 + fr.	2 T 2	192 lt. + 19.2 lt.
PYC+O	-----	KN F(2) 7050 + 7342	-----	-----
CYP+O	(C)	KN F(1) 5079 + 8259	units 6	576 lt.

[1] *CYP/PYC* is believed by Palmer (1999, 470) *inter alia* to be perfume; whereas *CYP+O/PYC+O* to be food.
[2] It is the dry measure.
[3] The use of *ku-pa-ro* or unligatured sign *CYP/PYC* was used to denote *C. rotundus L.* (Palmer 1999, 471).
[4] Probably error for *ku-pa-ro* (*Documents*, 558).
[5] *AROM* 2, where dot under two.
[6] Dots uder *PYC+O*.
[7] Dot under one.

Table 14. (Continued).

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)	TABLET	MYCENAEAN QUANTITIES	MODERN EQUIVALENCES
CYP+O	(C)	KN F(1) 5079 + 8259	units 5	480 lt.
CYP+O	(C)	KN F(1) 5079 + 8259	units 5	480 lt.
ku-pa-ro	(M)***	KN Ga(1) 517	AROM + PYC 1	96 lt. PYC 1
?[8]	(M)***	KN Ga(1) 518	AROM + PYC 10	96 lt. PYC 10
ku-pa-ro	-----	KN Ga(1) 519	-----	-----
ku-pa[-ro	-----	KN Ga(3) 454	-----	-----
PYC	(M)	KN Ga(3) 456	T[	≥ 9.6 lt.
CYP	(C)	KN Ga 461	units 10	960 lt.
PYC	(C)	KN Ga(3) 464	units 15	1,440 lt.
PYC	(C)(M)	KN Ga(3) 464	PYC 26 T 3	PYC 26 + 28.8 lt.
ku-pa-ro	(M)	KN Ga(3) 465	T 1	9.6 lt.
PYC [ ]	(M)	KN E 842	T 2	19.2 lt.
PYC+O	(C)	KN G 7509 + 7879	6[[9]	576[lt.
PYC[	-----	KN Ga(3) 8005	PYC[	PYC[
PYC	(M)	KN Ga 1058 + 5671	T 1	9.6 lt.
PYC+QA	(C)	KN Ga 5088	units 9	864 lt.
]PYC	(M)(C)	KN Ga 7344	PYC 4 T 2	PYC 4 + 19.2 lt.
PYC	(C)	KN Ga 7347	units 2	192 lt.
PYC	(C)	KN Ga 7347	units 3	288 lt.
PYC	(C)	KN Ga 7347	units 6	576 lt.
PYC (?)[10]	(C)	KN G 7352	units]3 T 2[	]288 lt. + 19.2 lt.
PYC+QA	(C)	KN Ga 7358	units 3	288 lt.
TOTAL				9379.2 lt.[11] + PYC 42

[8] *ku-pa-ro* is intended? It is not at all clear. Erard-Cerceau (1990) wrongly perhaps includes it in her list of coriander tablets.

[9] Dot under six.

[10] *PYC* perhaps understood (Palmer 1999, 484).

[11] Melena (1974c, 324) calculates their quantity to 8,688 litres.

Table 15. Quantities of condiments, perfume and dye plants of the Mycenaean period, as seen in the Linear B tablets: *Cistus creticus L.* (?).[1]

LINEAR B ki-ta-no *123[2]	TYPE OF TRANSACTION (C), (M), (W)	TABLET	QUANTITIES	MODERN EQUIVALENCES
AROM[3]	(M)	KN Ga(5) 1530 + 1531	AROM 58	5,568 lt.
[ki-ta]-no	(M)	KN Ga(5) 1530 + 1531	AROM 11 + 1[5]	1,056 + 96 lt.
ki[-ta-no[4]	(M)	KN Ga(5) 1530 + 1531	AROM 10 + 2	960 + 192 lt.
ki[-ta-no	-----	KN Ga(5) 1530 + 1531	-----	-----
AROM	(M)	KN Ga(5) 1530 + 1531	AROM 31	2,976 lt.
ki-ta-no	(M)	KN Ga(5) 1532	AROM 13	1,248 lt.
ki-ta-no	(M)	KN Ga(5) 1532	AROM 11	1,056 lt.
AROM	(M)	KN Ga(5) 1532	AROM 35	3,360 lt.
TOTAL				16.224 lt. + 288 lt.

Table 16. Quantities of condiments, perfume and dye plants of the Mycenaean period, as seen in the Linear B tablets: *Crocus spp.* (probably *C. cartwrightianus* and *C. sativus*).

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)	TABLET	QUANTITIES	MODERN EQUIVALENCES
CROC	(W)	KN Np(1) 85 + 5047 +[6]	QI[7] 6	-----
CROC	(W)	KN Np(1) 267	RO[	-----
CROC	(W)	KN Np(1) 268	RO 1	-----
CROC	-----	KN Np(1) 269	-----[8]	-----
CROC	(W)	KN Np(1) 270	P 2 QI 4	40 gr. + ?
CROC	(W)	KN Np(1) 271	QI 1 RO 1	~ 3 gr.+ ?

[1] Foster (1977a, 33) does not believe we could identify it as a perfume ingredient, because it is nowhere mentioned together with perfumes, and as is mentioned in the text, I believe, it could be ladanum, *Cistus creticus L.* which is an incense, amongst other things.

[2] Sacconi (1971, 29) identifies it as *ki-ta-no*, and see Table 4.

[3] I am leaving the *AROM* in this table, although they have also been included in Table 4, in order to show their connection to tablets where *ki-ta-no* is mentioned.

[4] Dots under *ki*.

[5] Owed 1 and the next are owed 2.

[6] It also includes **7938 + 8057** (*CoMIK*, 44). However, it is possible that crocus is understood in several more tablets of the **KN Np** series but these tablets are not included here.

[7] *QI* and *RO* are weights smaller than 3.4 gr. and will not be mentioned here. The reader can refer to Bennett 1950.

[8] *QI* 1 or *RO* 1 are possible (*CoMIK*, 112).

Table 16. (Continued).

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)	TABLET	QUANTITIES	MODERN EQUIVALENCES
CROC	(W)	KN Np(1) 272 + 7419 + fr.	Q 1	~ 3 gr.***
CROC	(W)	KN Np(1) 273	P 5 [[9]	100 gr.
CROC	(W)	KN Np(1) 274	N 1 P 1	250 + 20 gr.
CROC	-----	KN Np(1) 276	CROC[	-----
CROC	(W)	KN Np(1) 277	QI 4	-----
CROC	(W)	KN Np(1) 278 + 7436 + fr.	P 2	40 gr
CROC	(W)	KN Np(1) 286	N [	≥ 250 gr.
]CROC	(W)	KN Np(1) 5013	P 1	20 gr.
]CROC[	-----	KN Np(1) 7422	CROC [	-----
CROC[	(W)	KN Np(1) 7423 + 7641 [+]	CROC [ ] N2	-----
]CROC[	(W)	KN Np(1) 7424	]CROC[	-----
CROC[	-----	KN Np(1) 7923 + 8461 + fr.	CROC[[10]	-----
CROC[	-----	KN Np(1) 8458	-----	-----
]CROC	(W)	KN Np(1) 8459	P	≥ 20 gr.
]CROC[	(W)	KN Np(1) 9112	]CROC[	-----
CROC	-----	KN Np(2) 1000 + 5004	N[	≥ 250 gr.
]CROC	(W)	KN Np(2) 5002	N 1	250 gr
CROC	-----	KN Np(2) 5721 + 5945 + frr.	CROC N [	> 250 gr.
CROC	(W)	KN Np(2) 5725 + 5886 +	N 1	250 gr.
***	(W)	KN Np(2) 5982 + fr.	N 1	250 gr.
CROC[	-----	KN Np(2) 7417	CROC[	-----
]CROC	(W)	KN Np(2) 7418	N 1	250 gr.
CROC[	-----	KN Np(2) 7420	P[[11]	-----
CROC[	-----	KN Np(2) 7421	-----	-----
***	(W)	KN Np(2) 7439	N 1	250 gr.
]CROC	-----	KN Np(2) 7442 + fr.	-----	-----
]CROC	(W)	KN Np(2) 8249	N [	≥ 250 gr.
CROC	(W)	KN Np(2) 855 + 7434	P 3 P 6[12]	60 + 120 gr.
CROC	(W)	KN Np(2) 856 + 7915 + 7917	N 1	250 gr.
CROC[	-----	KN Np(2) 857	CROC[	-----
CROC[	-----	KN Np(2) 858	CROC[	-----
CROC	(W)	KN Np(2) 859	P 9	180 gr.
CROC	(W)	KN Np(2) 860	P 4	80 gr.
CROC	(W)	KN Np(2) 860	P 2[13]	40 gr.
CROC	(W)	KN Np(2) 861	N 1	250 gr.
CROC[	-----	KN Np(2) 9362 + fr.	-----	-----
CROC[	-----	KN Np(2) 9676	-----	-----
CROC	(W)	KN Np 2138	N[	≥ 250 gr.
ko-ro-ki-no-[	-----	KN X 974 + 5742	-----	-----
TOTAL				3,726 gr. + CROC

[9] Dot under 5 (*CoMIK*, 113).
[10] Dots under *CROC*.
[11] Dot under *P*.
[12] *P* 6 is a due.
[13] Quantity is due.

Table 17. Quantities of the condiment of the Mycenaean period, as seen in Linear B: *Salvia spp.* (sage).[1]

LINEAR B	TYPE OF TRANSACTION (C), (M), (W)	TABLET	MYCENAEAN QUANTITIES	MODERN EQUIVALENCES
pa-ko-we	-----	PY Fr 1200	-----	-----
pa-ko-we	(M)	PY Fr 1202	PA 5 S 1 V 4	28.8/9.6 + 6.4 lt.
OLE+PA	(M)	PY Fr 1205	S 2 V 4	25.6 lt.
OLE+PA	(M)	PY Fr 1206	PA 5 V 4	28.8 + 6.4
pa-ko PA[2]	(M)	PY Fr 1216	PA 1 + V 2	28.8 + 3.2 lt.
pa-ko-we	(M)	PY Fr 1217	V 1	1.6 lt.
pa-ko-we PA[3]	(M)	PY Fr 1220	V 4	6.4 lt.
OLE+PA	(M)	PY Fr 1220	S 1	9.6 lt.
OLE+PA	(M)	PY Fr 1222	V 1	1.6 lt.
pa-ko-we	-----	PY Fr 1223	S 2[4]	19.2 lt.
pa-ko-we	-----	PY Fr 1224	Z 2	0.8 lt.
pa-ko-we PA[5]	(M)	PY Fr 1226	V 3	4.8 lt.
OLE+PA	(M)	PY Fr 1228	V 1	1.6 lt.
OLE+PA	(M)	PY Fr 1229	V 1	1.6 lt.
pa-ko-we PA	(M)	PY Fr 1232	S 1	9.6 lt.
OLE+PA	(M)	PY Fr 1233	V 1	1.6 lt.
pa-ko[-we	-----	PY Fr 1235	PA 1	28.8 lt.
pa-ko-we PA	(M)	PY Fr 1235	V 3	4.8 lt.
OLE+PA	(M)	PY Fr 1236	S 1 V 1	9.6 lt. + 1.6 lt.
pa-ko[-we	-----	PY Fr 1240	-----	-----
]-we PA	(M)	PY Fr 1246	S[	≥ 9.6 lt.
TOTAL				≥ 250.4 lt.

[1] *pa-ko-we* (see list) probably refers to any of the sage species. It is measured in liquid weight (*S*).

[2] *PA* is referred as a shortened form of *pa-ko-we* (Hooker 1994, 248). It is mentioned as *OLE+PA* 1 *V* 2 which, possibly, indicate the quantity of 'saged' oil needed for 1 primary unit of oil. Could it mean that to one primary unit/whole number of 'plain' oil, a quantity of 2 lt. of 'saged' oil was added? It is therefore, probably, not referring to the quantity of sage but to saged oil (after all it is a liquid measure –see *S* measure), which has an unknown quantity of sage macerated in it. It should be remembered that *pa-ko-we* is an adjective, which denotes mixture with sage (Hooker 1994, 121). However, it might give an indication of the quantities in which 'saged' oil was circulated.

[3] *OLE+PA* again *V* 4.

[4] Dot under *S*.

[5] *OLE+PA* again *V* 3.

Table 18. Some[1] plants, which are believed to have been used as condiment, dye and/or perfumery during the Mycenaean period, but which have not been identified, as yet, in the tablets.

PLANT NAME	COMMON NAME	USES
Allium cepa L.	onion - κρόμμυον[3]	condiment
A. sativum	garlic - σκόροδον	condiment, preservative
Anethum graveolens	dill - άνιθο	condiment
Cistus creticus L.[2]	rockrose - αλδανιά/κίστος	perfumery, medicinal/incense, dye[4]
Juniperus spp.	junipers - κεδραία	incense, wood, dye[5]
Papaver somniferum	poppy - μήκων	narcotic, condiment, medicinal
Rubia tinctoria	madder - ερυθρόδανον	dye
Isatis tinctoria	woad - ισάτις η βαφική	dye
Styrax officinalis	storax - στύραξ	incense, condiment
Rhus coriaria	sumach[6] - ρούς	condiment, dye & tanning, perfumery
P. lentiscus var. chia	mastic tree - μαστιχόδεντρο	resin, unguent
Pinus halepensis	aleppo pine - πεύκο	resin, wood
Pinus pinea	pine nuts - κουκουναριά	condiment

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[1] Only some have been chosen here and these are the ones that, it is believed, might have had an economic significance and would, probably, have been mentioned with transacted quantities. Otherwise, the dyes, and condiments used in the Mycenaean period are thought to be innumerable but not all would have been mentioned on the tablets, due to their high availability, and hence their economic insignificance.

[2] See *ki-ta-no*, for discussion as, I believe, it is ladanum.

[3] There is another version, which is *κιδαρό* (**KN E 842**.3 - *ki-da-ro*) (*CoMIK*, 842).

[4] Frangaki (Φραγκάκι 1969, 33) mentions that it has been used for dyeing cotton and produces a cherry colour (*βυσσινί*).

[5] See above under *Juniperus spp.*

[6] It was found in the Ulu Burun wreck (Heldane 1991, 215; Bass 1997, 164), and one of its uses would have been for colouring wax in order to write in the wooden diptychs (books).

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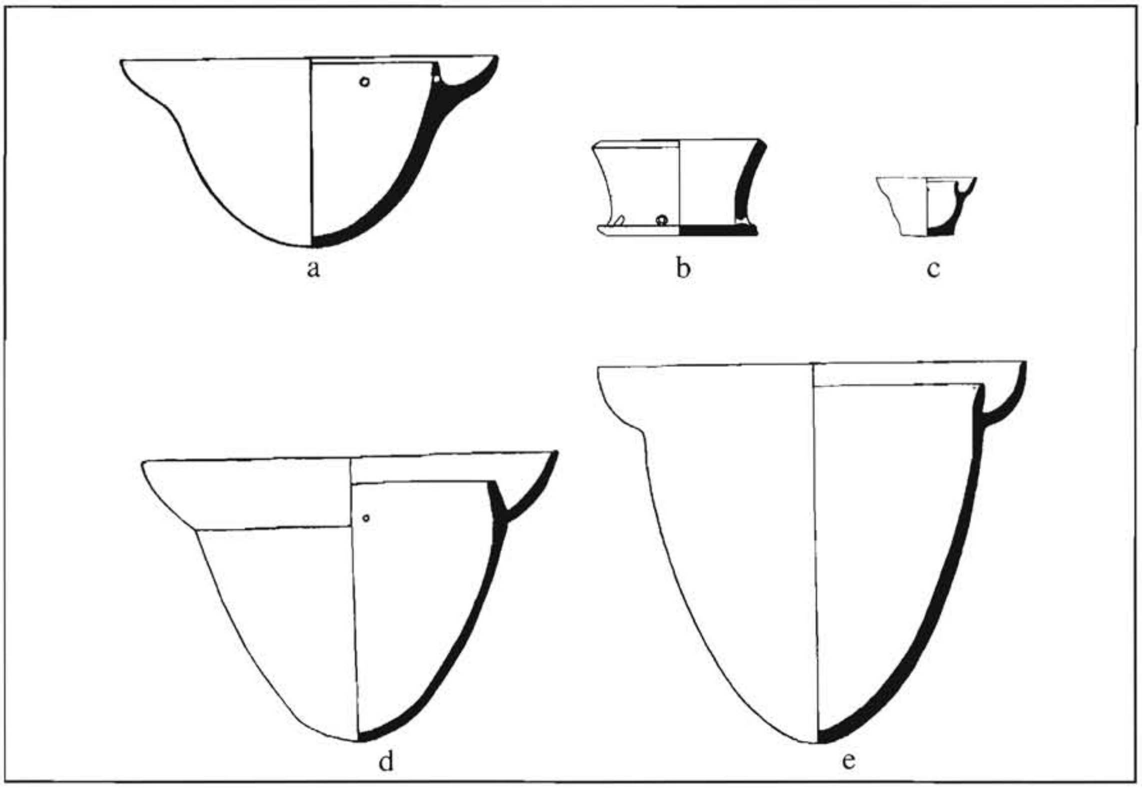

Fig. 1. Clay vessels (distillation apparatuses?) from Tepe Gawra. (a): It is attributed to stratum XI-A, 'Gawran', dated to the 4th millenium BC. (Tobler 1950, fig. 346). (b): It has eight holes disposed around the sides, which are expanded to a plain rim. Found in stratum VI which is dated to the 3rd millenium BC. (Speiser 1935, fig. 203). (c): It is from stratum XI-IX (dated to 4th millennium - beginning to middle). It was found in a grave which probably explains the fact that it is a fraction of the size of the others. (Tobler 1950, fig. 407). (d & e): Although these vessels are encountered in stratum XI-A they become more common later in stratum XI. Probably it is no coincidence that this stratum is distinguished by forthright social stratification (large houses, fortified town). [All drawings are 1:5 in scale].

Fig. 2. Ladanum (resin) from *Cistus creticus* (photo by Manolis Flouris).

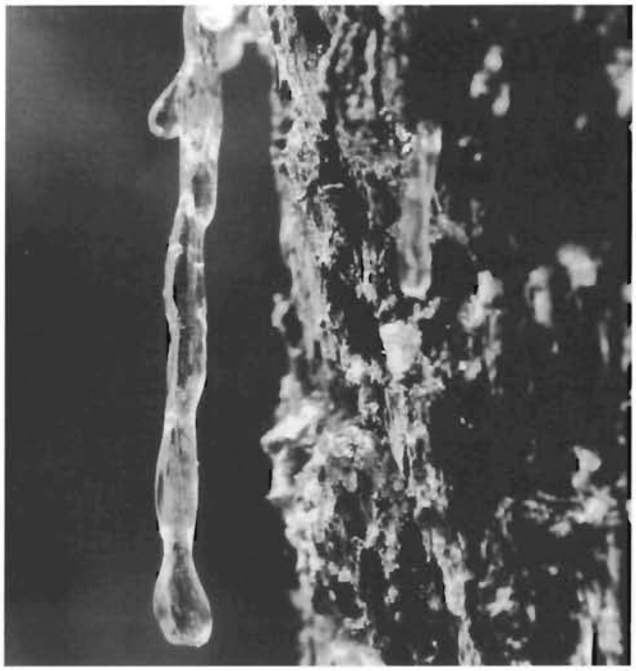

Fig. 3. *Pistacia lentiscus var. chia*: the mastic *gu* (photo from the front cover of Perikos 1993).

Fig. 4. Beads made from resin from the tomb of Tutankhamun (Hepper 1990, 20).

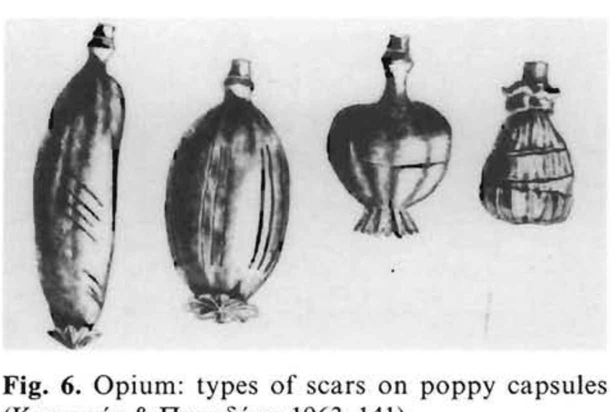

Fig. 6. Opium: types of scars on poppy capsules (Κρητικός & Παπαδάκη 1963, 141).

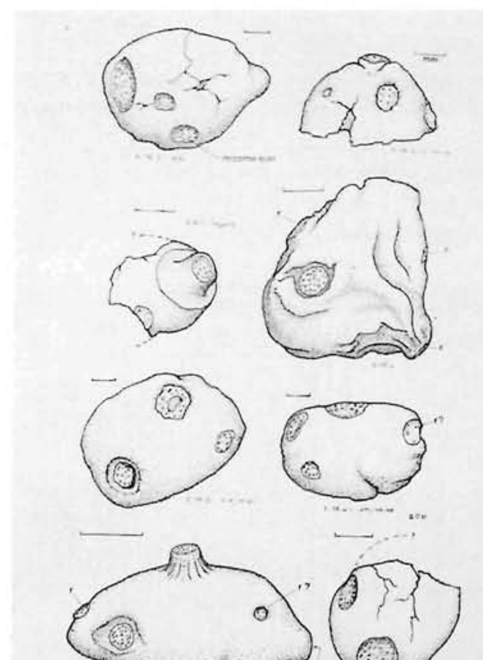

Fig. 5. *Cyperus rotundus* found at Wadi Kubbaniya, Upper Egypt (from Hillman 1989, 212, fig. 13.1).

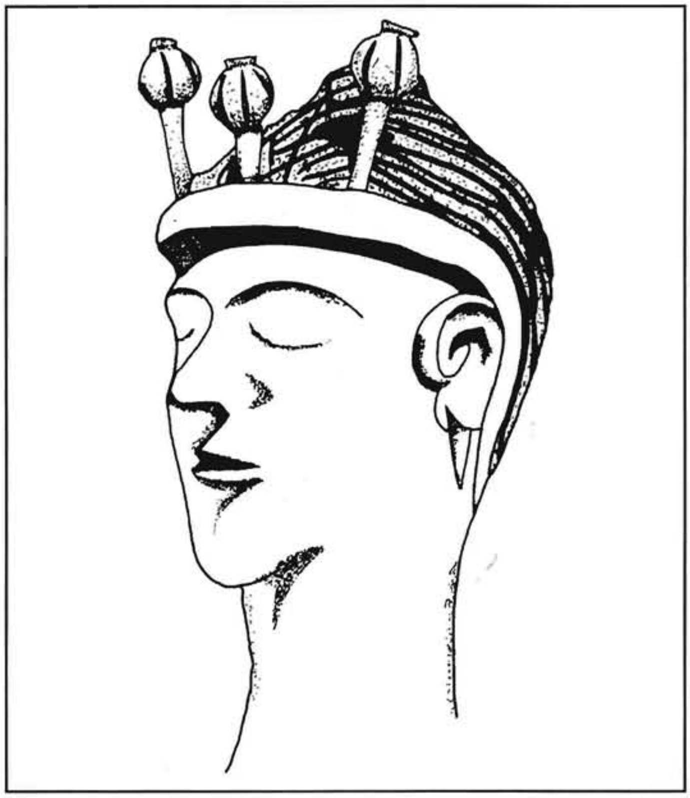

Fig. 7. Profile of the 'Poppy Goddess' from Gazi, Crete (drawing of the head only from Merlin 1984, 241, fig. 86).

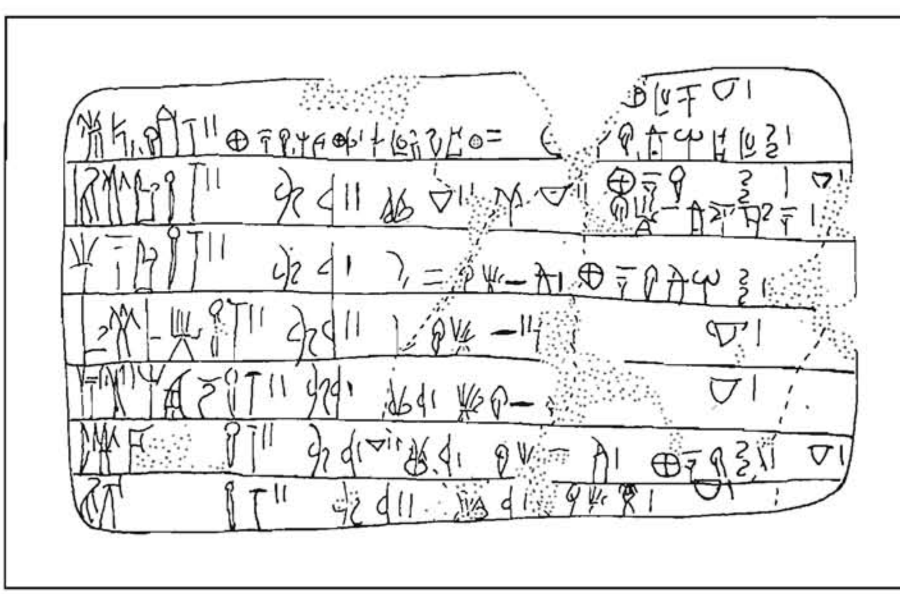

Fig. 8. Tablet **MY Ge 603** where ideogram **155* is portrayed as a measure of accounting (drawing from Sacconi 1974, 50).

Sheep shears, animal bells of various sizes, a leather bag, a leather saddle, and a balance for weighing animal products (ethnographic evidence from Sardinia).

PRODUCING AND RECORDING LEATHER AND OTHER ANIMAL PRODUCTS

Katerina Trantalidou

INTRODUCTION

From the Neolithic Age onwards, all the pre-capitalist societies in the Balkan Peninsula relied on the hard work of their members in order to survive. The main occupations were in sectors mainly associated with agriculture, animal husbandry, fishing[1] and craft industry –rudimentary or more advanced. The primary and secondary products resulting from these activities were circulated and bartered as soon as a surplus existed. The traditional means of production lived on in the Greek countryside even after the penetration of Western Capitalism, for which reason in the following text some Modern Greek data will be used among the various ethnographic parallels, always keeping the necessary distance and bearing in mind the specific gravity and historical circumstances of each culture and period. In the same way we shall draw information from sources of historical times, in order to pinpoint similarities that help us to reconstruct the picture of trade in the prehistoric and protohistoric periods. Organic remains, in contrast to the other archaeological finds, cannot of themselves contribute securely to understanding ideology and social or economic changes. Our working hypotheses demand a blending of all the archaeological data. Let us consider some of the issues that arise.

1. The flocks/herds

Osteological remains and literary testimonies provide considerable information on the internal structure of the flocks/herds (age, sex, place of stay),[2] but are not able to reconstruct their numerical strength.

We shall explain this. The bones found in settlements, regardless of their subsequent use –as fuel, as debris for raising the levels and/or composition of floors, etc.– are as a rule dietary refuse. They reflect some periods in the life of the settlement, but the quantitative relationship between this material and the flocks/herds –numerically– has not been detected to date. So, even though the size of the settlements, the density of habitation,[3] the land holdings and the possible crops, as well as the subsistence needs of the population for agricultural products are issues that have been discussed, the necessary correlation between settlement populations and the archaeological remains of stock-raising has not been made. Perhaps the only case in Greek antiquity for which we have extensive recording of flocks of sheep is on the Linear B tablets from Knossos and Pylos. There are also recordings of the other domesticated animals of direct

[1] Trantalidou 1996, 2000.

[2] Godart 1971, 1990; Melena 1983; Halstead 1988, 1990-91, 1992-93; Palaima 1989, 1992a; Trantalidou 1990; Τζαχίλη 1997, 60.

[3] Dickinson 1982.

economic value[4] (goats, pigs, cattle) in the known series of Linear B tablets as well as in Linear A tablets. The prevailing view is that the tablets preserve inventories of flocks and of individual animals for a short period of time, that which preceded the destruction of the palatial centres.[5] Furthermore, it is estimated that the flocks of sheep controlled by the palace of Knossos amounted to between 80,000 and 100,000 animals, and at Pylos from 30,000 to 40,000. These inventories were essentially intended for the animal products and indeed the control of wool production.[6] There is no need to point out the importance of wool as a raw material for producing textiles and carpets [7] in the economy not only of Mycenaean Greece but also of the entire Mediterranean, not only in antiquity but also in later history. In studies of recent history the circulation of wool to and from a region, its weight in kilos, okas, bales etc., and its value are recorded of necessity.[8] After all, in the modern global economy too, the place of wool in the stock exchange is juxtaposed to gold, crude oil or grain.[9]

In other words, the osteological remains will give us evidence for the orientation of the economy, particularly if the various chronological periods are studied comparatively. They cannot, however, document fully the status of stock-raising or hunting, without the help of literary and other archaeological evidence.[10]

2. The circulation of products

The issue of the circulation of the actual animals and their products can only be approached hypothetically. We do not know for certain the extent to which the palaces controlled even the movements of the flocks/herds.[11] Fortunately the issue in hand here, that is the circulation of

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4 Even though the curtailed presence of the dog in the Linear A tablets is puzzling for some researchers (Godart & Tzedakis 1992, 172), this phenomenon can be clearly explained in my view. The percentage of dog bones among the food residues in settlements is extremely low and of those bearing cut marks is even lower. Consequently the limited presence of the animal in the economy, which in my view –based on the interpretation of the osteological remains– diminishes in the LBA in southern Greece, whereas in Macedonia the tradition of eating dog lived on at least into Hellenistic times (cf. W. Yielding, poster presented at the 8th International Congress of the International Council for Archaeozoology, University of Victoria, Victoria BC, 23-29/08/1998). More importantly, dogs guarded the flocks/herds and were the companions of hunters. On the role of the dog in hunting and as an animal that gives its owner prestige see Hamilakis 1996.

5 Some researchers consider that the tablets correspond to the year before the fall of the palaces, while others that they come from various phases of the LM III period. Shelmerdine 1992, 571-572.

6 Killen 1962, 1963, 1964, 1968, 1969, 1984; Τζαχίλη 1997, 46-68; Young 1965, 1969; Lang 1966; Olivier 1967; Godart 1970; it is interesting that the last researcher determines the number of sheep that produced wool, the quantity of wool and the potential number of textiles that could have been woven from it. Olivier 1972, 1988; Spyropoulos 1970 (for the discovery of the palace archive at Thebes, with tablets recording wool); *Documents*, 195-213; Godart 1977; Melena 1987; Halstead 1990-91; 1992-93, 60-61; Ruijgh 1992; Shelmerdine 1992; Tournavitou 1995a, 257-262.

7 Tzachili in the present volume. Carpet-making is attested both in Egypt and the Mycenaean centres (e.g. Thebes and Knossos). We cite indicatively tablets **TH Of 35** and **KN Le 641** + *frr.*, on which are recorded the quantities of wool required and the existence of specialist female workers (Ruipérez & Melena 1996, 255). Carpets were woven from sheep wool and goat hair, as is attested for the villages of Pelion in the 18th century (Τσοποτός 1977, 173) or Smyrna during the 19th century (Τρακάκης 1994, 120).

8 *Foreign Office, Consular and Diplomatic Reports, Annual Series*; Lefeuvre-Méaulle 1916; Beaujour (VIII) 1974, 190-192; Αναστασόπουλος 1947, year 1884; Τσοκόπουλος 1984, 184-191; Quataert 1993, 51-160.

9 Contemporary newspapers of economic content.

10 The opposite is often the case. See note 4.

11 Frequently the interpretative consideration of such movements is based on ethnographic parallels. E.g., one of the hermeneutic models adopted in the past for Epirus, supposed that the hunter-gatherers of the Palaeolithic followed routes corresponding to those of the Sarakatsani, a view that was later abandoned. On the subject see Kourtessi-Philippakis 1983. On transhumance in Crete see Melena 1987, 407.

primary and secondary animal products (Table 1) is easier to approach, even though most of the products have not survived, on account of the physical and chemical erosion by the soil in Greece. Only ground that is very dry (Egypt, Nubia) or highly saturated (Northwest Europe, Northwest America) has preserved archaeological treasures of organic, perishable materials. In Greece, with few exceptions (such as the piece of red-dyed leather in a tomb in the area of Kazarma in the Peloponnese)[12] or the silk dress of a Byzantine noblewoman from Holy Wisdom at Mystras,[13] also in the Peloponnese, only a part of the craft-industrial products that were manufactured from perishable animal material, and indeed bone, tooth or horn, has survived. Frequently these products-archaeological remains bear witness to transactional processes when they are compared with the geographical environment of their find spot; for example, the presence of *Cervus elaphus* antlers in the Cyclades during the Late Bronze Age is linked with the transport of these from the Greek Mainland, since the environment of the Cycladic islands cannot support large game animals.[14] It is obvious that the transport of animal materials followed the same routes as other products.

Last, there is no doubt that before each commodity was circulated, in processed or unprocessed form –cf. wool or hide– it had to be counted, either by weight or volume.[15] This is a basic precondition of any transaction, on however small a scale. Moreover, according to one viewpoint,[16] the intentional monitoring of more and more merchandise and exchanging it at the most correct value possible, led to the invention of script.

RAW MATERIALS AND CRAFT INDUSTRIAL USE OF ANIMAL PRODUCTS

1. Bones

Bones make up the skeletal system of the vertebrates. Concurrently they are used for the storage of salts of trace elements such as calcium and phosphorus. The structure and 'architecture' of bones corresponds to their function, that is they are able to withstand bending and pressure while at the same time displaying flexibility so that fractures are avoided. These properties of bones, as well as the deposition of salts, which ensure their strength and resistance, contributed to the manifold exploitation of bones after the animal's death.

Bone objects (Fig. 6, 7), dating from the Palaeolithic Age to the present day, are displayed in the cases of archaeological and ethnological museums all over the world.[17] These are tools for everyday use in farming (cattle horns as reinforcements on pitchforks), collecting plants or removing the bark from tree trunks (chisels), animal husbandry (combs for carding sheep wool

[12] Πρωτονοταρίου-Δεϊλάκη 1969, 4.
[13] Μπακούρου 2001.
[14] Trantalidou 2000. Relations with Anatolia cannot be ruled out.
[15] Ventris & Chadwick 1956; Duhoux 1976; Petruso 1986; Μιχαηλίδου 1990.
[16] Goods and determining quantities: Godart 1977; Reade 1996.
[17] They are countless and appear in all cultures and periods from 30,000 BP onwards, when the bone tool industry begins. Indicatively: musical instruments, jewellery and toys, «*φυσητῆρας ὀστέϊνους*» (Herodotus IV.2.17); the bone flute of the Classical period, no. 3768 in the National Archaeological Museum, Athens, *Δημοκρατία και κλασική παιδεία*; «*Φλογέρες κοκαλένιες ἀπ' ἀητοκόκκαλο*» (i.e. bone flutes), Χρηστοβασίλης 1987, 44; similar objects of bone and horn core (Africa, Syria, Israel etc.) in Musée de l'Homme, Paris: Dournon 1993, fig. 2; necklace of pelican bones, from Panama, San Blas Islands: inv. no. 1924.46.28 in the Pitt Rivers Museum, Oxford; similar objects in Musée de l'Homme, Paris; sleigh on donkey metapodia, in the Nerantzi Aïvazi mansion, Kastoria (personal observations).

or horse mane), fishing (hooks, net weights), hunting (arrowheads), craft industrial production (processing hides using buffers of cattle ribs), book-binding (smoothers), basketry and sewing (from needles to sewing boxes), weaving (loom weights, spindle whorls). But everyday objects such as toys (of sheep 'knuckle-bones' to the metatarsals of ungulates for ice-skates), musical instruments (Neolithic flute from Dispilio, Kastoria), small cooking utensils (knife handles), dress accessories (pins, buttons), jewellery and cosmetic items, furniture –either completely of bone or with bone as part of other composite objects.[18] With respect to the material of interest for this essay, in Greece bone tools used for cleaning fat from animal skins have been found, as well as awls for piercing holes in the hides. These come from sites such as the Neolithic settlement at Prodromos, Karditsa, the Hagios Georgios cave at Kalythies, Rhodes, the Skoteini cave at Tharrounia, Euboea.[19]

Experimental archaeology permits the reconstruction of all stages in the process of making of a bone tool. That is, selecting the bone, preparing the section that will be used (removing the marrow if present, dipping in water to remove blood and to facilitate removal of the periosteum, cutting into several pieces), dipping it again in hot water, to remove the fat and to increase pliability.[20] There is no clear evidence of trade in products of the bone tool industry. We assume that they would have been counted in order to assure the success of each transaction. However, there must also have been cases where bones as a raw material were weighed. Recorded in the exports from the prefecture of Magnesia in Thessaly, for the year 1900, is a quantity of 1,236 cwt. of bones, destined for other regions of Greece and abroad.[21] The most probable explanation is that they were to be used as fuel.

2. Horn (bone and keratin sheath)

On some mammals, particularly hoofed ones (cattle, sheep, goat), the main horns are bone formations covered by an epidermal formation, a keratin sheath. Only rarely does the outside coating survive the erosive conditions in the ground. However, objects of this kind abound in museums with ethnographic collections. In the hollow horn the bone formation never bifurcates, except on one species of antelope. As a rule both sexes bear horns that are never shed, with the exception of the said species of antelope, which does not live in Greece.[22]

[18] Hodges 1964, 153-155; Stordeur 1979; 1980 (objects-Europe); Poplin 1980; Johnson 1985 (bone technology); Camps-Fabrer 1974, 1979, 1982; Driver 1984; Stewart 1996; *Δημοκρατία και κλασική παιδεία*, 76-77; also Delporte 1981 and Kozlowski 1992 (summary presentation of Palaeolithic works of art in bone and tooth). Visits to archaeological and ethnographic museums all over the world convince us that many objects were used in the same way by many social groups, diachronically and independent of each other: e.g. pierced 'knuckle bones' in the Corycian Cave (Central Greece), in settlements (Markiani, Amorgos, EBA) and graves in ancient Greece (Trantalidou & Kavoura, in press), 'knuckle bones' pierced horizontally to be used as jewellery in Africa (from the area named Basatoland, 1910), Pitt Rivers Museum etc.; van Neer 1994.

[19] Μουνδρέα-Αγραφιώτη 1980; Stratouli & Sampson 1987; Στρατούλη 1993.

[20] van Neer 1994.

[21] *Diplomatic and Consular Reports, no. 2557, Trade and Agriculture of the Province of Thessaly, for the Year 1900*, London 1901, 14. N.B.cwt. = quintal: 220½ lb. *avoir du pois*.

[22] *«τῶν δὲ κεράτων τὰ μὲν πλεῖστα κοῖλα ἐστὶν ἀπὸ τῆς προσφύσεως περὶ τὸ ἐντὸς ἐκπεφυκὸς ἐκ τῆς κεφαλῆς ὀστοῦν, ἐπ᾽ ἄκρου δ᾽ ἔχει τὸ στερεόν, καὶ ἔστιν ἁπλᾶ· τὰ δὲ τῶν ἐλάφων μόνα δι᾽ ὅλου στερεὰ καὶ πολυσχιδῆ»* ('Most horns are hollow from the point where they are attached to the bone which projects inside them from the head, but at their tip there is a solid piece. Their structure is simple. The stag is the only animal whose horns are solid throughout and branching') (Aristotle, *Historia Animalium*, 517a.22-517b; 500a).

The keratin sheath is suitable for diverse uses, such as musical instrument, beaker, spoon, etc.[23] In addition, the horn was used for carrying liquids and as a measure of volume. It is said, for example, that the horn of the Libyan wild goat held as much water as a large kylix, that is up to three measures of weight.[24]

In contrast to the animals mentioned, deer do not have a keratin sheath on their antlers and the bone formations are solid and branched. Only the males have antlers, except on reindeer where they grow on females too. Antlers are shed annually and replaced by new ones.[25]

Antler was used for making various objects, such as combs, jewellery boxes, toothpicks and many others.[26] 'The knife-makers and other such craftsmen made handles for these tools'.[27] 'The deer antlers ... were used in Medicine, as a sweetening powder for the blood, and cooling[28] as a styptic for diarrhoea, beneficial to the heart in the infectious paroxysms and easing women in childbirth'.[29] According to the modern[30] as well as the old tradition of hunters, 'burning deer antler wards off snakes'.[31]

Aristotle gives information on details of working the material; if horns from young cattle are warmed with wax they can be bent easily in any direction;[32] this is confirmed by later authors.[33]

The use of the bony part of the horn is similar to that of bones. In terms of technology, laboratory analyses have shown that horn is more resilient to vertical and transversal pressures than bone. In most cases horn, like bones, was worked in parts of the settlement with no workshop facilities, since no specific material and technical infrastructure is required. A special working area has rarely been identified, either because the excavation has not proceeded horizontally or because the osteological remains have not been collected according to position and to levels, or because there has been no study of the density of the material and the kind of waste, or last, because in antiquity there was essentially no differentiation of remains either, in the sense that technological remains and food debris coexisted in the same deposits. Among the exceptions we note House G in the Lower Town at Asine (Late Bronze Age), where the concentration of horns indicates that the specific space was used simultaneously for storage and for tool-making.[34]

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[23] MacGregor 1985; Hahn 1980; Ambrosiani 1981; Hardwick 1981 (mentions 99 different objects made from a whole or part of a horn). Cf. horn objects in the Pigorini Ethnographic Museum, Rome; the University of British Columbia Museum of Anthropology, Vancouver, Canada; the Hungarian Agricultural Museum, Budapest; the Museum für Völkerkunde, Vienna; the Ethnological Museum, Amman, Jordan; the Musée de l'Homme in Paris: Dournon 1993, fig. 2; other local museums.

[24] Aelian, *De Natura Animalium*, XIV.16 (horn for measuring liquids).

[25] The antlers of male deer are shed between February and March, and can thus be collected before they begin to rot and without hunting the animal.

[26] *Ἑρμῆς ὁ Κερδῶος*, 289. The encyclopaedia refers to the use of both the bone and the horn sheath. See also Bartosiewicz 1998.

[27] *Ἑρμῆς ὁ Κερδῶος*, 172.

[28] *Ἑρμῆς ὁ Κερδῶος*, 289.

[29] *Ἑρμῆς ὁ Κερδῶος*, 172. The views on the therapeutic properties of deer antler are also encountered in ancient Greek literature. It seems however that they enjoyed a wider diffusion. Junmin Nam Has, archaeologist and post-graduate student at the University of Athens, confirmed that comparable medicaments are still used in Korea today (personal communication).

[30] Ζέρβας 1947, 46.

[31] «*Τὸ τοῦ ἐλάφου κέρας θυμιώμενον ὅτι τοὺς ὄφεις διώκει δῆλον ἐστίν*». Aelian, *De Natura Animalium*, XX.

[32] «*Τὰ δὲ κέρατα τῶν νέων* (i.e. *βοῶν*) *χλιαινόμενα τῷ κηρῷ ἄγεται ῥαδίως ὅπου ἄν τις ἐθέλῃ*» (Aristotle, *Historia Animalium*, 595b.13).

[33] *Ἑρμῆς ὁ Κερδῶος*, 289.

[34] Moberg-Nilsson 1997.

Explicit literary and archaeological testimonies as well as later information exist, on the trade of horns: horns of wild cattle were circulated to the Greeks from the Paeonian and the Crestonaean country,[35] cattle horns from India reached Egypt in the Hellenistic period (indeed one horn 'had the capacity of three amphoras')[36] and were brought from Istanbul to the Aegean coast in the early nineteenth century.[37]

In the Linear B tablets wild goat (ibex) horns are counted in units. The tablets of the **Mc** series –18 in all– were found in the Armoury at Knossos and were badly damaged. Twelve of them give a number of 585 horns, for which it is unclear whether the tablets are the record of an excellent quota or an actual delivery.[38] It is thought that a selection was made of the horns whose length and curvature was appropriate to their use as bows[39] or as raw material for inlays in chariot-making.[40]

3. Other keratinous formations

These are: a) Hooves, present only on hoofed mammals. b) Keratinous plaques, the squamae incrusted on the bony plaques of reptiles. c) Keratinous sheaths, such as the jaws of tortoises, beak of birds etc. All the above epidermal keratinous formations had the same domestic industrial use (jewellery, furniture inlays, fuel etc.) as the sheath of hollow horns of mammals, because they can be bent and split, in contrast to bone, which breaks easily.[41]

4. Testudo or carapace

The testudo (*χέλυο/χέλειον*)[42] consists of wide bone plaques covered externally by the keratinous laminated formations (squamae) (Fig. 8) noted above. This carapace was suitable for the sound-box of the *barbiton* and the lyre. It was also used for making more recent musical instruments[43] as well as in 'various implements such as a compass, a powder-case (that is for

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35 «*...καὶ βόες ἄγριοι, τῶν τὰ κέρεα ὑπερμεγεγάθεά ἐστι τὰ ἐς Ἕλληνας φοιτέοντα*» ('...and wild oxen, whose horns are those very long ones which are brought into Hellas') (Herodotus, VII.126).

36 «*Πτολεμαίῳ τῷ δευτέρῳ φασὶν ἐξ Ἰνδῶν κέρας ἐκομίσθη, καὶ τρεῖς ἀμφορέας ἐχώρησεν. Οἷος ἄρα ὁ βοῦς ἦν ὡς ἐκπεφυκέναι οἱ τηλικοῦτον κέρας*» ('They say that a horn was brought from the Indies to Ptolemy II, and it held three amphorae') (Aelian, *De Natura Animalium*, III.34).

37 'In Istanbul many (horns) are worked and with all this there is a surplus to sell on the coasts of Europe too' (*Ἑρμῆς ὁ Κερδῷος*, 289). During the 19th century those horns from Gallipoli not used for making handles locally were exported to Marseilles (Βακαλόπουλος 1980, 132).

38 Ventris & Chadwick 1956, 51, 119, 301-303, 396; *Documents*, 552-553; Chadwick 1976, 130-132; Baumbach 1986, with later bibliography.

39 '... polished bow of the horn of a wild ibex', *Iliad*, IV 105. Evans also maintained that horns were used for making bows (Evans 1935, 833). Ventris & Chadwick 1956, 302. Dr A. Lebessi, Ephor of Antiquities, posits similar hypotheses for the subsequent use of horns dedicated in the sanctuary of Hermes and Aphrodite at Syme Viannou in Crete, during the Minoan and Hellenic periods (personal communication).

40 *Documents*, 456; Ruipérez & Melena 1996, 253-254.

41 «*ὄνυχές τε καὶ ὁπλαὶ καὶ χηλαὶ καὶ κέρατα, καὶ ἔτι παρὰ ταῦτα ῥύγχος, οἷον ἔχουσιν οἱ ὄρνιθες... Ταῦτα μὲν γὰρ καὶ καμπτὰ καὶ σχιστά, ὀστοῦν δ' οὐδὲν καμπτὸν οὐδὲ σχιστόν, ἀλλὰ θραυστόν*» (Aristotle, *Historia Animalium*, 517a; for scales 505a.24). All these have multiple uses, e.g. today ostrich talons are exported from ostrich farms in Greece to Japan.

42 Hesychius: «*Χελεύς*». Pliny, *Historia Naturalis*, VI.173; IX.38 '*chelium testudinum*'.

43 *Baglamas* with tortoise-shell soundbox, *achelonia* (*ἀχελωνιά* - sheep bells), Φάκλαρης 1982, 232-233, pl. 81a-b. In the Museum of Folk Musical Instruments in Athens research is being conducted on the making of musical instruments used from the seventh to the fourth century BC. The craftsman G. Polyzos has made a *barbiton* and a lyre. Newspaper *TO BHMA* 08-09-1996, 22.

gunpowder) and other such objects, made by skilled craftsmen who embellish them with gold and silver fitments'.[44]

Our knowledge of the primitive lyre, apart from the numerous references in literary tradition, has been enriched by finds from excavations,[45] which are associated either with the patron deity of music or with musicians. Although specialist craftsmen, lyre-makers (*λυροποιοί*), existed, the possibility that the musicians themselves made the stringed instruments they played cannot be ruled out. Of the constructional details it should be noted that in those cases where the sound-box was made of material other then tortoise shell, this was frequently decorated either in imitation of the scales of the carapace or with inlaid ivory leaves.[46]

It is clear from the above that the structure and morphology of the osseous tissues of the axial and lateral skeleton also determine what kind of artefact will be made from the specific tissue.[47] This is a similar situation to the use of teeth as the substrate for tools or jewellery, which are very many and, like other animal products, were used by all social groups and in all cultures.

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[44] *Ἑρμῆς ὁ Κερδῷος*, 345-346. There is also mention of their use for combs (*Ἑρμῆς ὁ Κερδῷος*, 123). The use of the keratinous formations of the tortoise shell for inlays in furniture (e.g. beds) is attested from Byzantine times (Κουκουλές 1948, 70).

[45] Archaeological finds: 1. Late Archaic lyre sound-box, in the Argos Archaeological Museum. 2. Carapace from the Late Archaic (early 5th c. BC) deposits in the Arcadian sanctuary of Apollo Epicurius at Bassae, in the National Archaeological Museum, Athens. 3. Carapace from a Classical cemetery (2nd half of 5th century BC), in the Arta Archaeological Museum. 4. Carapace from the small Archaic sanctuary of Apollo in Corfu. 5. Carapace from Attica, in the British Museum. 6. Carapace from the Lucifero cemetery at Epizephyrian Locri, in the Rhegium Archaeological Museum. The inventory numbers and detailed descriptions of the archaeological finds are given in the article by Faklaris (Φάκλαρης 1982). 7. Testudo, lyre soundbox from the area of Daphni, exhibited in the Piraeus Archaeological Museum; it was found in the 'poet's tomb', so called because the dead was accompanied by other tools of his art. I am grateful to my colleague Mrs N. Axioti, Director of the Piraeus Museum, for guiding me in the museum. The testudo is described in *Δημοκρατία και κλασική παιδεία*, 77. The lyre is frequently depicted in vase-painting and sculpture. I cite indicatively the following representations: 1. Apollo running and holding a lyre, 480-470 BC (Attic white kylix, Delphi Museum, no. 8140: *Δημοκρατία και κλασική παιδεία*, fig. 41). 2. Linos teaching Iphikles to play the lyre, 470 BC (red-figure skyphos, Schwerin, Staatliches Museum, no. 708: Κακριδής *et al.* 1986, fig. 6-7). 3. Herakles slaying Linos, 470-460 BC (red-figure kylix, Munich, Staatliche Antikensammlungen, no. 2646: Κακριδής *et al.* 1986, fig. 8). 4. Herakles slaying Linos, 480 BC (red-figure stamnos, Boston, Museum of Fine Arts, no. 66206: Κακριδής *et al.* 1986, 3, fig. 91). 5. Ariadne and Dionysos, 400 BC (interior of a red-figure kylix, London, British Museum, no. E 129: Κακριδής *et al.* 1986, fig. 149). 6. Mousaios, Terpsichore and Melousa, 440 BC (red-figure amphora, London, British Museum, no. E 271: Κακριδής *et al.* 1986, 3, fig. 160). 7. Schoolroom scenes, 485-480 BC (Attic red-figure kylix, Berlin, Antikenmuseum, Staatliche Museen Preussischer Kulturbesitz, no. F 2293: Τιβέριος 1996, fig. 132). 8. Music lesson, 510 BC (Attic red-figure hydria, Munich, Staatliche Antikensammlungen, no. 5H 2421 WAF: Κακριδής *et al.* 1986, fig. 101). 9. Female flute-player and komast, 520-510 BC (Attic black-figure plate, Basle Antikenmuseum und Sammlung Ludwig, no. Ka 421: Κακριδής *et al.* 1986, fig. 55). 10. Youths, 455-440 BC (inside a kylix, Göttingen, Archäologisches Institut, no. J31: Καββαδίας 1999, no. 37, fig. 47). 11. Youths, 460-455 BC (inside a kylix, Lyon, Musée des Beaux Arts, no. 482473: Κακριδής *et al.* 1986, no. 42, fig. 50-51). Ethnological finds from Africa in Pitt Rivers Museum.

[46] «*λύραι ἐλεφάντιναι*» ('ivory lyres') (*IG* I^2, 276, 15). Φάκλαρης 1982. He describes in detail the way in which the lyre was made.

[47] For the structure and composition of bone, horn, antler and ivory see Hodges 1964, 153-155. All the materials are worked with stone or metal tools, while ivory, being harder, is also worked with a drill. The author is also aware of modern examples. There are extensive discussions on the nomenclature and usage of the above materials in the ancient world of both West and East, as well as in the Middle Ages, with examination of many different artefacts, from carved antlers to chess pieces, in Poplin 1999, 2000a; Goret & Poplin 1998.

5. Teeth

Teeth are formations of the *χόριον* or *cutis vera* of the skin, analogous with the scales of fish. The incisors and canines of mammals (wolf, fox, bear, bovine, deer, horse, boar, hippopotamus, walrus) have been used in jewellery and tool making from the Upper Palaeolithic period to the present day. The size (the lower canines of the hippopotamus and the boar can reach 90 and 30 cm. in length respectively) and the quality of the tooth are taken into consideration for the object to be made. The weight of the raw material depends on the age and sex of the animal. The tusks of the male elephant weigh 30-45 kilos each, and of the female about 10 kilos.

In the selection and working of elephant ivory (Fig. 12) 'good is the heavy and thick, without or with few cracks, which if deep render this bone useless. Many things are made from it, combs, toothpicks, ear-picks, embellishments for wooden objects and various others'. Hippopotamus teeth, which 'are large, very white and solid', are suitable for making 'combs and such like, because they do not warp'.[48]

In Mycenaean times the majority of objects of tooth, whether by itself or inlaid in another material, were made of boar tusks[49] (e.g. the helmets clad with split tusks –normally of a male), hippopotamus canines and incisors,[50] and elephant incisors.

Research has shown that before the creation of the palatial centres in Crete, glyptics in ivory used hippopotamus teeth exclusively as raw material. This fact is not surprising. The exploitation of the teeth of this mammal was already known in Neolithic Egypt. The majority of ivory objects from the Chalcolithic and Early Bronze Age in the region of the Dead Sea and Palestine were made of this material, which is encountered even as far afield as Cappadocia in the twentieth to eighteenth centuries BC.[51] The ivory objects of the Protopalatial period in Crete are sporadic, but

[48] *Ερμῆς ὁ Κερδῷος*, 173-174, 230. In the Byzantine Age the use of elephant ivory as inlay is mentioned in tables, chairs and footstools (Κουκουλές 1948, 77-81), exactly as in Mycenaean times. Ethnographic descriptions fill out the picture of ivory working given by the literary testimonies and experimental archaeology for bone or horn. The Inuit (Eskimo) soak the bones or teeth 'in urine to soften them and they may be wetted with urine as the work progresses... Axes or adzes are used to rough out large bone objects but for all detailed work, and for ivory carving, the knife is the principal tool with its 80 or 100 millimetre blade, sometimes carved, set in a wooden or horn handle which tapers to a point. Chisels, sometimes made of beaver tooth, are used and pieces are finished with antler polishers, cut with notches so that angles can be smoothed. Bow drills are used for piercing holes and for some engraving work'. Pearce 1985, 14.

[49] According to Krzyskowska (1983), 10% of the material designated as ivory, from the Early and Middle Bronze Age in Crete, is of boar tusk. From the Late Bronze Age, when the examples proliferate, we cite the boar's tusk helmet from the Armenoi cemetery, in the Rethymnon Museum (LM IIIA-B, 1420-1200 BC). For a summary of boar's tusk helmets see Buchholz & Karageorghis 1973, 107. Similar objects are housed in the archaeological museums of Nauplion, the Athenian Agora, Herakleion, the National Archaeological Museum, Athens etc., personal observations as well as of Åkerström 1987; Δημακοπούλου 1988; Tournavitou 1992; Ιακωβίδης 1994; Stampolidis *et al.* 1998.

[50] Krzyskowska (1990) describes the morphological differences in the structure of ivory from the tusks of both the west Asian and the African elephant, of boar tusks as well as the upper and lower incisors of the hippopotamus. By comparing, on the basis of the above, the raw material of various objects (seals, rhyta, figurines) found in Crete and the Peloponnese –she gives a catalogue– and in conjunction with literary and iconographic testimonies, she investigates the circulation of ivory and of finished products. See also Krzyskowska 1984, 1988, 1992. The differences in the structure and morphology of the teeth/tusks are also analysed in the article by Penniman 1952.

[51] Krzyskowska 1983; Poursat 1997; Warren 1995, 1, where Crete and Egypt (raw material and final products) are correlated for the first time. Prepalatial objects of ivory include seals, figurines, amulets and small pommels. They are frequently recovered from burial dated to EM II - MM IA. Issues of morphology, provenance, circulation of final products in ivory in the Near East, are examined in the

the burgeoning of trade during the Late Bronze Age contributed to the proliferation of such objects in the whole of the Creto-Mycenaean world.

Certainly several will have been imported. However, the variety of the final products[52] –over 18,000 fragments were collected from just two houses outside the walls at Mycenae–, the presence of virtually intact tusks (three incisors were found at Zakros), the unworked pieces of ivory and waste from working (in the LM IB Royal Road at Knossos, at Palaikastro, Archanes, Nichoria, in the lower town at Pylos, at Tiryns, at numerous spots in Mycenae, at Thebes and in the Cyclades)[53] the wall-painting in the tomb of Rekhmire (New Kingdom) at Egyptian Thebes, where the Keftiu offer the Egyptians, among other gifts, tusks[54] –possibly of Asian provenance–,

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articles by Caubet & Poplin 1987, 1992; Cachet 1995; Caubet 1991, 1996. These also provide the relevant bibliography. It should also be noted that until the end of Antiquity the habitat of the hippopotamus was not confined to the Nile valley but extended along the swampy coasts of the Eastern Mediterranean, of Phoenicia and Palestine. The use of hippopotamus teeth as raw material is reflected indirectly during the period 2686-2181 BC in the tombs painted with scenes of a hippopotamus hunt, such as the Tomb of Ti at Saqqara (2465-2325 BC). Wilkinson 1992, 71; Shaw & Nicholson 1995, 129.

[52] In the excavations of just one house at Mycenae (House of Shields) the 9,000 objects are representative of ivory production in the LH IIIA-B period. They include inlays (strips, triangles, discs, rosettes, lilies, ivy leaves, nautili, whorl shells, dolphins, warrior heads, helmets, cusps/double axes, flame motifs), free-standing objects etc. Tournavitou 1992. Other types of objects that have been found in various Mycenaean centres are, indicatively: musical instruments (eight-stringed ivory harp: LH IIIA-B, in the tholos tomb at Menidi, Attica, Athens National Archaeological Museum inv. no. 1972); sculptures and inlays (ivory female statuette: LH II/LH III, in the Argive Heraion, chamber tomb 51 at Prosymna, Athens, Nat. Mus.; ivory sculpted group: LH/LH III, in the Archaic temple at Mycenae, Athens, Nat. Mus. inv. no. 7711; male head: LH IIIB, Nauplion, no. 15022; head of a helmeted warrior: LM IIIA-B, Apokoronos, Chania, no. K29; figure-eight shield: LH IIIB, citadel of Mycenae, Athens, Nat. Mus. inv. no. 1027); vessels (ivory pyxis lid: LH I/LH II, Mycenae, Athens, Nat. Mus.); tools (distaff with spindle whorl: LH IIIC, Perati in Attica, Athens, Nat. Mus. inv. no. 9027; needle: LH IIIB, citadel of Mycenae, Athens, Nat. Mus. inv. no. 4232; spoon: LH IIIB, citadel of Mycenae, Athens, Nat. Mus. inv. no. 2589); jewellery and cosmetic items (comb: LH IIIB, citadel of Mycenae, Athens, Nat. Mus.); pins: LH IIIB, citadel of Mycenae, Athens, Nat. Mus. inv. no. 2590). Persson 1942; Kantor 1960; Buchholz & Karageorghis 1973, 105-107; Poursat 1977; Chavane 1980; Dimakopoulou & Konsola 1981, 19-27; Δημακοπούλου 1988; Pini 1988. I express my warm thanks to colleagues Dr V. Aravantinos and Mrs E. Kountouri (M.A.) for guiding me round the excavation material from Thebes, now being conserved (ivory plaques, ivory pyxides, Linear B tablets and minor objects). For the use of elephant tusk as a musical instrument in Africa: Dournon 1993, fig. 2.

[53] van Effentere 1983; Branigan 1983; Xenaki-Sakellariou 1985; Melena 1987, 392-393, 416; Evely 1992; Krzyskowska 1992; Tournavitou 1992, 1995a. Blázquez (1972), by analysing stylistically works in ivory from Cyprus (throne revetted inside, from tomb 79 at Salamis; casket with relief representation, from Enkomi; colonnettes), Crete (pyxis with scene of capturing a wild bull, from Katsambas; acrobat, from the Palace of Malia), Attica (colonnettes, from Menidi, Spata), the Peloponnese (mirror handle, from the 'Clytemnestra Tholos Tomb', Mycenae; comb, from Routsi, Pylos) or Syria and comparing them with works sculpted in other materials (stone, bronze, gold), pinpoints the provenance, the workshops and the reciprocal influences in the above works, which are cited summarily and indicatively. Kantor (1960) deals with a corresponding issue, while Cox (1989) attempts a synthesis of the archaeological data and Linear B in his thesis.

[54] Krzyskowska 1990, fig. 5. Wace (*BSA* 50, 1955), in a footnote to the article by Taylor (1955, 250, note 2) observes that since there were no elephants in Egypt, it is most likely that the Mycenaeans imported elephant ivory from Syria. The issue keeps recurring (Hayward 1990) and the Ulu Burun shipwreck, in which there was also a tusk fragment, has rekindled discussion. The old view has not been refuted, but the possibility of the import of elephant ivory from the coast of Libya remains an open question (Krzyskowska 1988, 226-228; Warren 1995, 6).

as well as the textual evidence according to which the word *a-no-po* describes the unworked elephant ivory (**PY Va 482**) and the word *pi-ri-je-te* the ivory-cutter (recorded at Pylos and Knossos), leave no doubt on the working *in situ* of this exceptionally valuable raw material and of the considerable dimensions of the ivory trade during the Late Bronze Age. The Creto-Mycenaeans created an art with its own distinctive character in an imported material. For the needs of trade, tusks transported whole were counted but not presented in pairs.[55] The objects made of ivory were also counted. However, when the raw material was cut up and ready for working, then this was weighed, as emerges from texts from Ur (Third Dynasty) and tablets from Knossos.[56] It is noteworthy that in historical times (Archaic to Hellenistic period), according to the ancient authors, the sources of supply of elephant ivory were primarily North Africa[57] and secondarily Asia.[58]

6. Feathers

The feathers and the beak, the scales and the claws on the feet comprise the exoskeleton of birds and are keratinous derivatives of the skin. Feathers were used as secondary accessories in dress, defensive or offensive weaponry as well as other items for everyday use (fish hook with feather, feather fan etc.).[59] As a rule they are used singly or linked together, without any processing.

7. Shells

The shell that plays a protective role in many invertebrates is secreted from their body mantle and remains after the animal's death. Its composition differs according to the species of mollusc and is usually calcareous. The use of shells in jewellery and adornment, either singly or sewn onto garments, weaponry, musical instruments or decorative compositions on furniture and elsewhere, is well known from the diverse archaeological and ethnological data as well as from Linear B, cf. '*to-pe-za ... ko-ki-re-ja*' (table decorated with shells) in tablet **PY Ta 715**.[60]

Among the shells in the Mediterranean region, that of the mollusc *murex* seems to have been the most important economically because it was used as a dye: the shell was broken and the mollusc boiled over a low fire for a long time.[61] The hypothesis of the economical value is

[55] «*ἐλέφαντος ὀδόντας μεγάλους εἴκοσι*» ('twenty great elephants' tusks') (Herodotus, III.97). Melena 1987, 392-393.

[56] Melena 1987; Hiller 1992, 304-306.

[57] Pseudo-Skylax, 112; Hermippus ap Athenaeus, I.27; Philostratus, *Vita Apollonii*, IV. 2. Herodotus, II.178, III.937.

[58] Pausanias, V.12.3 (India). On the issue of trade as a whole in Classical times see Gill 1992.

[59] Ventris & Chadwick (1956, 377) consider that sometimes horns or feathers were added to the boars' tusk helmets. See also Blázquez 1972, 412-415. Wilkinson (1922, 103) mentions the use of feathers, particularly of ostrich wings, in the dress or on the heads of Egyptians for ritual purposes.

[60] The use of molluscs by 'early societies' as a raw material for covering dietary, cosmetic, ideological-ceremonial needs and as an object of trading transactions is discussed concisely in Biggs 1973. A synopsis of the Greek data up until the 1980s is given in Karali 1980. The subject of adornment in the Neolithic Age is the subject of a recent thesis by Kyparissi-Apostolika (Κυπαρίσση-Αποστολίκα 1998). For the technological viewpoint see indicatively Taborin 1972 (*Cardium* shells) and Tsuneki 1989. The latter is particularly interesting for the working of *Spondylus* in Greece. N.B. the use of triton shells in the whole world as a trumpet (Dournon 1993, fig. 2).

[61] The process of preparation (Aristotle, *Historia Animalium*, 546b, 574a. Pliny, *Historia Naturalis*, IX.133-135) is described by Faure 1991. Recently D. Ruscillo presented new experiments in making royal purple and biblical blue from murex species which she collected herself in Crete (10th Annual Malcolm Wiener Lecture, ASCA, 2-10-2001).

confirmed by the importance attached to the colour purple as such, by the existence of distinct professional groups (guilds) of purple-dyers mentioned in the ancient and Byzantine sources, and by the archaeological finds.[62]

It is deduced from the archaeological data that shells were counted. The use of the molluscs in trade is affirmed. More specifically for porphyra (*murex*), however, the passage in Aristotle[63] that examines the kinds and properties of the specific ostracoderm, cites that some of the large shells are as heavy as one mina, that is 436.6 gr., an observation which, in my opinion, should be associated with the special economic significance of this particular mollusc.

8. Hide[64]

Animal skins were the first processed animal material used by man to cover his needs for clothing, footwear and protective covering in general. Indeed, and as ethnological evidence indicates, it seems that in the Magdalenian period care was taken to preserve skins, possibly by drying them in the sun or the shade in an open area, with no particular infrastructure, and then perhaps smoking and softening the hide so that it became more pliable.[65] The earliest leather

[62] Those who prepared the basic dye were called *konchyliarioi* (*Codex Theodosianus*, XVI.10, XX.2, 5; Κουκουλές 1948, 180-181). Indeed there was a special group of fishermen, the *κογχυλευταί* or *πορφυρεῖς* (Pollux, *Onomasticon*, I.96, VII.137. Justinianus, *Codex*, XI.8) or *kotylarioi* (Dion. Chrysostom, VII.2); Hesychius: «*κημός· πλεκτὸν ἀγγεῖον ἐν ᾧ λαμβάνουσι τὰς πορφύρας, ἔστιν δ' ὅμοιον ἠθμῷ καὶ ἐν αὐτῷ τὸ δέλεαρ*». It seems from the archaeological remains that there was an increase in the use of purple in Late Antiquity, or at least then the control of fishing, processing and circulating the said mollusc were institutionalized. It is noteworthy that during the excavation of the balaneum located under present Amalias avenue in Athens, beside the road to the Mesogaia and the bed of the Eridanos river, dozens of murex shells were discovered. These were rubbish in antiquity. In the course of the excavations they were found under the floor of the thermae of Late Imperial times. However, because these were not collected (rescue excavations for the Athens Metro, 1993) it is not possible to speak with certainty about the existence of a purple-dye workshop near the other craft-industrial installations, such as the foundries. The hypothesis is mine and it has some value because I was the excavator of this sector. However, the question remains open because there was no statistical approach to the fragments and intact shells, which were in the majority. In the Minoan period it seems that there were purple-dye workshops at Itanos, Malia, Poros/Knossos, Stavromenos/Allaria, Kythera, Delos and elsewhere (Faure 1991).

[63] Aristotle, *Historia Animalium*, 546b.23, 574a.

[64] See also the preceding pages for the epidermal and chorial formations of the skin. Aristotle describes the skin of animals, its keratinous derivatives, its texture and characteristics (*Historia Animalium*, 485a.7, 493a.28, 502a.14, 503a.10, 511b.7, 517b.3, 10-13; 27; 519b.27; 521b.8; 524b.8; 532b.3; 578a.8; etc.), as do many manuals, such as Salzman 1923, 245-257 (leather-working and the cottage industries of Medieval England); Hodges 1964, 148-152 (he presents briefly the steps in working skins/hides: scudding, fleshing, sweating, liming, dressing, smoking, oil dressing, tawing, tanning, plumping, cutting, sewing); Reed 1973 (he describes the most important kinds of skins, i.e. cattle hides, calfskins, sheepskins, goatskins, the properties of each, the methods of working them; he gives many archaeological examples mainly from Britain, Egypt and the Dead Sea, and presents the ways of distinguishing the raw material from already processed skins); Waterer 1968 (with the phrase 'leather was man's first manufacture', the scholar gives a historical review of the methods of working, a glossary and a description of many final products); Forbes 1964 and 1966 (in addition to describing the skin, he cites numerous archaeological data from prehistoric Europe, Europe under Roman rule, Egypt, Mesopotamia and elsewhere, as well as literary sources, both for the final products and the working of the skin). The rich bibliography in English on leather and its technology is due to the production and preservation of many leather objects in Northwest Europe. During the Middle Ages in Britain leather working was the second most important craft industry after the wool industry. For the processing of leather in the Greek bibliography, see Ζαφειράτος 1989; Ζαρκιά 1997, 5.

[65] It is suspected that skin garments are depicted in the rock-carvings of the Epipalaeolithic (7th millennium BC) in the caves of Els Secans, Téruel and Cueva del Garros in Spain. The garment of a

finds are from Egypt and date to the Neolithic Age (Tasian and Badarian cultures). In tombs of this period the dead were buried wrapped or dressed in goat or gazelle hide.[66]

PROCESSING.[67] In the Aegean and the Southeast Mediterranean in general tanning as a means of processing hide began quite early, as evident from the Homeric texts[68] and the

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Mesolithic ivory statuette from Siberia is interpreted as 'fur skin' (Waterer 1956, fig. 106; 1968, 67-69; Forbes 1966, 12; Camps 1982, 239). The imprints observed on a human skeleton at Soungir in Russia are considered to be from fur trousers. Various attempts have been made to reproduce the cleaning, dressing and tawing of skins up to the sewing of them (cf. D.F.-F. Huguier *–restitution d'après les indications du F. Poplin–* in *Travail et société au Paléolithique*, Documentation photographique no. 6037, 22). Observations among Native American populations show that there are no fixed installations and these processes, from drying to stretching, take place in the open air (Irwin 1994, 143, 265; Noël 1997, 33, 38). Their tool kit includes scrapers, blades, knives, scarpins, combs –for removing hair– awls and needles –those of bone appear about 15,000 BC– for sewing the hides (for the process see Waterer 1956, 147-149; Forbes 1966, 12-13). For the use of the scraper for cleaning skins see Γραμμένος *et al.* 1994, 103. The corresponding ethnographic parallels for tawing (Zululand, North American Indians) attest the use of plants, animal fat (tallow), oil (castor, seal) and bone marrow. Eskimo women used to chew the skin until it was pliable (Waterer 1956, 147-149; Forbes 1966, 9-12, 67). This was also deduced from examination of the dentition of a human skeleton from the Middle Palaeolithic period, found at Apidima in the Peloponnese (Λυγκώνη & Παπαγρηγοράκης 1995).

[66] Forbes 1966, 22. The gazelle was game hunted *par excellence* in the Mesolithic and the Early Neolithic.

[67] The stages in working skins/hides (*δέρμα*): preserving (*συντήρηση*), drying (*ξήρανση*) and salting (*αλάτισμα*), tawing (*μαλάκωμα*), splitting (*σκίσιμο*), scudding (*αφαίρεση υπολειμμάτων της σάρκας και του υποδορίου ιστού*), washing (*πλύσιμο*), currying (*αποτρίχωμα*), liming (*ασβέστωμα*), shaving (*ξύρισμα*), deliming (*απασβέστωμα*), dressing with tallow and oils (*δέψη, μετάδεψη*) or inorganic substances, tanning, are presented by Ζαρκιά 1997, 6-33. Information on the traditional methods used in tanning, the tools, buildings, workforce are described in: Φαλτάιτς 1928, 24-28; Σταλίδης 1974, 84-85; Μαμαλούκας 1978; Ζέρβης 1979; Παππάς 1979; Τραυλός & Κόκκου 1980, 152; Γουργιώτη 1985, 411-417 (tanners are mentioned in Larisa in the early Ottoman period and possibly in Byzantine times); Τσοτορός 1986, 109; Καρδάσης 1987, 163; Σιφναίου 1996, 144, 39-46; Τρακάκης 1994, 225-228; Καλινδέρης 1958, 27, 43-58, 84-86; there is detailed reference to the 15 guilds existing in Kozani in the late Ottoman period, the composition and customs of each. The guild of furriers appears in a document of 1768 and numbers 20 persons. In parallel, always according to the archival material, there were 13 tanneries in the town in 1826, at least 19 in 1876, while in 1912 Kozani had 28 workshops, large and small, each with a maximum workforce of 40. Leather was also worked by shoemakers (*υποδηματοποιοί*), whose guild existed from 1768, saddlers (*σαμαράδες*) (for the outside of the saddle they took prepared leather), thong-makers (*λωροτόμοι-σαράτσηδες*), who made the reins, the bridles and other horse-trappings. In the years 1907-1908 there were over 80 shoemakers' and cobblers' workshops in Kozani, comprising four guilds depending on the type of leather/footwear produced, and some 27-30 saddlers. The above data are not only indicative of an average provincial town in West Macedonia (the picture for Siatista, Servia, Monastiri is analogous) or Epirus (in the early 20th century, when tanning was on the wane, there were still 17 workshops in Ioannina: Φαλτάιτς 1928, 25), but also of a region in which stock-raising and the large areas of oak trees and holm oak yielded the essential products for processing skins/hides. Indeed, perhaps the discovery of large quantities of vegetal remains (such as the large quantity of acorns in the prehistoric settlement at Sitagroi) should not be associated exclusively with fodder for animals or food for humans in times of poor grain harvest, and their possible use in processing skins/hides should be examined too. A vivid picture of the buildings, work and way of life of tanners in recent times is given by D. Chatzis (Χατζής 1983) in his short story *Sioulas the Tanner* (*Σιούλας ο ταμπάκος*). In the open-air Museum of Water Power at Dimitsana, there is an exhibit on pre-industrial tanning, presenting the procedure of working the fine skins with vegetable tanning materials, the workplaces, the restoration of the old tools and equipment of a traditional tannery (*ταμπάκικο*) as well as a film of all the old techniques (Ζαρκιά 1997, 15; personal observation). In 1928, 105 tanneries, 8 leather-goods workshops and 8 shoe-making factories were recorded (Ministry of National Economy, *Κατάλογος των κυριοτέρων εργοστασίων της Ελλάδος*, Athens 1928).

[68] *Iliad*, XVII 389-395; Here tallow is used for dressing. There are descriptions in the ancient Greek texts on washing pelts/animal skins (Aristophanes, *Plutus*, 166), placing the skins on benches in order to

Egyptian inscriptions. In Egypt, indeed, vegetable tanning and a combination of two methods existed (oil dressing, alum and oil dressing).[69]

The wall-paintings in Egyptian tombs illustrate various stages in the tanning process (soaking of hides or pelts - dressing a panther skin in a jar - stretching - slicking a skin - scaling over a horse - cutting leather with a half-moon knife) as well as the making of final products in leather (sandals, shields, tyres for wheels, chariot bodies, quivers),[70] products which are known in general from Linear B tablets too.

Secondary hide products[71] include: I. Garments and accessories of dress of all types[72] (tunics, breeches/leggings, greaves, jerkins, belts, gloves and skins)[73] etc.

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remove the hairs and flesh (scudding) (Aristophanes, *Knights*, 369), the process of tanning included soaking in a salt solution as a preservative, stretching the hides and oil-dressing to soften them and increase their durability (Lucian, *Anarcharsis*, 24). Last, there is information on the boiling of skins with vegetable substances, such as the *ῥοῦ τὸν βυρσοδεψικόν* (Theophrastus, *Historia Plantarum*, 3.18.5); Forbes 1966, 48-53; Χατζηδημητρίου 1997. There are descriptions by several foreign travellers to Greece, such as Olivier (mission in 1792), Sibthrorp (1794), Beaujour (1787-1797), in Σιμόπουλος 1973, 569-617 and in *Ἑρμῆς ὁ Κερδῶος*, 124-127 etc.

69 Waterer 1956 147; Lucas 1948; Forbes 1966, 8.

70 Wall-paintings in the tombs of Rekhmire and Hupe at Thebes, cf. also a model of a tannery (Salzman 1923, fig. 2,1; Waterer 1956, fig. III; Forbes 1966, 31, fig. 2, 9).

71 'Hides (the term applies to the skins of the larger animals such as cattle, horse, buffalo) and skins (the term, used for those of the smaller animals such as calf, pig, goat, sheep and also reptiles and birds)': Waterer 1968, 17.

72 In Greek: *χιτών, ἀναξυρίς, κνημίς, δέρρις, ζώνη, γάντια, δορά*. It is noted that the *κυνή* was a leather cap. The *πῖλος* was also of leather but also of other materials. Last, boxers covered their head with leather (Flacelière 1995, 203-204). The majority of finds from antiquity come from Egypt. These include remains of a garment with trace of sewing, a belt made of leather thongs (2nd millennium BC) at Balabish (Waterer 1956, fig. 118, 123) and leather loincloths which are displayed in the Ashmolean Museum, Oxford (inv. no. 1882. 15, New Kingdom) and the Museum of Fine Arts, Boston; the latter is of gazelle skin (New Kingdom, dated between 1570 and 1293 BC). Noteworthy among the iconographic evidence are the depiction of the gloves of an official from a Tel el-Amarna tomb (*ca.* 1370 BC), the leather loincloths of a Nubian mercenary (tomb of Tjanuny, Thebes, *ca.* 1570-1293 BC) or other Egyptian artisans (tomb of Rekhmire). For this type of garment see Hall 1986, 25-26 and 33-37; Forbes 1966, 32. In the representations in Greek vase-painting and sculpture, leather garments are worn by the Amazons in Oriental dress, that is leggings (*ἀναξυρίδες*) and eastern-style belt (cf. red-figure kylix with the duel between Achilles and Penthesileia, 460 BC, Munich, Staatliche Antikensammlungen, inv. no. 2688: Κακριδής *et al.* 1986, 3, fig. 95; red-figure amphora with Theseus abducting Antiope, *ca.* 500-490 BC, Paris, Musée du Louvre, inv. no. G 197: Κακριδής *et al.* 1986, 3, fig. 61). The Phrygians and Scyths (cf. Attic red-figure plate with Scythian archer, 520-510 BC, London, British Museum, inv. no. E 135: Τιβέριος 1996, fig. 91; red-figure hydria with the Judgement of Paris, 400-390 BC, Karlsruhe, Badisches Landesmuseum, inv. no. B 36: Κακριδής *et al.* 1986, 5, fig. 9). Waterer (1956, 167-178) presents iconographic evidence (e.g. peasants wearing gloves for agricultural tasks in the Luttrell Psalter, 14th century) and archaeological finds from Roman, Medieval and Modern Europe.

73 The animal skin/pelt was worn as an everyday garment (e.g. the herdsmen in the miniature frieze from Room 5 of the West House at Akrotiri, Thera wear a fleece; Ντούμας 1992) or by persons of different hypostasis –'in god'. In the tomb of Sennudjem at Deir el-Medina (*ca.* 1293-1185) a youth offering libations –therefore in ritual activity– wears a leopard skin (Hall 1986; Forbes 1966, 31; Robins 1996, 108). On the Hagia Triada sarcophagus, where preparations for a sacrifice and offerings to the gods are depicted, the female figures wear fleeces (Ventris & Chadwick 1956, 281). We recall that Herakles is always represented with the lion skin. Artemis (Τιβέριος 1996, fig. 133-139) is frequently shown with a fawn skin (cf. red-figure krater, *ca.* 470 BC, Boston, Museum of Fine Arts: Τιβέριος 1996, fig. 138-139; white lekythos, *ca.* 490 BC, St Petersburg, Hermitage, inv. no. 670: Κακριδής *et al.* 1986, fig. 68; red-figure amphora, late 6th century, London, British Museum, inv. no. E 256: Κακριδής *et al.* 1986, 2, fig. 61; red-figure psykter with Artemis, Apollo and Leto, *ca.* 480 BC, Munich, Staatliche Antiken-

II. Footwear (sandals, shoes, boots, buskins) (Fig. 1, 2).[74] The house of Simon, who from the archaeological remains was evidently a shoemaker working between 450 and 410 BC, was excavated in the ancient Agora at Athens.[75]

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sammlungen, SH 2417 WAF: Τιβέριος 1996, fig. 140). Hermes sometimes wears an animal skin (*δορά*) (kalpe by the Agrigento Painter, Boston, Museum of Fine Arts), the Maenads wear a *παρδαλή* or panther skin (cf. kylix, 490-485 BC, Munich, Staatliche Antikensammlungen, inv. no. Z 645: Boardman 1975, 218), as do the Satyrs in the thiasos of Dionysos (cf. red-figure krater, 400-390 BC, Naples, Museo Nationale Archeologico, inv. no. 2045: Κακριδής *et al.* 1986, 2, fig. 108) and the Centaurs (cup by the Foundry Painter, Philadelphia, University Museum: Kurtz 1989, pl. 59).

[74] The inhabitants of the Aegean wore moccasins of soft leather with thongs tied high on the calf (cf. winged sandal, LH IIIB chamber tomb, Voula, Attica, National Archaeological Museum, Athens 8557). The footwear of people from the Aegean is illustrated in Egyptian wall-paintings (Vercoutter 1956, 289-303). Footwear from Crete (?) was also exported to parts of Mesopotamia (cuneiform texts at Mari, palace of King Zimri-Lim: Cline & Cline 1991, 53). The Egyptians depicted in the wall-paintings do not wear shoes unless they are members of the aristocracy. Information on footwear in Egypt, the Middle East and Mesopotamia can be found in books and articles: Waterer 1956, 167; 1962, 72-76; Salaman 1986, 18; Vercoutter 1956, 289-303; Forbes 1966, 18-41; Bravo & Trupke 1970, 100-110; Valbelle 1985; 'Des cordoniers au travail', in *Villes et campagnes de l'Égypte ancienne*. Documentation photgraphique no. 6080, 25 (La Documentation française 1985); Parkinson 1991, 89-90. Egyptian footwear has been preserved in the tombs and examples are displayed in most of the Egyptian collections all over the world (cf. British Museum; Ashmolean Museum leather sandal 1888, 808).

[75] Among the movable archaeological finds from this particular building were a kylix inscribed with the name of Simon on the base, bone eyelet rings for the laces and the iron hobnails used for boots. There is a boot-shaped rhyton of Roman imperial times, with all these features, in the British Museum (Thompson 1960). Much information on shoemakers' workshops during the fifth and fourth centuries BC (tools, materials, basin of water for softening the leather etc.) is recorded on vases: a black-figure amphora in Boston, Fine Arts Museum, a black-figure pelike from Rhodes –Eucharides Painter– in Oxford, Ashmolean Museum, and a red-figure kylix from Attica, in London, British Museum (Waterer 1956, fig. 130-131; Thompson 1960, 239; Boardman 1978, 229). The names of footwear in antiquity are related directly to the material, shape, use and provenance. The forms are known from the rich iconographic and sculptural sources (Fig 1, 2) (cf. boots worn by those engaged in hunting or farming activities: statue of Artemis of imperial times, from Sicyon: Papachatzis 1978, fig. 142; Meleagros and Atalante on an Apulian amphora, *ca.* 330 BC, Bari, Museo Nationale: Κακριδής *et al.* 1986, 3, fig. 84; Perseus wears *πτερόεντα πέδιλα* (winged sandals) and a *κυνέη* (helmet), on a white-ground krater, *ca.* 440-435 BC in Agrigento, Museo Civico: Κακριδής *et al.* 1986, fig. 89; the three figures on the Eleusis relief wear sandals, *ca.* 440-430 BC, Athens, National Archaeological Museum: Κακριδής *et al.* 1986, 2, fig. 52). Types of footwear during the period of Roman rule in the West are presented by Waterer 1956, 168-170; Bravo & Trupke 1970; Bausier 1994. We note that in Byzantium, in the chain of shoe-making, between the tanners (*βυρσοδεψοί*) or curriers (*σκυτοδεψοί*), who undertook the primary processing of the skins/hides 'working in liquids' (*ἐνεργοῦντες ἐν τοῖς ὑγροῖς*) and the shoemaker (*ὑποδηματοποιός, καλιγάριος, καλιγάς, τσαγγάριος, ὑποδηματορράφος, ἠπήτης*) intervened the tawers (*μαλακατάρια*) who undertook the secondary working, preparing the leather for sandal-making (Κουκουλές 1948, 188-214, with full reference to the Byzantine sources). The distinction between sandal-makers and shoemakers continued to be made in Greece until the early 20th century (Σαλαμάνγκας 1959, 30). In Dimitsana during the years 1903, 1904, 1920 and 1925 there is mention of 2, 1, -, 6 leather merchants; 7, 7, 1, 2, tanners; 1, 2, 2, 2 saddlers; 15, 5, 4, 4 sandal-makers; 7, 12, 5 and 3 shoemakers respectively (Χαραλαμπόπουλος 1995, 124). In Chania, Crete, the handicraft of sandals stopped in 1978 (Χαλκιαδάκης 1997, 315). In the West leather footwear has been found at archaeological sites mainly from the Middle Ages and after, examples of which are displayed in local museums (cf. Hald 1972). In Berlin, Museum für Vor- und Frügeschichte SMPK –as well as in some open-air museums in Northern Europe– there is a reconstruction of a shoemaker's workshop from the 15th-16th century. The tools used in the Middle Ages were very similar to those used by shoemakers in the late 19th century BC. In Oxford, Pitt Rivers Museum, there are bone tools of this kind from Britain, e.g. for laying the stitches between soles, or left humerus of a goose used for polishing soles and shoes.

III. Vases.[76] There are indications that at Knossos leather flasks were used for carrying oil; also water conduits, sacks of all types (Fig. 5) and sheaths (*θῆκες*).[77]

IV. Thongs (*ἱμάντες*) and baldrics (*τελαμῶνες*) for securing stone or metal tools in the bone (Fig. 9), horn or wooden haft,[78] for making sandals and for tying footwear round the ankles or up the calf,[79] for boxing,[80] for the rim of and for attaching chariot wheels,[81] for horse's reins and

[76] Chronologically skin/rawhide vessels preceded clay ones. At Lower Palaeolithic sites in Norway remains of skin/hide vases were found together with stones that were heated and plunged in the vase to heat the water it contained. Vases of deerskin and tanned cowhide found at Schlewig and at W. Smithfield in England, date from the Neolithic (Forbes 1966, 13-16). A skin vase was found in a tomb in Nubia (Forbes 1966, 23; Waterer 1956, fig. 110), while it is speculated that one of the men depicted in the tomb of Rekhmire at Thebes holds a skin vase (*ca.* 1450 BC) (Waterer 1956, fig. 120). Askoi should be included among skin vases (e.g. a. for wine-wineskin: cup from Vulci by the Nikosthenes Painter, Castle Ashby: Boardman 1975, fig. 93; Sicilian krater, mid-4th century BC, Lipari, Museo Archeologico Eoliano, no. 2297, inv. no. 2045: Κακριδής *et al.* 1986, 5, fig. 169; b. bag of air, e.g. Aeolos' bag of winds: Etruscan sealstone, second half of 5th century BC, Paris, Bibliothèque Nationale: Κακριδής *et al.* 1986, fig. 177). In Mesopotamia bags full of air were used to transport people on the floodwaters of the rivers (Forbes 1966, 43), while in Rome a distinction was made between the makers of wineskins (*urticularius*) and of water skins (*ampullarius*). On bags for carrying oil in Minoan Crete: Ruipérez & Melena 1996, 169. The bags for carrying solid commodities are of a different type. Included among the offerings to the dead in tombs of the Middle Kerma period (2400-1750 BC) were one or more young caprines, which had been placed in goatskin bags. In these bags the hairy side of the skin was on the inside (Chaix 1987, 298-299). It goes without saying that skin/hide vases were used until recently: 16th-century leather bottle (Oxford, Ashmolean Museum 1985, 3). For a brief discussion of vases for carrying liquids (*φλασκίον, ἀσκοδάβλα, ἀσκός, κιβύσιον*) in Byzantium and later times, see Μπακιρτζής 1989, 100-105.

[77] These include quivers as well as scabbards for swords and knives (Waterer 1968, 76-83, drawing 2). Cf. dagger-sheath of tanned cattle hide (Neolithic?) from Wiepen Kathen, Germany, and quivers in the tomb of Tutankhamun: Waterer 1956, fig. 119, 163. The quiver of Similaun man was of chamois skin (*Rupicarpa rupicarpa*) (Spindler 1997, 24). There are numerous modern examples in ethnographic museums: deerskin quiver (America, Athabaska, mid-19th century) in St Petersburg: *Peter the Great Museum*, pl. 19. At the site of La Tène a skin bag containing the 27-piece tool kit of a leather worker was found (Forbes 1966, 16). Cf. also an early 20th-century leather tool bag in Oxford, Pitt Rivers Museum.

[78] There are cases in which the leather is wound around the tool and constitutes its handle. In others the stone or metal working end is attached to the handle with leather thongs using resin. There has been practical experimentation on this matter (Anderson-Gerfaud & Helmer 1987, fig. 36, 37d; Plisson 1987, 75-85). Corresponding objects with metal working end –one of the carpenter's tools from a Theban tomb (Stead 1994, 48) is bound with leather thongs– are exhibited in museums with large collections of Egyptian antiquities (bronze axe-head with leather binding, Amarna, city of Akhenaten I, Oxford, Ashmolean Museum N50. 30 1921. 1129, 1130). An axe of Similaun man (found in the glaciers) was made in a similar manner (wooden handle, copper working end, thongs) (Spindler 1997, 26). A leather thong-rope was also used for harpoons for fishing/hunting, by Eskimo seal or walrus hunters (Irwin 1994, 73; Le Mouël 1978, 16-17). Thongs are also use in more complex farming tools, to hold the wood in place (Rome, Pigorini Museum).

[79] The mummified hunter found in the Alps had fur boots bounded by leather strips (newspaper *Καθημερινή* 06-10-1991; Spindler 1997, 20; Egge 1997, 28-34).

[80] Thongs are shown on the hand of a boxer on a fragment of a grave stele (540 BC, Athens, Kerameikos Museum; Γιαλούρης 1996, fig. 59). On the bronze Cista Ficorini pyxis Pollux is represented with thongs on the wrists (330 BC, Rome, Villa Giulia, inv. no. 24787, inv. no. 2045: Κακριδής *et al.* 1986, 4, fig. 102; hand of a boxer, from a bronze statue, 2nd century BC, Athens, National Archaeological Museum, X 15111: *Το πνεύμα και το σώμα*, fig. 175).

[81] The chariot wheels found in the tomb of Tutankhamun had rawhide round the joints and leather tyres. There were comparable constructional specifications in Mesopotamia (Forbes 1966, fig. 7, 140). In all probability the same technique was employed by chariot-makers in Mycenaean times.

trappings in general,[82] for anything that supports, holds, joins, lashes or helps in hanging, e.g. for the quiver (Fig. 5),[83] the hat (Fig. 4),[84] the shield grip (Fig. 3),[85] ship's sails,[86] leather sacks for

[82] We cite indicatively from the Egyptian wall-paintings those in the tombs of Neferhotep (Thebes: Åkerström 1987, fig. 51, 2) and Nebanum (Thebes: James 1997, fig. 32), in which numerous details of horse trappings are depicted. For Egypt more generally see Forbes 1966, fig. 6. In contrast, those recorded in the Linear B tablets as well as depicted in vases of the LBA and Geometric periods help very little in understanding details because they are highly schematic. Among the very few exceptions are the Pyla krater (Nicosia, Cyprus Museum: Åkerström 1987, fig. 91); in the wall-paintings from Tiryns (Åkerström 1987, fig. 54, 87). The author analyses the representations on vases, the chariot tablets from Knossos and the wall-paintings of the Mycenaean period, compares them with Egyptian and Mesopotamian parallels, and concludes that the chariot had a wooden frame and that the reins were leather (Åkerström 1987, 123-128). Comparisons could be made with a chariot model from Thessaly (LH IIIB, Megalo Monastiri, Volos, Archaeological Museum), which could be interpreted as a substitute for an actual chariot (Αδρύμη-Σισμάνη 1988, 135). We do not know whether the Mycenaean chariots had hoops *–termides–* of leather. We do know, however, that the parts of the wheel were assembled using rawhide, although in several cases metal was used, mainly bronze. In tablet **KN Sd 4401 + 8718** + *fr.* we read 'two chariots ... provided with wheels, with red leather, equipped with reins, with leather blinkers...' (Ruipérez & Melena 1996, 199-204). More information can be gained from the sculpture and the painted decoration of the Archaic period, during which chariot races and the warrior's departure on a chariot were particularly popular subjects. E.g.: the groom arranging the reins of Achilles' chariot on a sherd of a black-figure kantharos (560 BC, Athens, National Archaeological Museum, inv. no. Ακρ. 611: Κακριδής *et al.* 1986, 5, fig. 29); the preparation of Priam's chariot on a black-figure hydria (520-510 BC, Madrid, Museo Arqueologico National, inv. no. 10920: Κακριδής *et al.* 1986, fig. 43); Adrastos standing in his chariot, on a black-figure hydria (*ca.* 500 BC, Würzburg, Martin von Wagner Museum, HA 61: Κακριδής *et al.* 1986, fig. 135. This image appears in all the representations of chariot races) etc.

[83] Quiver of Herakles on a black-figure lekythos (500-475 BC, Athens, National Archaeological Museum, inv. no. 1132: Κακριδής *et al.* 1986, 4, fig. 43); quiver of a Scythian archer, on a red-figure plate (520-510 BC, London, British Museum: Κακριδής *et al.* 1986, 4, fig. 43). The baldrics of Artemis' quiver are leather too, as are the thongs that keep the scabbard in place, e.g. of Pandion's sword, on a red-figure krater, or of Herakles', on a red-figure amphora (red-figure lekythos, 430-420 BC, New York, Metropolitan Museum: Κακριδής *et al.* 1986, fig. 111) (Fig. 3).

[84] Cf. straps on Odysseus' hat, on red-figure pelike (440 BC, Boston, Museum of Fine Arts). We have already spoken about leather hats/caps. Here we note the straps/thongs. The straps on the cap of the man found in the Alpine glacier were of leather (Spindler 1997, 21). A broad-brimmed leather hat was considered an essential item of dress for travellers in the Mediterranean, into recent times (Σιμόπουλος 1975, 11; referring to the British traveller H.W. Williams, *Travels in Italy, Greece and the Ionian Islands*, Edinburgh 1820).

[85] Ajax's shield on a black-figure amphora (520-510 BC, Munich, Staatliche Antikensammlungen); the shield and general defensive weaponry of the giant Polybotes on a red-figure kylix (420-400 BC, Berlin, Staatliche Museum); the shields of Diomedes and Aeneus on a red-figure krater (490-480 BC, Boston, Museum of Fine Arts, inv. no. 97.368: Κακριδής *et al.* 1986, 5, fig. 54).

[86] Tzachili has noted that the sails were made of smaller pieces of cloth which were sewn together. If one looks carefully at representations of ships of different periods (on a steatite seal-stone: 1460-1400 BC, Herakleion, Archaeological Museum no. 1733; on a small stirrup jar from Asine: mid-12th century BC, Nauplion, Archaeological Museum no. 3319; on the Roman marble sarcophagus of the Nereids, Rome, Pretestato Catacomb; on a coin of Corcyra (Corfu) from the reign of Septimius Severus: AD 193-211, Athens, Numismatic Museum; on mosaics: 3rd century AD, Rome, Museo della Civiltà Romana; 3rd-4th century AD, Paris, Musée du Louvre; 6th century AD, Ravenna, San'Apollinare; Σπαθάρη 1995, fig. 37, 52, 172, 190, 206, 207, 213) this squaring can be seen on the sails. It is not clear with what they were sewn, i.e. floral or faunal raw material. However the case of leather strips or ropes cannot be ruled out. Caesar writes in *De Bello Gallico* that the Veneti had soft leather sails.

pack animals, the hides used for beds or chairs,[87] for the collars and the tethering of pets and domesticated animals,[88] as well as for making ropes (e.g. in Pylos **Ub 1318**, hides are delivered for making rope from plaited leather),[89] etc. We should consider that the beginnings of weaving are to be found in the interweaving of leather thongs[90] and of plant fibres. In ancient Greece and Rome as well as in Byzantium, the thong-makers had a separate guild (*loriarius*,[91] *λωροτόμος*[92]) as important as that of the shoemakers, the flask makers, the saddlers, the shield makers and the others associated with leather.

V. The largest pieces of leather were used in saddle-making,[93] for defensive weaponry (shields, helmets, panoplies),[94] offensive weaponry (bows), cabinet making (folding stools,

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[87] In a tomb of the Middle Kerma culture (2400-1750 BC) the bier had a wooden frame and an under-cover made of crossed strips of leather (Chaix 1987, 298). At Akrotiri, Thera, negatives of this were found in the volcanic ash. Cf. stool (*diphros*) on an Attic red-figure kylix (485-480 BC, Paris, Musée du Louvre, inv. no. G 152: Boardman 1975, fig. 245.1). Bed in which the straps tied to the wood can be seen, in a symposium scene on a Corinthian krater, 600-590 BC, Paris, Musée du Louvre, inv. no. E 635: Κακριδής *et al.* 1986, fig. 73.

[88] In a female burial of the Ancient Kerma culture (3000-2400 BC) –Sudan, east bank of the Nile– the mummified body of a bitch was found at the feet of the dead. The animal had been strangled with a leather thong, which broke its spine at the height of the atlas, axis and cervical vertebrae (Chaix 1987, 298). A dog collar (pink, green and white leather with metal studs) is mentioned from the tomb of Maiherpepi in Egypt (1782-1650 BC, Valley of Kings, West Thebes). There are several iconographic examples: Janssen & Janssen 1989, fig. 3, 4, 8 (cat collar), 14 (long-tailed monkey tied under its owner's chair) etc. It is natural that there was a corresponding use in Greece during the LBA and after. On a limestone relief from Egypt (14th century BC, Bologna, Museo Civico Archeologico) the farmer uses a whip with leather lash, while ploughing.

[89] Ruipérez & Melena 1996, 262-263. The equipment of Similaun man included long strips of leather as ropes (Spindler 1997, 21).

[90] Forbes 1966, 13.

[91] Forbes 1966, 99.

[92] Leo the Wise, *The Book of the Eparch*, XIV.1.2. The rein-makers (*χαλινοποιοί* or *χαμέαι* or *ἡνιορράφοι*) belong in the same category: Pollux, 110, 117; Κουκουλές 1948, 201.

[93] The Latin word for saddler is *capistarius* and the Byzantine *σαγματοποιός* or *σαμαράς* or *σελάς* –the last making saddles exclusively for horses. Waterer (1956, 182; 1968, 86) gives numerous examples of means of transporting and facilitating transporting which are made of leather, from antiquity to the present day. For the saddler's workshop in Pylos: Ruipérez & Melena 1996, 184.

[94] The ceremonial shields of Tutankhamun were covered with cheetah skin. In the tomb of Kenamon there were seven shields covered with leather and 10 leather quivers. Corresponding items are mentioned in the tablets from Mesopotamia (Forbes 1966, 31-32). In Egypt there are depictions of panther-skin shields: wall-painting in the tomb of Rekhmire (see note 91). Leather weaponry/armour was used by warriors of the Thracians (Herodotus, VII.75 –*peltas* = a small, light shield of leather), the Scyths and the Vikings (Waterer 1956, 169; 1968, 92-96). The earliest Greek shields were also of leather, as were other parts of the defensive weaponry. The helmet was lined with leather and so were the greaves, the shield itself was originally of leather and subsequently revetted with bronze, the bronze breastplates were joined together and tied with strips of leather etc. (Åkerström 1987, 129-134; Ruipérez & Melena 1996, 204-206). In general, the army required huge quantities of leather (Forbes 1966, 53). For more recent times see Waterer 1968, 94-96. Ethnographic examples: panoply from Tibet in Oxford, Pitt Rivers Museum (1961.2.126a). Shield-makers were also a separate class of professionals, known in Greek as *ἀσπιδοπηγοί* and in Latin as *scutarii* (Forbes 1966, 53).

footstools, beds, mattress bases, pillows, revetment of wooden chests[95] etc.), shelter and housing (tents, door canopy, curtains-*vela*[96] etc.), shipbuilding,[97] musical instruments,[98] toys,[99] bellows for smelting and casting metals,[100] as well as for writing materials and book binding in recent times.[101]

[95] In a tomb of the ancient Kerma culture the dead was laid on two processed ox-hides, one on top of the other (Chaix 1987, 298). The seat of one of the folding stools in the tomb of Tutankhamun was of goatskin (Forbes 1966, 32; Shaw & Nicholson 1995, 33). In Egypt leather that had been dyed was used frequently for covering chests, footstools, beds etc. (Shaw & Nicholson 1995, 33). In Mesopotamia ox-hides, sheepskins and goatskins, raw or tanned, were used for furniture (seats) (Shaw & Nicholson 1995, 42). It is surmised from the literary sources and the iconography, under-covers on beds and chair seats were either of leather or skin/hide (*δορά*): in a wall-painting from Knossos, female figures sit on a folding stool covered by a fleece (*μηλωτή*) (Herakleion, Archaeological Museum), a practice also preserved in the Homeric epics. Dionysos usually sits on a leopard skin (cf. red-figure krater, Athens, National Archaeological Museum: Βαλαβάνης 1991, pl. 130). The Barberini faun also sits on an animal skin (Roman copy of a relief of 200 BC, Munich, Staatliche Antikensammlungen und Glyptothek; Γιαλούρης 1996, fig. 210). The practice of placing skins of wild beasts, and indeed leopards, as the under-cover on beds, carried on into Byzantine times too (Κουκουλές 1948, 73). When this under-cover was made of leather it was called *δερμότυλον* (Κουκουλές 1948, 71). Cushions/pillows were also made of leather sometimes, a practice that continued into quite recent times (Σιμόπουλος 1975, 10-11, citing the observations of the Englishman John Oliver Hanson, *Recollections of Smyrna*, 1813, who visited Greece in the early 19th century).

[96] The use of hide/leather tents, known to this day from diverse ethnographic parallels (cf. natives of North America: Irwin 1994, 57, 106, 136); ethnological reconstitutions in Musée de l'Homme, Paris; in open-air camps in the Palaeolithic Age is considered certain, regardless of what the frame was made of (jaws, skulls, tusk of mammoth at Mejiritch in the Ukraine: 17,000-14,000 BC); timber at the Princevent site, Seine et Marne in the Paris basin, 8000 BC). Hide/leather tents are mentioned for mobilized and migrant peoples in general, in historical times. In an inscription at Karnak (1300 BC) the Libyans have hide/leather tents (Waterer 1956, 164). These light structures were used in more recent times: Dodwell mentions the use of a hide windshield between house doors (Σιμόπουλος 1975, 161, citing Dodwell, *A classical and topographical tour through Greece during the years 1801, 1805 and 1806*, London 1819).

[97] We refer to hide/leather boats known both from ancient literary testimonia and ethnographic parallels (Irwin 1994, 69, 169-171). Ethnological examples in Musée de l'Homme, Paris.

[98] Skin/leather was mainly used in percussion and string instruments. A drum (clay, skin, from Ebendorf, Kreis Wolmirstedt, *ca.* 3000 BC; Berlin, Museum für Von Frügeschichte, inv. no. 11744; Maenads with drum, Attic red-figure stamnos, 420 BC, Naples, Museo Archeologico Nationale, inv. no. 81674: Τιβέριος 1996, fig. 169). The sound-box of string instruments was also covered with skin/leather (Φάκλαρης 1982, 226). Egyptian harp with body covered in rawhide (Waterer 1956, fig. 149). Ethnographic examples in Oxford, Pitt Rivers Museum. Japanese lute-spiny violin covered with cat skin on both sides, twisted silk strings played with a horse-hair bow: Vienna, Museum für Völkerkunde; the bagpipe (*τσαμπούνα*) is made from goatskin and more rarely sheepskin or donkey skin –because it is larger and more durable (Παγκοζίδης 1991, 256). Harp from Gabon, similar to those found in Pharaonic Egypt, inv. no. 35.61.279, Musée de l'Homme, Paris: *Chefs-d'oeuvres du Musée de l'Homme*, 71; harpe birmane, MH 39.31.1, Dourdon 1993, fig. 4, 10.

[99] We refer to leather balls which in Egypt were stuffed with plant or animal fibres and covered by pieces of leather, often dyed white or red, stitched together (Waterer 1956, 164, fig. 128; 1968, 88; Oxford, Ashmolean Museum: Queen's College loan 1166).

[100] Numerous ethnographic examples (blacksmith's bellows from East and South Aftica as well as Calcutta in India, in Oxford, Pitt Rivers: Coll. 1865, 1925, 1910 and 1899); Fogg 1981, 15 (Britain); Nibi 1987, 82-85 (Egypt).

[101] The use of sheepskins and goatskins in Egypt, Mesopotamia and Asia Minor goes back a long time, as mentioned by Herodotus. The earliest vellum or parchment (*διφθέρα*, *περγαμηνή*) or *membrana*, in

KINDS AND QUALITIES OF LEATHERS. Depending on the use for which they are intended, hides/skins are processed by different tanning methods and are distinguished into coarse (cow, ox, buffalo, bull) for soles, light coverings, horse trappings, saddles, thongs and belts; medium coarse (calf, pig) for coverings, military accoutrements; light (goat and sheep) for bags, footwear, gloves, bookbinding[102] etc. These properties were undoubtedly known in antiquity, which is why in most cases the species of animal from which they come is specified in inventories: in the **Ma** taxation series from Pylos –because the working of hides was subject to taxation– the total of cow hides recorded is 234. A levy of cattle hides (?) is also mentioned in tablet **C 902** from Knossos. In the **Mc** series from Knossos the levies recorded refer to goatskins.[103] It seems that the hides were stored or held by the central authority to be distributed to the tanneries.[104] From the earliest document in Greece concerning tanning, the famous tablet **PY Ub 1318**, which includes information on the distribution of hides and the artisans who received them, we learn of the existence of processed or tanned (*diphthera*)[105] and unprocessed or raw (*wri:nos*) hides, even though other scholars claim that the latter word probably defines the cattle hide.[106] We learn that the hides are dyed[107] and selected according to the species of animal (goat, pig, deer).[108] We learn that they can be used in farming implements (harrow), pack saddles, thongs for saddles and panniers, ropes, sandals, shoelaces, protective coverings for the yokes of oxen and cowls. (Here we should add also the relative information recorded in the **Sd** series of tablets from Knossos). Last, the number of hides given to the artisans[109] to manufacture the above objects is specified. There is also indirect evidence on the procedure by which the raw material reached the workshops, because in general raw materials, for example ivory, wool or

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Latin, preserved comes from Egypt (*ca.* 2000-1786 BC) and is now in Berlin; there is a mathematical text written on skin (*ca.* 1300-1100 BC), in the British Museum. Forbes 1966, 28-29; Reed 1973; Leach 1995. On the subjects in recent times, *Ἑρμῆς ὁ Κερδῷος* II, 140-142. A series of documents from Sinai, many of them on vellum/parchment, has been published recently: Νικολόπουλος *et al.* 1998.

[102] Κρεμμυδάς 1972, 173; Γουργιώτη 1985, 412; Τσοτορός 1986, 109; Ζαρκιά 1977, 11.

[103] Ruipérez & Melena 1996, 171. Brice (1988) argues that the Linear A symbols (cf. *MA* 4 from Malia) in the form of a hide, are not associated with inventorying of hides but of metal ingots, like those recovered from the Kaş shipwreck. This form gives us indirect reference to the value of hides/leather, an issue not discussed in the present article.

[104] Melena 1972, 34-41.

[105] Ilievski 1967, 25.

[106] Palaima 1989; Ruipérez & Melena 1996, 262; Palmer 1999, 466.

[107] Palmer 1999, 468-469. For the tools, methods, colours obtained, the provenance of the dyes and those workshops for dying plant or animal fibres identified in excavations in the Mediterranean region (Egypt, Pompeii), see Forbes 1966.

[108] In addition to the animals already mentioned in the text and footnotes (goat, sheep, bovines, pig, deer, panther, antelope and gazelle), in Egypt hippopotamus hide was also used, in Palestine the skins of fish or sea mammals, and in Mesopotamia (for which the inventories are so detailed that the pelts, the skins with hairs, the rawhide and the tanned leather can be distinguished) ass hide was used –indeed it was used for footwear in these countries until at least the 18th century (Hald 1972, 19). Moreover, in 16th-century England the kinds of skins/hides used were of sheep, kid and fawn, lamb, horse, dog, buck, doe, calf, goat (Salzman 1923, 253).

[109] Ruijgh 1966. Of the records of raw material and final products of leather in antiquity, the most detailed evidence comes from Mesopotamia: the animals from which the hide/leather comes is specified, as is its age of slaughter, the degree of processing the skin/hide –therefore the quality, durability and pliability of the raw material– as well as the finished products and their potential use (door, shield, boat, chariot, chair, throne, by a goldsmith, to hold silver, container, musical instruments, bag, oil bag, ox yoke, garment, sandals, shoes): Forbes 1966, 40-42. Analysis of many Mesopotamian documents reveals that most of the hides/skins had been tanned and that most came from sheep and cattle.

horn, were distributed to the workshops either by the central authority, which had collected them, or obtained directly from the producers.[110]

We shall comment on some elements of the tablet **PY Ub 1318**. It is clear that in the Pylos document not all the possible uses of hide are mentioned. However, many can be surmised from the later literary testimonies, the archaeological remains and the ethnographic parallels of other countries. It is characteristic, for instance, that there is no reference to the use of hide for garments either in this document or in any of the tablets that have survived. And this because the use of hide for clothing[111] decreased as the use of vegetable fibres and wool increased, as the technique of weaving evolved and as a higher cultural level was achieved [112] –a symbolic fact for ancient Greek literature. Hides/skins, and indeed raw, were worn by populations that have not achieved this level,[113] as well as by herdsmen and, mainly, hunters.[114]

On the contrary, leather has a continuous use for footwear. In the Pylos tablet, as well as in texts from Mesopotamia and Egypt,[115] the sandals were to be made of goatskin. Footwear both in the Middle Ages[116] and in later times,[117] was made from sheep or goatskin. In parallel, cowhide was mainly used for uppers, mentioned by Xenophon,[118] and rarely pigskin, which was mainly for soles.[119] The hunters used skins as they were, with the pelt on the inside.[120]

It seems that the same skins (goat and pig) mentioned in the Pylos tablet[121] were used for saddles, harnesses, military accessories, for centuries.

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[110] Shelmerdine (1987) with reference to the workshops at Pylos, the status of the workforce in these –men and women– the way in which they were paid, the procedure of obtaining the raw material, the products manufacture as well as the possible taxes paid to the central authority.

[111] We cite a few ethnoarchaeological examples: The garments loincloth, chemise, belt, gaiters etc. work by the ice-man found in the Tyrol (Alpine Ötztal glacier) were sewn from the skins of goat, deer, ox and bear (Egge 1997, 33); the garments of the eight-month-old Eskimo boy (15th century) from the Qilakitsok graves (Greenland, Greenland Museum: Brothwell 1986, 108, pl. VII); dress of deerskin trimmed with porcupine quills (America, Athabaska, early 19th century); kaftan of deerskin (Siberia, Evenk, 19th century); parka of deerskin (Siberia, Nganasan, 19th century) in St Petersburg (*Peter the Great Museum*, pl. 18, 132, 137). There are garments of the Eskimo and Indians (Inland Tingit/British Columbia: Montagnalis Naskapi/Labrador; Arapaho, Wyoming, 19th century) in Vienna (Museum für Völkerkunde: Feest 1993, fig. 40, 41, 71).

[112] Block 1985.

[113] Pausanias, X.38.3.

[114] Roche-Bernard 1993, 35-38, who also cites ethnographic examples from the Gallo-Roman period and comments on relief sarcophagi from the cities of Déols and Arles-Trinquetaille.

[115] Forbes 1966, 24-32.

[116] Salzman 1923, 253-254; Grew & de Neergaard 1988, 41.

[117] 'The skin (i.e. of goat) was used after tanning for all kinds of footwear and other furnishings', *Ἑρμῆς ὁ Κερδῷος*, 21; Αναστασόπουλος 1947, year 1884, 1174; Ζαρκιά 1997, 11.

[118] Xenophon, *Anabasis*, V. Grew & Neergaard (1988) mention that on the basis of the excavation data for 60 shoes made in England between the mid-12th and the mid-15th century, 70% were of cowhide. This percentage depends of course on the raw material available. It is known that in the arctic regions reindeer and seal skin were used.

[119] Γουργιώτη 1985, 412-415. The author comments also on the kinds of skins/hides used for every object in the Larisa area.

[120] Hald 1972, 20. On the basis of 16th-century documents the author describes how hunters made their footwear from deerskin. Information is also given on footwear made from the skin of seal, horse (by the Swedes) and polar bear soles (by the Eskimo). There is also reference to hunting seal, the skin of which was used for footwear and the blubber for lighting fuel, is mentioned for the Ionian island of Zakynthos in recent times (Σιμόπουλος 1973, 502, based on descriptions by A. Grasset Saint-Saveur, Paris, year VIII, 7, 11).

[121] Κρεμμυδάς 1972, 173; Βακαλόπουλος 1980, 120-136; Γουργιώτη 1985, 415; Τσοτορός 1986, 109; Ζαρκιά 1997, 11.

However, the most important datum in the Pylos document, as far as this article is concerned, is the numerical recording of skins/hides distributed (e.g. 3 *diphthera*). In reality, in all the documents of an economic nature from the ancient world, either directly (Mesopotamia)[122] or indirectly (inscriptions with prices of skins/hides in different parts of the Roman Empire), the skins/hides are either counted or weighed and frequently both together.[123] The weight of skins/hides (*δέρματα*) and their quality depended on the season in which the animals were slaughtered. The quality of both skins/hides (*δέρματα*) and pelts/fleeces (*διφθέρες*) is better if the animals are slaughtered in the winter months. Written and oral testimonies indicate that the skins of small domesticated animals are at their best in the months of February and March. The heavier the winter and the colder the climate, the better were the skins (*δέρματα*) and pelts/fleeces (*διφθέρες*).[124]

The quality of skins/hides traded, as mentioned already, determines: a) their use: in Gallipoli skins of goats slaughtered in the summer were used, after the relevant processing, as vessels for oil and wine,[125] b) their weight: in a 14th-century Cretan contract we read that 190 hides weighing 6,734 pounds in all, were of cattle and cost 413 *υπέρπυρα* (*hyperpyra*) and 10 *γρόσσια*,[126] and c) the form of the transit trade, particularly in those regions with important agricultural and stock-raising production, and in which textiles and skins/hides were basic sectors of industrial activity (Tables 2-4).

9. Animal fibres (ἴνες)

I. Pelt/fur (*διφθέρα*)

The pelt (skin with hair/fur), such as that of the leopard,[127] bear, cheetah, wolf, lynx, squirrel, hare, goat, sheep and other animals, was used treated or untreated as a garment, at first by all and

[122] Forbes 1966, 55.

[123] Vakalopoulos (Βακαλόπουλος 1980, 131, 136) mentions that 'the skins/hides produced after the mid-19th century in Gallipoli weighed on average 90 pounds each. Specifically, the hides of oxen and cows were brought from Adrianople and each load weight around 30 pounds'. For the sheepskins exported to England, 'the price came to £8 per 120 skins of total weight 320 pounds'. Elsewhere the historian mentions that in the mid-19th century some 4,000 bales were exported along the Adrianople-Gallipoli railway network. Towards the end of the century, 12,000 loads (each weighing 5½ okas) of raw hides/skins were exported from the Peloponnese: 3,000 from Mani, 2,000 from Methoni, 2,000 from Patras and 1,000 from Gastouni (Σιμόπουλος 1973, 643, referring to X. Scrofani who recorded the trade in all products during the year 1794-1795). For the conditions of commerce in Epirus see Ζώης 1893, 53. Tables 2-4 give us an insight into the export trade of skins/hides from the 18th till the early 20th century and primarily the fact that interests us here, that they were first counted and/or weighed before being circulated. Analogous information was given orally by P. Kalaïntzis who runs a tannery in the Xiropotamou area, Drama, 'the skins were sold by the kilo', and M. Farazoglou, a leather merchant in Psyrri, Athens, 'the weight varies according to the size'. Both informants told us in detail how skins/hides are treated, which is no different from that described in the foreign bibliography. N.B. oka = 28 lb. = 1.28 kg.; 2.20 lb. = 1kg.; cantar = *ca.* 100 lb.

[124] Βακαλόπουλος 1980, 131; *Ἑρμῆς ὁ Κερδῷος*, 153. This does not, of course, apply to the skins of animals from warm climates, such as the leopard (*Ἑρμῆς ὁ Κερδῷος*, 151-152).

[125] Βακαλόπουλος 1980, 131. Sibthorp, who travelled in Greece in 1794, notes that in Attica 8,000 goatskins became bags for oil, wine and honey (Σιμόπουλος 1973, 615).

[126] Γάσπαρης 1995 (ASV, Notai di Candia, b22 (Francesco da Crose), fol. 13r/October 1339). In another document (December 1338) 22 cantari (approx. 1254 kilos) of cattle hides cost 194½ *hyperpyra*. The majority of contemporary documents and studies refer to the price of skins/hides. We have not dealt with this issue here because it does not arise from the Linear B tablets.

[127] In the tomb of Sobekhotep the Nubians wear animals skins and bear animal skins as gifts to Tuthmosis IV (Shaw & Nicholson 1995, 204). The priestess wears a leopard skin in Spell 23 (*Book of the Dead*, papyrus of Hunefer); Shaw & Nicholson 1995, 212.

later by some classes (herdsmen, hunters), as well as by officials, since according to one view the Linear B word *διφθεραφόροι* (fur-clad) can be used to characterize the attire of the figures in a wall-painting from Pylos. As has been discussed already, in the Bronze Age Mediterranean this garment was worn by persons associated with priestly rituals and was later established as a garment of individuals with divine powers.[128] In more recent times pelts/furs were used for everyday garments –sometimes luxurious– and costume accessories.[129]

The skin was sometimes used as a cover for animals. In Mediterranean countries, in order to improve the quality of the sheep's wool, the animals were covered during the winter, with either woollen textiles[130] or skins.[131]

As far as the commercial aspect of pelts/furs is concerned, the data we have from the nineteenth century is that: All are sold by the number, singly for the large skins, that is of wolf, bear, leopard etc., or by weight, as for white fox; or in lots of forty (the so-called Russian *soroki*, because *soroe* is forty), as for sable, ermine, otter; or by the thousand, as for the chinchilla. The scraps from the worked sable, otter and other furs are sold by the oka'.[132]

Beaujour mentions trading in batches of 20 pairs or *sorokia* of 40 pelts, depending on the species of animal.[133]

II. Fleece/hair (*τρίχωμα*)

GOATS. The fleece of the goat and the wild goat (ibex) consists of short soft hairs (the fine under wool or 'down'), which are covered by other longer outer hairs.[134] The use of the hair of

[128] Σαπουνά-Σακελλαράκη 1973. According to the author, the animal skin was worn by priests, slaves and high-ranking officials, as everyday garb or for religious duties. See also note 70.

[129] Foreign travellers make frequent mention of the heavy furs worn by Balkan peoples in the wintertime (Σιμόπουλος 1973, 294, 350-351, quoting R. Chandler, *Travels in Asia Minor or an account of a tour made at the expense of the Society of Dilettanti*, Oxford 1774, and E. Habessi, *État actuel de l'Empire Ottoman*, Paris 1792). In the mountains they wear sheepskins cut in the same simple way: in summer with the fleece outside and in winter with it inside (Σιμόπουλος 1973, 658-659, quoting from A.L. Castellan, *Lettres sur la Morée et les îles de Cerigo, Hydra et Zante*, Paris 1808). Already in Byzantine times there was the profession of furrier and mention of furriers' workshops (Κουκουλές 1948, 189), which continued into recent times too (Φαλτάιτς 1928, 25; Χαραλαμπόπουλος 1995, 121-122; Καλινδέρης 1958, 27-39). In the late 18th century 120 bales of hare skins (1 bale weighed 60 okas) were exported from Arta annually (Σιμόπουλος 1973, 641, on the basis of reports by X. Scorfani). In the early 19th century 10,000 hare skins, 8,000-9,000 okas (1 oka is equivalent to 9-10 pieces) were exported through the port of Thessaloniki to Marseilles, where they were used in millinery (Σιμόπουλος 1973, 75, referring to the text by Beaujour, who notes that the best hare skins were the winter ones because they had a denser, glossier fur). Pelts described generically as *αγριμικά* (of hare, fox, ferret etc.) were exported to Germany in the early 20th century: see the Greek skins in the German market, *Δελτίον Εμπορικού και Βιομηχανικού Εμπελητηρίου Αθηνών*, 07-11-1926, 347; Αναστασόπουλος 1947, year 1884, 1174-1175.

[130] Strabo, IV.4.3 (from south Galatia?).

[131] Lambs were also covered in Calabria, Miletos, Attica and the Megaris (*ὑποδίφθεροι ποῖμναι*); Horace, *Odes*, II.6.10; Columella, VII.2.5; Martial, V.37.2; VIII.28.4; XII.6.3; Forbes 1964, 16, 69. For Judaic Law, which separates the black from the white sheep and makes provision for the covering of the new-born lamb: Forbes 1964, 9, 67. For Gaul: Pliny, *Historia Naturalis*, VIII.236; Varro, *De re rustica*, II.2.18; 11.7 (*oves pellitae*). On a grave relief with representation of a horse and groom, there is a skin over the animal as a kind of saddle (early 3rd century BC, Athens, National Archaeological Museum); Γιαλούρης 1996, fig. 230. The lion skin and leopard skin were used as a blanket for the mounts 'of many Ottoman officers' in past centuries (*Ἑρμῆς ὁ Κερδῷος*, 22, 137).

[132] *Ἑρμῆς ὁ Κερδῷος*, 152-153.

[133] Beaujour (VIII) 1974, 220-226.

[134] Ryder 1993. For the description of the hair of viviparous animals see Aristotle, *Historia Animalium*, 517b-518a.

caprines for textiles for clothes, covers, carpets or ropes is common in the Mediterranean.[135] In many parts of Greece in the nineteenth century goat hair 'mixed with sheep's wool was used in coarse-weave cloth, from which over-garments (cape, capote) are sewn for travellers, and for shepherds and farmers, to protect themselves from the rain, because after this garment is fulled the goat hairs lie on the surface as a kind of down and shed the rain'.[136]

'Throughout Turkey they weave dense and loose cloth from goat hair, *σακκιά* (sacks) (i.e. sacking)'.[137] 'They likewise weave goat-hair blankets for covering the horses and other animals, for bags...'.[138] Last, another use is for ropes 'of goat hair, knitted or twined'.[139]

In other cases (caps, gaiters/leggings) the softened animal skin with the hairs still in place was used.[140]

Goat and pig hairs were also used for building material.

PIG. In Byzantium a kind of waxed thread with a pig's hair at the end was used for sewing.[141] This tradition persisted until the nineteenth century. Pig's hair was used 'for making various brushes ... for cleaning clothes'. It was also used in gold jewellery-making, 'for washing the metals for the goldsmith', and in 'painting',[142] for paintbrushes and meshes/sieves.

HORSE. Literary and ethnographic observations indicate the use of the horse's mane or tail for making mesh, that is a fine sieve; for weaving sacking in order to reinforce the weft, which was frequently mixed with hairs of other young animals such as lamb's wool, always to achieve

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[135] Lucas (1948, 44) mentions that pieces of cloth of goat hair were preserved in Egypt and are dated to Hellenistic and Roman imperial times. However, of the 4,000 pieces of cloth recovered from the labourers' village at Tell el-Amarna (Egypt, 14th century BC), only 38 are of sheep's wool and two of goat hair (Ryder 1993, 39). We mention also the textiles found in the excavations at Dura-Europos, where wool was abundant as a raw material. There are, however, textiles of cotton, silk, linen and goat hair too (Bellinger & Bellinger 1945). It emerges from the Roman literary sources (Virgil, *Georgics*, III.303; Pliny, *Historia Naturalis*, VIII.76; Columella, *De re rustica*, VII) that these are probably loosely woven textiles that covered the needs of the poorer classes.

[136] *Ἑρμῆς ὁ Κερδῷος*, 265. The corresponding woven cloth of goat hair was called *σάκκος* (Flacelière 1995, 187). The Byzantines made robes from the hair of nanny goats or billy goats, as well as under-mattresses and carpets. Those of Cilicia are called Cilician, commonly *kilims* (Κουκουλές 1948, 24, 73). The bedspreads and heavy blankets made from goat hair are called *αἰγιόμαλλα* (Κουκουλές 1948, 75). For the bedspreads we have the description by A.L. Castellan, who visited Monemvasia in 1797 (Σιμόπουλος 1973, 659). Mention should be made here of the goat-capes of Kea, commented on by Pitton de Tournefort, *Relation d'un voyage au Levant*, Paris 1717, and J. Aegidius von Edmund who toured the Ottoman East in 1729 (Σιμόπουλος 1970, 724; 1973, 153). In the 19th century they also wove shawls. 'The left-over hair is spun into yarn and sent to Europe via Smyrna...' (*Ἑρμῆς ὁ Κερδῷος*, 21). Even today the Bedouins in the desert live in tents woven from dark goat hair (Keohane 1994, 58).

[137] *Ἑρμῆς ὁ Κερδῷος*, 285.

[138] *Ἑρμῆς ὁ Κερδῷος*, 193-195. It is noteworthy that in several cases the sacking is of specific dimensions, e.g. in Serres in the early 19th century they made 'dense hair sacks' that 'held about 60 okas of weight'. There were loose hair sacks that 'held over 100 okas'. In the list of occupations in Thessaloniki, in the 16th century, that of the hair-sack-maker is mentioned (Belilbaşi 1996).

[139] *Ἑρμῆς ὁ Κερδῷος*, 273, 286. This is known as *τριχιά* in Modern Greek.

[140] «*αἰγείην κυνέην κεφαλῇ*» ('and on his head a goatskin cap'): *Odyssey*, XXIV 231; Flacelière 1995, 204; *Edictum Diocletiani, Udones* (Mommsen & Blummer 1893), Tzachili (Τζαχίλη 1997, 15-16) believes that the cap belongs in the category of textiles that were not woven but made through intertwining-matting various animal fibres (wool and hair). In Byzantium there was the occupation of *skouphas* (cap-maker). Head-coverings were burnished with a pig's tusk (Κουκουλές 1948, 215).

[141] Κουκουλές 1948, 215; *Ἑρμῆς ὁ Κερδῷος*, 286.

[142] *Ἑρμῆς ὁ Κερδῷος*, 286, 349. In Egypt it seems that brushes were made of hairs from the giraffe's tail, mixed with goat hairs (Lucas 1948, 44).

a softer weave, to reduce the volume of wool used (economic reasons) and to achieve a lovelier decorative effect.[143] Horse hairs have regularly been used as bow strings.[144]

CATTLE. The use of cattle tails was analogous to that of horse tails. In Egypt there is reference to the use of this hair in jewellery.[145]

CAMEL. The use of camel hair rope is attested in Egypt.[146] Textiles, presumably of second quality, made of camel hair, were imported to other Mediterranean lands.[147]

HARE, BEAVER, BADGER. Latin authors mention textiles made of hare and beaver hair, while the weaving of badger hair is attested archaeologically.[148] All the evidence comes from the West. On the contrary, in the East hairs from the tail of the elephant and the giraffe were used.[149]

SHEEP. As the Mycenaean tablets show,[150] the most valuable commodity that man obtained from this animal was its wool. In the wild forms of the species[151] the outer coat of hair, which was shed each spring, was superior to the softer wool beneath it. However, the domestication of the animal, which took place about 11,000 BC, brought multiple changes in its morphology, including the growth of the wool at the expense of the hair, the natural moulting of which gradually ceased.[152]

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143 Roche-Bernard & Ferdière 1993, 61-62, give archaeological examples from Gaul. The admixing of hairs of other animals, such as goat, or of plant fibres, such as nettle, a raw material used mainly in Northern European countries, is a common phenomenon. For the latter see Hald 1980, as well as the fairytale by Hans Christian Andersen, about Eliza and the swans.

144 Oxford, Pitt Rivers Museum. The artefacts are from Assam in India (Asia) (inv. no. 1923.84.1159/ 1923.84.871) and the Northern Territories of Ghana in Africa (inv. no. 1940.11.2). The one-stringed Bedu violin, called a *rabab*, has a bow made of hair from the tail of a horse or a camel (Folklore Museum, Amman, Jordan).

145 A bracelet dated between 3400 and 2980 BC was partly made of cattle hairs, possibly from an ox tail (Lucas 1948, 43).

146 This is an archaeological find that is dated between 2980 and 2900 BC (Lucas 1948, 44).

147 Two pieces of cloth have been found, one at the site of Lattes, the ancient harbour of Montpellier, which is dated to the 5th century BC, and one in Marseille, in the excavations in the Bourse block, of debatable date (Roche-Bernard & Ferdière 1993, 62-63). In Greek the term 'camel wool' (*μαλλί καμήλου*) is used, *Ἑρμῆς ὁ Κερδῷος* II, 33. For the use of camel skin and hair in Byzantium: Κουκουλές 1948, 25.

148 The expressions *Vestes leporinae, Strictoriae leporinae, lana leporina* are encountered (see note 135). The Greek terms are 'hare wool', 'beaver wool' (*Ἑρμῆς ὁ Κερδῷος* II, 6, 33; Roche-Bernard & Ferdière 1993, 60-61).

149 Lucas 1948, 44. An ornament of elephant hair is also cited.

150 Note 6.

151 *«ἐν Αἰθιοπίᾳ γίνεσθαι ... πρόβατα ἐρίων μὲν ψιλά, τρίχας δὲ καμήλων ἔχοντα»* ('in Ethiopia there occur ... sheep destitute of wool but with the hair of camels') (Aelian, *De Natura Animalium*, XVII.10). This is the species *Ammotragus lervia*, which has a mane and tufts of wool on its fore limbs.

152 Ryder 1983, 1992. Some of the most important consequences of domestication on the morphology of the animals were the decrease in the size of the horns, decrease in the height of body, decrease of the encephalon of the cranium, increase in size of tail, change in the colour and primarily the quality of the fleece. In the area of Kurdistan (Tepe Sarab on the Kermnshah plateau) a sheep figurine dated *ca.* 5000 BC gives the first indications of the existence of fleece (see also Ryder 1993, 38). In my opinion, the LBA practice of removing the hairs of animals with large combs –a practice that lived on into Roman times– should be attributed to the natural renewal of the fleece. For 'plucking' (Greek *τιλμός: τίλλω «τοῖς τίλλουσιν τὰ ὑποδίφθερα»* (*Pap.Cair.Zen.* 430.3); 'you pull out hairs' (*τριχῶν τίλσεις*), Aristotle, *Ethica Nicomachea*, 1148b.27) and 'shearing' (*κουρά*) (*Pap.Cair.Zen.* 433.26, sheep-shearing, wool shorn) as well as the works following, see Τζαχίλη 1997, 81-99 with many references to the Mediterranean region. The shears are defined as 'knife for shearing sheep' (*κουρίδες μάχαιραι αἷς κείρουσι πρόβατα*), Cratinus, 37; 'knife for shearing billy-goats' (*τραγοκουρίες μάχαιραι*), Lucianus Piscator, 46. There is a host of works in ancient Greek pertaining to the gathering and processing of wool. The Latin texts (Cato,

However, because there is a rich bibliography on wool, both as raw material and as final product, throughout the Mediterranean region in all periods, and all stages of processing,[153] no more will be said about these animal fibres here.

SILK. The fibre in modern silk textiles comes from the cocoon spun by the domestically reared insect known as the mulberry-feeding moth (*Bombyx mori L.*, *βόμβυξ ὁ σηρικός*) (Fig. 10, 11). The cocoon is a continuous filament of serin, which is secreted from special glands in the lower lip of its grub, the silkworm. This secretion solidifies in the air, to form the silk filament. The cocoon consists of three layers of filament, whose overall length if unravelled is 1,000 m.; 30,000 silkworms produce about 6.5 kilos of silk. The import of silkworms from China, systematic rearing of them and the spread of silk production in the Mediterranean are linked with the reign of Emperor Justinian, that is the fifth century AD. However, silk textiles were known in the Eastern Mediterranean in Late Imperial times,[154] the time of Pliny and of Aristotle,[155] and even in Classical times.[156] Women soaked the cocoons of Lepidoptera of the species *Saturnia pyri* or *Pachypasa otus* to obtain a kind of silk yarn, which they wove. However, the discovery of a fossilized cocoon of the same family in the excavations at Akrotiri, Thera, in conjunction with the representations of chrysalises on Minoan sealstones and in the wall-painting of the flotilla from Thera, are convergent indications that a wild form of silk was already in use in the Late Bronze Age.[157]

'PINNA WOOL' (*ἔριον πίννης*) known as 'the wool from the sea' (*τὰ ἐκ θαλάττης ἔρια*).[158] The pinna is a bivalve mollusc of the Mediterranean shores, which attaches itself to the rocks or

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Varro, Virgil, Palladius, Columella, Pliny) are extremely analytical with regard to the rearing of sheep, the washing of the animals before shearing (Columella, II.2.35), the plucking of the wool by hand (Pliny, *Historia Naturalis*, VIII.73), the shearing season depending on the climatic conditions (Palladius, V.7; VI.6) and mainly the commercial circulation of wool in the various parts of the Empire: Frayn 1984; Forbes 1964, 22-26.

153 We can add to the bibliography given in previous notes: Forbes 1964, 2-36 with many examples from the Eastern Mediterranean diachronically; Raistrick 1972, 92-100; Hodges 1964, 123-232; Barber 1991, 20-30; Roche-Bernard & Ferdière 1993, 54-60; Ryder 1983; *Diplomatic and Consular Reports, Foreign Office*, London 1992, for the circulation of wool in Greece.

154 Galen, Basil the Great and John Chrysostom mention that their contemporaries wear silks (Κουκουλές 1948, 24). These textiles were worth their weight in gold.

155 «*Ἐκ δέ τινος σκώληκος μεγάλου, ὅς ἔχει οἷον κέρατα καὶ διαφέρει τῶν ἄλλων, γίγνεται πρῶτον μὲν μεταβάλλοντος τοῦ σκώληκος κάμπη ... ἔπειτα βομβυλίς, ἐκ δὲ τούτου τοῦ ζώου ... καὶ τὰ βομβύκια ἀναλύουσι τῶν γυναικῶν τινὲς ἀναπηνιζόμεναι κἄπειτα ὑφαίνουσιν· πρώτη δὲ λέγεται ὑφῆναι ἐν Κῷ Παμφίλη Πλατέω θυγάτηρ*» ('Out of a certain large larva, which has as it might be horns, and is different from the rest, there arises first of all a caterpillar ...then a *bombylis* (cocoon), then out of this a *nekydalos*... Some of the women actually unwind the cocoons from these creatures, by reeling the thread off, and then weave a fabric from it; the first to do this weaving is said to have been a woman of Cos named Pamphile, daughter of Plates') (Aristotle, *Historia Animalium*, 551b.10). This is the species *Pachypasa otus*, which were not reared but were exploited by the women of Cos, Amorgos and Sidon in Classical times. Pliny, *Historia Naturalis*, IX.75-78; Horace, *Satires*, I.101-102; Ovid, *Ars Amatoria*, II.298.

156 Τζαχίλη 1997, 35-36 with reference to the Kerameikos cemetery and Hochmichele in Southwest Germany. More generally see Hodges 1964, 125; Barber 1991, 30-32; Roche-Bernard & Ferdière 1993, 63-64. There is mention in general of the circulation of silk textiles from the Eastern Mediterranean to the West, via Marseille (sarcophagus at St Victor) and thence to Central and Western Europe.

157 Panagiotakopoulou 2000, with relevant bibliography. She also cites other archaeological, literary and iconographic parallels.

158 Alciphron, I.2: the byssus of *Pinna nobilis L.* It is also mentioned by Tertullian. «*αἱ δὲ πίνναι ὀρθαὶ φύονται ἐκ τῆς βύσσου ἐν τοῖς ἀμμώδεσι καὶ βορβορώδεσιν*» ('pinnae grow erect out of their *byssos* in sandy and muddy places') (Aristotle, *Historia Animalium*, 547b.15).

anchors itself in the sand with a tuft of fibres. These fibres were used for extremely fine textiles in Late Antiquity[159] and until quite recently in some areas of the Western Mediterranean.[160]

In all cases the animal fibres are weighed. In the Linear B tablets each unity of wool (the wool of four rams constitutes a unit) is equivalent to about 3 kilos.[161]

In the Ur tablets, 30 rams yield 40 kilos or, in another record, 24 sheep yield 53 kilos.[162] In a much later period in Greece, in the nineteenth century, the data were 3 litres of wool per ewe and 4 per ram.[163]

In the Late Bronze Age it is most likely that the sheared wool, which was weighed, was transported wound into round bales (*ποκάρια*).[164] In Modern Greece it was transported either in the form of a package (bale),[165] or in sacks [166] of predetermined weight. Sometimes the weight was given simply in okas[167] or tons.[168] There was sorting by quality (soft-hard, white-black, first-second shearing etc.).[169] No corresponding sorting can be deduced from the records on the tablets.

For goats we know that the average weight of the hair yielded by a domesticated nanny goat is 50 gr.[170] At Ur 35 sheep and 41 goats yielded 59 kilos of hair,[171] while in Attica in the eighteenth century the annual production of goat hair was over 250 cantara.[172]

It is deduced from the Edict of Diocletian that both silk fibres and camel hair were sold by the pound, that is 325 gr.[173]

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[159] Textiles made of byssus were considered luxurious (Κουκουλές 1948, 25; Roche-Bernard & Ferdière 1993, 62); 'it supercedes all the rest of the silks in the world': *Ἑρμῆς ὁ Κερδῷος*, 71.

[160] Roche-Bernard & Ferdière 1993; *Ἑρμῆς ὁ Κερδῷος*, 71, 127 (byssus). It is also known as *seta d'ostrica* (= ostracoderm silk).

[161] Τζαχίλη 1997, 53.

[162] Forbes 1964, 7.

[163] Σιμόπουλος 1975, 349, inventorying Leake, *Journey Through Some Provinces of Asia Minor in the Year 1800*. The fleece of a slaughtered animal will have yielded 2,200 to 4,400 kilos if compared with contemporary data from the West (Roche-Bernard & Ferdière 1993, 58).

[164] Tzachili describes in detail, incorporating all the earlier bibliography, the passage from Homer «*φέρειν πόκον ἄρσενος οἰός*» ('beareth the fleece of a ram') (*Iliad*, XII 451), as well as the evidence from Ptolemaic Egypt, and concludes that the recording of wool is uniform because in all probability the palace received the fleeces unsorted, handed them over to the workshops and awaited textiles of different qualities. According to the data, the total wool production for year preceding the destruction of the palace was 17,000 units, i.e. 52,000 kilos (1 *LANA* - 3 kilos; 17,000:3 = 6.333 kilos). For the distinction of wools by quality, the price of one talent of wool, the ways of circulation, see Forbes 1964, 3-7; Heltzer 1978.

[165] Among the commodities exported from Gallipoli in the mid-19th century were 4,000 bales of leather, 4,000 bales of wool (Βακαλόπουλος 1980, 136).

[166] Σβορώνος 1996, 121-123: 2,600 okas of raw wool were placed in 22 hair sacks. During the 18th century, wool from Thessaly was transported in hair sacks 3½ fathoms each and 77 okas in weight.

[167] In 1858 106,086 okas of wool were exported from Kavala (Βακαλόπουλος 1980, 120).

[168] Αναστασόπουλος 1947, year 1927, 1198-1200.

[169] Αναστασόπουλος 1947, year 1927, 1198-1200; Μισταρδής 1928, 128: During the final years of Ottoman rule (1907-1911), 600,000 okas of wool from the first shearing and 150,000 okas from the second shearing were exported from Macedonia.

[170] Ryder 1993, 43.

[171] Ur III; Forbes 1964, 7.

[172] Σιμόπουλος 1973, 615 (inventorying the information given by the naturalist Sibthorp). As Beaujour notes, the units of weight current in the Greek economy in the 18th century were the cantaro, the oka and the dram. One cantaro is equivalent to 137 pounds and 8 ounces. One oka = 3 pounds and 2 ounces or 50 ounces (Beaujour (VIII) 1974, 246).

[173] Roche-Bernard & Ferdière 1993, 62-65. In Greece in recent times the cocoons of silkworms and silk were weighted. The weight is given in okas. In 1871 32,992 okas of cocoons were exported (Αναστασόπουλος 1947, year 1876, 336, 1404, statistics for the years 1870-1875); *Ἑρμῆς ὁ Κερδῷος*, 68.

10. Sinews (ἡ νευρά, τὸ νεῦρον, τὰ νεῦρα)[174]

Some fibres of the nervous system of vertebrates are long and without myelin. It must have been these which were widely used in antiquity, because Aristotle notes that the nature of the nerve is such that it can be split lengthwise and stretched considerably.[175] The tendons, which according to the philosopher from Stageira are a double nerve, are in all probability the products symbolized by ideogram **142*[176] and mentioned in 14 tablets from Knossos. Their use is not specified. However, the numerous examples, ethnographic and literary, suggest corresponding use in the LBA. In the nineteenth century the Bering Straits Eskimo used combs about 15 cm. long, with two or more teeth, to transform the sinews of animals into thread. Specifically they used tendons from reindeer legs, which they dried and beat with a club until the fibres were loosened. The tendons were then split and cleaned.[177] The use of sinews as thread is considered certain already in the Upper Palaeolithic[178] and continued at least until the Middle Ages. This means that the ancient Greek words *νευροραφέω, νευρορράφω, νευρορραφία,*[179] which are associated with shoemaking or cobbling, essentially refer to the sewing of pieces of leather with sinews (*νεῦρα*).

Sinews were also used as bowstrings, as ascertained from parts of bows preserved in Egypt,[180] as strings of musical instruments[181] and as fishing line.[182] The strings of the lyre and the string of its bow were made of sheep gut (intestine).[183] A corresponding use is mentioned in Medieval[184] and later times: 'String, the small intestine of animals, from which the worked intestines of sheep also take this name, dried, shredded into fine threads and spun together. These strings were used mainly in musical instruments, lyre, guitar and the various variations of these, in later music ...'.[185]

The sinews/tendons mentioned in the **Mc** tablets, which record income of materials intended for making chariots, are weighed.[186]

174 «*τὰ δὲ νεῦρα διεσπασμένα περὶ τὰ ἄρθρα καὶ τὰς τῶν ὀστῶν ἐστι κάμψεις*» ('the sinews, on the other hand, are scattered about round the joints and the flexions of the bones') (Aristotle, *Historia Animalium*, 515b). «*Πλεῖστα δ' ἐστὶ νεῦρα περὶ τοὺς πόδας καὶ τὰς χεῖρας καὶ πλευρὰς καὶ ὠμοπλάτας καὶ περὶ τὸν αὐχένα καὶ τοὺς βραχίονας*» ('The greatest number of sinews is found in connexion with the feet, the hands, the ribs, the shoulder-blades, the neck and the arms') (Aristotle, *Historia Animalium*, 515b.15).

175 «*Ἐστὶ δ' ἡ τοῦ νεύρου φύσις σχιστὴ κατὰ μῆκος, κατὰ δὲ πλάτος ἄσχιστος καί τάσιν ἔχουσα πολλήν*» (Aristotle, *Historia Animalium*, 515b.15).

176 Melena 1972, 42-44 ('tendons to make the bow-string'); Ruipérez & Melena 1996, 254.

177 Hald 1972, 30-32. For more modern techniques see Reed 1973, 734. It goes without saying that the combs were made of broad bones, a practice which prevailed to this day, despite the replacement of bone by wood and iron. Later, the comb was one of the basic tools in stock-raising, used for carding, in order to remove dirt and to separate the matted fibres. Τζαχίλη 1997, 93-97; Roche-Bernard & Ferdière 1993, 58-59. In Byzantium carders were called *λανάριοι* or *κτενισταί* (Κουκουλές 1948, 191).

178 Sinews or leather strips were used for sewing. The leather garments of Similaun man were sewn with animal tendons (Spindler 1997, 20).

179 These names also existed in Byzantium (Κουκουλές 1948, 214).

180 Lucas 1948, 41. The first finds date to the Badarian Culture, in the period 2980-2900 BC and in the period 1788-1350 BC.

181 Lucas 1948, 41. According to Aristotle, bowstrings were also made from the camel penis.

182 Ryder 1983, 734.

183 Φάκλαρης 1982, 230.

184 Ryder 1983, 734. The author mentions the use of the sheep stomach as a bag.

185 *Ἑρμῆς ὁ Κερδῷος*, 349.

186 Melena 1972, 53-54; 1988. Each goat yielded about 1 kilo of sinews. Indeed if we consider that ideogram **142* represents sinews (Ruipérez & Melena 1996, 254) and not honeycombs, as Ventris & Chadwick had originally proposed, then according to the 14 tablets of the **Mc** series, 278 kilos of sinews are recorded (Ruipérez & Melena 1996, 302).

11. Fat, lard, suet (ἄλειφαρ, πιμελή, στέαρ)

'Suet (*στέαρ*), unguent (*μῦρον*), anointing oil (*χρίσμα*), oil (*ἔλαιον*)':[187] From these almost synonymous words, lard and suet are animal products. In the Linear B tablets the craft-industrial product *a-re-pa* (*ἄλειφαρ*) is recorded,[188] which is translated as unguent, anointing-oil for smearing, ointment.[189]

Craftsmen known as *ἀλειφάζοοι* or *ἀλειφόζοοι* are recorded in Pylos.[190] Plant oils were mainly used as the base for producing this aromatic product, but sometimes animal fats (lard) were used as well.[191]

The ancient authors distinguish clearly between lard (*πιμελή*) and suet (*στέαρ*), the former being fat that can be melted but does not solidify when cooled.[192] Lard and suet were also used in food, medicines, candle-making (i.e. as lighting material), as lubricants etc.[193]

The unguent, as a product in fluid form, and indeed in the luxury trade, had to be put in vases in order to be transported. These containers, irrespective of the material from which they were made, were of standard size and therefore had a measurable capacity or volume.[194] During the nineteenth century cod fat, which was used in tanning and lamps, was transported in barrels that weighed 'about 4 cantara'.[195]

12. Glue

Among the earliest adhesives are those obtained from the colloidal substances existing in the fibres of the connective tissue. In Egypt bones, skin, connective tissue and tendons were boiled

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[187] Hesychius.

[188] *a-re-pa*: **PY Un 718**, *ἄλειφαρ* and *ἄλειφα*: Lejeune 1971, 343, 360; Hooker 1994, 82; *ἄλειφαρ* = unguent, anointing-oil, oil, fat.

[189] Ventris & Chadwick 1956, 50, 123, 132. *Ἄλειφαρ* was used in the sacrifices before the burial of the dead. «*...καθήραντες σῶμα καλὸν ὕδατί τε λιαρῷ καὶ ἀλείφατι*» ('...and cleansed they fair flesh with warm water and with ointment') (*Odyssey*, XXIV 44); «*...χερσὶ δ' ὅ γ' ἀμφοτέρῃσιν ἀνείλετο λευκὸν ἄλειφαρ*» ('...with both hands he took up the white fat and was angry at heart') (Hesiod IX.553).

[190] *a-re-pa-zo-o* (e.g. in **PY Un 249**, **PY Ea 812**); it is considered to be related to the occupation of *μυρεψός* (Theophrastus, *Historia Plantarum*, IV.2.6). *Μυρεψός, μυρέψης* = one who boils and prepares unguents, perfumer. Words deriving from *μυρεψός* are *μυρεψία*: unguent making; *μυρεψέω*: to prepare unguents; *μυρεψεῖον*: unguent workshop; *μυρεψητήριον*: vase for preparing unguents; *μυρίς*: box for unguents. For the profession of *μυρεψός* in Byzantine times see Κουκουλές 1948, 205.

[191] «*Ὁ Γάγγης τρέφει κήτη καὶ ἐκ τῆς τούτων πιμελῆς ἄλειφαρ ἐργάζονται*» ('The Ganges rears a huge fish from the fat of which they prepare unguent') (Aelian, *De Natura Animalium*, VII.12.41).

[192] Aristotle (*Historia Animalium*, 520a) states that lard and suet are found in different parts of the body of vertebrates. He also mentions, with respect to soups, that those made of animals containing fat congeal. «*Πιμελὴ δὲ καὶ στέαρ διαφέρουσιν ἀλλήλων. Τὸ μὲν γὰρ στέαρ ἐστὶ θραυστὸν πάντῃ καὶ πήγνυται ψυχόμενον, ἡ δὲ πιμελὴ χυτὸν καὶ ἄπηκτον· καὶ οἱ μὲν ζωμοὶ οἱ τῶν πιόνων οὐ πήγνυνται, οἷον ἵππου καὶ ὑός, οἱ δὲ τῶν στέαρ ἐχόντων πήγνυνται, οἷον προβάτου καὶ αἰγός*». Palmer thinks that the στέαρ 'is probably beef fat, which solidifies at a higher temperature than mutton or pork fat', and cites examples from Egypt, where they were stored in corresponding jars (Palmer 1999, 468).

[193] On the use of fat for lighting see also the later tallow candle. Fatty substances (plant and animal) were used in the maintenance of the leather parts or metal sections of offensive and defensive armour and weaponry, etc. Moreover, animal fat (suet) was sometimes used for making soap –adulterating the plant oil. In Byzantium those soap merchants who did this were expelled from the guild, with shaven head, at least as far as we know from Leo the Wise, *Book of the Eparch*, XII.8.

[194] «*ἐν δ' ἐτίθει μέλιτος καὶ ἀλείφατος ἀμφιφορῆας*» ('and thereon he set two-handled jars of honey and oil') (*Iliad*, XXIII 170: funerary customs from Patrocles). More recently: *ἀλειμματοδοχεῖον* = ointment container. On the capacity or volume of vases in general and their transportation, see Katsa-Tomara 1990.

[195] *Ἑρμῆς ὁ Κερδῷος* II, 113.

to obtain gelatin. When the liquid gelatin cooled it was used for sticking inlaid decoration on wood (e.g. of ivory) or gypsum. In all likelihood it was also used in painting as a medium for the pigments. The use of glue in Egypt is confirmed from 2980-2900 BC onwards.[196] The use of skins for preparing glue is also confirmed in the ancient Greek texts.[197]

13. Eggs

Three uses of eggs are known in general: a) in man's diet,[198] b) in circulation of luxury items made of ostrich eggs throughout most of the Mediterranean[199] for converting the calcareous shell (outer membrane of the egg) into a luxury vase, c) in painting, mixing the content of the eggs with mineral pigments, a hypothesis made by those who study the wall-paintings of Egypt.[200]

Although there is no evidence on the circulation/exchange of eggs in general, we suggest rather a local consumption and a counting of them in order to agree on a transaction.[201]

14. Milk products

Milk is the whitish liquid secreted from the lactiferous glands or mammae of female mammals. Its composition is such that it is of great nutritional value and reflects the needs of the organism, depending on the environmental conditions. So the milk of the cow, goat and sheep is of similar composition. On the contrary, the milk of the reindeer, which lives in regions with limited food supply, is richer in lipids and proteins but poorer in water. Cheese seems to have been the most important of the milk products,[202] perhaps because it could be kept for longer and

[196] Lucas 1948, 8-10; Hodges 1964, 163.

[197] Aristotle (*Historia Animalium*, 517.29) stresses that all subjects contain a sticky and mucilaginous substance, some in smaller and some in large quantity, like those of the cattle from which they make glue. 'The scrapings of parchments for making glue'. *Ἑρμῆς ὁ Κερδῷος* II, 141.

[198] Goose eggs (*ὠὰ χήνεια*): Eriphus, VII; Aristophanes, *Lysistrata*, 856. *Ὠόγαλα* = egg mixed with milk: Aëtius, IX.42; Paulus Aegineta, III.42.6-8.

[199] Sakellarakis 1990. The author refers to the technique of converting the ostrich eggshells into rhyta (13 have survived in the Aegean region), their use in religious rituals and the possible trade routes for them, mainly via Egypt or Libya. We note that in the wall-paintings in the tomb of Rekhmire (1470 BC), to which we refer frequently, the inhabitants of Nubia bear ostrich eggs, in addition to ivory, skins and feathers. Decorated ostrich eggs have survived in Egyptian tombs (e.g. Naqada, tomb 1480, Oxford, Ashmolean Museum). In the LBA ostrich eggs circulated throughout the Mediterranean as far as Mesopotamia. Later they are found in Etruscan tombs (Poplin 2000b) and in the Middle Ages the fashion of converting ostrich eggs into vases was revived. Lucas (1948, 49) mentions the use of ostrich eggshell for making jewellery (disc beads, pendants). Ostrich eggshell has been used in the decoration of Christian churches (Hagion Oros; Michailidou, personal communication).

[200] Lucas 1948, 5-7; Hodges 1964, 163.

[201] There is no evidence in Linear B, but this is a practice that persists to this day. We simply mention indicatively that during the years 1901 and 1902 24,200 and 38,750 eggs respectively were sent from Thessaly to the rest of Greece (*Diplomatic and Consular Reports, Annual Series. Trade and Agriculture of Thessaly for the Year 1901, 1902*, no. 2764, 12; no 2947, 14-15).

[202] There are several references to milk and its products in the ancient sources (Homer, Herodotus: *«ἐπεὰν δὲ ἀμέλξωσι τὸ γάλα, ἐσχέαντες ἐς ξύλινα ἀγγήια»*, Galen, Aristotle etc.). Aristotle in particular (*Historia Animalium*, 521b.20-523b.13) devotes a significant part of his text to describing the properties of milk, from the thinner of the camel to the thicker of the cow and especially of the sheep, as well as the manner of cheese production. Of the milk products butter, although in is mentioned by the ancient authors (Herodotus notes its productions by the Scyths), does not seem to have been used much in the Aegean, given that the dominant edible lipids were the olive and its oil. Moreover, the Scyths, as a people from further north,

was easier to store. Cheese is among the products that the Mycenaeans offered to the gods.[203] In the tablets it is indicated by the ideogram **156*.

Milk is measured by the capacity or volume of the vases –usually amphorae– in which it is carried. In Epirus there were cows that yielded up to one and a half amphorae of milk.[204] Cheese, in contrast, which was carried in baskets,[205] is counted in units: different officials offer successively to Poseidon 10 (heads), 5 (heads) and 5 (heads) of cheese (tablet **PY Un 718**).[206] The data from Modern Greece show that both cheese and butter are weighed (Table 5).

15. Beeswax and honey[207]

Honey was used in the diet –in various combinations– as hydromel or mead, mixed with milk,[208] as medicine, e.g. for eye conditions,[209] and for stock-raising. Wax was used in painting,

consumed more animal fats («*τὸ μὲν πῖον (τοῦ γάλακτος), ὃ βούτυρον καλέουσι*», Hippocrates, *Περί Νούσων*, IV.5) in the treatment of wounds: «*διαχρίουσι βουτύρῳ*» ('smear with butter') (Aelian, *De Natura Animalium*, XIII.7. In the *Book of the Eparch* there is reference to professionals in Constantinople who were involved with cheese and butter (Χριστοφιλόπουλου 1935). It is possible, however, that the use of butter as a foodstuff became generalized in the late 19th century. For recent times see *Ἑρμῆς ὁ Κερδῷος*, 295. For milk, its quality, its secondary products both in antiquity and more recent times, see Ryder 1983, 721-755 and 1994, 3-10, with special reference to the states in the Balkan Peninsula.

203 Ventris & Chadwick 1956, 51; Chadwick 1972, 181; 1973, 386, 392, 588; Palaima 1992b, 65; Palmer 1999, 467.

204 Aristotle, *Historia Animalium*, 522b.15-16, 522a.30; «*καὶ γαυλοὺς ἐμπλῆσαι βοῦς ἀγαθὸς ἐστί*» ('at filling the milk pail - at all these things the ox is excellent') (Aelian, *De Natura Animalium*, II.57).

205 Ventris & Chadwick 1956, 281. The authors note analogies between tablet **PY Un 718** and the Hagia Triada sarcophagus (LM III period), on which the preparation of a sacrifice is illustrated. They assume that the baskets could contain cheese ready for offering. See also «*τάλαρος, ἐνῷ ὁ τυρὸς ἐπιμελείας τυγχάμνει*»; Hesychius: 'the privately called cheese-baskets' (*τυροβόλια*); Schol. Aristophanes *Vespae*, 560; see also Panagl 1972, 76-81.

206 Ventris & Chadwick 1956, 282-283. The authors (p. 281) also mention a late 4th century BC inscription from Cos (*SGDI*, 3636-3638) 'twelve sheep cheeses' (*τυροὶ οἴεοι δυώδεκα*).

207 «*γλύκιστον ἐν ἀνθρώποις παρασκευάζον, τὸ μέλι*» ('sweetest of fruits that man has, namely honey'): Aelian, II.57; Aristotle, 551b, 553a.18-554b and Aelian, V.42 describe in detail the organized society of bees, the manner of collective feeding, construction of the beehive, reproduction, life cycle etc. Wax is a substance secreted from the abdominal glands of the worker bee and honey is the nectar of flowers, which is swallowed and regurgitated. Initially it is liquid and requires 20 days to thicken «*Συνίσταται δὲ τὸ μέλι πεπτόμενον ἐξ ἀρχῆς γὰρ οἷον ὕδωρ γίγνεται, καὶ ἀφ' ἡμέρας μέν τινας ὑγρόν ἐστι (διὸ κἂν ἀφαιρεθῇ ἐν ταύταις ταῖς ἡμέραις οὐκ ἔχει πάχος*» ('Honey becomes firmer as it matures: to start with it is like water and stays liquid for several days; hence, if it is taken off during that time it is thin') (Aristotle, *Historia Animalium*, 554a.6). Aristotle notes that the best honey is from thyme: «*Δῆλον δ' ἐστὶν εὐθέως τὸ ἀπὸ τοῦ θυμοῦ· διαφέρει γὰρ τῇ γλυκύτητα καὶ τῷ πάχει*» and that in Pontus there are bees that produce honey twice a month. In Amisos the honey is viscous and the bees produce it without a comb «*ποιοῦσιν αἱ μέλιτται ἄνευ κηρίων πρὸς τοῖς δένδρεσιν*». There are also bees that make triple combs in the earth (Aristotle, *Historia Animalium*, 554a.10; 554b.8-21). More recently the honey of Mt Hymettus was in great demand, and in general of Attica, Thessaly and the Cyclades (Siphnos, Kythnos, Andros: Σιμόπουλος 1970-1975). According to Pouqueville, in the Peloponnese during the 19th century apiary and wax production accounted for 0.08% of craft industrial activities, while according to Sakellariou this was 3.40%. In Gortynia, according to Pyrrhos of Thessaly, craft industrial products covered 3.50% of the production (Τσοτορός 1986, 88, 90).

208 Aelian, *De Natura Animalium*, XV.7. It was also mixed with wine; see H. Martlew, in *Μινωιτών και Μυκηναίων Γεύσεις*, 166, and P.E. McGovern, in *Μινωιτών και Μυκηναίων Γεύσεις*, 206ff.

209 «*εἰ γοῦν μέλιτί τις Ἀττικῷ τὴν χολὴν αὐτοῦ (τοῦ ἀετοῦ) διαλαβὼν ὑπαλείψαιτο ἀμβλυνόμενος, ὄψεται καὶ ἀξυτάτους γοῦν ἰδεῖν ἕξει τοὺς ὀφθαλμούς*» ('mix an Eagle's gall with Attic honey and rub

tanning, shipbuilding, bronze casting (moulds), coating writing tablets, mending objects.[210] Scenes of bee-keeping are preserved in the wall-paintings in the tomb of Pabesa in Egypt (late seventh - early sixth century BC).

On the tablets in Linear B script, significant quantities of honey are recorded, which was offered to the gods.[211] In palatial times the bee-keeper worked under the supervision of the *me-ri-da-ma-te*.

Honey was transported in amphorae[212] of ½ to 1 litre in capacity. Wax was weighed and recorded in units of weight.[213] In Greece more recently, honey and wax were weighed and the yields were measured in cantara or okas[214] (Table 6).

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it on his eyes, he will see and will acquire sighte of extreme keenness'): Aelian, *De Natura Animalium*, I.42. Lucas 1948, 7-8. In Egypt honey was used for embalming the dead; Hodges 1964, 162-163. During the Ottoman period guilds of candle-makers (*κηροποιῶν*) or wax-moulders (*κηροπλαστῶν*) appeared in towns of Northern Greece, such as Kozani (Καλινδέρης 1958, 26), Edessa (Σταλίδης 1974, 91-96; the author gives details of candle-making and the tools used) and Thessaloniki (Belilbaşi 1996, 67-84). In general the number of beehives in the territory of the Greek state was in 1873: 180,008; in 1874: 160,534; in 1875: 166,900 and in 1898: 500,000. Specifically, in Attica there were 17,000, in Chalkida 10,000, in Phthiotida 8,600 and in Evrytania 7,268 beehives (Αναστασόπουλος 1947, year 1877, 412; 1898, 747).

[210] Wilkinson 1992, 114-114. The author notes that honey was one of the most important products of Egypt, since it was used in the diet, in preparing medicaments and ointments. The beehives were cylindrical in shape. There were cylindrical beehives, about 3 feet high, 1 foot in diameter and with a movable lid, in the Peloponnese, as Beaujour describes them (Σιμόπουλος 1973, 698). Doumas (1988, 21) mentions a clay vessel from LBA Thera which was possibly associated with bee-keeping. In previous centuries, 18th and 19th, the beehives were woven baskets of wicker, chestnut or hazel, coated inside and out with clay. Fine branches were placed in the upper opening and covered with clay and straw (pisé) to protect the bees from the wind. In Thessaly the beehives were constructed of mud bricks. To protect the bees from the wind, a scrap of woollen cloth was hung in front of them.

[211] Cf. **KN Gg(1) 702**: to all the gods an amphora of honey, to the Potnia of the Labyrinth an amphora of honey; Chadwick 1972, 233; Ruipérez & Melena 1996, 166-167. The authors suspect that the honey wine was in fact mead (hydromel). Analytically for honey in Mycenaean times, see Μπουλώτης in press.

[212] **KN Gg(3) 717**: offering to Poseidon; **KN Gg(3) 705**: offering 1 amphora to Eileithyia and 1 ampohora to all the gods.

[213] Ventris & Chadwick 1956, 290-295 (**Ma** series from Pylos).

[214] In years of good harvest the yields in honey reach 3,000 cantari and in wax 2,000 cantari. The honey of Attica was famed of old: a hive with 4,000 bees yielded 6 litres of honey. The same hive produced 34 litres with double the number of bees. The four monasteries on Hymettus and their dependencies (*metochia*) had 6,200 hives, and private individuals had corresponding hives. The honey was exported to Constantinople, London and Marseille, and economically covered the balance of payments for overseas trade of the area (Σιμόπουλος 1973,698-699, on the basis of the detailed description by Beaujour). In the same period Chalkidiki exported 30-40,000 okas of wax and Thasos 25,000 okas, most of which was absorbed by various Italian cities and Marseilles (Σιμόπουλος 1973, 705). In the 18th century wax was also sent from Thessaloniki to Marseille. It was transported in sacks, e.g. 5 sacks of wax net weight 1,000 okas (Σβορώνος 1996, 122). In the early 18th century (P. de Tournefort, *Relation d'un voyage au Levant*, Paris 1717) Samos produced 200 cantari of honey and 100 cantari of wax (Σιμόπουλος 1970, 725). In the late 18th century the Peloponnese (X. Scrofani, *Voyage en Grèce fait en 1794 et 1795*, Paris et Strasbourg, an IX - 1801) exported 1000 cantari of yellow wax (Σιμόπουλος 1973, 644). In the late 17th century the harvest from Attica reached 360,000 litres of honey and 24,000 litres of wax. For a picture of production per hive, we note that according to data for the 19th century, each hive yielded 6 okas of honey and 100 dramia of wax.

Epilogue

This brief review of secondary animal products has shown the self-evident. There was full exploitation of all the anatomical parts or secretions of the animal in all cultures, from the Palaeolithic Age till the Industrial Revolution and even into the twentieth century, when new synthetic materials were produced which flooded the market. Otherwise, despite the technical progress that helped increase production and possibly made work easier, the same materials were used for millennia. In order to circulate they were counted (hides, horns), weighed (wool, hair, sinews, pieces of ivory, cheese, wax) and measured in volume (milk, honey). Which products were recorded in the earliest Greek archives and why? It emerges that the palatial economy was concerned first and foremost with controlling the production of wool, which was associated mainly with clothing and, secondarily, animal products used in making defensive or offensive weaponry (leather, sinews, horns). In third place came the raw materials and final products that are associated with luxury trade (ivory). Last, the offerings of cheese and honey to the gods, that is the indirect incomes of those directly serving the gods, are recorded.

These recordings also express clearly the trends of trade in Mycenaean Greece and are the canvas on which we are able to read and to reconstruct the economic picture of the period, beginning from the fixed points that we broached in our introduction, such as the kinds of raw materials, the environmental conditions and the level of technology.

In conclusion, we quote an excerpt from the *Commercial Encyclopaedia* written by N. Glykis from Ioannina and published in Venice in 1815: 'The Holy Scripture wishes to show us that pastoralism is contemporary with agriculture, by telling the story of Adam's two sons, the one a shepherd, the other a farmer; however pastoralism, being of a simpler nature was known first, and before this was hunting; and because these two are involved with animals, the one with wild, the other with domesticated, and offer to trade meat, fat, oil, skins, bones, wool, wings, milk, butter, cheese and the like, it is right to speak preparatorily about them for use by those studying Commerce'.

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Table 1. Raw materials and craft industrial use of animal products, excluding foodstuffs.

RAW MATERIAL	CRAFT INDUSTRIAL USE - FINAL PRODUCT
1. SUPPORT SYSTEM	
1a. (Bones, Horns)	Tool-making, Adornment, Inlay. Sheaths and accessories of weapons (daggers, swords, helmets). Musical instruments. Cohesive building material. Glue. Fuel.
1b. Carapace	Jewellery. Musical instruments. Inlays for furniture.
1c. Ostracoderm shell	Jewellery. Tools. Conches.
2. CONNECTIVE TISSUES AND NERVOUS SYSTEM (TENDONS, MEMBRANES, SINEWS)	Fibres for sewing. Musical instruments. Bags (askoi). Bow strings.
3. SKIN AND PRODUCTS OF THE CUTENIUS LAYERS AND CHORION OF THE SKIN	
3a. Skin	Pelts and raw skins/hides. Processed skin/hide (leather). Clothing. Footwear. Furniture. Defensive weaponry (cuirasses, shields). Equipment for chariots and pack animals (bridles, saddles), sacks, tools (thongs of prehistoric tools, bellows for metalworking). Musical instruments. Parchment/vellum.
3b. Animal fibres, hair. Wool.	Textiles. Clothing. Carpet-making. Rope-making. Tools (brushes). Building works.
3c. Teeth. Ivory	Tools, adornment, inlays in defensive and offensive weaponry (daggers, swords, helmets), in furniture, musical instruments etc.
3d. Feathers	Decoration. Fans. Carpets (Egypt).
3e. Keratinous coat (horns, hooves, keratinous plates of carapace)	Vessels, musical instruments, jewellery, furniture inlays, fuel.
4. VARIA	
4a. Fat	Lighting. Unguents. Wax. Cosmetics (soap, much later).
4b. Egg shells	Decorative material. Vases.
Egg white	Albumin (Egyptian wall-paintings).
4c Beeswax	Building material (wall-paintings, wood, gypsum). Shipbuilding. Art works in bronze or other materials. Coating on writing tablets etc.

Table 2. Average quantity and weight of the hides which were exported during the year 1898 from Piraeus (*Diplomatic and Consular Series, Annual Series no. 2225, Trade and Agriculture of the Piraeus for the year 1898*, Foreign Office, London 1899).

TYPE OF HIDES	QUANTITY OF HIDES	AVERAGE WEIGHT PER 100 PIECES (KILOS)
Lamb	250,000	80
Sheep	25,000	90
Goat	50,000	120
Kid (1st quality)	40,000	27
(2nd quality)	40,000	50
(3rd quality)	50,000	60
TOTAL	455,000	-

Table 3. Indicative examples of the production and circulation of animal skins/hides in Greece, from the late 18th to the early 20th century (N.B. 1 kilo - 22 okas).

PLACE	PERIOD	KIND OF SKIN/HIDE	TOTAL NUMBER PER ANNUM ('PIECES')	TOTAL WEIGHT PER ANNUM	TANNING	IMPORT	EXPORT	SOURCE
Peloponnese (mainly the banks of the river Pamisos, near Messini: locality Nisi)	1783 1784 1785 1786 1787 1788 1789 1794-1795	Ox (few), buffalo, fleece, nanny goat, billy goat	32,200 48,480 18,900 12,125 103,725 11,785 369,155 80,000	- - - - - - - -	- - - - - - - -		France via Italy	Κρεμμυδάς 1972
Central Greece Amphissa (Salona, Charmaina quarter)	1796	processed leather of nanny goat or billy goat (Morocco)	40,000	-	10			Ασδραχάς 1964; Παππάς 1979

Table 3. (Continued).

PLACE	PERIOD	KIND OF SKIN/HIDE	TOTAL NUMBER PER ANNUM ('PIECES')	TOTAL WEIGHT PER ANNUM	TANNING	IMPORT	EXPORT	SOURCE
Thessaly Larisa, banks of the Peneios	18th century	ox, buffalo	-	-	-			Γουργιώτη 1985
Islands Syros, beach of Hermou-polis	1832-1857 1827 1851 1852 1870 1871 1872 1873 1874	wet or dry skins/hides (ox, nanny goat, processed leather of nanny goat or billy goat (Morocco), processed leather of young steer (*vaketa*)	27,500 50,000 220,000	528,825 kg. 258,869 okas 215,509 okas 376,827 okas 309,792 okas	5-6 12 7 10	Argentina France Englnd Turkey	Rest of Greece Turkey Rgypt West Europe	Καρδάσης 1987 Αναστα-σόπουλος Α', 344-345 Καρδάσης 1987
Lesbos coastal areas (Gera)	1885 1890 1892 1894 1909 1913			150,000 kg. (hides)	13 9 16 17 17			Σιφναίου 1996
Macedonia	1907-1911	sheepskin, fleece, goatskin	705,000 600,000 350,000					Μισταρδής 1928
West and Central Macedonia	1914	hare, fox, wild cat, badger, ferret, weasel, otter, wolf, jackal	200,000 10,000 2,000 3,000 4,000 1,000 500 600 2,000					Αναστα-σόπουλος Β', 1935

Table 4. Exports of skins/hides from areas with important harbours, in the Greek State in the late 19th and the early 20th century, to Europe, mainly the Austro-Hungarian Empire, Germany, Italy, Turkey and the rest of Greece. The data are based on the *Annual Series, Diplomatic and Consular Reports, of the Foreign Office, London*. N.B. 1 kilo = 22 okas, 39½ okas = 1 imperial cwt.

PLACE	YEAR	TYPE OF SKIN/HIDE	TOTAL NUMBER OF PIECES	TOTAL WEIGHT	DOCUMENT NO.
Piraeus	1890	hides and skins		33,017 okas	1099
	1893	tanned hides		2,031 cwts	1527
	1894	tanned hides		1,744 cwts	1527
	1895	tanned hides		1,235 cwts	1694
	1898	hides	455,000		2225
Patras	1895	sheep skins	20,000		1500
		lamb	400,000, 530,000		1500
		goat	10,000		1500
		kid	100,000		1500
Volos	1885	hides		593 cwts	98
		skins		2,986 cwts	98
	1886	hides		891 cwts	98
		skins		2,000 cwts	98
	1900	tanned hides		381 cwts	2557
		raw hides	133,947	-	2557
	1901	tanned hides		823	2764
		raw hides	271,639	-	2764
	1902	tanned hides		1,016 cwts	2947
		raw hides	248,303		2947
Thessaly	1904	tanned hides		748 cwts	3361
		raw hides		5,019 cwts	3361
	1905	tanned hides		873	3617
		raw hides		4,923	3617
	1906	tanned hides		1,211	3818
		raw hides		5,325	3818
	1907	tanned hides		1,409	4034
		raw hides		5,341	4034
Magnesia	1908	tanned hides		12 cwts	4492
		raw hides		4,301 cwts	4492
	1909	raw hides		4,006 cwts	4492
	1910	raw hides		4,298	4731
	1911	raw hides		5,244 cwts	4929
	1912	raw hides		2,547 cwts	5429
	1913	raw hides		2,701 cwts	5429
Crete	1901	goat and sheep skins	136,423		2932
	1902	goat and sheep skins		210 tons	3097
	1901-1905	goat skins	183,089		4056
	1905	goat skins	206,560		3828, 4056
	1906	goat skins	259,687		3828, 4056
	1908	goat skins	152,608		4603
	1909	goat skins	214,134		4603
	1910	goat skins	190,854		4776
	1911	goat skins	197,576		4982
	1912	goat skins	236,354		5393

Table 4 (Continued).

PLACE	YEAR	TYPE OF SKIN/HIDE	TOTAL NUMBER OF PIECES	TOTAL WEIGHT	DOCUMENT NO.
Corfu	1907	hides	4,504	-	4458
		sheep skins	8,145		4458
	1908	hides	3,286		4458
		sheep skins	8,224		4458
	1909	cow hides	3,254		4458, 4484
		sheep skins	11,262		4458, 4484
	1910	cow hides	2,148		4484
		sheep skins	8,152		4484
	1911	cow hides	5,144		4668
		sheep skins	7,266		4668

Table 5. Exports of quantitites of cheese from Attica or Thessaly (or parts of them), mainly to the rest of Greece and secondarily abroad, in the late 19th and the early 20th century. In the years 1900-1907 all the production not consumed by the local population is included. Source: *Annual Series, Diplomatic and Consular Reports on Trade and Finance in Greece, Foreign Office*, London.

AREA OR PORT	YEAR	WEIGHT	DOCUMENT NO.
Volos	1885	95 cwts	98
Volos	1886	100 cwts	98
Piraeus	1890	135.149 okas	1527
Thessaly	1900	2,000 cwts	2557
Magnesia	1901	1,671 cwts	2764
Thessaly	1902	6,893 cwts	3148
Thessaly	1903	6,465 cwts	3148
Thessaly	1904	4,176 cwts	3361
Thessaly	1905	6,965 cwts	3617
Thessaly	1906	6,434 cwts	3818
Thessaly	1907	8,737 cwts	4034
Magnesia	1908	57 cwts	4492
Magnesia	1909	1,559 cwts	4492
Magnesia	1910	1,366 cwts	4492
Magnesia	1911	602 cwts	4492
Magnesia	1912	1,505 cwts	4492
Magnesia	1913	1,540 cwts	4492

Table 6. The production of honey and wax in Greece in the late 19th century (the weight is given in okas) (Αναστασόπουλος 1947, vol. A, year 1877, 412).

YEAR	NUMBER OF HIVES	HONEY	WAX
1870		104,043	2,871
1871		59,200	2,182
1872		102,949	2,770
1873	180,008	76,599	1,140
1874	160,534	52,705	1,172
1875	166,900	117,416	911

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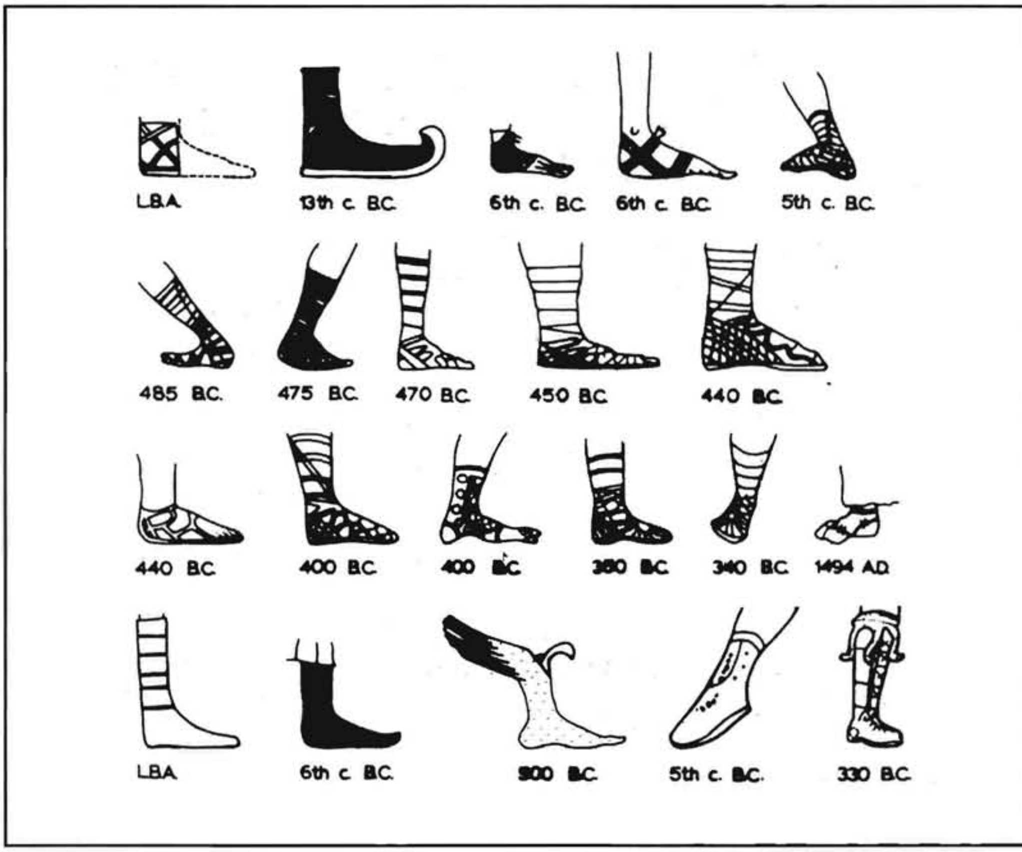


Fig. 1. The development of male footwear from the Late Bronze Age till the 15th century AD. The drawings are of characteristic types found in the iconography (vases, icons) and sculpture.

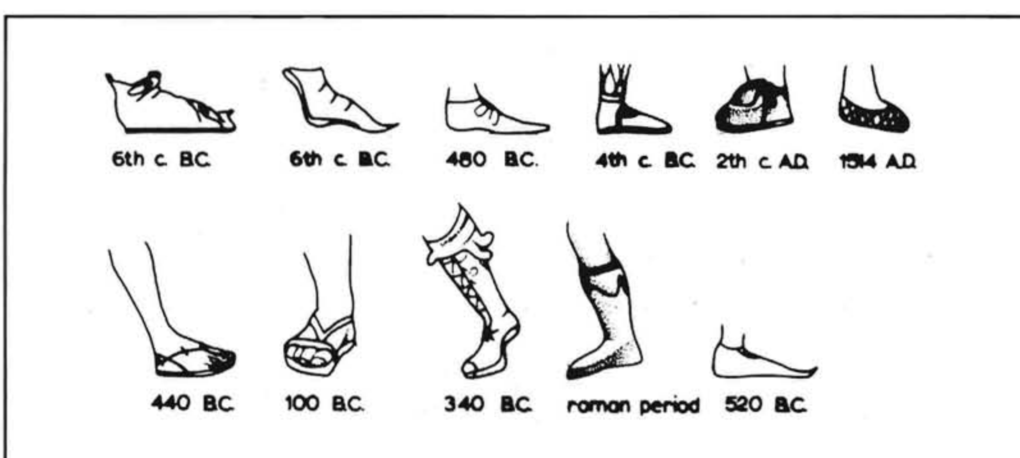


Fig. 2. The development of female footwear from the Archaic period till the 16th century AD. The drawings are of characteristic types found in the iconography (vases, icons) and sculpture.

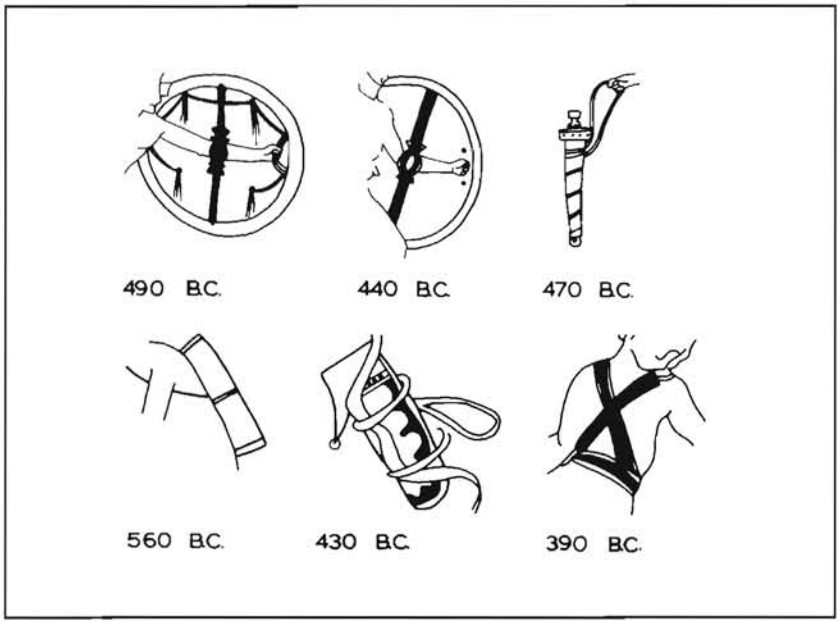


Fig. 3. The use of leather straps in defensive and offensive weaponry. Drawing of details depicted in Attic vase-painting.

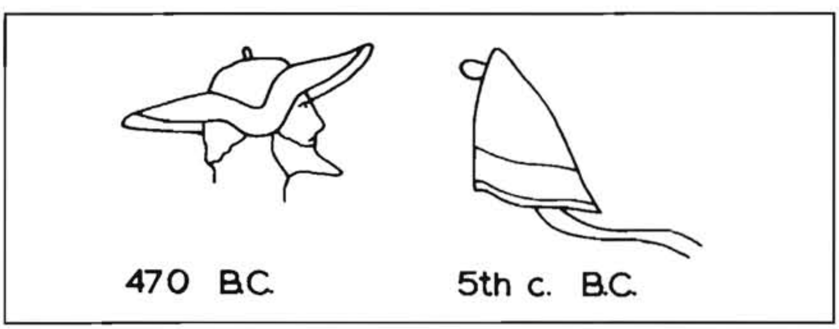


Fig. 4. The use of leather in dress (*πέτασος* = brimmed hat, *πῖλος* = cap). Drawing of male head-coverings depicted in Attic vase-painting.

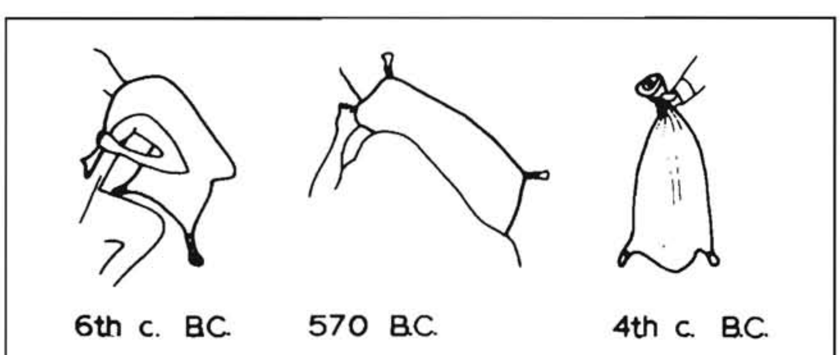


Fig. 5. Skin flasks (*ἀσκοί*). Drawing of wineskins depicted on Greek vases.

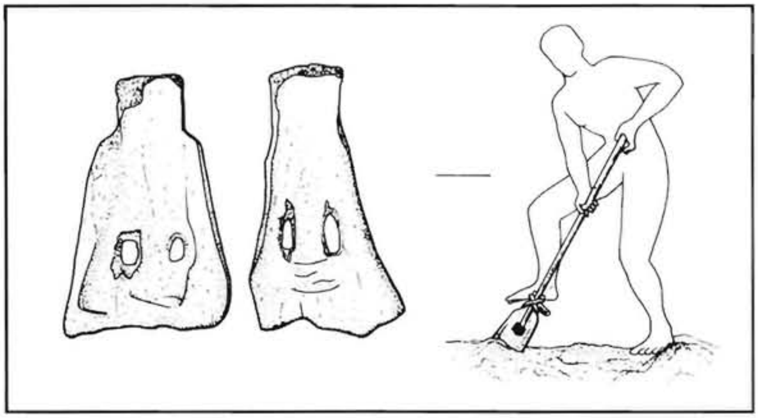


Fig. 6. Using a scapula as a farming tool (China).

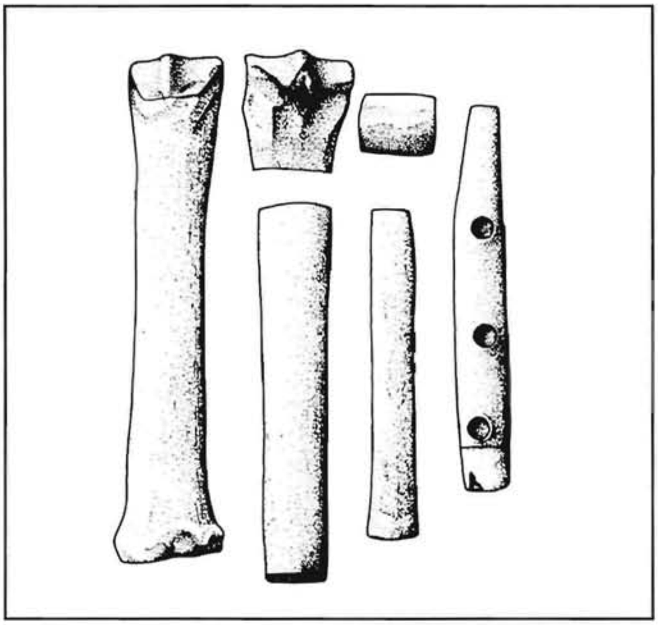


Fig. 7. Making flutes from horse metapodia.

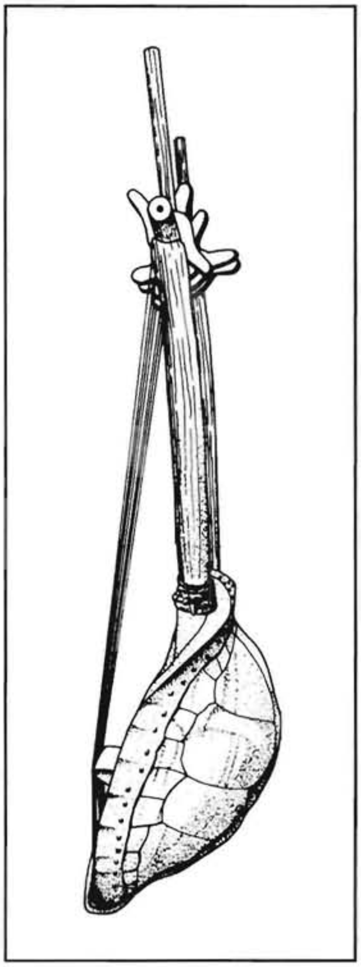


Fig. 8. Reconstruction of a lyre.

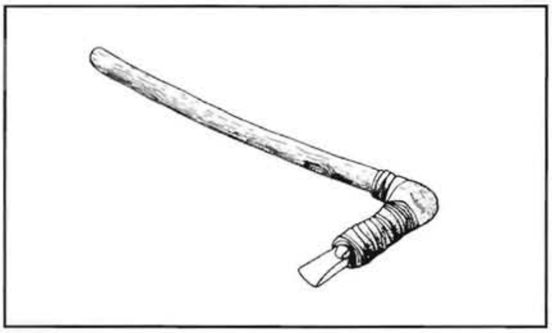
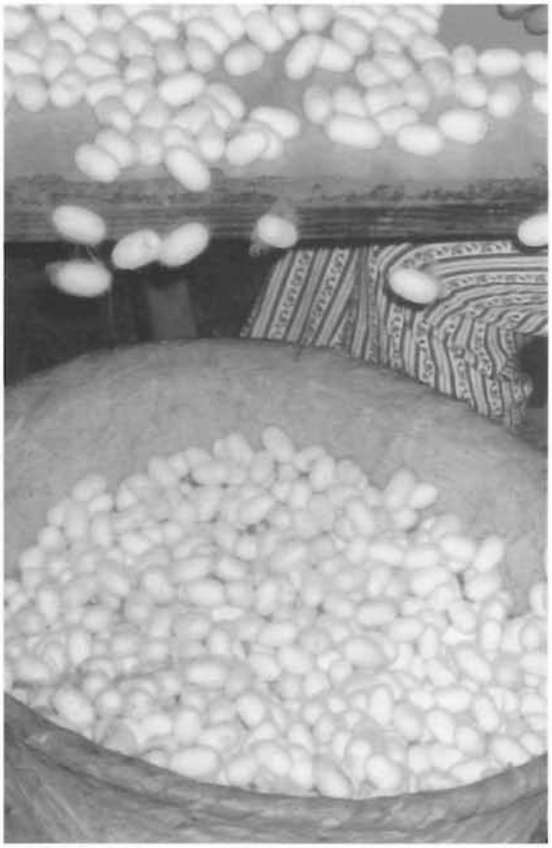


Fig. 9. Thongs used on a tool (Alps, Bronze Age).

a



b

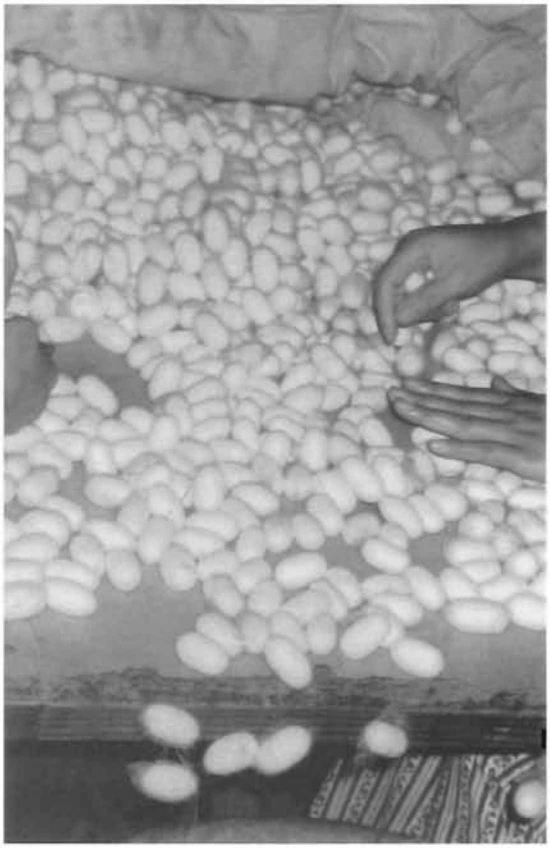


Fig. 10. Selecting cocoons in a handicraft industry in modern Beijing, China (photo K.Trantalidou).

Fig. 11. Stretching the silk fibres in a handicraft industry in modern Beijing, China (photo K. Trantalidou).

Fig. 12. Modern tools for carving ivory. Canton Museum, China (photo K. Trantalidou).

Potteries in Margarites, Crete: the storage of mass-produced vessels according to type and size (collection of postcards of Ch. Boulotis). It resembles an illustration of a field in a modern electronic database.

APPENDIX
THE DATABASES ON THE QUANTITIES RECORDED IN LINEAR B TABLETS

Alkis Dialismas

INTRODUCTION

'The originality (and importance) of the research proposal lies in the fact that it introduces the parameter of quantity in the general debate concerning production, trade etc. ... The goal of the research is also very specific: which of the exchangeable goods (and raw materials) of the period's technology are weighed and what quantities are referred to (in the tablets)..., and also by what methods the result of the counting is recorded'.

This abstract comes from the detailed text of the research proposal that was submitted by Dr Anna Michailidou to General Secretariat for Research and Technology, for the approval of this programme. It sheds light on the starting point and foundations of the research, i.e. what is weighed, how is this recorded and in what quantities. The first step for the successful accomplishment of the research is the collection of the evidence from the Linear B tablets and their classification in a way that helps the processing. The selection of relevant books and articles from the bibliography concerning the subjects of metrology, Aegean scripts and the economy of ancient world is of equal importance.

The management of this great volume of material would have been very difficult without the use of an electronic database. It was more than obvious that the needs of this research would have been better served by a database that could provide the ability for classification, grouping and specific selection of various kinds of information. It needed also to be flexible enough to be adapted to the special requirements of Linear B.

1. SELECTION OF DATABASE

The first and most distinctive feature of the database needed to be flexibility and the ability for quick and easy intervention. It has already been mentioned that the material is massive and of rather great variability. That means that no matter how wisely the database was constructed from the beginning and, at the same time, no matter how much effort was spent to foresee all the possible varieties of records, it was highly probable that we would have to make changes in the structure of the database (for example, to add new fields or to create new tables/catalogues with supporting evidence which might attract our attention on the course of the research).

A second major need was the ability to make queries and pose questions: the amount of data, the combination of raw material, final product and quantity compels us to pose complicated queries, to cross-check the evidence from different tablets and archives and possibly to use mathematical and statistical functions in order to shape a better view of the fragmented information of the tablet.

Finally, a third prerequisite was that the database could be disseminated easily and widely in the world of researchers. Right now the body of data that has been collected is certainly useful and permits the extraction of some conclusions. However we hope that this programme will be refunded in order to make it possible to record the rest of the goods as well, the ways that they are counted and their quantities. The accomplishment of such a goal will assemble an electronic database with a combination of information of value for the researcher under the condition that the structure of this database will be easily accessible and understandable.

By summing up these requirements, i.e. a flexible database, capable of posing questions and queries and widely disseminated and relatively easy to use, we arrived at the MS Access. This is a database, that with a little help from an expert,[1] could become a very useful tool for the researcher. It works in both a PC and a Macintosh environment, and since it is supported by Windows can be widely used. As we shàll see it is a very flexible programme and permits various changes at any time. One of the most important advantages is its ability to ask questions, construct queries (simple and combined) and group the data. On the other hand the ability to publish the Access database with Excel multiplies our choices for mathematical and statistical questions. Finally a database of Access can also be published with Word, providing many options for formatting the text.

2. Contents and Function of the Database

The main goal of the database was: a) to analyse the tablets based on the components that interest us, i.e. raw material / final product / quantity and b) to concentrate all comments, concerning of course the same components, that have been written by the researchers of Linear B or others. Consequently the database should first give a table with fields containing: a) subjects from the tablets (for example products, quantities, terms for offices or economy), b) the identity of the tablet, c) comments concerning its contents, references and remarks.

Because of the bulk of the data and the need for quick and easy classification it has been judged appropriate to divide the information into more than one table. We created four tables[2] (I-IV, see Fig. 1), one for the identity of the tablet under research (called Tablet - *Πινακίδα*), one for raw materials –as we said, only for these that were weighed or were possibly weighed– (Raw Material - *Πρώτη Ύλη*), one for products that are produced (even partly) from weighed raw materials (Final Product - *Τελικό Προϊόν*), and, finally, a table containing comments that other researchers have made on these tablets (Bibliography - *Βιβλιογραφία*). These tables can function as totally independent creations, as small databases. Moreover, the four tables can function as a large, unified table. That means that the user of the database can simultaneously search, combine data, gather them together and build with them new tables, from two or more of the old ones or parts of them. Thus we avoid both overloading the main table with data and distending it with

[1] At this point we should thank the computer expert that was co-operating with K.E.R.A., Mr V. Frangopoulos, for his valuable help in technical problems, for his splendid introduction to the subject of MS Access and databases in general and, of course, for his boundless patience and understanding. Working with him proved that co-operation between computer experts and archaeologists could be very productive if both sides are willing and if they have the basic knowledge of archaeological needs and the computer respectively.

[2] The term 'table' in a MS Access database represents the area, the form and the structure in which the data are stored, and it should not be confused with the meaning of 'table' as picture or schematic way of presenting data.

too many fields (reducing difficulties in bringing the tables up to date and helping in shaping the data, their distribution in the database, their processing and leaving space for future additions). Of course every table or query can be presented on the screen or printed on paper, in many ways.

2.1. Detailed description of the tables (Fig. 1)

2.1.1. Tablet (Tables 1, 7)

This table, as previously mentioned, forms the 'identity' of the tablet. It contains only three fields: the number of the tablet and two fields for key words. Our ambition for the future, if the proper opportunity occurs, is to enrich this table with the full text of the tablet, philological comments and pictures or drawings of the tablet.

The first[3] field contains the full number of the tablet under question, as presented in the most recent edition of the corpus of every archive, for example **KN Ga(1) 678** + *fr.*, **PY Tn 316** etc. The second and the third field contain key words, intended to help in grouping, classifying and searching. The terms that are used as key words are the names of raw materials and products referred in the tablets, and financial and professional terms. They are cited both by their Latin transcription and their Greek translation (for example *ka-ko* - *χαλκός* (copper), *ka-ke-we* - *χαλκεῖς* (smiths), etc.). When the Mycenaean word is not fully preserved, it is completed if it is safe (for example *po-ni-ki* is turned into *po-ni-ki-jo*). The translation is as close as possible to the Mycenaean term, provided it is understandable in this way, using always help from other works, like *Docs²*, *Hooker 1994*, *Ruipérez & Melena 1996*, etc. In cases where the meaning of the Mycenaean word is either not known or very doubtful, the term remains without translation. In cases where we know the kind of the object but not its exact name, a general term is cited, for example *a-te-we* - *vase* (*άγγεῖο*).

2.1.2. Raw material and final product (Tables 2-3, 8-9)

The tablets that are chosen to be included in the database, are not cited as pure text –because in this way we would not be able to focus on our interests–, but they are analysed in terms of raw material, final products and quantities. As will be seen from the structure of the tables every sheet of data is dedicated not to a whole tablet but to a single record (of raw material or final product) of the tablet. Thus if a tablet contains five records it will consist of five sheets of data in the Final Product table. By shaping the database in this way we can treat the commodities that concern us both as part of a tablet and independent records. Moreover we are neither affected by the phenomenon of the multiple records of a product in the same tablet –which is very common in the Linear B texts– nor forced to repeat the whole text of the tablet for each record. So the structure of the two tables, one for raw materials and one for final products, is the following:

The first field is called Commodity (*Αγαθό*) and concerns the raw material recorded in the tablet or used to construct the product that is recorded. The term is always written down in modern Greek; the Mycenaean word for it, if it is recorded, it is cited in the next field.

This second field is called Raw Material (*Πρώτη Ύλη*) or Final Product (*Τελικό Προϊόν*) respectively to the table (this is the only difference between the two tables), and we cite here the Mycenaean name of the raw material or final product, both in Latin transcription and Modern Greek translation.

[3] The real first field of every table contains the auto-numbering of the records, an element that is necessary for the correct function of the database but has nothing to do with the research.

The third field, named Special Features (*Ειδικά Χαρακτηριστικά*), is filled in not only with characteristics of the recorded commodity (for example the colour of a textile) but also with terms that assign the object of the record to financial transactions or dealings (for example if it is a debt or if it is distributed through a certain distribution system - *ta-ra-si-ja*, etc.).

The fourth field concerns the rest of the commodities that are recorded in the same tablet and it is naturally called Other Commodities (*Άλλα αγαθά*). This field permits us to form an overall idea of the tablet that contains the studied record.

The next field is called Line (*Στίχος*) and it contains the number of the line of the record.

From this point a series of field was created concerning the units of measurement used in Linear B. Each field is equivalent to one unit (*L*, *M*, *N* etc.) and it is filled in with a number according to the quantity that accompanies the commodity of the record (if for example we have the record *AES M* 1 *N* 2, the field-units *M* and *N* are completed with the numbers 1 and 2 respectively). Thus, numbers are connected to their units and they can also function independently in the finally applied system. This situation enables us to group and analyse the quantities recorded in Linear B through the statistical abilities of Access and –most important– of Excel. Right now there are 25 fields reflecting 25 units or ways of recording quantity. Our first priority is of course the methods of weighing and counting but we have also introduced the basic methods of measuring volume, and fields for special cases –if the unit is not preserved we use the field Unknown (*Άγνωστη*) or if the ideogram of the commodity symbolises the largest unit Commodity-Unit (*Μονάδα-Αγαθό*). New units are easily added whenever needed thanks to Access flexibility. This means that if this research programme is further funded to be expanded to commodities that are measured in volume or are simply counted, there will be no need for the creation of a new database but the work can be continued on the one already constructed.

The penultimate field is called Tablet (*Πινακίδα*) and contains the full number of the tablet, while the last field is named Comments (*Παρατηρήσεις*) and is completed with remarks on any unclear parts of the record, with comments concerning our possibly insufficient knowledge of the commodity, etc.

These three tables form the part of the database that is based on information from the archives, the tablets. Its design provides the possibility for change and addition if necessary. However, the most important aspect is that it favours the expansion of the database to other areas of interest (like raw materials or products that are measured by volume) or the addition of even more information. A good example of this is the experimental addition made during the last three months of the programme. We decided to create a new table that contains the professional groups and the offices recorded in Linear B.[4]

This table V (Fig. 1), called Profession (*Επάγγελμα*), although not necessary for the processing of the subject of the research, is certainly a valuable help. It contains (see Table 5) the number of the tablet and nine –so far– fields referring to professional or administrative sectors: stock breeding (*κτηνοτροφία*), textiles (*υφαντουργία*), tanning (*βυρσοδεψία*), agriculture (*καλλιέργεια-μεταποίηση*), metallurgy (*μεταλλουργία*), crafts (*άλλοι τεχνίτες*), services (*υπηρεσίες*), hunting-beekeeping (*θήρα-μελισσοκομία*), offices (*αξιώματα*), and finally a field for comments (of the same nature as the other tables). In these fields we filled in professionals and officers, in the appropriate fields, recording the Mycenaean term and its translation, wherever possible. In this case each form of data corresponds to a tablet not to a record.

[4] This table has been formed and completed by Katerina Voutsa, who is currently doing her Ph.D. in the University of Athens related to professional groups in Linear B, and she is the writer of the relevant chapter in this volume.

All the data of this table related to records of the other tables (i.e. professions and offices that accompany records of raw materials and finished products), have been already recorded either as special features and/or as key-words in the table *Πινακίδα* (I). The data of this table are not, therefore, indispensable for the purpose of the current research. However it is good to have knowledge of the professional groups that coexist in the archives. This table can easily be combined with the others or be attached to them. It is also a guide for imagining and creating other tables containing financial, geographical terms, names etc., helping us to realise how useful and effective this or any other database for Linear B could be in the future.

2.1.3. Bibliography (Tables 4, 10)

In this section we have started collecting comments of researchers relating to raw materials, products made of them, ways of measurement, and also some comments concerning on economy, trade exchange and financial administration of the Mycenaean world, as they emerge from Linear B tablets. The final goal of the database would be to work as an electronic 'anthology' of the above bibliography.

The structure of the table is the following. The first three fields concern information about the identity of the book or article that contains the comment and an abbreviation which is connected with the same abbreviation in the bibliographical database (see below). The fourth field contains the number of the tablet for which the comment has been written (and represents the link with the other tables of the database). Through these fields we define the identity of the comment, i.e. who made it, where and for what tablet.

Next follow the fields that describe the contents of the comment. First there are four fields which inform us whether the comment contains the text of the tablet and, if it does, in what manner: in Latin transcription, in ancient Greek or translated with any modern language.

The following field is called Special Bibliography (*Ειδική Βιβλιογραφία*) and refers to bibliographical notes that are in the comment, concerning our research interest.

Then there are three fields that are addressed to the comment itself. In the first we cite the comment. The citation is in the language of the abstract, in quotation notes and we mention the number of the page. The next field is intended to contain a summary of the comment in cases where the last one is too large or it contains information of less importance for our research. Then there is another field for various remarks (for example correction of the number of a tablet if the author uses an old numbering).

The last field contains the name of the researcher who provided the remarks.

From the above it becomes clear that each sheet of data in the table Bibliography refers to each tablet that is contained in the comment selected from a book or an article. This means that if three tablets are mentioned three sheets of data will be completed, containing the same comment (actually the only difference in these almost identical sheets will be the number of the tablets). This permits us to gather together everything that has been written for one tablet.

3. The Database for Bibliography (Fig. 2, Table 6)

The creation of a more general bibliographical database, not necessarily attached to the Mycenaean tablets but focusing to the central aim of our research, proved to be much more easier in construction than the main database, since its content was simpler and it proved possible to find many examples of electronic bibliographical databases. For reasons of co-ordination it has been decided to follow the form of the electronic database of the Centre for

Greek and Roman Antiquity of the National Hellenic Research Foundation with small changes in order to adapt the database to our needs. MS Access was again used in order to have the same facilities and make the two databases compatible.

Briefly, it should be mentioned that the main table of the bibliographical database consists of 21 fields which contain classical fields for bibliographies such as for authors, titles, date of publication (separate fields for monographs or periodical reviews, etc.), place of publication, editors, numbers of pages, translators, abbreviation, and other more specific fields concerning key-words, and a small summary of the contents.

4. Conclusions - Perspectives

The accomplishment of the two-year period research programme of K.E.R.A. 'Prehistoric Technology and Exchange: Counting, weighing and recording raw material and final product' produced among other things two electronic databases. The first, the main database, contains more than 1,300 tablets, the total number of the tablets offering information on weighing and counting raw materials and their products, processed as described above. Analysis of them produced more than 1,700 records of raw materials and 1,300 of final products. At the same time the database is accompanied by a bibliographical archive of comments and theories relating to the research interests; this archive, still in progress, contains to date more than 350 records. The second database, the bibliographical one, provides an overall view of the subjects of the research with regard to the way it is presented: summaries, key words, etc.; these elements, which have been used many times before for electronic bibliographical databases, and the 800 current records constitute a great help for the archaeologist seeking evidence from the written sources of the Aegean world.

The Linear B archives form the best source of information for the economic conditions of Late Bronze Age Aegean and a database in which the economic elements of the archives are collected and analysed, is a valuable aid to research. Its contribution is obvious from the tables that are incorporated in some of the articles in the second part of this volume. Moreover we present here a series of tables (1-11) concerning subjects of raw materials and final products that are representative of the possibilities of the K.E.R.A. database, if future funding permits its continuity.

MAIN DATABASE: TRAPEZA

Table I: Tablet
- [Autonumber]
- Tablet
- Key-words 1
- Key-words 2

Table II: Raw-material
- [Autonumber]
- Commodity
- Raw-material
- Special feature
- Other commodities
- Line
- Unit-L
- Unit-M
- Unit-N
- Unit-P
- Unit-Q
- Unit-QI
- Unit-RO
- LANA
- PA
- Unit-T
- Unit-S
- Unit-V
- Unit-Z
- GRA
- *155vas/Basket
- Unit-commodity
- Number
- MU
- MO
- ZE
- AROM
- AROM+PYC
- PE
- DE
- Unknown
- Tablet
- Comments

Table III: Final-product
- [Autonumber]
- Commodity
- Final-Product
- Special feature
- Other commodities
- Line
- Unit-L
- Unit-M
- Unit-N
- Unit-P
- Unit-Q
- Unit-QI
- Unit-RO
- LANA
- PA
- Unit-T
- Unit-S
- Unit-V
- Unit-Z
- GRA
- *155vas/Basket
- Unit-commodity
- Number
- MU
- MO
- ZE
- AROM
- AROM+PYC
- PE
- DE
- Unknown
- Tablet
- Comments

Table IV: Bibliography
- [Autonumber]
- Author
- Article/Book
- Abbreviation*
- Tablet
- Latin transcription
- Greek transcription
- Translation
- Content
- Special references
- Comment of author
- Summary
- Remarks
- Compiler of datasheet

*Links this table with the database of bibliography.

Table V: Profession
- [Autonumber]
- Tablet
- Stockbreeding
- Textiles
- Tanning
- Agriculture
- Metallurgy
- Other craftsmen
- Services
- Hunting & beekeeping
- Offices
- Comments

Fig. 1. Structure of the main database.

BIBLIOGRAPHY

[Autonumber]	Translator	Pages
Author/s	Publisher	Abbreviation*
Title of book or article	Title of journal/review/edited volume/series	Summary-Remarks
No of volumes	Editor of volume/series	Key-words
Publication place	Volume_no	Compiler
Publication year	Issue_no	Date of entry
Editor	Issue_year	Last modification

*Links this database with the table IV (Bibliography) of the main database

Fig. 2. Structure of the database for bibliography.

Table 1. The first tablets entered in the database (tablets recording perfumes). From left to right the serial number, the full number of the tablet, key-words (1) emerging from the text of the tablet and general key-words (2) concerning the interests of the research programme.

A/A	ΠΙΝΑΚΙΔΑ	ΛΕΞΕΙΣ - ΚΛΕΙΔΙΑ 1	ΛΕΞΕΙΣ - ΚΛΕΙΔΙΑ 2
1	KN Ga(2) 427 + 8102	o - όφελος, a-pu-do-si - απόδοση, po-ni-ki-jo - φοινίκιο	φοινίκιο, αρωματικό (;), βαφική ύλη (;), οικονομία
2	KN Ga(2) 426	po-ni-ki-jo - φοινίκιο	φοινίκιο, αρωματικό (;), βαφική ύλη (;)
3	KN Ga(2) 7426	po-ni-ki-jo - φοινίκιο	φοινίκιο, αρωματικό (;), βαφική ύλη (;)
4	KN Ga 461	o-pe-ro - όφελος, CYP - κύπερος, a-pu-do-si - απόδοση	κύπερος, αρωματικό, οικονομία
5	KN Ga (3) 465	ku-pa-ro - κύπερος	αρωματικό
6	KN Ga(1) 518	a-pu-do-si - απόδοση, AROM+PYC - κύπερος	αρωματικό, οικονομία
7	KN Ga(1) 519	ku-pa-ro - κύπερος, *171, a-pu-do-si - απόδοση	κύπερος, αρωματικό, *171, οικονομία
8	KN Ga(1) 674	ko-ri-ja-do-no - κορίανδρος, pe-ma - καρπός, ma-ri-ne-we, AROM - αρωματικό	κορίανδρος, αρωματικό, ιδιότητες προσώπων
9	KN Ga (1) 675	wa-na-ka-te - του άνακτα, pe-ma - καρπός, AROM - αρωματικό	αρωματικό, κοινωνία, οικονομία
10	KN Ga(1) 676	ko-ri-ja-do-no - κορίανδρος, AROM - αρωματικό	αρωματικό
11	KN Ga(1) 677 + 7769	AROM - αρωματικό	αρωματικό
12	KN Ga(1) 678 + fr.	ko-ri-ja-do-no - κορίανδρος, AROM - αρωματικό	αρωματικό

Table 2. Datasheet which records raw material (*πρώτη ύλη*) listed in the tablets.

α/α: 764

Αγαθό: *142

Πρώτη Ύλη: *142

Ειδικό χαρακτηριστικό:

Άλλα αγαθά: *150, CAPf - αίγα, CORN - κέρας, OVISf - προβατίνα

Στίχος: .B

Μονάδα-L: 0	**Μονάδα-T:** 0	**Μον.-αγαθό:** 0
Μονάδα-M: 6	**Μονάδα-S:** 0	**Αριθμός:** 0
Μονάδα-N: 0	**Μονάδα-V:** 0	**MU:** 0
Μονάδα-P: 0	**Μονάδα-Z:** 0	**MO:** 0
Μονάδα-Q: 0	**GRA:** 0	**ZE:** 0
Μονάδα-QI: 0	***155vas/Basket:** 0	**AROM:** 0
Μονάδα-RO: 0		**AROM+PYC:** 0
LANA: 0		**PE:** 0
PA: 0		**DE:** 0
		Άγνωστη: 0

Πινακίδα: KN Mc 1508 + 1564

Παρατηρήσεις συντάκτη: Άγνωστη η ερμηνεία του ιδεογράμματος. Οι Ruipérez & Melena, 1996 (254) προτείνουν ότι συμβολίζει τους τένοντες.

Table 3. The tablet **PY Sh 734** (with records of armours) as analysed record by record in the database. Due to lack of space the rest of the units have been omitted (cf. Table 2). Tables 2 and 3 show respectively the way in which a single record and a whole tablet are analysed in the database.

Α/Α	ΠΙΝΑ-ΚΙΔΑ	ΣΤΙ-ΧΟΣ	ΑΓΑΘΟ	ΤΕΛΙΚΟ ΠΡΟΪΟΝ	ΕΙΔΙΚΟ ΧΑΡΑΚΤΗ-ΡΙΣΤΙΚΟ	ΑΛΛΑ ΑΓΑΘΑ	ΑΡΙΘ-ΜΟΣ	ΠΑΡΑΤΗΡΗΣΕΙΣ ΣΥΝΤΑΚΤΗ
163	PY Sh 734	01	χαλκός (;), δέρμα (;), λινάρι (;)	ARM - θώρακας		O - o-pa-wo-ta - ελάσματα (;), PA - παραγνα-θίδα	1	Οι πινακίδες θωράκων κατα-γράφονται γιατί ενδεχομένως αποτελούνται και από προϊόντα που ζυγίζονται (*Docs*[2], 375-378, 379-380, 522-523).
164	PY Sh 734	01	χαλκός (;)	O - o-pa-wo-ta - ελάσματα (;)	me-zo-a_2 - μείζονα	ARM - θώρακας, PA - παραγνα-θίδα	22	Οι πινακίδες θωράκων κατα-γράφονται γιατί ενδεχομένως αποτελούνται και από προϊόντα που ζυγίζονται (*Docs*[2], 375-378, 379-380, 522-523). Ειδικά για τη λέξη o-pa-wo-ta = ελάσματα, δισκία βλ. *Docs*[2], 376.
165	PY Sh 734	01	χαλκός (;)	O - o-pa-wo-ta - ελάσματα (;)	me-u-jo-a_2 - μείονα	ARM - θώρακας, PA - παραγνα-θίδα	12	Οι πινακίδες θωράκων κατα-γράφονται γιατί ενδεχομένως αποτελούνται και από προϊόντα που ζυγίζονται (*Docs*[2], 375-378, 379-380, 522-523). Ειδικά για τη λέξη o-pa-wo-ta = ελάσματα, δισκία βλ. *Docs*[2], 376.
166	PY Sh 734	01	χαλκός (;)	O - o-pa-wo-ta - ελάσματα (;)	KO - ko-ru-to - κόρυθος	ARM - θώρακας, PA - παραγνα-θίδα	4	Οι πινακίδες θωράκων κατα-γράφονται γιατί ενδεχομένως αποτελούνται και από προϊόντα που ζυγίζονται (*Docs*[2], 375-378, 379-380, 522-523). Ειδικά για τη λέξη o-pa-wo-ta = ελάσματα, δισκία βλ. *Docs*[2], 376. Εδώ πρόκειται για ελάσματα κράνους (ko-ru-to).
167	PY Sh 734	01	χαλκός (;)	PA - παραγνα-θίδα		ARM - θώρακας, O - o-pa-wo-ta - ελάσματα (;)	2	Οι πινακίδες θωράκων κατα-γράφονται γιατί ενδεχομένως αποτελούνται και από προϊόντα που ζυγίζονται (*Docs*[2], 375-378, 379-380, 522-523). Το ίδιο ισχύει και για τις παραγναθίδες (βλ. *Docs*[2], 376-8).
168	PY Sh 734	1 (verso)	χαλκός (;), δέρμα (;), λινάρι (;)	ARM - θώρακας		O - o-pa-wo-ta - ελάσματα (;), PA - παραγνα-θίδα	1	Οι πινακίδες θωράκων κατα-γράφονται γιατί ενδεχομένως αποτελούνται και από προϊόντα που ζυγίζονται (*Docs*[2], 375-378, 379-380, 522-523).

Table 4. Datasheet in which comments from books or articles are cited concerning the tablets that interest the programme.

α/α: 299

Συγγραφέας: Zaccagnini, C.

Έργο/σελ.: Aspects of copper trade in the Eastern Mediterranean during the Late Bronze Age, in Traffici Micenei nel Mediterraneo, ed. Marazzi, M., Tusa, S., Vagnetti, Lucia, Taranto, 1986, 413-424.

Συντ. βιβλ/κής βάσης: Zaccagnini, 1986

Πινακίδα: KN Oa 730

Λατινική Μεταγραφή: Όχι **Ελληνική Μεταγραφή:** Όχι

Μετάφραση: Όχι **Περιεχόμενο:** Ναι

Ειδική βιβλ/φία: Bass, 1967, p. 57, 60, 18, Parise, 1968, p. 127, 1971, 1962-4, 1970-71, Petruso, 1978a, Bennett, 1950

Σχόλιο συγγραφέως: "...slight but constant deviation between the weight of the oxhide ingots and the weight of the (Mycenaean) talent" - p. 415 – "As concerns the Mycenaean talent, the situation is still not clear. The main element for the determination of its weight rested on the well known 29 kg weight from Knossos..." [Σ.Σ. αναφέρεται στο Aegean unit] "...this fractioning of the Mycenaean talent is by no means attested in the linear (A and) B tablets" - p. 416 – "In short, I believe that the weight systems centered on the '65' gr. unit, on the one hand, and on the sequence: talent - double mina - half mina - etc., on the other, at least originally were independent of one another. // However, this does not mean that the two systems had no reciprocal interconnections. On the contrary, I strongly suspect that the '65' gr. unit, which - to all appearance - has a long history behind itself, represented an important cross-point between the Mycenaean and other weight systems, in the course of the Late Bronze Age." - p. 421 – "In the Mycenaean (and, more generally, Aegean) world, the 10-multiple of this same unit [Σ.Σ. εννοεί 'σίκλο' 6,5 gr.], possibly with a slight lower value in its average median weight (i.e. 62-65 gr. vs. 67-69 gr.) functioned as means of contact with the Eastern shekels (through its 10- and 8- subdivisions) and could also be used as alternative subunit for reckoning weights of trade goods below (or up to) the Mycenaean talent, in accordance with Near Eastern metrologic practices" - p. 422 -.

Περίληψη: 60 ingots = 52 2/30 talents. Άρα 1 ingot = 26/30 του ταλάντου. // Δεν δέχεται την άποψη του Δαβάρα για άγκυρα. Αναφέρει τις μελέτες Petruso (= τάλαντο 29,5 kg. και Parise (= τάλαντο 31,2 kg.) - p. 416 -. Υποστηρίζει τη μονάδα των 65 gr. (έναντι 61 του Petruso) την οποία θεωρεί ως 8 φορές τον ελαφρύ σίκλο των 7,9 gr. ή 10 φορές σίκλο 6,5 gr. Το σύστημα αυτό το Αιγαιακό δεν βασίζεται στην μνα (βλ. σχόλιο) - p. 421 -.

Παρατηρήσεις συντάκτη: Να ερευνηθεί γιατί η ιδιαίτερη αναφορά στο σύνολο στις πινακίδες Jn 389 και Jn 845. // Ο ελαφρύς 'σίκλος' των 6,5 gr. που προτείνει είναι σε θεωρητικό επίπεδο, αναφέρει βέβαια και σταθμά (Nuzi) με αυτό το βάρος, ωστόσο είναι πολύ κοντά στο 7,5 gr. (Nuzi, Ugarit, κ.ά.). Την τιμή των 6,5 gr. αναφέρει και η Pia de Fidio σε αδημοσίευτη συμβολή της στον χαριστήριο τόμο Killen.

Συντάκτης: Ά. Μιχαηλίδου - Ά. Διαλησμάς

Table 5. Datasheet in which professional groups recorded in the tablets are cited.

α/α:	107
Πινακίδα:	TH Of 36
Κτηνοτροφία:	
Υφαντουργία:	no-ri-wo-ki-de - ειδικές υφάντρες, a-ke-ti-ra$_2$ - ασκήτριαι, ειδική υφάντρα εργαζόμενη στο τελείωμα των υφαντών
Βυρσοδεψία:	
Καλλιέργεια – Μεταποίηση:	
Μεταλλουργία - Μεταλλοτεχνία:	
Άλλοι τεχνίτες:	
Υπηρεσίες:	
Θήρα - Μελισσοκομία:	
Αξιώματα:	wa-na-ka[- ανακτορικές
Σχόλια:	Η ετυμολογική ερμηνεία του όρου no-ri-wo-ko δεν είναι απολύτως σαφής, είναι όμως βέβαιο ότι αφορά γυναίκες οι οποίες ασχολούνται με την υφαντουργία (Morpurgo - Davies, 1979, 100). Ο όρος a-ke-ti-ra$_2$, εμφανίζεται επίσης με τις γραφές a-ke-ti-ri-ja και a-ze-ti-ri-ja και οι δυο επικρατέστερες ερμηνευτικές προσεγγίσεις είναι εκείνη των Killen (Killen 1979, 151-181), ο οποίος προτείνει ότι σχετίζονται με την τελική φάση της διακόσμησης των υφασμάτων και του Melena (Ruipérez-Melena 1996, 241) ο οποίος προτείνει ότι σχετίζονται με το ξύρισμα του χνουδιού των υφασμάτων. Σχετικά με τις παλαιότερες απόψεις οι οποίες δεν εντάσσουν τον όρο στην υφαντουργική δραστηριότητα βλ. Lindgren 1973,17. Στην πινακίδα αυτήν ο όρος a-ke-ti-ra$_2$ χαρακτηρίζεται επίσης ως wa-na-ka[-te-ra (Βλ. επίσης τα σχετικά σχόλια με τους επαγγελματίες ka-na-pe-u, e-te-do-mo και ke-ra-me-u).

Table 6. Datasheet of the database for bibliography.

α/α:	663
Συγγραφέας/-είς:	Palmer, Ruth
Τίτλος:	Wine in the Mycenaean Palace Economy
Αριθμός τόμων:	1
Τόπος εκδόσεως:	Liège
Έτος εκδόσεως:	1994
Επιστημ. εκδότης:	
Μεταφραστής:	
Εκδότης:	Université de Liège, University of Texas
Τίτλος περιοδ./σειράς:	Aegaeum, Annales d'archéologie égéene de l'Université de Liège et UT - PASP
Επιστημ. εκδ. σειράς:	Laffineur, R., Palaima,T.G.
Αριθμός τόμου:	10
Αριθμός τεύχους:	
Έτος εκδ. περιοδ.:	
Αριθμός σελίδων:	xxx+219
Συντομογραφία:	Palmer 1994
Περίληψη-παρατηρ.:	Εξονυχιστική ανάλυση του προϊόντος. Ασχολείται με την προϊστορία του, την εξέλιξη του ιδεογράμματος, το σχετικό με το κρασί λεξιλόγιο, την παρουσία του κρασιού στις πινακίδες της Πύλου, Κνωσού, Μυκηνών και στα σφραγίσματα της Πύλου. Επισημαίνει και αναλύει τη σχέση του κρασιού με προϊόντα του ενδιαφέροντός μας. Επίσης αναλύει οικονομικούς όρους που σχετίζονται με πινακίδες του θέματος έρευνας.
Λέξεις - κλειδιά:	οικονομία, κρασί, μέταλλα, υφάσματα, βιοτεχνία, μαλλί, φυτά, alum
Συντάκτης:	Ά. Διαλησμάς
Ημερομ. εισαγωγής:	6/5/1997
Τελευταία τροποποίηση:	

Table 7. The datasheet of the tablet **KN Lc(1) 525** in the table 'Tablet' (I).

α/α:	235
Πινακίδα:	KN Lc(1) 525
Λέξεις κλειδιά 1:	wa-na-ka-te-ra - ανακτορικά, TELA^3+TE - ύφασμα, LANA - μαλλί, tu-na-no - ύφασμα, TELA^1 - ύφασμα
Λέξεις κλειδιά 2:	ύφασμα, μαλλί, υφαντουργία, οικονομία

Table 8: Records of the tablet **KN Lc(1) 525** as analysed in the table 'Raw Material' (II).

ΑΓΑΘΟ	ΠΡΩΤΗ ΥΛΗ	ΕΙΔΙΚΟ ΧΑΡΑΚΤΗ-ΡΙΣΤΙΚΟ	ΑΛΛΑ ΑΓΑΘΑ	ΣΤΙΧΟΣ	LANA	ΠΙΝΑΚΙΔΑ	ΠΑΡΑΤΗΡΗΣΕΙΣ ΣΥΝΤΑΚΤΗ
μαλλί	LANA - μαλλί		TELA^3+TE - ύφασμα, TELA^1 - ύφασμα	.a	100	KN Lc(1) 525	Πιθανώς δε σώζεται ολόκληρη η ποσότητα μαλλιού
μαλλί	LANA - μαλλί		TELA^3+TE - ύφασμα, TELA^1 - ύφασμα	.b		KN Lc(1) 525	Δε σώζεται η ποσότητα μαλλιού.

Table 9. Records of the tablet **KN Lc(1) 525** as analysed in the table 'Final Product' (III).

ΑΓΑΘΟ	ΤΕΛΙΚΟ ΠΡΟΪΟΝ	ΕΙΔΙΚΟ ΧΑΡΑΚΤΗ-ΡΙΣΤΙΚΟ	ΑΛΛΑ ΑΓΑΘΑ	ΣΤΙΧΟΣ	ΑΡΙΘ-ΜΟΣ	ΠΙΝΑΚΙΔΑ	ΣΧΟΛΙΑ
μαλλί	TELA^1 - ύφασμα	tu-na-no - ύφασμα	LANA - μαλλί, TELA^3+TE - ύφασμα	.b	3	KN Lc(1) 525	
μαλλί	TELA^3+TE - ύφασμα	wa-na-ka-te-ra - ανακτορικά	LANA - μαλλί, TELA^1 - ύφασμα	.a	40	KN Lc(1) 525	

Table 10. Datasheet of the tablet **KN Lc(1) 525** in the table 'Bibliography' (IV).

α/α:	208		
Συγγραφέας:	Ventris, M., Chadwick, J.		
Έργο/σελ.:	Documents in Mycenaean Greek, Cambridge, 1973, 314-5, 315, 486.		
Συντ. βιβλ/κής βάσης:	Docs^2		
Πινακίδα:	KN Lc(1) 525		
Λατινική Μεταγραφή:	Ναι	**Ελληνική Μεταγραφή:**	Όχι
Μετάφραση:	Αγγλική	**Περιεχόμενο:**	Ναι
Ειδική βιβλ/φία:			
Σχόλιο συγγραφέως:	'The ideogram translated as WOOL is derived from a Linear A monogram of the signs MA+RU; its meaning is indicated by its prominent place on the SHEEP tablets (see p. 203). Even where wool is counted together with CLOTHS in large numbers, its method of measurement is betrayed by occasional fractional amounts reckoned in M (e.g. on 211 = Lc 532); Bennett has shown that 3 M go to the normal WOOL unit of weight, which is therefore equivalent to about 3 kg (approximately the weight of a heavy blanket or of a present day winter overcoat). On the Mainland WOOL only occurs with whole numbers; and on Mycenae 227 = Oe 127 it is itself introduced by pa-we-a$_2$, suggesting that it has come to mean an indivisible unit of woollen material parallel to the cloth ideogram. // Parallel accounts of cloth and wool are found at Alalakh, e.g. no. 357 (Wiseman, 1953, p. 99): 'Account of thirty-seven pieces of cloth and thirty-five measures of wool belonging to the sakanaku official's store'; and at Ugarit, e.g. RS, xi, 732B (Virolleaud, 1940, p. 257): Five tunics, 500 shekels of purple wool ... for the king, // Two tunics, 200 shekels of purple wool...for the queen, // One tunic, 100 shekels of purple wool...for the king's son, // One tunic, 100 shekels of purple wool...(for various officials). // .... The Lc- and L- series, on the other hand, probably represent for the most part receipts of cloth and wool from outlying villages, since they are introduced by place-names and include entries of o-pe-ro 'debt' (L 473, L 869) and a-pu-do-si 'delivery' (L 5867, L 5930)... // CLOTH+TE: Mycenaean wheels are distinguished as being te-mi-*71-ta (Pylos WHEELS+TE) or o-da-ku-we-ta (see p. 370). The second term is also applied to woollen cloths on 220 = L 870, and it is possible that they refer to different kinds of decorative border, CLOTH+TE ... in Bennett's Index (p. 116) must be corrected to CLOTH+PA (e.g. Le 786). // tu-na-no: the meaning of this term is unknown. It regularly occurs with the plain CLOTH ideogram on the second line of tablets whose first lists CLOTH+TE (with pe-ko-to) or plain CLOTH (with ko-u-ra). On 212 = Lc 535 all three categories are separately totalled. The traces of numerals after the second WOOL seem to include hundreds'. - p. 314-315 -.		
Περίληψη:			
Παρατηρήσεις συντάκτη:	Αναφέρεται στις πινακίδες υφασμάτων γενικότερα αλλά και στην KN Lc(1) 525 ειδικότερα.		
Συντάκτης:	Ά. Διαλησμάς		

Table 11. Datasheet of the tablet **KN Lc(1) 525** in the table 'Profession' (V).

α/α:	336
Πινακίδα:	KN Lc(1) 525
Κτηνοτροφία:	
Υφαντουργία:	
Βυρσοδεψία:	
Καλλιέργεια – Μεταποίηση:	
Μεταλλουργία - Μεταλλοτεχνία:	
Άλλοι τεχνίτες:	
Υπηρεσίες:	
Θήρα - Μελισσοκομία:	
Αξιώματα:	wa-na-ka-te-ra - ανακτορικά
Σχόλια:	

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