THE DEVELOPMENT OF PREHISTORIC MINING AND METALLURGY IN ANATOLIA

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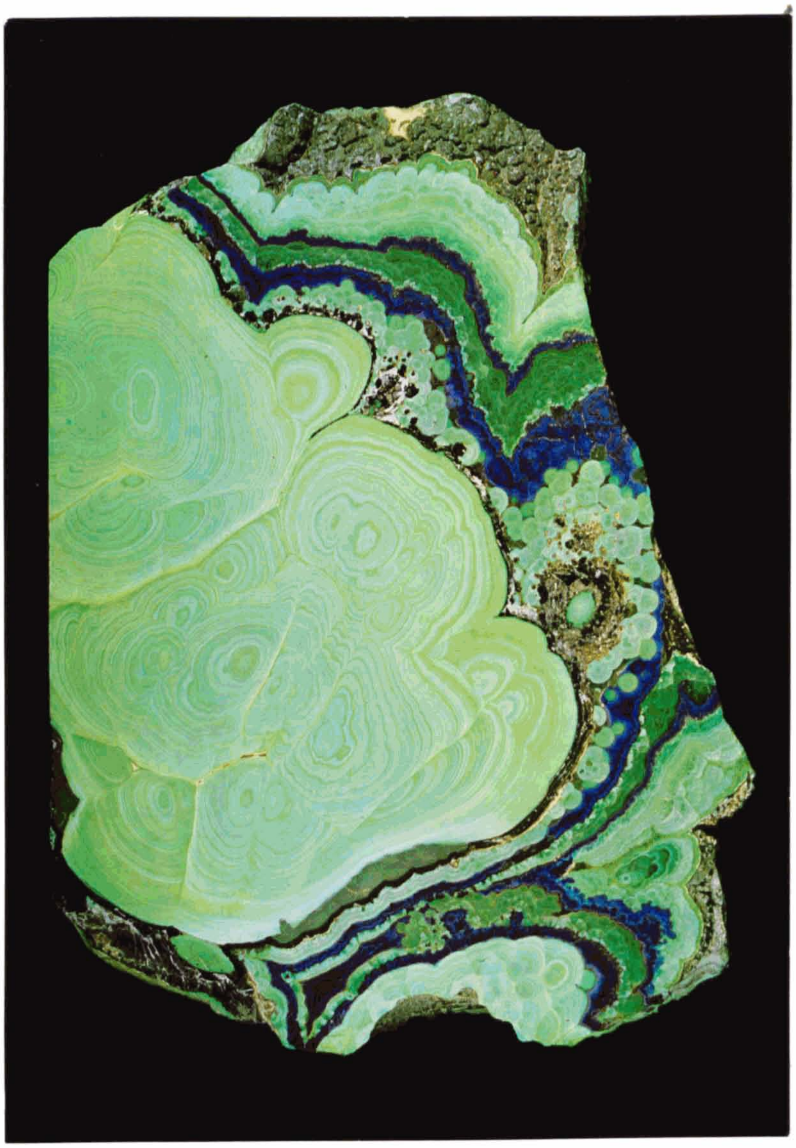

Malachite and Blue Azurite

ABSTRACT

It has long been known that Anatolia (approximately present-day Turkey) participated actively in diverse aspects of metallurgy from as early as the Neolithic period. This thesis treats various facets of the metallurgical industry from its outset in the 7th millennium B.C. to the end of the Early Bronze Age (ca. 2000 B.C.). It collects together much of the geological data pertaining to the metalliferous ores of gold, silver, arsenic, and copper. Subjects also discussed are the methods of mining and smelting. Concomitant with these is a report on surveys made by the author (under the auspices of the Turkish Mineral Exploration and Research Institute) on the location of early mining and smelting sites in Turkey. Analyses of slag and ore are included in the Appendices and Catalogues. The metalwork itself is presented in Catalogue form, and full reference is made to all the prehistoric Anatolian metalwork which has been analyzed.

Based on the above data, the development of the metallurgical industry as a whole is viewed over the course of 5 millennia. Many more copper deposits, unknown to archaeologists and historians, are brought to light in this study. The presence of these deposits allows us now to widen our scope of the development of the metallurgical industry. Instead of seeing it as dependent on a few major deposits such as Ergani, Mürgül and Kastamonu, we can now reserve the option of offshoots and separate development in different areas of Anatolia. The metalwork, in fact, suggest this, though it does not become apparent until EB II, from when the bulk of our documents dates. Earlier material is not lacking and does suggest an even more dispersed series of local metallurgies. Chalcolithic metallurgies were probably loosely associated, perhaps by sharing common sources, but they still appear to have remained culturally distinct. It was the coming together of the Chalcolithic cultures that provided the prolific metallurgical development witnessed in EB II and EB III.

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Abbreviations and Prefixes

Abbreviations:

C.A.H.	Cambridge Ancient History
Ilios	H. Schliemann, Ilios, London 1881
O.I.P.	Oriental Institute Publication. Chicago Univ. Press
Troja	H. Schliemann, Troja, London 1884

Prefixes of Analysis Numbers and Their Sources:

AA-	Neuninger et al, 1964
BI-	Metropolitan Museum (Cf. Appendix VI)
CSS-	Smith, 1973
D-	Desch, 1928
E-	Esin, 1967
I-	Ilios
K-	Kosay, 1938
L-	Lamb, 1938
LG-	Lloyd and Gokce, 1951
So-	Bittel, 1940
SS-	Schmidt, 1902
Str-	Stronach, 1957
Tr-	Troja
Ty-	Tylecote, 1966

Other Prefixes:

A-	for "artifact" which refers to items in Catalogue A
S-	for "site" which refers to ancient mining and smelting sites in Turkey in Catalogue S

PREFACE

Apart from the interpretations in this thesis there is only a small portion of the material presented here which is unpublished. What I have attempted to do is to pull together a wide range of data which, although published in geological and scientific journals, has not been brought to the attention of the archaeological community. In a sense, this data is new. The essential goal of this thesis is to organize the information available on diverse aspects of the copper industry in prehistoric Anatolia, note the locations of known copper deposits, give guidelines to the analyses of prehistoric metalwork, and trace the development of the metallurgical industry as a whole.

The general works on ancient deposits are very much in need of updating and clarification. References have been cited and re-cited so many times that the original report has been lost and the information transformed. For example, the works of Forbes (see"Bibliographical Note") bring together a large body of information, but much of it is modified by Forbes' over-simplified view of ancient metallurgical practices. Moreover, many details which are necessary for us to make an objective assessment were omitted by Forbes. Recently, Yakar (1976) has reiterated Forbes' views, and doing so he perpetuates a number of Forbes' misinterpretations. To offer an alternative to works such as these I have endeavored to give an accurate account of what has been reported on metal deposits and, as best I could, provide the original reference.

There are two catalogues. Catalogue S lists the copper mines (S-1 to S-125) and the lead mines (S-126 to S-169) reported to have given evidence of former or ancient exploitation. The information in most cases is very vague, as no ancient mines have been systematically investigated in Turkey to this day. Some of the new information pertaining to copper sources was acquired in the course of surveys performed by myself and Ergun Kaptan, under the auspices of the Turkish Mineral Exploration and Research Institute in Ankara. The most important metal sources investigated during these surveys are discussed in detail in Chapter 6. In the text mining and smelting sites are referred to by number, preceded by the initial S-. All of the sites in the catalogue are plotted on distribution maps. The location of some sites is uncertain, and in these cases I have plotted them approximately. The "Map Reference" in Catalogue S makes use of the map quadrants on the MTA 25,000:1 map series and is an aid in locating the general area of the deposits. This map series is not available to the public, but in the MTA Publications on minerals maps show the general quadrant lay-out. Once the co-ordinates are known other maps (i.e. 500,000:1) can be used quite adequately to situate the deposits. The "Map Reference" gives first the map number, then the quadrant number which is is the following order: 1- upper left, 2- upper right, 3- lower left, 4- lower right. A "Map Reference" giving the co-ordinate 1/4 would indicate area map 1, quadrant 4. In this case the area would be around Edirne.

Catalogue A brings together metal artifacts which have been analyzed (listed first) plus other pieces considered to be important. When referred to in the text these artifacts are preceded by the initial A-. The catalogue gives a general indication of the metal composition of the artifact, if known. The main constituents (i.e. ≥1%) are written first, and the trace elements are listed afterwards (i.e. after /tr:). These designations are only a general guide and should not be used for detailed interpretations; rather, one should use the original analyses, the references of which I have provided. The slag analyses in Catalogue S which carry the reference de Jesus and Kaptan were analyzed spectographically. The lower detection limits are as follows:

% Sn	0.002
As	0.1
Sb	0.01
Ag	0.0001
Ni	0.002
Bi	0.001
Au	0.001
Co	0.001
Zn	0.04

Illustrations have been included on the one hand to help in the descriptions of specific pieces, and on the other as representatives of the great variety of metalwork from Anatolia. I have included some non-prehistoric material, for the lack of prehistoric examples. Falling into this category are the pot bellows from Kültepe (A-681) the smelting furnace from Hissarcikkayi (see Chapter 2 E.), and mining tools from Europe (A-698-706). In my discussions on metalwork I have used the term "bronze" to indicate the alloy of copper with tin, where the latter is $\geq 1\%$. Occasionally I have used "tin-bronze" for emphasis. In reference to the alloy copper-arsenic the term "arsenical copper" is used. When arsenic or tin are absent or less than 1% the term copper or unalloyed copper is used, and when no analyses are known the artifacts are referred to, simply, as copper. I have included discussions of other metals: gold, tin, arsenic and silver, but the emphasis of this thesis is on copper. The discussions of the other metals round out the extent of the activities of the prehistoric metallurgist.

The chronology followed here is essentially that of Mellaart (1974 and 1975) and Easton (1976). I have not wanted to become involved in the intricate problems of absolute dating, although I have attempted to date relatively some unstratified pieces.

I was assisted throughout the entire course of my research and writing by numerous scholars and institutions. My research in Turkey could not have taken place without the generosity and participation of the Turkish Mineral Exploration and Research Institute. I am deeply indebted to its Director General, Professor Dr. Sadrettin Alpan, who was the principal instigator behind the surveys performed in 1973 and 1974. I was ably advised in organizational and geological matters by Drs. Seljuk Demirsoy and Fetullah Özelçi of MTA. Other participants in the field work were Dr. Ibrahim Tekkaya, Mr. Ertan Toykuru and Miss Suna Toncer. My constant companion, guide and collaborator was Ergun Kaptan whose enthusiasm kindled my own. I thank him for his unfailing help and friendship.

I am grateful to the British Institute of Archaeology in Ankara where I resided during the first year of my research and to its Director, Dr. David French, for the facilities and kindnesses extended to me. I thank particularly Dr. Elizabeth French who guided my first steps on Anatolian soil. Most of the three years I resided in Turkey was made possible by a Fellowship from the American Research Institute in Turkey (ARIT). I sincerely thank the President of this organization, Professor Hans Güterbock, and its Delegates who accorded me an uncommon generosity and faith in my work. I thank also the Institute of Archaeology of London University which was indulgent to my needs and allowed me the opportunity for travel over an extended period. The librarians of the Institute were ever-responsive to my research requirements,which facilitated my tasks considerably. In 1971 I was aided by a travel grant from the Central Research Fund of London University, which set me on the road to this adventure and for which I am deeply grateful. I am indebted to Mr. Clayton Panlaqui and to the Santos Company for financial assistance which covered some of my travel and all of my maintenance costs during the long period of writing up.

In the course of my research I kept up a heavy correspondence with people who had made important investigations in the field of ancient metallurgy. I benefitted much from their experience. My research often exceeded the bounds of ancient metallurgy strictly speaking, and I was assisted by people in many different fields. They gave me instruction, shared their research, and offerred me publications. Under this heading I should like to list the following with my gratitude:

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I am grateful to the Istanbul Archaeological Museum and to its Director, Dr. Necati Delanay, who permitted me to study objects not on display. Drs. Nezih Firlatli and Nuşin Azgari facilitated my task to a great degree. I spent many hours in the Ankara Museum, and I should like to thank its Director, Raci Temizer, and its staff for the way in which I was always warmly received. The British Museum also kindly allowed me to inspect many pieces of metalwork not on display. I offer my thanks to the latter and to Mr. Terrance Mitchel for making this possible. My thanks goes to the Oriental Museum in Chicago and to its staff for making it possible for me to study a number of metal items. Through the kindness of Professor John Brinkman I have been allowed to use the photographs of the unpublished copper bulls on Plate XVI. My thanks goes to Mrs. Eve French for the drawings of the Horoztepe material and to David Giles who sent me complementary information on the Kozlu Mine. I am also grateful to Dr. R. Schuiling for allowing me to include his distribution map of tin deposits (Map 18). I thank Dr. Paul Craddock of the British Museum Analytical Laboratory for permission to use his analysis of the Arpachiya chisel (Appendix VII). I thank Dr. Pietr Meyer for permission to use his analyses of the Metropolitan Museum material (Appendix VI). K.R. Maxwell-Hyslop advised me on a number of points in this thesis for which I am grateful.

I cannot overlook the constant and generous counsel I received from my supervisor, Mr. James Mellaart. He was not only a source of inspiration but a check against my misguided interpretations. The dictum,"on n'a rien que par les autres," is born out by the help I received in writing these pages, but as it all passed through my hand, I alone must stand responsible for any inaccuracies or oversights.

No one will ever write the definitive work on ancient metallurgy, for new finds continuously re-shape the general picture. Two important works have been recently published: R.F. Tylecote's <u>A History of Metallurgy</u> (London 1976) and R. Brinkmann's <u>Geology of Turkey</u> (Stuttgart 1976). Unfortunately my thesis was too far advanced into its final stages for me to consider these works. While each is of considerable importance, neither affects my general conclusions.

Prentiss S. de Jesus

INTRODUCTION

It would be unnecessary to write at great length to justify a study on ancient metallurgy, for its importance is widely accepted, even without question. The key role that metal played in the development of man's tool kit, of his weapons of war, as a symbol of wealth, and as a medium of exchange can hardly be ignored. Evidence for the beginnings of metallurgy is still lost in the dust of the Near East, but for practical purposes we can establish it at any point which suits us, providing our definition of it is clear. The hard-core facts are in no way changed. Some scholars may wish to see the beginning of metallurgy as the first use of native copper hammered into some kind of object or tool. Others may wish to see it at the moment when fire is used to soften brittle copper (i.e. the act of annealing). Still others may wish to stipulate that the practice of melting or smelting copper is the real beginning. It is not important where we wish to draw the line, but it is an increasingly popular notion to speak of metallurgy once heat is used at some stage in the production process, whether for smithing, melting or smelting, hence the term pyrotechnology.

Mother Nature herself did much in putting man on the road to metal exploitation. Deep in the earth She formed metal solutions and brought them up to the surface through the fractures in the earth's crust. Erosion broke away the parent rock and exposed native metals which man ultimately found and used. She also had the generosity to provide these metals in areas where man was likely to live. But in the beginning man was not tempted by them. The exploitation of native copper would have been an unnecessary burden on the paleolithic hunter who could fashion all the tools he needed out of flint in just an hour's time. The use of metal in paleolithic times would not have improved the quality of man's life. Nevertheless, man probably tinkered with native copper for a thousand years before he found any useful applications for it. In some cases ancient man knew and used the copper oxide before he bothered with native copper. The bright green color of malachite was probably used to make coloring for rugs or paint, and when mixed with grease malachite makes an ideal eye mascara (see Chapter 2, no.8).

For metallurgy to develop, man had to be in a situation which allowed him the time to explore and experiment with native copper. This situation did not come about until the Neolithic when sedentary life permitted a certain amount of leisure and gave rise to the development of crafts and art. But even with the introduction of copper and the discovery of its properties, it did not immediately replace traditional materials. As Gordon Childe aptly points out,"It was simpler to use the plentiful local materials for equipment than to organize the importation of regular supplies of metal to replace them... By itself (metallurgy) did not take man very far" (<u>What Happened in History</u>, Middlesex 1964:82, 83). The first steps towards the use of metal were feeble, hesitant, promising at best. The occasional copper bead, a few borers and bits and pieces are hardly what we can call revolutionary innovations. Rather, these small tools and trinkets reflect only man's curiosity with this material and with its transformation. It is clear that he was looking for an application, but it was long in coming. At its outset metallurgy was but a simple curiosity, and the discovery of copper and its properties brought no immediate transformation of society.

At Çatal Hüyük, for example, where both copper and lead were known, metal played no vital role in the material life of the people. Yet, the sophistication in other crafts existant for well over 1000 years shows that these Neolithic people were very advanced materially. Their spiritual life, too, was surprizingly rich in tradition and imagery. Even later Near Eastern cultures were able to develop brilliantly without the use of metal. We need only mention in passing Samarra and Halaf, exemplary in their manufacture of pottery. Hence, copper (and metal in general) was not necessary for the maintenance of customs, social structure, religious life, or food supply; and, surely, these are the most essential aspects to man's existence. Despite this, the use of copper was ultimately adopted.

Why was it used, if other materials sufficed? It was realized in the course of experimenting with copper that it possessed properties quite unlike other natural materials. It could be bent, flattened, and sharpened. It was discovered that if one hammered copper excessively it would become hard, even brittle to the point of breaking. It was also observed that when it hardened it could be made pliable again by heating it in a fire; hence, the discovery of annealing. Until the discovery of the fusibility of copper at a high temperataure (1083°C) metalwork was limited to the size of the piece of native copper found. In other words, the early coppersmith could not make a piece of metal bigger, anymore than he could make a piece of obsidian bigger. But by melting small bits of native copper together, a whole range of large objects were open to the smith's imagination. Moreover, old worn-out tools and weapons could be remelted and recast, thereby minimizing material loss.

As the demand for copper became greater, native copper sources were no longer sufficient, and the metallurgist was faced with the problem of finding new sources. Aided by technological improvements -- hotter furnaces, better choice of materials, and a feeling for his craft -- he ultimately discovered the art of smelting copper ore. He also learned to cast moulten copper into pre-prepared moulds, he learned to cast one piece onto another, and he saw how the workability of copper was improved when alloyed with arsenic or tin. The increased production of copper led again to technological advance. Mines were more effectively exploited, and new ones located. Smelting techniques improved, and copper became an important article of trade. Since one of its principal uses was for the manufacture of weapons, copper became indispensable, even imperative, to the survival of societies in a hostile world.

At this point in time, probably during the Early Bronze Age, yet another material made its appearance. When breaking up the slag to recuperate the small globules of copper, the smelter noticed prills of shiny metal material which were the result of the smelting process but which were not copper. It had some of the metal properties of copper, but it was hard and difficult to work. This material was not entirely unknown to the smelter, for he recognized it as similar to the metal which comes from the sky: meteoritic iron. Smelting experiments with different material led the smelter to identify the type of earth from which this iron came, and it was from this point onwards that the production of iron slowly entered into the metallurgist's repertoire. Unlike copper ore, iron ore could be found in many areas of the world, so many, in fact, that iron has been coined "the democratic metal:" a ressource available to all. Copper did not go out of fashion with the discovery of iron smelting because the smelting procedures for copper ore and the smithing technology is simpler than that for iron. Although harder, iron does not possess characteristics vastly superior to copper or bronze, which must have stemmed its development as an industry.

A generation or so ago, archaeologists dealt with the development of metals and metallurgy in a very casual way, thinking that metal meant civilization, and as far as the Near East is concerned they tended to link all metal-using cultures together. It was the feeling then that one center was responsible for the development of the metallurgical techniques such as smelting and casting and that this technology spread to other areas of the Near East. Authors chose various countries from where this metal technology was supposed to have spread, such as the Caucasus, Iran, or Egypt. But as the archaeological data began to accumulate, it became increasingly clear that this was not quite the case. Archaeologists had been trying to fit their pre-conceived notions to the material, rather than let the material suggest its own patterns of development. The appearance of metal alone was not enough to link cultures together.

Independent discovery of copper smelting is a fait accompli with which we have to reconcile ourselves. This is a hard blow to the traditional diffusionist theory, though diffusionism on local and regional levels still played a prominent role in the exchange and transfer of cultural elements. Nevertheless, we can no longer hold that one particular area was parent to the discovery of smelting which was ultimately practiced throughout the Near East by the

4th millennium B.C. Little by little authors have been putting the emphasis on regional studies (i.e. Renfrew, 1967 and 1969; Branigan, 1968 and 1974; Calmeyer, 1969; and Catling, 1964), and it is increasingly evident that when we take the Near East as a whole we are dealing with several separate metallurgical histories, each with its own genesis. No doubt, some became more advanced than others, much in the same way that some pottery was better made than others. Generally speaking, we can already isolate Early Bronze Age metallurgical traditions of the Aegean, Cyprus, Syria, Anatolia, Mesopotamia, Egypt, and Iran. In some cases, such as in Anatolia, smaller families can be discerned. In these pages we deal with some of these.

The archaeologist's problem with metalwork is similar to his problems with other materials: their manufacture, their provenience, and their role in the material make-up of a society. In his assessment of metalwork he must endeavor to take into account the composition of the metal, as it can give indications as to manufacture which are not visible to the naked eye. Although compositions of metalwork were considered important, early archaeologists rarely bothered to have their metal finds analyzed. Our illustrious forerunner, Schliemann, was one of the few who provided us with analyses (the only tin-bronze identified in Troy I is thanks to Schliemann, see A-586). More recently, large-scale analytical work has provided us with a good corpus of analyses for comparison (i.e. S.A.M.; Esin, 1967; Eaton and McKerrell, 1976). When possible, sections of metalwork are studied to determine their manufacturing technology. This has given us yet another dimension to metalwork: smithing technology. Geological work in recent years has provided us with more information on deposits and ore types so that we can consider the whole process of metallurgy, from its mining stage to the final product. Experimental archaeology has helped us to lay to rest many old theories on metallurgical techniques. The work of Slater in Oxford, Eaton and McKerrell in Edinburgh and others are providing guidelines to the use of ore, the types of furnaces used and the various concepts of smithing and smelting technology. At this very writing laboratory experiments are producing findings which are extending our knowledge of prehistoric technology.

Analytical work is not just a question of seeing what a metal is made of. It is a complex area of investigation which is full of traps for the unwary. Copper ore bodies carry with them inherent impurities; together with fluxes added during the smelting operation, and the differences in smelting procedures, the general character of both the metal and the slag will vary. The analyst has to (try to) sort out all this, otherwise analyses tell us little. Even with the aid of advanced scientific methods of analysis and investigation, we have only begun to understandancient metallurgical techniques. Hence, many of our conclusions must remain ever-tentative. All studies which stem from archaeology are based primarily on the recovery of material things, and as it is improbable that all facets of the metallurgical industry are retrievable, we cannot hope of ever learning everything.

Turkey : The Formation of the Anatolian Land Mass

Over 50% of the Anatolian land mass is over 1000 meters high. This is due to the unique position of Anatolia, which forms a section of the great Alpine-Himalaya Tertiary range, situated at the edge of the Arabian Shield.[1] The northeraly movement of the latter has caused corresponding shifts in the crust beneath Anatolia which has resulted in some folding in the south (i.e. the Anti-Taurus), as well as pushing up the ultrabasic core of Cyprus. However, volcanic eruptions, especially in the Southeastern and Eastern regions of Anatolia, indirectly indicate subsidence of areas within the Anatolian land mass.

According to Evans (in Campbell, 1971:385, map p.153), Turkey finds itself between two massive plates and is itself composed of two smaller places (Map 1). The Turkish plate covering the greater part of Turkey, Cyprus and the Area between, and the Aegean plate which takes in Western Turkey, the Aegean, Crete, and part of Greece. The Turkish plate is said to be moving westwards with the Anatolian fault (= South of the Pontic Mountain Range) acting as the northern boundary. The Aegean plate is moving Southwest and is over-thrusting the Mediterranean floor just south of Crete.

Faulting is prevalent throughout Anatolia, and until recent years, it was not considered a very important factor in the physical appearance of Anatolia. Now, there is more evidence that faulting played an active role in mountain building. Orogeny had formed the general outlines of the mountain ranges in three succeeding Alpine phases (cf. below) but intensified epeirogenic uplift during the Tertiary and Quaternary raised blocks in these mountain ranges to great hights.

One may depict Turkey as being composed of four zones (Map 2):

1. Pontids (Northern Folded Zone)
2. Anatolids (Central Folded Zone and the Central Massif)
3. Taurids (Southern Folded Zone)
4. Border Fold Zone (Arabian platform)

Prior to the above major Alpine folds the first mountain building movements so far detected are in the form of angular discordances in early Paleozoic deposits. Caledonian and Hercynian orogenies are also indicated. These disturbances were limited by the Russian shield to the north and the Arabian shield to the south. It is assumed that these movements are aligned in an wast-west direction, similar to the later folding patterns.

The main branches of Anatolian folded structures are best seen in relation to the Alpine orogenies (Map 3). The Northern Anatolian Fold is an extension of the Alpide branch consisting of the Northern Alps, the Carpathians, the northern Balkan ranges, and the Elburs mountain range to the East. The Southern Anatolian Fold is related to the Southern Alpine branch, the Alpennines, the folded zones of Yugoslavia, Albania, Southern Greece, and Southern Iran. The Northern and Southern zones border each other in Eastern Anatolia, whereas in Central and Western Anatolia they are separated by Central Folds. and the Central Massif.

The Central Folded regions show approximately the same stratigraphy as the two main folds (Northern and Southern). The massifs on the other hand consist of metamorphic rocks which are believed to have been derived from Palaeozoic or earlier rocks. Some metamorphism, however, is post-Palaeozoic, mainly Jurassic and in some cases Late Cretaceous sediments overlie Central Massifs.

The date of the folding and the orogenies extends over several periods. As stated above, there was some pre-Alpine movement. However, the first dynamic changes occur in the Mesozoic (Triassic, Jurassic and early Cretaceous). In the late Cretaceous period angular folding suggests strong unconformities, especially in the axial zones of the Northern and Southern Folds which continued and culminated in the Eocene and Miocene periods. The folding direction of the Northern and Southern belts are quite distinct, as the Northern Fold is from South to North, and in the Southern Fold the direction is from North to South. Back folding has also been detected in both of these belts, but it is thought that it is of much later date and was caused by depressions and in areas of a fault. No dominant folding direction has been detected in the Central Folded Zone.

A. The Pontids (The Northern Folded Zone)

Surface outcrops over the region are generally Mesozoic or Lower Tertiary Age, such as Cretaceaous flysche and volcanic materials. There are also a great variety of clays, shales, sandstones and limestones.

Set here and there in these folds are a number of uplifted blocks (horsts) composed of Paleozoic and intrusive rocks. Also are areas of Neogen (late Tertiary) lavas, particularly in Ordu and Giresun Provinces. The general structure of the Pontic Zone is one of long narrow mountains deeply cut in an East-West direction. They are broken by short gorges which give the inland water courses access to the Black Sea. Towards the east the whole mountain system tends to become elevated. In the west (Sakarya, Marmara) there are few mountain peaks which exceed 1000 m. This is somewhat due to the downward fault of the area during the late Tertiary. The folded structures in the area of Bursa and Balikesir are covered over by alluvial and sedimentary deposits. East of the Sakarya bassin there is an abrupt rise in altitude, and this mountain barrier extends to the Kizilirmak.

Just south of the Black Sea coast the land rises to high peaks, and these ranges continue in an East-West direction from Kastamonu through Sinop and beyond.

From the Gerede and Devrez basins lie the Koroğlu Dağlari (2400 m.) which developed on resistant volcanics. It is in this area where the Northern Folded Zone has a marked North-South orientation, going through Ankara almost as far as Tuz Gölü.

In the East but West of Gumuşhane the range is a development largely on Neogene (Late Tertiary) volcanics. To the east of Gumushane the range is mainly on Cretaceous volcanics. The highest peaks are generally intrusions. South of this range is a long narrow trench, the valleys of the Kelkit (flowing West) and of the Çoruh (flowing East).

South of this corridor are a series of East-West ranges which ultimately link up with the Anti-Taurus. To the East in Kars and Erzurum Provinces the area is composed of largely recent volcanics (High standing dessecated lava) and continue right into Soviet Armenia.

B, Central Massif and the Central Folded Zone

This area cannot be treated as one, since it comprises distinctly different features. A line running south from Bursa to Aydin provides us with a general boundary. On and east of this line are a series of block mountains and rift valleys (horsts and grabens). Some of the uplifts reach more than 1000 meters in height, such as Ulus Dagi (1773 m.), Akdag (2089 m.), Simav Dagi (1801 m.), and Bozdaglari (2160 m.). These peaks are generally situated in the Central Folded Zone and not in the Central Massif. The areas in between these ranges and peaks are deeply cut by the tributaries and upper reaches of the Buyuk Menderes and the Gediz, These water courses plus the Kucuk Menderes provide areas of rich alluvial soil and ideal environment for farming.[2] This low-lying western area belongs to the Aegean plate which is undergoing a shift different from the Anatolian plate. As seen in Map 1 the lithosphere of the Aegean plate is enlarging thereby creating a cross-movement with respect to the rest of the Anatolian land mass. This movement is not only causing a widening of the Dardanelles, the Sea of Marmara and the Bosphorus, but it tends to isolate the Aegean plate from the orogenies of the Anatolian plate. Hence, we should not be surprised to note a rather conspicuous difference between the Central and West.

Moving towards the heartland of the Central Anatolian plateau we find the land generally higher and many more mountains. The Konya basin to the south and the Sakarya basin towards the center are the low areas of this Central Zone. The difference between them is that the Sakarya basin is generally well-watered and provides a major drainage watercourse to the Black Sea. The Konya Basin on the other hand, is relatively dry and has no drainage outlet to the sea. Folding took place in Tertiary times in the Konya basin, but not extensive enough to raise areas to heights of the Central Anatolian Plateau. Studies show that it was a large lake even as late at the Oligocene (35 million years ago), but during the Pleistocene (ca. 16,000 B.C.) it dried up. It underwent local climatic change due to a reduction in the vegetation, an increase of the salinity of the water bodies, and general deterioration of aerable land. No doubt the ravages of man and beast had a hand in hestening this environmental change in the closing chapters of this region, but probably the most important factor was the formation of slopes which did not allow for the evacuation from the basin of the saline and calcareous waters. The latter were the result of erosion and normal drainage of the surrounding rocks. Evaporitic minerals began to form rather late in the basins history (Evans in Campbell, 1971:398), but continued rain fall in the general area allowed for the growing of grasses for the support of animal and human life. These conditions prevailed well into the Holocene (Cohen, 1970:124).

Apart from Tuz Golu which has a history similar to that of the Konya basin, what we take to be the Central Anatolian Plateau is a large land mass raised to a height of 1000 meters and more. It is cut by the western flow of the Kizilirmak and the Tuz Golu basins which are Quaternary alluvial deposits and constitute the North-eastern extension of the Central Massif. Northeast of Ankara and Tuz Golu are many small river valleys, the result of intense folding in this Central Zone. There are peaks in this area rising as high as 2000 meters. In Kayseri Province volcanic peaks go even higher, such as Hasan Dagi (3258 m.) and Erciyas Dagi (3916 m.). The greater part of the folded zone lies within the loop of the Kizilirmak. This area is cut by numerous streams and rivers and is cut in an almost haphazard fashion. In the past, prior to man's extensive exploitation of woodland areas, the Central Anatolian Plateau was densely wooded and well-watered. Its natural drainage system leads to the Black Sea like the Northern Anatolian Folded Zone.

C. The Southern Folded Zone

This zone constitutes the most homogeneous of the four geological zones. It extends from the southwestern most tip of Turkey to the eastern border, passing through Beyşehir, Antalya, Adana, Maraş, Elaziğ, and Van.

The western portion of this mountain complex contains a number of small basins, and some high peaks have developed on basic and ultra basic rock such as Akdağ (3025 m.) and Yeşil Göl Daği (2047 m.).

The Southern Taurus Mountain Range is dotted with high peaks and generally constitutes a barrier between the South Anatolian coastline and the interior. This barrier is cut only by a few important rivers, the Aksu, the Kopru, the Alra, the Boksu, the Ceyhan, the Sehan, and the small river channel of the Cilician Gates, the Tarsus.

Farther east the Taurus finds itself between the Northern Folded Zone and the Border Folded Zone of the Arabian Platform. This area is very mountainous, especially near the Eastern border of Turkey where volcanics are common. There are no fewer than five major volcanos northeast of Lake Van. Some erupted as late as the Quaternary. Mt. Ararat (Büyük Ağri), the largest peak in Turkey (5164 m.). is likewise volcanic and has a geological history similar to Little Ararat (Küçük Ağri, 3925 m.). Between Lake Van and the northern boundary of the Arabian platform there is a tangle of mountain peaks and valleys. They are cut by one principal water system, that of the Murat-Euphrates rivers.

D. The Arabian Platform (the Border Folded Zone)

This region may be described as a gently mountainous area composed of Mesozoic or older rocks, but more than one third of the surface deposit (7200 sq. km.) is volcanic basalt. More than seven volcanos are known between Diyarbakir and the Syrian border. The highest points are related to recent lavas west of Diyarbakir such as Karacadağ (1919 m.). Some of the Volcanic flows are said to be younger than the Pleistocene.

E. Late Movements

Epeirogenicism continued through the Tertiary and indeed continues even today. For example, the Tuz Gölü region was depressed later than the Pleistocene, and depressions causing the Aegean and Marmara basins did not occur until the early Pleistocene, The Black Sea bagan to subside in Upper Cretaceous times and was joined and cut off from the Mediterranean Sea (i.e. Northeast Aegean) several times throughout its history.

Some grabens (downward moved blocks between two faults) are common to many areas of Turkey, and in some cases they are known to have been dropped 1000-2000 meters.

F. Physical Features

The general layout of the Anatolian land mass has been described in the foregoing pages. However, a few more remarks regarding prominent physical features are now in order, as they are a consequence of the geological setting.

As in the formative periods of the Anatolian lithosphere, climatic conditions, temperature, rainfall, winds and erosion have altered - and are still altering - the land forms as well as determined cover or exposure of the land. Forests tend to follow the coastal outline, though only generally. Man and beast have denuded much of Anatolia's interior forests, and only those areas less accessible have continued to perpetuate forests. Desciduous trees are closest to the coastline and are limited almost entirely to the Black Sea coast in areas below 1000 meters. Mixed forests occur in the Pontic Mountain Range and extend from the Caucasus to Çanakkale (mainly fir and spruce). For the survival of such forests the land had to be well-watered. High precipitation zones prevail today (cf. Map 6). These areas are now situated largely along the coast and in the east, but in the past a good portion of the Central Anatolian Plateau was also very well-watered and was fairly densely forested with cedar, juniper, oak and pine.

The present drainage system probably differs little from the past, except that the inland drainage systems are probably smaller in area due to the enroachment of larger drainage systems. There are six general drainage systems: Black Sea, Marmara, Aegean, Mediterranean, Tigris-Euphrates and Inland (Map 4). Another drainage system in the

East - the Aras - affects only a small portion of Eastern Turkey, the waters of which are carried over into the Caspian Sea.

The steep gradients of most of Turkey's rivers and their abrupt seasonal fluctuations in water-flow have all but eliminated them as an effective means of transport. However, in the west the rivers tend to be slower moving and offer possibilities for some transport as well as tapping for irrigation. The greater part of Turkey's waters flow into the Mediterranean, either directly or indirectly via the Sea of Marmara and the Aegean.

The river drainage systems, combined with the topographical variants, climatic conditions and no doubt other factors as yet undetected contributed to the founding of development of Anatolian communities of the past. These natural conditions were in themselves effective borders which bound some groups together and kept other apart. People of the past, just as today, were dependent on what the land could provide. Cultural features of communities in different areas are distinguishable by how the natural provisions (water, wood, mineral resources and wild life) were put to use.

G. The Origins of Metalliferous Ores[3]

It need be stressed, though an obvious fact, that it is not the abundance of ore within the Earth's crust that constitutes a valuable and usable deposit, but the concentration. Copper, for example, is present in great abundance in the soil of the Earth and even in living organisms, including the human body. Indeed, these small quantities of copper are necessary to life. It is only when there is a concentration of a metal mineral in the soil or rock that we can speak in practical terms of an ore.

It is extremely difficult to obtain information about the formation of metal ores, for not only do they occur in a great variety of ways, but they have their origins deep within the Earth's mantle. Since the time the Earth was molten some 4.7 billion years ago, the heavier elements have sunk to the interior far below the slaggy material which first made up the Earth's crust. These elements are now far beyond our reach. The lighter elements such as oxygen, silicon and aluminium have remained within the Earth's crust; today they constitute about 90 % of it.

The Earth and the magma below the crust are still cooling today. New minerals are constantly being fromed and work their way to the Earth's crust just as they did in the remote geological past. As the magma cools, elements which were originally randomly dispersed, seek stable bonds with other elements, sometimes with like elements, sometimes not. In any event, they form minerals of various kinds. Some of the elements being ionized (i.e. charged plus or minus) electro-chemical bonds with other elements. In other cases, specific gravity, molecular size, and other physical properties are the bonding factors. Prior to the bonding, magma sorting takes place by what is called magmatic differentiation. Here the magma is divided up either by affinities or by opposite characteristics, i.e. liquid immiscibility, fractional crystallization, gas volatility and thermal diffusion. One can see that the associations created are essentially a selective process and follow certain patterns. Depending on the nature of the elements and the compounds they eventually form, the various minerals segreate from the rest of the dough-like melt, though these segregations are not always in a solid or semi-solid state. The elements and the compounds with high melting points solidify first, and the last of the group to do so are the gases, as one would expect. It is basically this latter category that contains the metallic minerals.

When the hot magma reaches a temperature of ca. 600°C it begins to solidify, except for a group of volatiles which go into solution with magmatic water. Included in this solution are metals. As the magma finally solidify and becomes rock, our "metallic" solution becomes concentrated in the caveties and fissures of the host rick and is even injected into it. When the solution crystallizes it forms a class of minerals called pegmatites. These are crystalline igneous rocks which contain many rare and important types of metals, such as uranium, tungsten, polybdenum and tantalum. Cassiterite (tin ore) is often found in oxidized zones of pegmatite formations.

However, other metal gases -- containing lead, zinc, and copper -- continue to rise as the temperature of the surrounding magma drops, but these gases can remain in the magma until they encounter cooler environments such as water descending from the surface. Then, the contact of the gases and the water forms solutions which move away from the hot magma. The situation is similar to the above, except that the water source this time is from above, not from within the magma. The temperature and pressure push these solutions upwards, through fissures and cracks in the crust until surface conditions are reached. The solutions penetrate the rock (often limestones) and finally arrive at a stabilized state, thus forming metal ores in veins as we know them. This invasion of metal solutions into pre-existing rocks may be accompanied by what is called hydrothermal replacement, in which case the host rock is replaced by the newly arrived ore.

The two types of ore formation described above, magmatic and hydrothermal, are sulphide deposits which are the principal sources of present-day copper. But whether ores are magmatic or hydrothermal in origin, they can undergo still further transformation on or near the Earth's surface.

G1. Placer Deposits

Erosion will separate the heavy surface minerals from the light ones. Minerals of like specific gravity will collect together. If, for example, a river bed dries up, these deposits may later be covered by other sediments which protect the deposited minerals from further weathering. These are called placer deposits. Gold, platinum, cassiterite (tin ore) and other heavy metals often occur as placers. Copper, on the other hand, is not normally found in this form.

G2. Secondary Enriched Ores (Gossans) (Figure 1)

Where erosion has removed the earth and exposed the metal ore (s) this outcrop will be subject to further weathering. Here the rain-water and exposure to near-surface environmental conditions will take the ore into solution and carry it down to the water table where it can be redeposited in the form of oxides. This point of deposition is called the "contact zone" and is referred to as a secondary enriched zone, the primary zone being the ore body below the water table. In the contact zone can be found a great variety of copper ore as well as native copper itself. This type of deposit is called a gossan. The upper leached area of the gossan will consist of a layer of hydrated iron oxide in the form of limonite from which the copper and sulfur have been removed. This iron layer is sometimes called an "iron hat" and can contain enough iron so as to make iron mining worthwhile.

G3. Alluvial Deposits

When erosion water cuts away surface earth and reaches a mineral deposit the latter is not only exposed but can be broken up the action of the water's flow. In cold climates ice can form in cracks in the rock, expand and break up the rock. When warmer weather comes, water will wash away the small, light bits of rock, thereby contribution to the latter's decomposition. If the mineral is soluble in water, such as salt, the water will carry it down in solution to lower areas. Copper, which is also soluble in water to a certain degree, is often picked up from its principal ore body by water flow and redeposited elsewhere in the form of carbonates. Usually occurrences like this are not exploited on a grand scale, rather they serve to lead one back to the principal ore body where the ore is richer.

As for tin, the situation is quite different. Cassiterite is not soluble in water, hence when it is subjected to erosion and environmental alteration it does not change chemically but physically. The host rock is broken down by natural weather action, and the cassiterite rock is then freed. As it is washed down a stream, the cassiterite is broken up into smaller and smaller bits. Cassiterite, having a high specific gravity, will be sifted and sorted by the action of the water flow. Bits of like size, weight and composition will hence collect together and form rich deposits. It is this type of deposit which in fact is still the principal source of tin today. This type of deposit is similar to a placer, but here the action of ore-sorting is still a continuing process. Where the deposits ultimately form depends much on the water flow. It is characteristic for deposits to build up just before bends in rivers and streams.

Gold also occurs in a way similar to cassiterite, only it will often be found in the native (i.e. metallic) state, either in nuggets or small particles.

Notes to Chapter 1:

1. See C.A.H.. Vol. I, Pt.I, map facing p.10.

2. But no a single prehistoric site is known in the Buyuk Menderes Valley (personal communication from J. Mellaart).

3. This section is a paraphrased version of H.G. Bachmann's excellent article, "The Origin of Ores," Scientific American, Vol. 202, no.6, June, 1960:146-152. This author could not find better words than Dr.Bachmann's to describe this phenomenon.. Also consulted for this section were Rosenfeld, 1965; and Norddeutsche Affinerie, 1966.

CHAPTER 2

Copper Ores and Copper Production

A. Nature and Sources of Copper ore in Turkey

Copper ore is relatively abundant in Turkey. It occurs in various forms, and its distribution encompasses a large area of the country, even though only a few deposits (discussed below) are worth large-scale exploitation. The information on these deposits included in this chapter has been drawn largely from MTA publications which are the most up-to-date available to the public. The easiest way to view copper deposits in Turkey is to follow the MTA classification of ore types (MTA, 1972:1-6) which are grouped by age, area, and composition (cf. Chart I). There are 14 groups in all, and they are all copper-bearing except groups 1-4e and IV which are lead ores. The latter will be dealt with elsewhere in these pages.

The most prevalent type of copper ore available today is chalcopyrite. It is often associated with lead and zinc ores to the extent that all three metals (lead, copper and zinc) can be mined and smelted from the same ore body. Although copper ore is widely distributed, only a few areas in Turkey today are mined for it. The Ergani mine (Ore Group III) is the most famous deposit because it has been exploited for a long time, but just how long no one really knows. The Ergani ore is typical of a massive sulfide deposit which, according to one source, mineralized sometime around the Oligocene (i.e. Middle Tertiary).[1] In antiquity a certain amount of oxidized ore was available at Ergani, judging from present remains (Tylecote, 1970:291). Native copper was probably easily accessible in earlier times and may have been responsible for leading early man to the recognition of copper ores (see "The Discovery of Smelting" infra).

The Kure mining area (Ore Group I) continues to be an important source of copper today. Copper ore is actually no longer extracted at the Kure mine itself but at the near-by site of Asikoy.[2] The ore here is chalcopyrite with pyrite and some bornite, and -- like Ergani -- has vast reserves.

Near Artvin the Murgul-Kuvarshan Mines (Ore Group II-1) are also in animportant mining district. Mining at Kuvarshan Maden has now ceased, as the deposit appears exhausted, but Murgul is still operation. Chalcopyrite is the principal ore mined, but there are secondary mineralizations (especially in the upper part) of bornite, chalcosite, covellite as well as chalcopyrite. In the "ancient workings" (cf. Catalogue S, no. S-75) malachite and azurite occur.[3]

In antiquity native copper was probably much more abundant in surface outcrops than it is today, but still copper nodules can be picked up in a number of copper producing areas in Turkey (cf. Map 11). Many of the numerous remains of former mining and smelting activity could have been the work of prehistoric peoples. Only one copper deposit is confirmed to have been exploited in prehistoric times, the Kozlu mine (S-97), which was discovered in 1972 and reported in 1974 by Giles and Kuijpers. This mine, discussed below (see "Mining Techniques") provides us with valuable information regarding prehistoric mining methods. Other copper deposits with evidence of former workings (S-98, S-95, S-9) are also discussed below.

The distribution of copper deposits across Turkey from the Caucasus to the Troad provides a number of opportunities for copper exploitation by prehistoric peoples. Two types of mining activities may have been practiced in Turkey. One would be the intensive exploitation of a particular site, such as at Ergani and at Murgul, and the second would be small-time exploitation at a number of localized deposits, such as at the many small surface deposits along the Black Sea Coast in Gumusane, Giresun, and Trabzon Provinces (cf. Map 9).

The Ergani Copper deposit (S-121) has always maintained a special interest for archaeologists, not only because of its strategic location in Eastern Turkey on the main route between Central Anatolia and Assyria (Muhly, 1973:206-7), but also because of its continued wealth and because it has always been considered one of the principal sources of copper since early antiquity. Incongruously however, no archaeological material has yet been recovered to confirm this (de Jesus, 1976:229). Even though geologists and archaeologists from the last century (i.e. Smith, 1845) to present times[4] have written about and studied Ergani, (and sometimes with conflicting conclusions) in no case has any evidence been produced to indicate the exploitation of this deposit in antiquity. Slag dumps of unknown age have been noted at Ergani (Birgi, 1951:339), but as we see from previous surveys dealing with slags (de Jesus, forth-coming) there is no way to date them on sight alone unless they are accompanied by other (datable) material. Modern exploitation of the deposit has unfortunately erased much of what remained of any former workings. Even so, it is curious, that if ancient mining had taken place no unstratified ancient material has been brought to light. Recently, carbonized wood which was thought to be from ancient mining operations (Wheeler, Maddin and Muhly, 1975:34) has turned out to be only two or three hundred years old after C-14 analysis.[5] Notwithstanding its lack of evidence from antiquity, Ergani, probably was exploited in the past. Our "proof" is no more than an an impression, as it would seem unlikely that a deposit of such imposing size and wealth would escape recognition by ancinet copper miners.

Until more information is available about the nature of the former mining activities little can be said about the role of these deposits in antiquity. The locations of these mines carry with them their own implications not necessary to discuss here.

B. Trace Elements in Copper

Friedman _et al_ (1966) have provided some figures on natural-occurring trace elements in copper, as a native metal, as an oxide, and as reduced sulphide ore (cf. Table 6). The purpose of their research was to show the usefulness of neutron activation analysis (NAA) over conventionel chemical analysis and emission spectroscopy. The authors claim that because of the high sensitivity of NAA a wide range of trace elements can be detected, even if they occur in very small amounts. Friedman and his colleagues further state:

> From our studies on metal produced by reducing many different ores it was found that silver, arsenic, bismuth, iron, antimony, and lead were the most important metallic impurities in relating the metal back to the original type of ore. (Friedman _et al_, 1966:1505)

Others have given figures for impurities in copper, using NAA (cf. Table 5) (Fields et al, 1971), but the values tend to be higher than those of Friedman's group.[6] In both cases this data represents an average of trace element amounts in largely world-wide copper deposits. But it is not in this way that regional characteristics will emerge (Fields, 1971:137). Although some general patterns can be seen in these studies, such as percentage ranges, the details of immediate value to the historian and archaeologist (i.e. characteristics of specific ore deposits, variations in trace element patterns in time and space) are all lost by statistical applications.[7] Some trace element patterns will, of course, be world-wide in character, but the real revelations will come only when more analyses are performed on Old World deposits and when local trace element patterns are determined.

Rare trace elements such as selenium, scandium and indium have not been looked for in Old World copper deposits or metalwork, and until they are (and on a large scale) these elements, detected by Fields et al (ibid.), will not have any useful application in ore identification. As stated above, the research on trace elements in copper has produced widely varying results.[6] This is largely due to the lack of standardization between the respective analytical approaches but also, to a certain degree, to the indiscriminate choice of samples. However, these failings can be easily overcome by careful selection of ores and artifacts, and only then can metal analysis play an important role in trace pattern research.

As far as the character of Anatolian ores is concerned, there is at the moment only general information available. Most of the detailed data are contained in unpublished reports now in the MTA archives, largely inaccessible to the general public. The analyses of Anatolian copper deposits contained in these reports have not been considered here, but it is hoped that in the future some of them will be brought to the attention of archaeologists for documentation. The only comprehensive published account of Anatolian ores is that of MTA Publication no.133, Lead, Copper and Zinc Deposits of Turkey (Ankara 1972), in which some analyses of principal trace elements are given, such as the tell-tale trace elements Ni and Co which are thought to characterize Anatolian deposits.

However, from the analyses of slag (esp. de Jesus and Kaptan, 1973; 1974) we can get some idea of the trace element percentages of Ni and Co in the ore, assuming that the slag impurities are a true reflection of the original ore impurities.

In Çorum and Çankiri Provinces the highest Ni content was recorded 0.15 % at four sites and 0.1 % at four different sites. Cobalt tended to be lower in these cases, ranging from 0.0015 % - 0.07 %. Cobalt reached 0.1 % in two cases (Cozoğlu Mahallesi, S-9, and at Gemilik, S-86), but otherwise it tended to be 0.01 % the amount of Ni when they were both present.

The number of samples considered here is much too small to provide any valid distribution patterns, but of the slag from the 55 sites sampled 40 contained Ni and Co within detection limits of emission spectroscopy. The range of Ni, when present, was 0.003 - 0.15 %, and cobalt varied from 0.0015 - 0.1 %.

Compared with Fields' data (Fields et al, 1971:139, Table 9.6) cobalt is present in oxidized ores in amounts essentially equivalent to that in Anatolian copper slags. In the light of this, cobalt, on the order of ca. 0.1 % in an ore, should not be taken as strictly an Anatolian feature. The presence of nickel, on the other hand, tends to be higher in Anatolian copper ores than in non-Anatolian copper ores. This feature will no doubt cause some eyebrows to raise, for the evasive copper source of the Sumerians likewise contained nickel as elusive a major trace element. However, one should not be lured too easily by these figures and conclude that Anatolia was the area from which the Sumerians obtained their copper. First, the nickel content in Sumerian bronzes tends to be proportionally greater than what we have seen in Anatolian copper ores (i.e. slags). Secondly, Anatolian bronzes do not generally contain nickel in the proportions represented in Sumerian metalwork. The high-nickel copper used in Sumerian bronzes came from a yet unknown source.

Orpiment and realgar can occur with gangue material associated with other ores. Apart from the examples mentioned above, there is some evidence that arsenic was present in copper ores exploited in antiquity. The copper slag from Sakapinar (S-95) was shown to contain 0.1 % As in one sample, but it was absent in two other samples from the same site. In the same area, at Bahçelidere (S-95), two samples of slag proved to have 0.1 % As each. No other analyses of slag from this area had traces of arsenic. Even though no arsenic was detected in the only ore analysis from this area (at İnkaya) it is evident that at least some parts of the ore-body in the Bakir Çay has arsenic disseminated throughout, but it is not known in what form nor in what quantities. Further geophysical prospection of this deposit would be definitely worthwhile.

Another copper-arsenic association is found in the analysis of one of the copper borers from Çayönü (A - 1). Presumably the copper is native, but it contains 0.8 % arsenic in addition to 0.03 % nickel and small traces of tin, silver and iron. This amount of arsenic seems high for native copper, although admittedly a few analyses of native coppers from elsewhere have contained As in appreciable quantities (see Table 6). The copper in the artifacts from Çayönü are thought to originate from the Ergani deposit where native copper is known to exist, but a piece of native copper from Ergani (A-615) was shown by Esin to be almost pure copper with just a small trace of iron. The difference between these two analyses does not necessarily mean that the Çayönü copper did not come from Ergani, for only two analyses cannot be said to be very representative. The Ergani deposit is so extensive that a wide range of impurities and amounts is possible. Again, we must wait for further information on Ergani ore and its impurities before any association can be detected.

C. Prospecting for Copper and Other Ores.

As Forbes (1963:109-12) mentions, the early prospector no doubt had methods of locating deposits which are unknown to us. Many copper minerals have a very distinctive color, as mentioned in Chapter 1, and this visual characteristic may have been one guide to locating copper deposits. It is important to point out that copper minerals were used before the development of metallurgy. Copper carbonates had been used since the Neolithic period for coloring, as mascara and perhaps even as an ointment.[8] Hence, the whereabouts of copper deposits were no secret by the time Neolithic man became interested in processing copper ore for metal.

If colors were a guide to copper ores, the prospector could recognize a fair number of good exploitable ores visually. Chalcopyrite is recognizable by its brassy yellow; cuprite is distinctively deep red; malachite is deep - to light green; azurite and chrysocolla are various shades of blue; and bornite presents a characteristic group of iridescent colors. In exploitating these deposits the miner could also have unwittingly collected tenorite, chalcocite and the so-called grey copper ores. Hence, the brightly-colored ores can lead to others not so easily recognizable.

We cannot be sure, but it is unlikely that the ore prospector relied entirely on visual recognition. In the course of prospecting he most certainly would have gained enough practical experience and intuitive knowledge of where the ores could occur and what types of rocks produced copper. He may even have devised some simple tests for the identification of certain ore types and for an evaluation of their quality.

Would it not have been possible for the ancient prospector to identify the ore he is seeking by the taste of the water which flowed throught it? Agricola (1950:34) points out that prospectors of his day used six different tastes with which to identify some six general categories of minerals. A. Johansen (1973:87) mentions the use of taste as one of the means of identifying iron ores in the Middle Ages in Sweden. Other criteria for selection were colour, particle size and find context.

Arsenic ore can be identified by the garlic odor given off when it is struck by a hard implement or stone. Ores and minerals leave characteristic color traces when scratched on a stone. The weight of gold, lead and tin ores certainly offer some means of sorting them from lighter parent rock.

The prospector was probably quite observant and knew well the textures and workability of many types of materials. He may have used his familiarity with natural phenomena to develop prospecting methods such as dowsing. Although this method of mineral and water detection has been scorned by many scholars and scientists, there is conclusive proof that the use of the divining rod is valid in certain circumstances. Modern research has proved that professional dowsers have been able to locate many types of minerals, including metalliferous ores.[9]

A few words regarding dowsing zones may be worthwhile, as they have a rather interesting connection with copper deposits. It has been shown in modern studies that minerals such as copper lie within these zones, or may even be responsable for forming them.[10] It has further been noticed that certain types of plants and trees thrive very well within these zones and others do not. It is said, for example, that cucumbers, celery, onions, maize, privet hedges and ash trees will hardly grow at all, if planted above a dowsing zone (Tromp, 1968:388-9). This present writer himself has observed certain phenomena which have relationships -- though not fool-proof -- with copper deposits. It was noticed that dwarfed forms of juniper (Plate IV, 1,2) very often grow directly out of copper slag dumps or in areas known to be copper-bearing. Ernst Preuschen (in Norddeutsche Affinerie, 1966:29) has pointed out another similar observation:

> Archaeologists have but little difficulty in finding these (slag dumps) due to their being usually overgrown with the copper-tolerating Silene inflata ("bladder campion"). This plant is a never-deceiving indicator of copper poisoned soil.

Many mineral and plant associations have been known for some time, but it is only within the last few decades that it has become the subject of intensive research. Regarding plant indicators of copper, a number of them have been confidently identified by geobotanists (Brooks, 1972:30-1).

It is said that bees swarm on branches of trees located in dowsing zones (Watson, 1975:112), and it has also been observed that ants frequently build their nests in a dowsing zone. This author has noticed in his survey of mines and slag dumps in Central Anatolia that ants very often inhabit copper slag dumps, or their hills are located near-by. Whether this is due to some particular feature found in the ants or whether it is a question of food supply is something for the botanists and entomologists to work out.

Would these natural anomalies have been entirely ignored by the ancient prospector? When his livelihood depended on his ability to locate worthwhile deposits, it is probable that he used many indicators, some of which we may have mentioned here.

D. Preparation of Copper Ores

D1. Copper Oxides

For the Anatolian smelter it is unlikely that in terms of tonnage the percentage of copper in the ore mined was more than 8 % pure.[11] This means that before such an ore can be smelted it must be processed and concentrated. Only at Timna has an ore-processing site been excavated enough to provide ample documents pertaining to ore selection and preparation for the entire Near East. According to Roghenberg the ore mined in the 4th millennium B.C. was mostly a question of collecting copper outcrops on the surface (Rothenberg, 1971:10-11; idem., 1966:87), which led to open cast working and eventually tunnelling. Mostly malachite was mined at Timna, but some chalcocite (sulfide) was recovered in the smelting area, which implies that the early smelter may have known how to oxidize sulfide ore.[12] In the case of the Timna copper deposits the ore, essentially malachite, is disseminated through limestone. The latter, being a relatively soft rock, can be broken with stone tools, examples of which were found at the site. The ore lumps were then crushed with stone hammers to break away the limestone gangue, a process known as hand-cobbing.

The ore-processing phase at any metallurgical site is of course important, and depending on the gangue material different methods are used. In the case of light gangue, the ore can be washed to remove the unwanted material and thereby make up a concentrate of the ore. Experience and manual dexterity is necessary in this step, whether using a washing method (i.e. a sluice) or sieve. It was probably quickly understood by the ancient smelters that the wash water still contained some of the desired ore, and it was allowed to set, thereby permitting a residue of ore to accumulate. The residue was then concentrated further for smelting. This was a common practice in the Middle Ages (Agricola, 1950:274-310), but probably hand-cobbing and dry crushing (with mortar and pestle) were the most common methods of copper ore preparation in antiquity. The wet methods using running water (i.e. strake or buddle) are normally associated with the heavy ores such as cassiterite and gold.

D2. Sulfide Ore processing

The principal difference between sulfide ore preparation and that of copper oxide is that there is a roasting process involved before the concentrate passes on to the smelting stage. After the preliminary sorting, crushing and concentrating of the ore, it is roasted. This has the effect of driving off most of the sulfur in the ore. In the Middle Ages "Cakes" were made of sulfide concentrate mixed with water and dried. These were then roasted between seven and nine times, the end result being a black copper oxide (Agricola, 1950:349-351). The chemical process of oxydizing copper sulfide may be expressed as follows:

$$2\ Cu_2S + 3\ O_2 \longrightarrow 2\ Cu_2O + 2\ SO_2$$

Or, to put it another way:

Concentrate + fire and oxygen ⟶ Copper oxide + gas

Once roasting has driven off most of the sulfur, the ore is ready for smelting. In certain processes an entire oxidation of sulfide ore is undesireable due to the loss of potential copper in the form of smoke and dust and because the sulfide smelting reaction cannot take place (cf. infra).

D3. Smelting

The smelting of oxides is a process which can vary. The simplest method heats copper oxide with charcoal in a reducing furnace at a temperature between 800-900°C (but see "Copper Smelting Furnaces" infra). The reaction may be expressed:

$$2\ CuO + C \longrightarrow 2\ Cu + CO_2$$

It is unlikely that the ancient smelter could perform an operation as neatly as above, since he had to deal with impurities of many kinds in his concentrate. Moreover, he had to use temperatures much higher than the modern smelter due to the inefficiancy of his equipment. However, by dint of experience he probably learned to treat ore concentrates containing different impurities and he would have devised methods to control the smelting reaction so as to produce an acceptable copper.

The color of the smoke emerging from the smelting furnace may have been one of the indicators used by the ancient smelter to control the reduction process. Agricola (1950:235) offers us some interesting insights in this respect. He briefly describes how the medieval smelter added pyrite and chalcopyrite to the furnace if the smoke was blue; or, if it was white he added sulfur and rusty iron. It is probable that the smelting process used in prehistoric and ancient times was not a one-step operation, and the reaction took place over the course of several hours. Consequently, continuous control over the reaction was necessary to produce the desired result.

After describing the methods for controlling the reaction Agricola further explains:

> The color of the fumes not only gives us information as to the proper remedies which should be applied to each ore, but also more or less (indicates) as to the solidified juices which are mixed with it, and which give forth such fumes. Generally blue fumes signify that the ore contains azure; yellow, orpiment; red, realgar; green, chrysocolla; black, black bitumen; white, tin; white with green patches, the same mixed with chrysocolla; the middle part yellow and the other parts green show that it contains sulphur." (Agricola, 1950:235)

This is, in effect, a list of assay tests similar in principle to that used by the modern field geologist. It is possible that the ancient smelter also used such guidelines to identify the ore content.

D4. Smelting Sulfides

1. First Method

In the case of copper sulfide concentrate, there are optional methods of treatment and smelting. The simplest way of dealing with copper sulfide concentrate is to roast it to an oxide as described above and then smelt it. One can smelt the oxide as one would an ordinary copper oxide ore. For example, in the case of chalcopyrite, the oxidizing (i.e. roasting) process may be expressed:

$$2\ CuFeS_2 + 2\ O_2 \longrightarrow Cu_2O + 2\ FeO + 4\ SO_2$$

This produces a copper oxide mass which is then smelted in a normal reducing furnace:

$$2\ Cu_2O + C \longrightarrow 4\ Cu + CO_2$$

The disadvantage of this system is that it loses potential copper in the slag and in the form of dust and smoke. Although not expressed in the formula above, the iron oxide (FeO) also figures in this reaction, since it is not possible to sort out completely all of the gangue from the oxidized copper ore. Iron in this form acts as a flux such as was used at Timna where it was accompanied by siliceous material (i.e. sand and limestone). Fluxes were, of course, important to the succes of the reaction. Large amounts of prepared flux were found at Timna in the form of fossilized wood converted into hematite. Manganese oxide found in the slag is also thought to have been used as a fluxing compound, in addition to sea shells which contain calcium oxide (Rothenberg, 1967:257; Lupu, 1970:21).

2. Second Method

An alternative method produces a copper matte (copper enriched sulfide and iron oxide). To do this the furnace (oxidizing) temperature must be controlled such that the iron sulfide in the concentrate is oxidized, but not the copper sulfide. The principle behind this step is that under heated conditions iron will tend to lose its sulfur more easily than the copper will. If the temperature is carefully controlled the reaction will produce a copper matte:

$$2\ CuFeS_2 + 3\ O_2 \longrightarrow 2\ CuS + 2\ FeO + 2\ SO_2$$

H-G. Bachmann (1968:422) has, incidentally, detected this oxidation process in two MBA slags from Alaca.

If it looks to the smelter as if some of the copper sulfide is also being oxidized, he need only add more iron sulfide. The copper oxide will pick up the sulfur from the iron and join the bulk of the matte at the bottom of the furnace. The oxidized iron will go into the slag on the top of the smelt, in which case the reaction is:

$$Cu_2O + FeS \longrightarrow Cu_2S + FeO$$

This may be what Agricola was describing in the case of his "blue fumes" (Agricola, 1950:235). This copper matte can now be converted to copper metal by smelting it with copper oxide in a reducing furnace. This reaction may be expressed:

$$Cu_2S + 4\,Cu_2O + C \longrightarrow 10\,Cu + SO_2 + CO_2$$

As one can see, this process smelts simultaneously two different types of copper ore. Both copper oxide ore (malachite) and copper sulfide ore (Chalcocite) were apparently worked at the Chalcolithic site No. 39 at Timna. Although not reported as such, the simultaneous smelting of these two ores may have been practiced (Rothenberg, 1966:87; idem., 1972:27-51).

The reactions and processes used in ancient and prehistoric times still remain obscure. Although we are fairly certain that since the beginning of the IIrd millennium B.C. the smelter was able to deal with sulfide ores such as chalcopyrite and bornite, we do not yet know specifically what steps he used to produce the copper metal or what problems he encountered. Hence, the above discussion should be viewed only as some of the possible smelting methods practiced in antiquity.

E. Copper Smelting Furnaces

Despite the great abundance of prehistoric copper work produced in Anatolia, no smelting furnaces dating from this period have yet been reported. The lack of examples of smelting furnaces is due to the nature of the copper industry. As stressed elsewhere in this thesis the bulk of the metallurgical activity probably took place at or near the deposits or near the wood (i.e. fuel) supply. As most of the prehistoric settlements investigated by archaeologists are not located in these areas, metallurgical equipment is simply not found. There are some exceptions. Smithing equipment is sometimes located in settlements. The Middle Bronze Age smithy at Kültepe, for example, is one of the more fortunate discoveries (Özgüç, 1955).

However, the problem still remains that we have no documentation on prehistoric smelting furnaces in Anatolia. Some late examples are known, so in view of the absence of earlier furnaces it is worthwhile to mention these briefly.

Near the village of Hisarcikkayi (S-87) a smelting furnace was located in 1973 by MTA (de Jesus and Kaptan, 1973:55-59, 144-5) and dates from ca. Late Roman Period. The condition in which it was found was far from ideal, as it had been uncovered and broken open by a local villager prior to MTA's visit. However, some information was recoverable. The furnace was built into the slope of a hill (Figure 10). It might have been placed in this way so as to benefit from air currents, but no strong winds were noted at this particular location. Alternatively the orientation might have been one of convenience, as the slag could be emptied from the furnace and simply shoved down the slope.

What survived of the back wall provided an interesting feature. The wall was made of a kind of coarse clay or mortar which was first applied on the original cut into the slope. This mortar layer was between 5-15 cms. thick. After one or two smeltings a kind of slag layer had adherred to the wall. This layer apparently impaired the refactory qualities of the furnace, for it had been subsequently covered with another layer of mortar. Another one or two smeltings were then performed, again leaving a layer of slag. Due to the fragmentary state of the furnace it was not possible to determine how many times the furnace had been used and how many times its walls had been coated with mortar, but judging from the state of the surviving walls the original size-volume of the furnace had been reduced by at least one-half.

In front of where the opening of the furnace was situated was what seems to be a tapping pit. Slag and ash filled this depression, but none of the fragments looked like they had been tapped out of the furnace. They were generally small broken pieces and showed no signs of flow.

There were no signs of blast air equipment, though in the reproduction in Figure 10 bellows have been added on a theoretical basis. An additional element to the furnace was located in the village of Hisarcikkayi. This was what seems to have been at one point the furnace bottom. It was a flat stone measuring about 50 x 80 cms. and about 10 cms. thick (Plate I (3)). Two other fragments no doubt belonged to the largest pieces but it was not discernable just how they fit together. This stone had two shallow channels cut into it at each of its short sides. These could have been sow channels for copper flow.

This flat stone bottom might not have been an element in the original furnace construction, as the rock bottom of the slope also seems to have served as part of the furnace at one time. It seems likely that, in view of the repeated repairs done to the furnace throughout its use, some adaptions were made, the addition of the rock slab bottom being one phase.

The analysis of the slag (S-87) showed a high trace of sulfur, suggesting that this furnace was uses in producing copper matte, hence a matting furnace and not a smelting furnace as such.

An example of a smelting furnace is only suggested by fragmentary evidence from the Bakir Çay, north of Merzifon (S-96). In a small slag dump (Plate III (1)) were found no fewer than 10 tuyeres (Plate III (2)). They all showed traces of having been subjected to intense heat, and a number of the tips showed small straces of slag. No furnace was found in or near this dump, but fragments of flat, clay mortar lining (?) incrusted with slag were uncovered from the dump. None of the fragments was large enough to reconstruct a furnace, but in view of the great number of tuyere fragments and the mortar bits, small bowl-type furnaces might have been used. These could have been non-tapping furnaces, using blast air (cf. reconstruction Figure 9).

A smilar furnace might have been in use at Orencik (Çorum Province) (S-90), but again the remains were too fragmentary to provide unequivocal evidence of type.

Recently, evidence for smelting in the Chalcolithic and EBA periods has come to light at Norşuntepe (private communication from H. Hauptmann and also Zwicker, 1977). Slag and ore was found within the settlement, but no smelting furnace was located. Surely if the excavators had had enough time they would have found the smelting complexes.[13] Nevertheless, Norşuntepe offers the first Anatolian example of smelting within a settlement, apart from the inference of smelting at Çatal Hüyük (see "Conclusion").

Smelting furnaces outside of Anatolia have been found in various contexts: at industrial sites[14] such as at Timna (Lupu, 1970; Rothenberg, 1966), in the South Sinai (Rothenberg, 1971) and at Medzamor (Vidal, 1969). They are also known in settlements such as at Tell Jemmeh (Petrie, 1928:6, pl.IX), Tell Abu Matar (Perrot, 1957:18-19, pl.I, fig.5), Enkomi (Tylecote, 1971:53), and Kition (Karageorghis, 1973:16-17). Of the various furnaces cited here, beyond the fact that they come from different areas and from different periods, they vary widely in design and size. As more examples of smelting furnaces are uncovered, we may find that this diversity persists and that we are dealing with different types of smelting methods which bear little relationship to one another. We may ultimately find that each furnace design is representative of a particular metallurgical tradition,as culturally distinct as the fabric and design of pottery.

A few words should be expressed on the problem of smelting temperatures. It has often been thought that due to the high temperature required to melt copper (1083°C) that smelting was discovered before melting. To debate such questions is a waste of rhetoric, for the available evidence does not point to one having been invented before the other, nor is it important at this point of our knowledge of ancient smelting methods. In all likelihood smelting and melting were simultaneous discoveries. Copper ore under ideal conditions will reduce to copper metal at about 800°C. The metal produced at this temperature will be in the form of globules or prilles of varying sizes. However, the ancient smelting operations probably worked at much higher temperatures due to the varying degrees of efficiency of the furnaces and of the homogeneity of the ore concentrate.

Modern experiments suggest that smelting in antiquity may have been practices at temperatures well above 1150°C (Lorenzen, 1966:16; Anstee, 1960). In the light of this we can say that in practical terms the temperature needed to reduce copper ore is also capable of melting copper metal. If for some reason the ancient smelter was only able to produce copper prills in his smelting operation, melting them together would have been the only logical follow-up.

A simple copper prill is of no greater use than a piece of native copper of the same size. Smelting would only have produced a quantity of small pieces, whereas smelting followed by melting provided the means of producing large pieces. It was only then that the discovery of copper ore reduction found its utility and value.

F. The Discovery of Smelting

A variety of theories have been offered to explain how man came upon copper smelting. This event has held a particular fascination for archaeologists and historians, and for good reason, but for the most part they have attempted to reconstruct an event for which we have absolutely no documents. What they have suggested are little more than their impressions.

Peake and Fleure (1927:10) suggested that a piece of native copper may have accidentally fallen into a campfire and "melted into beads which would be afterwards found in the ashes, or that malachite, or even copper pyrites, might be reduced to metallic form in the same way."[15] Childe (1966:116) also opted for the campfire theory and even went so far as to suggest that "the reduction of copper might have been discovered more than once," but he scored down the importance of the discovery by adding that "its significance need not (have been) immediately appreciated." One geologist unrealistically thought that "forest fires, started by lightening, were probably responsible for introducing man to the art of smelting" (Pearl, 1966:18). T. Reed (1934:384) suggested that the fusion of copper was discovered first and that "smelting was, most probably, a logical and natural outgrowth of melting operations, not a chance discovery, as nearly all the literature on the subject assumes." Reed's view was not heeded by his contemporaries, for they felt that smelting was much too complicated a process to have been discovered other than by accident.

The campfire theory of Peake and Fleure (1927:10) had long remained a popular theory, but in the course of time it lost its supporters. In fact, recent experiments have shown it to be a completely invalid concept.[16] After unsuccessful attempts to reduce copper ore in a campfire, Coghlan (1939/40:57-63) suggested that the discovery of smelting may have come about when some form of copper ore was used to decorate pottery and was accidentally reduced to metal during firing. However, he later abandoned this idea to join Reed in suggesting that smelting developed out of the routine melting down of native copper. To provide support for this concept Coghlan turned to the question of furnace technology:

> Since highly fired pottery of the Tell Halaf and Al'Ubaid cultures dates back to a time well before the discovery of smelting we need see no difficulty concerning furnace technique: if the required temperature was obtained in the pottery kiln there is no reason why a melting-furnace should not have been evolved to give an equally high temperature. It appears that, on the whole, we may regard the discovery of smelting as a logical process following on from the melting of native copper. (Coghlan, 1951:23)

Many authors have since rallied to this point of view(Cohen, 1952: 23-4; Gille, 1966:8-9; Knauth, 1974:37).

Rothenberg (1966:91) suggests that smelting was a methodological development. Moreover, he presents convincing evidence that, as far as Timna is concerned, smelting was first discovered in a crucible operation. In addition to the Timna finds, support of this view also comes from Tell Abu Matar where crucibles, ore, and slag have been found (Perrot, 1957:18-19).

As the traditional diffusionist theory is no longer tenable (Renfrew, 1976:183-4), we are now faced with the situation of smelting having been discovered not once, but many times. Wertime (1964: 1257) holds that the independent discovery of smelting does not seem possible because of the complicated processes involved, but he does not take into account that the vast differences in the technological development and the culture of early copper-producing societies do not suggest a common origin in any way. However complicated the smelting process might appear, it would be naive of us to think that its discovery was made only once in the course of human history.

If we find that the independent discovery of a phenomenon is remarkable -- even unbelievable -- it is very likely that we have too restricted a view of ancient man's intellectual ability. We too often see his course through history as a series of ad hoc adaptions to natural conditions or events. Man's desire to exploit the potential of the physical world in order to improve his well-being is the essential motivation behind experimentation. It is in turn experimentation -- trial and error -- which ultimately leads to discovery and innovation. It is precisely man's inquisitiveness and his willingness to experiment which authors have failed to consider. Professor C.S. Smith suggests an orderly pattern to the development of pyrotechnology and saw smelting as a stage in that development brought about through experimentation:

> (Smelting) need not have been an entirely accidental discovery. Once the change-producing properties of a hot fire were known, the fundamental human instinct of curiosity could have led someone to experiment empirically, for no other reason than that he enjoyed the sight of unexpected things happening when colored and heavy stones were heated. (Smith, 1965:910)

Yet, Smith does not feel that this experimentation with copper ores was performed with the expressed purpose of attempting to extract copper metal, and he implies that smelting was not so much accidental as it was unexpected.[17]

Settling into communities, domestication of animals, development of agriculture are never explained as having accidental or unexpected origins. These innovations are direct and practical solutions to needs within a society. We cannot isolate metallurgy, writing, or irrigation as having a less clairvoyant origin. There can be little doubt that man's first contact with copper metal was native copper, but the frustration of always having to deal with small bits of metal must have urges the copper smith to seek ways of fusing them together. It must have often occurred to him that with a hotter fire he might be able to melt them together. And the idea of smelting copper from its ore may have appeared more obvious to the ancient copper-smith than we have heretofore considered. It must not have been too difficult for him to make the association between native copper and copper ore. Native copper occurs, more often than not, associated with copper ore, i.e. the oxides; the metal itself is often covered with oxidation. Upon cleaning the metal the smith would have seen that the oxide and the native metal are somehow related. In addition, the oxidation occurring on tools made from native copper would have been a constant indication that copper oxide and the metal are two different forms of the same substance. The copper-smith may also have reasoned that if moist conditions produce copper oxide, such as the case of oxidized native copper from a stream bed, that heated conditions might reverse the process.

Just before the time smelting is discovered in different parts of the world, all the technology needed to perform the process is well-established. We must not forget that pre-metal societies were already familiar with different kinds of fire treatments (Muhly, 1976:84). There were fires for heating, cooking, baking, creamation, destruction, and drying, just to name a few. There were fires which burned brightly, and there were fires which smoldered. The fact that the physical state of materials could be changed by fire was certainly no secret to ancient man. He, himself, changed the tasteand aspect of food by cooking it; he made wood into charcoal, and he saw solid substances, such as beeswax, turn into liquid when heated and turn back into a solid state when left to cool. He saw an ice-covered pond gradually melt into water when spring came, and he saw it turn back into ice when winter returned. He saw water transformed into steam when poured on a fire. He saw salt dissolve in water. These and countless other phenomena must have been studied for their potential usefulness, but to make them useful he had to translate them into human terms. And this meant experimentation. Copper smelting is the result of one such inquiry.

G. Charcoal-making

For the hot, non-oxidizing fires employed in the early metallurgical industry, charcoal was an indispensable fuel. As much of Anatolia was wooded in prehistoric times there was abundant supplies of fuel, but in the course of time it might not have been always within easy reach, as we shall see below.

The essential process involved in making charcoal is to burn off all the resinous substances in the wood and drive off the water without burning away the fibrous material. The result is an almost pure carbon mass. The virtues of wood charcoal might have been recognized quite early in man's history. When lit charcoal burns slowly, it gives off little smoke, steady heat, and, while ignited, can be carried in a recipient from place to place, A dry wood fire, on the other hand, burns fast and although it gives off a lot of light and heat, it must be repeatedly tended to. A. Lucas(1962:456) points out that charcoal was known as early as Badarian times in Egypt. Partington claims that charcoal fires were used in the Old Kingdom (Partington, 1934:21). From archaeological finds it is difficult to distinguish what is prepared charcoal and what is charred wood from a destruction fire or hearth fire. However, it is conceivable that charcoal-making was a craft commonly known in Neolithic times in many parts of the Near East.

Again, we have no information on the specific ways in which charcoal was made in the early days of metallurgy, but we can make a fair guess, for the process, being fairly simple, has few variations. We are fortunate to have insights into charcoal-making in later periods, the most informative being the medieval iron-smelting site near Hardangavidda, Norway (Johansen, 1973:87-8 and fig.5). Although far removed in space and time from our sphere of investigation, we at least have here an idea of what a charcoal kiln could look like.

Charcoal can be made of most woods.[18] Juniper and conifers were commonly used because of their abundance in cool climates, mimosa and tamarisk are known to be made into charcoal in warmer regions

(Partington, 1934:21). Johansen found that the Norwegian charcoal kilns were simple semi-circular depressions ranging in diameter between 1.5-5 meters. The wood was stacked up and covered with turf. Before being completely covered the wood was ignited and then left to burn, or rather smolder, for about two weeks. The amount of turf covering the kiln was so gauged that smoke and the emitted gases were able to go off into the atmosphere. Enough oxygen was available in the wood itself and in the spaces between the pieces so as to allow the fire to consume and drive off everything which was not carbon.

The preparation of charcoal was no easy task for the prehistoric smelter. Trees had to be felled, cut to manageable pieces and finally stacked and ignited. Smelting operations of the early metallurgical industry used vast amounts of charcoal, and one wonders whether the smelter might have perhaps obtained his supply from those devoted exclusively to making it.[19]

The charcoal makers probably stayed as close as possible to the tree line; that is to say, they performed all of their tasks where the trees were felled. Charcoal is much lighter to transport than green wood; charcoal-making can reduce the weight the wood by as much as 50 %.

It was not always the fuel which was transported to the smelting site. There are instances of the ores being transported to the fuel, as in the case of the Ergani mines of the last century (see Chapter 6, Part A, infra). We must realize that fuel, smelting furnaces and mines cannot all be locally available indefinitely. When the fuel or the ore gives out obviously something is going to have to be transported if the industry is to be continued.

Charcoal making cannot be classed as a "domestic industry" such as making beads or weaving, which can be practices at any time of the year and in the home. To make charcoal, one must go to the material -- the trees -- which in the case of Anatolia, was more often than not situated at high altitudes, say 1000 meters or more. The winter months of the year in these parts can be sever, and only when warm conditions prevail is it a suitable time for making charcoal. The task is never easy, for each year the people concerned had to travel farther and farther to the trees, thereby lengthening the trip back to the "consumer", as it were.

We must remember too that wood had other uses, such as for house construction, cooking fires and the like. But it is probable that the majority of the wood cut in prehistoric times was used for fuel, either domestic or industrial.

In a highly wooded region it may gave taken several hundred years to completely exhaust the tree supply. During that time a metallurgical industry would have built up a sever and irreversable dependence on its fuel supply. It is easy to see that fuel supply was the Achilles's heel in the system, since it had to be brought from farther and farther away, and perhaps closer and closer to hostile territory. The difficulty in fuel supply might have led not only to more efficient furnaces and smelting procedures, but it was the most important single factor which regulated the output of metal. Other authors hold this same view (Allen, 1970:10-11), but it is crucial that we have much more date on tree growths, periods of deforestation, location and size of slag dumps, and the efficiency of furnaces before we can work out any estimations of the quantities of wood consumed over a specific period.

H. Tuyères and Bellows

Tuyères (or bellows nozzels) are associated with metalworking, specifically with metal smelting or metal melting furnaces (Figures 9, 10, 11). These tuyeres would have to be close to the fire so as to direct the air blast into the burning coals. It is logical then that a number of those recovered show signs of either vitrification at the tip or scorching from the intense heat of the furnace which would be somewhere between 1000° - 1300°.

The use of bellows pre-supposes the existence of tuyères and vice-versa. Many more tuyeres have been found than bellows because the former necessarily need to be made of a fire-resistant, hence durable, material such as clay. Bellows, on the other hand, can be made of skins or wood or both. The absence of clay pot bellows where tuyeres have been found would seem to suggest that bellows were, more often than not, made of perishable material. For example, no bellows were located (i.e. identified) at Norşuntepe (Hauptman in Mellink, 1975) amidst casting equipment, nor in Cyprus (DuPlatt-Taylor, 1952:150-3; Tylecote, 1971:53-8) where smelting furnaces were found, nor at Gezer (Macalister, 1912:265) where tuyères were found, nor at Timna (Rothenberg, 1972). Tuyeres broke, became clogged with slag or melted in the course of use and were often thrown away. Whether of perishable material or ceramic; bellows, on the other hand, could have served throughout the life of the smith or smelter.

The earliest examples of Anatolian tuyères are the one from Beycesultan VIII (Figure 13 (4)) and the three from Poliochni Rosso (Figure 13 (5,6,7)), all EB I in date. We know from other metallurgical material (i.e. moulds and analyses of metalwork) that by EB I the practices of smelting, casting and bronzeworking were beginning to spread to all parts of the Eastern Aegean and Western Asia. This, of course, implies the use of melting furnaces and smelting furnaces fired by bellows. The Beycesultan and Poliochni examples of tuyères are from smithing bellows; that is to say, they were used not for smelting but in a furnace used for melting copper in a crucible. The only clear-cut examples of smelting tuyères are those located in the MTA survey of 1973,[20] in the Bakir Çay region (Amasya Province) (Plate III (2)). Unfortunately, no precise date can be ascribed to them, but it is possible that this smelting site dates to the **late Phrygian period.**

There are two EB II examples from Poliochni (verde-rosso) (Bernabò-Brea, 1964:CLCVIII, 1,2 and CLXX, 7,8) which show a continuous use of these artifacts at that site. Thermi provides us with 3 EB II examples (Figure 13 (8,9,10)) which tie in closely with those of Poliochni.

As for Troy, Schliemann publishes a "funnel" of mica schist from his "Burnt City" (Figure 13 (1)) (Ilios:410-11, no.476), but they are most likely tuyères. He also mentions that "funnels of terracotta of the same shape are numerous in all three upper prehistoric cities at Hissarlik" (i.e. Schliemann's Troy III, IV, V; Ilios: nos.1338, 1339) which would be roughly EB III in date.[21]

Not all tuyères are alike at all periods. The clay tuyères (unpublished) from the MB I smithy at Kültepe Ib (Özgüç, 1957) are longer than those previously mentioned and have their blast orifice on the side at one end. The mouth end which connected to the bellows is essentially the same diameter as most tuyère mouths, i.e. ca. 5 cm. These are melting furnace tuyères which, it would appear, were operated on the surface of the ground, as opposed to those which are inserted into the furnace bowl below the ground.[22]

The use of ceramic pot bellows in antiquity is not confirmed until ED III times, the oldest being those found in the smithy at Tel edh Dubai (al-Gailani, 1965) (Figure 12 (1)). Discussing Egyptian metalworking, Wainwright (1944:95-6) points out that prior to the 18th Dynasty (ca. 1580 B.C.) only blow-pipes were used, but in Mesopotamia bellows were in use a thousand years before their introduction into Egypt. According to Wainwright the use of the blow-pipe in Egypt may go back as far as the 4th Dynasty (ca. 2800 B.C.). Evidence for the use of blow-pipes elsewhere in the Near East is totally lacking. The 18th Dynasty bellows as they are depicted in the tomb of Rekmirê are similar to an example (possibly E.D.) from Tello (Figure 12 (2)), originally reported as a "fire pan" (Cros, 1910:151), but correctly identified by Coghlan (1951:69). Other examples of Near Eastern bellows are known (see A-679-684).

The earliest Anatolian bellows come from the MB I smithy at Kültepe Ib (Özgüç, 1955:79), but only long after Anatolia had proved its capabilities as a metal producer and a purveyor of metallurgical techniques. As stated above, bellows could have existed earlier, but were possibly made out of perishable material and have not survived. To explain the absence of bellows, another factor must be taken into account. Except for Norşuntepe in the Early Bronze Age (Zwicker, 1977; Muhly, 1976:92) and Alaca in the Late Bronze Age (Bachmann, 1968:420-2) smelting was more commonly an activity practiced outside settlements, and hence, bellows have not been found in the course of traditional settlement excavation.[23]

No conclusions about the development and initial use of either smithing or smelting bellows in Anatolia and the Near East is yet possible. One can provisionally say that with the advent of copper smelting bellows were used, which could take us as far back as the 7th millennium B.C. A fuller discussion of bellows types will have to wait until more material is available.

I. Moulds

The first moulds used in antiquity may not have been more than crevasses in stones or depressions in clay into which moulten copper was poured. Later, simple open moulds were used to cast flat axes, chisels and other simple tools.[24] The earliest known tools in Anatolia probably made by this method are the Late Chalcolithic flat axes and chisels from Mersin XVI (Garstang, 1953:132, fig.80b),[25] which date from about 4300 B.C. No moulds of any kind are known from Late Chalcolithic contexts, so the inference here is strictly indirect.

The Can Hasan macehead (Plate XXVII, I) is the earliest cast implement known from Anatolia (ca. 4750 B.C.) (French, 1962:33). Its importance lies in its means of manufacture which at the moment is still somewhat a matter of conjecture. It is made of almost pure copper, as shown by Esin's analysis (A - 168). It is roughly spherical in shape with a shaft-hole through its center. One has the feeling that the macehead was cast, incorporating the shaft-hole (i.e. the hole was not drilled).[26] The mould from which it was cast was probably made by hand out of soft, wet clay and shaped into a spherical matrix, the top left open for pouring in the molten copper. For the shaft-hole a simple piece of carbonized wood or a shaft-shaped piece of clay may have been placed upright in the mould prior to casting. Any excess tailings or flanges which remained after casting could be easily ground down or broken off.[27]

Cire-perdue casting (Hodges, 1968:72) was probably practiced early in EBA, but the evidence is in almost every case indirect. In other words, few cire-perdue mould fragments have been found, one of which is an EB I axe mould from Poliochni (Bernabo-Brea, 1964:591, pl.LXXXV d; Branigan, 1974:82, fig.4) (Figure 15 (1)). Although the surviving fragment is a quite convincing example of this technique, one does not see how this particular mould was used, since it is not broken in such a way that a cast axe could be freed from it. Hence, we must admit that the mould was never used in antiquity. Perhaps it did not conform to the standards of the smith, or it broke before it could be used. The curvature of the mould suggests a shape more akin to a shaft-hole axe than a flat axe, which would make this the earliest example of this type of axe known from Anatolian-Aegean contexts. Another (but less sure) example of cire-perdue casting comes from Thermi IV. An oblong receptacle of coarse clay is described by Lamb (1936:121, fig.37 (367)) as being recipient for oil. Yet this object (and a second unstratified one similar, ibid., fig.37 (601)) could be a cire-perdue mould for a hammer or similar tool, perhaps even with a shaft-hole.[28] It must also be said that such a mould need not have been made over a wax model. The simplicity of the shape would easily allow for dispensing with the wax stage since the matrix could be made directly out of clay.

Risking repetition of what has already been stated, it must be stressed that cire-perdue casting of objects is, at best, only inferred, whether it be for figurines or tools. Its confirmation will only be conclusive with the discovery of the mould fragments themselves.[29] It had once been considered certain that the Chou and Shang ritual bronze vases with their intricate details were cast by the cire-perdue method. Recent research has shown that this is not the case at all, that multiple piece mould casting was used exclusively. It was not until later that cire-perdue casting was introduced in China and only after multiple mould casting had reached a peak in its development (Smith, 1968:7-8; Barnard, 1961).

There are many more examples of "non cire-perdue" casting. Seeden (1970:41) points out that some of the LBA Biblite dieties were cast in two-piece moulds. In fact, some as-cast examples still have flanges along the side where the two mould halves met. In some finished examples it is evident that by hammering some details were applied, and the arms were bent forward (Dunand, 1939, text:425; plates:CVII, no.6556).

Until now, multiple piece mould casting has not been mentioned in the context of Near Eastern metallurgy, but proof of its use is but a breath away. Recently, a very large fragment of copper (!) statue of Naram-Sin was recovered in Iraq (Ayish, 1976), and study showed that it was hollow cast, possibly using multiple piece moulds. The manufacture of such an impressive piece must have been based on an earlier development. The chapter on multiple piece mould casting will have to wait until we have more documentation.

What little metallographic study that has been done on prehistoric metalwork reveals that a certain amount of finishing was performed on cast objects (Smith, 1973). Surfaces were abrazed, hammered and reshaped, especially in the case of open or flat cast tools (Coghlan, 1961:67-70; Watkins, 1974:60-1; Charles, 1969). A few of the Alaca bulls were not cast onto their stand but forced into pre-prepared slots and hammered into a fixed position by distortion of the metal around the feet of the animal. Alteration and distortion of the cast figures by hammering may have been significant enough to disguise the fact that some of them came from the same mould. Although none of the Alaca or Horoztepe bulls appears to be an exact duplicate of another, there are nevertheless some close similarities. Consider, for example, the two bulls in the Oriental Museum (Figures 26 (1)(2) and Plate XVI(1)). The Boston Museum pair, too, are not totally unlike each other (Plate XVI(2); cf also Young in Doeringer <u>et al</u>, 1970:86, fig.3). Horoztepe also yielded a pair of bulls whose size and shape are very close in spite of the effects of corrosion (Figures 19 (1)(2)).

Several metalworking traditions are already in evidence by EB II, and, as we shall see below, they do not all favor the same techniques. Where multiple piece mould casting may have been practiced in one area, it need not necessarily be inferred that it was known in another. The problem of cire-perdue or piece mould casting in the Early Bronze Age is still an open question.

Supposing that cire-perdue casting was practiced (and not the hand moulding of matrices as described above) in the prehistoric Near East, a number of pieces are candidates for the first existing examples of it. It is thought by some authors that the cylinder seal with copper decorative figure from Mesopotamia is the oldest example of cire-perdue technique (Frankfort, 1939:pl.Ib), dating to the Proto-literate B period (ca. 3400 B.C.).[30] But now, after more recent finds, older examples[31] of cast objects are the copper maceheads from Abu Matar (Perrot, 1957:18-19, pl.I(3)) and possibly the Can Hasan macehead (French, 1962:33).

Bi-mould casting was known from Troy I onwards in the form of a small jewellery mould (Figure 16 (1)). Its technique in the first settlement at Troy presupposes its development before, and in this case elsewhere.[32] However, at this point in our meager documentation of N.W. Anatolian settlements it is not possible to say where this technique (and other metallurgical techniques known in Troy I) was developed. It was particularly adapted to the manufacture of shaft-hole axes and tools such as we find in EB II at Karaz (Koşay, 1959:409, no.Kz.a/174) (E.17622), at Ahlatlibel (Koşay, 1934:76, 91 (AB 345) (Figure 27 (4)), and at Alaca (Koşay, 1951:167, K 29, pl.CLXXXIV (1)).[33] But moulds of shaft-hole axes are rare. In fact, it is not until the end of EB III (i.e. EB III A) that EBA examples are known, the earliest being those from Norsuntepe (Hauptmann in Mellink, 1975: pl.38 (8)).[34] In Central Anatolian terms the Norşuntepe moulds date to the period of the Assyrian Colony period at Kültepe, where, incidentally, a shaft-hole axe mould was also found (unpublished).

Two-piece moulds seem to have been developed when details in relief were desired on both sides of an object such as the raised midrib on a spearhead or dagger.[35] This technique simply entails placing together two mould halves and pouring in the molten metal through the opening at the top. Blegen recovered a fragment of a two-piece clay mould from Troy Ic (Blegen, 1950:fig.221, no.38.100). The fragment clearly shows a pronounced midrib channel in the middle of a blade. A similar clay mould from Thermi II (Figure 17 (1)) (Lamb, 1936:159, fig.44 (31-67)) dates to this same period. Another fragmentary mould from Troy II (late) shows the midrib channel in the middle of the blade with a short tang (Figure 16 (4)). From Troy IV comes a very important two-piece mould fragment (Figure 16 (7)), for it shows runners on both sides of the mould, a technique developed to allow for the escape of gases emitted during solidification of the molten copper and to allow for excess copper run-off.[36] Between Troy II (late) and Troy IV the runner system seems to have been instituted, but there is no direct evidence for its use elsewhere in Anatolia during the entire Early Bronze Age,[37] this being probably due to the lack of appropriate finds. That two-piece moulds were used in the casting of blades with pronounced midribs from the Central Highlands -- and so common from this area -- is only suspected, not confirmed. The absence of moulds from the few EB II sites in Central Anatolia (Alishar, Alaca) and the Pontic region (Horoztepe, Mahmatlar) suggests that the metalwork was brought in from outside the settlements. This was not the case in Northwest Anatolia, at Troy, which appears to have produced some, if not most of its own metalwork. Two-piece jewellery moulds are known from Troy I onwards (Figure 16 (1)), which shows that even small settlements possessed the technology and the means to provide themselves with luxury items at an early phase in the Early Bronze Age.

Two very important open moulds are reported as having come from Schliemann's "Burnt City" (Ilios:nos.599, 600). As some confusion seems to have arisen in Schmidt's subsequent cataloguing of these items, it is desireable that we should attempt to put the record straight. Schliemann's rendering of the fragmentary mould A-686 (i.e. Ilios:no.599) is uncharacteristically amateurish, however enough details are discernable to be able to identify this piece with SS 6726. We need only look at the way in which the stone is broken, and the arrangement of the mould matrices to see that what Schliemann has depicted is the lower portion of what appears in the photograph of SS 6726 (Plate XXVI (7) and Figure 16(3)). The upper part of this mould was possibly found amongst the ninety-odd mould fragments that Schliemann said he found in the Burnt City (Ilios:432).

The importance of mould SS 6726 (and now represented by both Ilios: nos. 599 and 600) lies principally in the matrix for the spearhead (Plate XXVI(7)) which clearly indicates a provision for casting a slotted blade. One can distinguish two slot holes into which were inserted either pieces of carbonized wood or clay before casting. This is the only surviving example of this technique. The shape of the spearhead is typical of Trojan examples from Level II,[38] the only difference being the conspicuous lack of a long tang in the mould. It is conceivable that the tangs were cast on afterwards, but this is not certain. Other types of spearheads are known to have been cast with bent tangs in place (Watkins, 1974:190, fig.2). Only one close parallel currently exists, a fragment of a slotted blade with a short tang from Thermi's "mixed deposit," hence possibly contemporary (Lamb 1936:176, pl. XXV (32.2)). It is reassuring that the spearhead with slotted blade, of which there are many variants elsewhere in EB II-III Anatolia (see Chapter 7, note 5), was cast in a re-useable mould. There is, consequently, the possibility of finding more moulds in the future.

Notes to Chapter 2:

1. Recent studies have placed the sulfide deposit at Ergani at 31.5 ± 0.8 million years ago (= Oligocene, i.e. Middle Tertiary), W. Griffith, J. Albers, and O. Oner, 1972:701. Also P. de Winjkerslooth, 1972:190-8.

2. For further geological information regarding this deposit, T.G. Murdock, 1960: and CENTO, 1966.

3. For more geological information regarding this deposit, P. de Wijkerslooth, 1946:102-110 (Turkish) (= 111-119 in German).

4. Von der Osten, 1925:150-1; Birgi, 1951:338-40; Childe, 1952:162-3; Ryan, 1960:60; Tylecote, 1970:291-2; Griffith et al, 1972; MTA, 1972:93-6; Muhly, 1973:199-200, 206-7; Maddin and Muhly, 1974:4-7.

5. Sample no. P-2323. Using 5730 half-life, sample gave A.D. 1816 ± 77, and with MASCA correction gave A.D. 1800-1600. Private communication from Dr. E.K. Ralph.

6. Patterson, 1971:314-315, published somewhat lower values of trace elements in copper minerals and metal, but they are single analyses, not averages. Patterson's material was analyzed by a combination of emission spectography and X-ray floresence spectometry.

7. Bowman et al (1975) have continued this work and have presented more statistical data on the probabilities of impurity occurrences in copper-ores. Although ore types may be detectable using their statistical approach, it is virtually impossible to determine regional characteristics.

8. Copper carbonate powder has been found at the "pre-metallurgical" sites of Tell Abu Huera (Ceramic phase, ca. 6000 B.C.) and Mureybet (information given in lectures at the Institute of

Archaeology - London by Andrew Moore and Jacques Cauvin in 1975). Predynastic Egyptians used malachite for painting the eyes, Childe, 1969:n.43; Lucas, 1962:80-4; and Partington, 1935:6,141. It has been said by some scholars that eye paint is an effective prevention against eye disease and counteracts the infectious effects of dust in dry areas. A malachite bead was found at Shanidar, Iraq dating to some 10,000 years ago, Solecki, 1969: 311-314. For other early occurrences, see "Conclusion."

9. Watson, 1975:112-117. A documented scientific approach to dowsing is presented in Maby and Franklin, 1939. The first surviving allusion to dowsing for finding minerals occurs in a 1430 German manuscript, Barrett and Besterman, 1926:7. Georgius Agricola, 1950, also mentions the use of dowsing for finding minerals. Although he does not advocate its use, he does give a fair description of the method. The rods are forked and usually made of hazel wood. He says that according to the users the twig is more effective if the hazel bush had come from an area of a vein. It is nevertheless clear from Agricola's description that he is a non-believer in the effectiveness of dowsing, for in concluding he advises:

> Therefore a miner, since we think he ought to be a good and serious man, should not make use of an enchanted twig, because if he is prudent and skilled in the natural signs ... there are the natural indications of the veins which he can see for himself without the help of twigs (Agricola, 1950:41).

10. Tromp, 1968:379; Idem., 1955:9-19

11. Perrot, 1957:32, n.1, reports that a sample of copper ore collected at Tell Abu Matar contained 56.05 % Cu.

12. Unless he had already understood the method of smelting both oxide and sulfide ore simultaneously, cf. "Smelting Sulfides," Second Method, infra.

13. They were denied this opportunity because of the rise of the Keban Dam waters.

14. The so-called smelting furnaces at Khirbet Nahas and Khirbet Jariyeh mentioned by Glueck (1940:59, fig.26; 63, fig.28) are not furnaces but probably habitation structures of some sort. Likewise, the "smelting furnaces" at Mari (Parrot, 1939:14-16) are probably smithing areas. This might also be true of the "smelting furnace" at Phaistos (Bernier and Bonti, 1951:213-216).

15. The original idea for the campfire theory may have originated with early writers such as Peake and Fleure (1927:10-11), but it certainly took on the dressing of scientific credibility when Rickard suggested it as a possibility (Rickard, 1932:114).

16. Experiments performed by Dr. E. Slater of Oxford have shown that a temperature of 1030°C was reached in reconstructed clay furnaces without forced air. However, oxidizing conditions prevailed. Information reported at the Archaeological Symphosium in Edinburgh, April, 1976.

17. The best discussion known by me is to be found in Bjorkman's M.A. thesis (Bjorkman, 1968:297-307). She presents much more background detail to this controversy. I have only attempted to isolate one essential point of this question: whether the discovery of smelting was accidental or not.

18. For some woods used in Mesopotamia, Levey, 1959:21; and Limet, 1960:116, and n.2.

19. For some eye-opening figures on this subject for Roman smelting, Allen, 1970:10-11.

20. Information to be reported in MTA Bulletin 1977, P.S. de Jesus, "Metallurgical Practices in Early Anatolia," (forthcoming). The C-14 date obtained for Subaşi in the Bakir Çay is 223 B.C. ± 300.

21. Two of these (Figures 12 (2,3)) carry some kind of incised sign which, as yet, has not been found to be particularly meaningful. Although not specifically identified as tuyères, in view of their size and shape, they might very well have served this purpose.

22. Anatolian tuyères of later date have been found. A course earthenware fragment from Gordion has recently been identified as a tuyère. City Mound. NCT-A2, under the first floor. Cat. No.2791 P 919 (Unpublished). My appreciation is extended to P.I. Kuniholm for pointing out this artifact to me and to Ellen Kohler for the complementary details. At Sardis a tuyère was located in the context of the 6th century B.C. gold processing shops. It was found in association with a gold cementation furnace (Ramage, 1970:23-4, fig.14).
For tuyères from other areas not already mentioned, see:
1) K. Branigan (1974:203), from Troy and Araphini.
2) Y. Yadin, Hazor I (1958), pls.XCVI (30), XCVIII (31), XCVIII (61-14).
3) Y, Yadin, Hazor II (19), pls. CXLVII (10), CXCIV (5), XLVIII (3).
4) K. Ohata, Tel Zeror (1967), pls. XXVII, XLVI
(N.B. My thanks to Chris Davey for pointing out a number of references to tuyères in the Near East.)
Branigan has classed his tuyères under the heading "pouring cones," although he gives no reason for doing so. Pouring cones are known from the painting in Rekmirê's Tomb (18th Dynasty), the only Bronze Age illustration we have of their use (Wainwright, 1944:94-8, fig.1).

23. However, in addtion to the Kültepe Ib example (supra) a few other smithing bellows have been found in settlements: at Alaca (Hittite period) Koşay and Akok, 1973:pl.LXXVIII, no.AL.T.119; pl.XXXIII, no.AL.p.132; and pl.XXXIII, no.AL.T.3; and at Sardis (6th century B.C.), Ramage, 1970:24.
A summary of Near Eastern sites (including Greece) which have produced either smelting or smithing remains can be found in Muhly, 1976:90-94.

24. However, Deshayes (1960, I:52 and n.6) is of the opinion that in a few cases closed moulds were used for "flat" axes with convex sides. One of the examples he cites dates from the IVth millennium B.C. (Ibid., II: pl.VII (3)).

25. There are three examples from Mersin XVI. These axes have been analyzed by Esin:A-184, A-185, A-203.

26. The macehead has since been cleaned, and the shaft-hole is more easily distinguishable as a cast feature. It is somewhat irregular and uneven on the inside, and the edges of the shaft-hole are smooth and do not bear any indications of drilling.

27. A sharpening or smoothing stone for metal has been identified at Tarsus EB II (Goldman, 1956:306, fig.436, no.12 (T.47.23). It is unlikely that this is a unique example.

28. A IIIrd millennium B.C. "clay shoe" was found at Pulur (Koşay, 1964:80, pl.XXXVI (P 52)) may also be such a mould. However, the presence of a mould here is definitely incongruous in view of the backwater character of the settlement.

29. Hodges (1968:73) places justifiable caution on the interpretation of cast artifacts solely on their appearance:"The observation that an object appears to have been modelled in wax... is a subjective one that has no real validity, and a far more critical examination should be made before any final conclusion is drawn."

30. This reference was first pointed out by C. Hillen in his Phd. dissertation, The Early Devolopment of Metal-working in the Ancient Near East, University of Chicago, 1955, and later quoted by Bjorkman, 1968:340, n.210.

31. The magnificient hoard of metalwork from Nahal Mishmar, (Bar-Adon, 1962), has been attributed by its discoverer to the Chalcolithic Period in Palestine. However, the unprecedented character of the

manufacturing techniques and the cultural symbolism of many of the pieces indicate an intrusive group of a later period. Affinities with Palestinian metalwork is lacking, and one must go to the Vounous ritual terracottas for satisfactory parallels. Compare, for example, the Nahal Mishmar copper "crowns" with bird and bucrania accessories, Bar-Adon, 1962:pl.40, with the ritual red clay incised bowl from Vounous, Archaeologie Vivante, Paris 1969:52 (VII), 68 (74), and especially with small Cypriot terracotta model shrines, Karageorghis, 1971:figs.3,4. The parallels are difficult to reconcile, for Cyprus at this time offers no hint of a metallurgy as sophisticated as that represented by the Nahal Mishmar group. Moreover, Cyprus does not provide all the parallels. There are clearly many pieces from the hoard that are foreign to EBA Cypriot culture. Whatever the geneology of the Nahal Mishmar metalwork, it is difficult to accept for its manufacture a date prior to the end of the 4th millennium B.C. (and therefore slightly **later** than what Muhly, 1976:88, advocates).

32. A recent article by H.P. Schäfer (1971) attempts to establish a parallel between this mould and 2nd millennium B.C. examples, and on the strength of these parallels he "re-stratifies" the Trojan mould to the second half of Troy II. This re-attribution would be to deny the mould of its stratigrafical context which Schliemann clearly states is from the first settlement (Ilios: 248). The racquet pin on the mould is not inconveniently associated with the period of the first settlement. Similar 3rd millennium B.C. pins are known (Brown, 1951:fig.29, n0.1204; Mallowan, 1947:pl.LIII, no.30 and p.213 (for more refs.)), although, admittedly, they are not as early as Troy I.

33. It is the opinion of Deshayes, (1960, I:406-416, 228-230), that the shaft-hole axe was first developed in Iran which was subsequently passed on to its neighbors, eventually ending up in Central Anatolia. Cf. also Childe, 1952:143-7, 156-61, fig.83. It has been pointed out that a IVth millennium B.C. "shaft-hole axe", possibly the earliest, from Sialk III was cast in an open mould, (Mallowan, C.A.H., 1970:449; Ghirshman, 1938:pl.LXXXIV,

S.251, XXIII, 8). The artifact is actually a hoe and is thought by Deshayes to be forged, Deshayes, 1960; I:231. The earliest shaft-hole axe, according to Deshayes is the example from Tepe Khazineh, de Morgan, 1906:145, fig.308; Deshayes, 1960, I:155, 160; II:67, pl.XX,1.

34. The ribbed shaft with the somewhat high-set blade are characteristics common to N. Syrian examples, Thureau-Dangin, 1936:106, pl.XXIX; Deshayes, 1960, I:157, 178. However, the best parallels approximately contemporary with the Norsuntepe moulds come from Transcaucasia, Deshayes, 1960; I:200, 202; II:pl.XV (10) (13); and Gimbutas, 1965:549, fig.369, and Central Anatolia (an unpublished axe thought to come from the Pontic region is now in the Ankara Museum).

35. Outstanding exceptions are the shaft-hole maceheads (often wrongly called crescentic axes) from the Pontic region, Plate XVIII and Figure 25 (1-5). The criss-cross patterns on the "blades" appear only on one side, the reverse being blank. Although not confirmed, one suspects that these maceheads were cast in two-piece moulds. We must not forget also the Biblite deities cast in two-piece moulds (supra). Regarding the Pontic maceheads, there is one bone example from Alaca, Arik, 1937:pl.CLIX (Al 996), which, also decorated on one side, resembles closely the example on Plate XVIII (5).

36. Figure 16 (7) drawn here is taken from <u>Atlas</u>, pl.142, no.2812. Cf. also <u>Ilios</u>:no,1267 and SS 6776.

37. An intermediate form of runners seems to be represented on a drawing of a pin (?) mould from Troy III, but Schliemann's rendering is not too clear (<u>Ilios</u>:no.1266, and SS 6729).

38. Cf. <u>Ilios</u>:no.811 = SS 5843
<u>Ilios</u>:no.812 = SS 5842
<u>Ilios</u>:no.813 = SS 5844
<u>Ilios</u>:no.814 = SS 5845

All these examples come from Treasure A, dated here to Troy IIg.

CHAPTER 3

Tin

Part A : The Nature and Sources of Tin Ore

Although tin is known to exist in vein or lode type deposits, there is fair enough indication that to a great degree the secondary, i.e. alluvial or placer deposits were exploited first by ancient man. Therefore, tin mining is practiced where water courses are, or were. There were some notable exceptions, the most commonly cited being Cornwall (Randall-Lewis, 1965; Charles, 1975). Here the tin ore occurs as stannite, a tin sulfide ($Cu_2SFeS.SnS_2$), below the copper deposit. As the copper is extracted, the ore body gradually changes with depth from copper to tin. It has been considered by some authors that the smelting of a mixed ore body may have given rise to the development of bronze. Although difficult to prove, the idea is nevertheless an attractive one. But where such deposits do not exist in other parts of the world, another explanation must be sought.

Dr. R. Schuiling has begun to compile data on the primary deposits of tin in the world, and to date he has collected over 500 references of tin occurrences. Schuiling explains the possible causes of tin deposits in the following way:

> There may be some indication ... that for economic concentrations (of tin) to occur a combination of geochemical culmination and an 'event' is necessary. A geochemical culmination is considered a continent-sized, lower crustal belt along which a particular element has been enriched relative to its normal abundance... An 'event' is any geological process, by means of which this enriched material is brought up, or further concentrated as for example by the development of granite instrustions accompanying an orogeny ... Only if the appropriate process acts on already enriched starting material will economic concentrations of tin minerals result. (Schuiling, 1967 (a):547-9)

Schuiling rightfully points out the importance of understanding the nature of the contexts in which tin occurs (Schuiling, 1967 (b): 539-540). Generally, tin is associated with acid rocks (i.e. igneous rock with 10 % or more free quartz), which can be rhyolites (or dacites), subvolcanic quartz, porphyries, intrusive granites or pegmatites. Schuiling has noted that tin occurs in various rocks according to age of the deposit. For example, in the Tertiary the frequency of tin deposits is concentrated in volcanic rocks. In the Pre-Cambrian age the deposits are almost exclusively found in pegmatites. To sum up the frequency of occurrences, Schuiling states:

> As tin deposits associated with granites, more especially roofzones, are the most important from an economic point of view, it is not surprising that the bulk of economic tin deposits is of Mesozoic Age, with Hercynian deposits being a good second. (Schuiling, 1967 (b): 534)

This is indeed an important observation, for as our knowledge of the geological make-up of regions becomes more precise, the means of finding tin deposits are increased. In other words, the geologist can concentrate his investigations in rocks where -- statistically -- tin has been shown to occur most often.

Although he is not at the end of his study, Schuiling has plotted an impressive number of occurrences which give rise to the idea of tin belts (cf. Map 18). A reconstruction of the continental fit some 150-100 million years ago reinforces this view (Schuiling, 1967 (a): 548, fig.2). The tin belts in present-day Eurasia and Australia also appear quite well-defined (Map 18).[1] One belt -- related to Hercynian granites -- runs from Cornwall to Brittany, through the Massif Central to Elba, and Tuscany. Another belt passes through Northern Portugal and Spain, where, again, the tin deposits are related to Hercynian granites. A European-Asian belt starts with the Erzegebirge tin province and extends eastward through Southern Russia, to Uzbekistan, and then veers slightly northward to Mongolia and finally ends up in Northeast China. Another belt descends from Northeast Russia and passes through Japan and Korea, Southern China, Southeast Asia and Malasia.

On the continent of Africa three belts running north-south can be distinguished. One extends from the northern coast of Morocco down to Liberia. A second appears somewhat vaguely on the north coast of Algeria, passes through Niger, Nigeria, Cameroon, Gabon, Angola, Namibia, and the Western part of South Africa. A third belt starts with high concentrations in Tanzania in the region of Lake Tanganyika and extends down through Zambia, Rhodesia, the southern part of Mozambic, Swaziland and South Africa. A concentration of deposits is noted in the Eastern Desert of Egypt which may or may not belong to the extension of the third north-south belt.

In Australia an indigenous (?) belt follows the west, north, and east contours of the land mass. Schluiling's case for tin belts is a strong one. He further points out:

> The boundaries of the belts have been drawn in such a way that at least all the productive localities are included in the belts... (The) density of tin occurrences within the belts is ... 20 times the density of tin occurrences outside the belts ... (The latter) are usually isolated points: mineralogical curiosities in some ... deposit of other minerals. (Schuiling, 1967 (b):533)

Some of these occurrences have been discussed in archaeological literature and are directly related to archaeological finds. The most important discovery in recent years is the tin mining area east of the Aral Sea in Kazakhstan where the deposits are said to have been exploited from as early as the Middle Bronze Age.[2]

Closer to Turkey, I.M. Toll (1921:851) made references to tin deposits in the Lebanon in the Kesserwan district (cf. Map 19). These alluvial occurrences have been heralded as a source of tin in ancient times, and have been abundantly cited in archaeological literature (Lucas, 1928:100; Wainwright, 1944:57-64); however, no indication of ancient exploitation in this area has come forth.

Northwestern Iran has also been said to contain tin deposits, but the claim may be based on the account of a misinformed traveller. Sir Richard Wilbraham had travelled throughout the Caucasus and

Northwest Iran and published his notes in which he observed, "(at Angird) within a compass of a few miles are found the richest veins of iron, tin and copper ore, apparently inexhaustable. The Iron mines alone were being worked ..." (Wilbraham, 1838:71). This casual reference to a tin occurrence does make us wonder whether perhaps Wilbraham was simply misinformed, never having seen deposits himself. Nevertheless, this occurrence of tin entered into the literature.[3] It has recently been reported that very small traces of tin have been found area of Zahedan in the Dasht-e Lut (Muhly, 1976:98). The sample reported contained 0.003 % Sn. However, this small trace cannot be considered very significant. Muhly (1976:98) signals the recent discovery of stannite in Iran, but the extent to which it played a role in ancient metallurgy has yet to be determined.

de Morgan (1905:119) stated that tin occurs 25 kms. from Tauris (Tabriz), and other authors have cited deposits in Khorassan, at Astrabad, in the Kuh-i-Benan mountains and in the Qara Dagh mountains.[4] Crawford (1938:79-80) offered evidence disproving the "tin deposit" at Ragodje-Alokaband near Meshed. Moreover, the failure to confirm any of these deposits by the Geological Survey of Iran which has researched these areas would seem to exclude them from being important sources of tin in antiquity.[5]

Some "tin deposits" emerge out of misunderstandings. In discussing the geological setting of Hedjenan (Azerbaijan) De Launay (1911:652) observed that molybdenum and copper were associated at this site. Just prior to that he mentioned in passing, and without reference to any specific site, that molybdenum and tin are frequently associated, due to their common origin. Apparently using De Launay as a source, Karajian (1920:186) interpreted these remarks as proof enough that there was a tin deposit at Hedjnan; unfortunately, Karajian has been quoted as the authority ever since. By misreading De Launay Karajian has likewise construed a tin deposit at Maigri on the Araxes, and between Mt. Sahend and the Araxes.[6]

In an early article on tin deposits in the Caucasus, Field and Prostov (1938:341-2) gave the following summary of the results of other authors known to them:

> The problem of native tin in the Caucasus has been studied by archaeologists since the discovery of bronze implements. G. Babst (L'Etain, Paris, 1884, etc) was the first archaeologist to study the problem. His conclusions were against the possibility of native tin in the Caucasus. Azurai7 who, at the request of Virchow, studied the geology of the Caucasus, reported that cassiterite (SnO_2) did not occur. E. Chantre, E. Mortillet, and J, de Morgan also believed that tin was not obtained locally.

In the subsequent discussion Field and Prostov argued that during the rise of Caucasian metallurgy of the IInd millennium B.C. tin was exploited locally. Using an indirect approach, they reasoned that because of the local character of the metalwork the tin, like the copper, was obtained from Caucasian deposits. As for the North Caucasus, to further support their case for Caucasian tin, they stated that there was a proliferation of bronze objects "through the end of the second to the beginning of the third millennium B.C." (Field and Prostov, 1938:342-3) (This latter statement is definitely erroneous unless we understand "third millennium B.C." to be a misprint and that the authors meant "first millennium B.C.") The material to which they make reference is mostly badly-dated Late Bronze Age and Iron Age tomb groups excavated by de Morgan (1899:15, 34, 35; and Schaeffer, 1948:404-443), and it does not -- by itself -- present a concrete case for the existence of Caucasian tin.

In discussing the metallurgy of the North Caucasus of the IInd millennium B.C., Sulimirski (1970:230-1) states, "The growth of this centre was to a great extent connected with the development of the Caucasian metallurgy based on local deposits, mainly of copper; no tin deposits exist in the Caucasus, except for a small region in Southern Ossetia, and arsenic was used instead for making bronze (arsenic bronze)". Despite these remarks, according to Muhly and Mellaart,[8] there does seem to be a case for the existence of a tin deposit near Yerevan, but it does not seem to have been exploited prior to the IInd millennium B.C., but more information is needed.

The deposits indicated by Schuiling (Map 18) in the Caucasus and North Caucasus are certainly of interest to archaeologists, and these deposits would be well worth further investigation.

The minor occurrences in Turkey noted by Schuiling were taken from Hintze (1915:1702) and Ryan (1960:62-3). Let us look closer at the claims of tin deposits in Turkey. The best assessment of the known occurrences of tin is offered Professor U. Esin (1967:107-8):

> In Anatolia metals such as As, Ni and Pb are found in great amounts in early artifacts, but tin is rarely encountered. However, at the end of the last century and at the beginning of this century, J.G. Taylor and R.Leonard mentioned in their travel reports that at Kojik-Tillik near Erzincan tin occurs, but MTA's subsequent research proved that this was not the case.[9] But in the Sakarya Basin at Bilecik, Mihalgazi (Gömele), Akcasu and Koyunlu (Söğüt) tin was shown to exist.
>
> It was moreover shown that in former times there were workings at Mihalgazi and the ore was richer in comparison with the other occurrences.[10] Hence, Anatolia has very little tin, and we can conclude that the tin cam by way of Mesopotamia, as it is indicated in the Kültepe texts, and copper was sent from Anatolia to Mesopotamia."[11]

In addition to the claims of tin occurrences in the Sakarya Basin (Map 20) Ryan (1960:62) mentions a deposit at Inhisar not far from Bilecik, but unfortunately he does not give very complete information. He does say, however, in reference to two of the deposits that "tin has historically been recovered in İnhisar and Mihalgazi Townships."[12] If the claims to tin occurrences in the Sakarya Basin remain valid for the time being, we still have no idea of the extent and the date of the workings there.

Forbes (1950:238; Idem., 1964:130) has stated that there are tin deposits near and north of Kastamonu and others at AkDağ, west of Sivas, and still another at Tillek. The Tillek deposit is said by Forbes (1950:238) to be "in association with copper ores on the south-west slopes of Dudjik Dagh and Kubaba Dagh." For his sources, Forbes cites Crawford and Karajian.[13] But Crawford does not give his source. He may have been using Karajian who also did not give his source. Possibly Karajian was using Taylor (1860)[14] whom he included in his bibliography. In any case, whoever is quoting whom, MTA's investigation of this area did not locate a tin deposit, as Professor Esin pointed out above. Forbes (1950:238) cites many other deposits throughout Turkey, but as he does not give the source of his information, we are not able to evaluate the reliability of his claims.

One large trace of tin has turned up in the analysis of some Ergani native copper (S-121) (A-617). Although on the order of 0.27 % it is by far the largest amount reported in Western Asia (Desch, 1928:437). This account of tin in the Ergani native copper has gone unnoticed since its publication, even though the sample may be no more than a geological curiosity. Other analyses of Ergani native copper (A-615, A-618) did not show similar traces of tin.

What is of more interest is the presence of tin in some ancient Anatolian slags. All of them come from the Bakir Çay (S-95) area in Amasya Province. The consistency with which it occurs leads one to believe that exploitable percentages of tin are associated with the copper ore-body in this area. The amounts of tin in the slag are as follows:

Site (S-95)	%Sn Anal.no.1	Anal.no.2	Anal.no.3
Bahcelidere	0.007	0.007	
Sakapinar	0.07	0.004	0.003
Şamelik Der.	0.007	0.003	

Another site in this same neighborhood gave:

Site (S-96)	Anal.no.1	Anal.no.2
Subaşi	0.004	0.007

Even though the analysis of a sample of the ore at İnkaya (S-95) did not show any trace of tin, it does not invalidate the presence of tin in other areas of the deposit. If tin occurs in the copper ore-body in the amount of 0.07 % (as in the copper slag at Sakapinar) the tin is extractable. By just hand-cobbing and washing on a strake or buddle, tin ore of this grade could be made into a concentrate containing as much as 70 % tin. Hence, the Bakir Çay area provides the evidence of at least one tin deposit in Turkey, contrary to all of the theories that it does not exist there. Whether the tin itself was exploited and made into tin metal or whether it was smelted with the copper ore to produce a tin-copper alloy (i.e. bronze) is a question which will require more fieldwork in the area to answer.

Part B : The Use of Tin in Antiquity (Sources, annaku)

It was Landsberger (1965) who finally laid to rest the proposition by Lewy (1957:13) that the Sumerian AN.NA (the Akkadian annaku, annakum) was lead. He produced overwhelming evidence that annaku is tin and that the Sumerian A.BAR (the Akkadian abaru) is lead. There is no need to retrace Landsberger's meticulous study of these two vocables, but in the light of recent analyses (performed since Landsberger's article) it would be appropriate to see how his conclusions stand up. According to recipes of bronze (Sumerian:ZABAR, Akkadian: sipparu) known from texts of the IIIrd dynasty at Ur, the ratio of tin to copper is mentioned at between 1:6 and 1:9 (Limet, 1960:71,73; Muhly, 1973:243-4). These ratios would have given bronzes of ca. 16.7 % and 14.3 % tin. These textual accounts differ somewhat from the analyses of Sumerian metalwork (see infra) where the tin content of bronzes tends to be somewhat lower. While this does not invalidate Landsberger's conclusions, it does demand some kind of explanation. The discrepancy between the textural and analytical results need not be in conflict over a few precent of tin, for we do not yet know the manner in which tin was added to copper. There may have been loses in the alloying process about which we know very little and which we have not taken into account.

Eaton and McKerrell(1976) have looked at this problem from another point of view. Relying on analyses of almost 3,000 Near Eastern, Greek, and Aegean metal artifacts dating between 3000-1600 B.C. they have traced the use of tin bronze and arsenical copper. They show that as far as Sumerian bronzes are concerned, few of the objects analyzed ever reached the standard ratio of tin to copper as reported in the texts (i.e. 1:9 = ca. 14.3 % Sn), and even fewer still reach the upper limits expressed in other texts (i.e. 1:6 = 16.7 % Sn). They further point out that according to their analyses arsenical coppers are much more common than tin-bronze. They conclude from this that "the analytical data do not therefore support the cuneiform texts in their descriptions of tin bronze," (Eaton and McKerrell, 1976:179). Turning their attention to the wide-spread use of arsenic, they suggest that annaku could be the alloying element with copper to make "bronze," but that the ancient metallurgist did not make a distinction between tin and enriched arsenical oopper. He was more interested in the workable end result of alloying annaku with copper, and in Eaton and McKerrell's view this annaku could have been arsenic-enriched copper (on the order of As ca. 20 %) as well as tin. These authors suggest that the ancient metallurgist used what he could get his hands on, tin or arsenical copper, and applied it in the proportions of his recipe. In the case of tin, the result would be a bronze where Sn 14 %, and in the case of arsenical copper, the result would be an arsenical copper where As ca. 3 % (Eaton and McKerrell, 1976:180). According to the authors, this explanation would account for both the tin bronzes and low arsenical coppers from Early Dynastic Mesopotamia. This interpretation will certainly have its adherents in future publications, but the picture is far from flawless.

First of all, if we accept this interpretation we have to admit that not only did the early metallurgist not care to make a distinction between tin and enriched arsenical copper but that the alloying recipes were the same for both. Hence, no account was taken of possible variations in behavior of the two alloying metals. Secondly, although Eaton and McKerrell's arguments are plausible from the point of view of their analytical results, it seems so unlike the ancient metallurgists not be able to (or wish to) distinguish between the two alloying metals. While their color might be similar, surely their texture and malleability were noticeable enough such that they were easily recognizable as different materials. There is no reason to believe that the early metallurgist would let these characteristics escape definition. Hence, if there had been commerce of enriched arsenical copper, a term other than annaku would certainly have been used. However, one cannot deny that Eaton and McKerrell have provided some important data, particularly regarding the wide-spread use of arsenical copper, and it is the nature and origin of this metallurgical practice which will be the preoccupation of archaeologists and scientists in the years to come.

Returning to the problem of the use of tin, it has been too often claimed or implied by authors that the ancient smith needed tin to produce a proper casting. A quick look at the analyses of

Alaca metalwork shows this not to be the case. For example, sun disks are made out of tin-bronze (i.e. A- 383, A- 385, A- 387) and at least one is made of arsenical copper (i.e. A- 384) . The use of two different alloys is also evident in the other classes of metalwork, chisels, lituus, vessels, and the like.[15] Moreover, unalloyed (smelted) copper was used for the manufacture of a number of these items. This clearly shows that whatever difficulties arise in trying to work arsenical copper or just unalloyed copper, the metalworkers of Alaca had certainly overcome them. To a greater or lesser degree this is also true of the EBA metalwork of Kayapinar, Horoztepe, Mersin, Kusura, Tarsus, Soli, Alishar, Mahmatlar, Ahlatlibel, Tilmen Huyuk, Troy, the Troad, Yortan, and Thermi. Hence, when tin bronze is lacking unalloyed copper or arsenical copper was easily substituted.

We should not, then, view these EBA cultures as tin-hungry, or that their existence and development of their metallurgies relied on tin. But if tin was not indispensable, why, then, did they use it occasionally, if not arbitrarily? It would appear that from wherever the tin was coming, the supply was irregular, That is, when it was available it was used, but when it was not other alloys were substituted.

Indirectly, this has a bearing on the possible tin deposits in the Near East. If we consider the regional character of, say, Alaca EB II metalwork, it would seem strange that the metalworkers would wish to use a material which was not indigenous to their area. That is, there would be no reason to import a foreign material such as tin from a distant land when, in the course of regular metallurgical practice, they could do very well without it. Hence, there would be no reason to use tin in Anatolia unless it were available easily, if not locally.

Those authors who have chosen to envisage the supply of Near Eastern tin in distant places are surely stretching the general picture out of shape. Until modern geological research can inequivocally prove (or disprove) the existence of deposits in the Near East, the modern archaeologist and historian will have to bide their time.

Part C: Tin Processing

Archaeologists have yet to come across any early exploitations of tin deposits, either in vein or alluvial form. The surviving mining and ore-processing evidence in Cornwall dates from La Tene period (Tylecote, 1962:63; Leeds, 1927: 205-37). There are a number of good accounts of tin-processing in Medieval Europe (Agricola, 1950: 312-18, 336-47; Randall-Lewis, 1965:1-32) but none yet relating to the ancient Near East. It would hence be best to defer the discussion of tin-processing until some evidence of the type of deposits available to the ancient metalworker comes forth.

Notes to Chapter 3

1. Map 18, as yet unpublished, is reproduced here by permission and courtesy of Dr. Schuiling.

2. Crawford, 1974:243; and Masson and Sarianidi, 1972:128. The latter suggested that workings might have begun earlier. The archaeology of these mines and the related sites is discussed by Kuzmina, 1966.

3. This "deposit" was subsequently quoted by Delaunay, 1911:652, n.1, and later by Crawford, 1938:80.

4. Lucas, 1928:100, notes 6-10; also Forbes, 1950:fig.49 and pp.238-9. Background to these deposits is discussed by Muhly, 1973:260-1.

5. Crawford, however, was convinced there was: "there is definitely tin in Iran," Crawford, 1938:80. Those deposits cited by some authors remain, however, dubious: Gowland, 1912:252; Coghlan, 1951:16-17. But cf. Muhly's remarks on evidence for a recent claim to tin placers near Tabriz, Muhly, 1973:260-1.

6. Karajian, 1920:186; and De Launay, 1911:652-3. Unfortunately, the much-quoted Forbes has perpetuated these errors of interpretation, Forbes, 1950:238. But now, cf. remarks in Muhly, 1973:260-1.

7. In Field and Prostov's footnote this author is quoted as: Azurai, <u>Zeit. fur Ethn.</u> (1884) 58-60, "Uber das Vorkommen von Zinnstein und die Bronze-industrie des Kaukasus."

8. Mellaart, 1968:200-202; also Muhly, 1973:421 n.160 and p.463, n.793.

9. Esin's note 5, p.108:

> "J.G. Taylor, 'Journal of a Tour in Armenia Kurdistan and Upper Mesopotamia,' <u>Journal of the Royal Geographical Society</u> Vol 38 (1868) 281-361; R. Leonard, <u>Paphlagonia, Reisen und</u>

Forschungen in nordischen Kleinasiens (1915) 318; W. Witter, 'Metallurgische Bermerkungen zur Vorgeschichteforshungen' R.G.K. Bericht Vol 29 (1939/41), pp.157-8; M. Lucius, 'Die magmatischen Erzlagerstaetten Anatoliens und ihre Beziehungen zur Tektonik,' from 1932-33 MTA Report No.660 (unpublished), pp.15, 16 and 49. Lucius confirmed traces of tin in a cutting of a mixed copper deposit; A. Helke, 'Bericht über eine geologische Lagerstaetten kundliche Exkursion in das Vilayet Tunceli,' 12 Maerz 1938. From MTA Report No.571 (unpublished), p.10; Helke is of the opinion that one cannot find tin in Dojik Dağ. In analyses of examples from Tillek he did not find any tin."

10. Esin's note 6, p.108:

"H. Kleinsorge, 'The geological report on Ankara Villayet, Karapurcek, and the neighborhood of Biyamli Tepe,' (unpublished) Report dated 25 April. From MTA Report No.1074, p.3.

In the Bayamli Tepe samples only small quantities of tin were found: 0.24 %.Copper, Nickel, arsenic and gold ores were also encountered. From the results of the spectral analysis Kleinsorge noted that there were only traces in varying degrees.

"Gisements staniferes de Gümele," For 1900. From MTA Report No.935 (unpublished), pp.7-12.

E. Zimmer, 'Rapport sur la région stannifère de Gümele; Étude sur le terrain,' Septembre 1938. Date du rapport, 3-IV-1940. From MTA Report No.1115 (unpublished).

V. Stchepinsky, 'Bilecik vilayeti maden zenginlikleri hakkinda' (Report on the Richness of ore in Bilecik Vilayet) Mission of 1940. Study date: 4-29.IX.1940. Report date: 20.III.1940. From MTA Report No.1232 (unpublished)."

11. Esin's note 7, p.108:

"E. Bilgic, Sumeroloji Arastirmalari 1940-41, pp.922-924.

J. Lewy, 'Some Aspects of Commercial Life in Assyria and Asia Minor in the Nineteenth Pre-Christian Century'. 'Journal of the American Oriental Society, 78/2, 1958, s. 93-97."

12. Ryan may have been drawing his information from Hintze, 1915:1702.

13. Crawford, 1936:87-8; <u>idem</u>, 193879-81; and Karajian, 1920:186:

A Tertiary cassiterite tin ore is described in Kurbaba Mountain near Tillek (Armenia), and between Sahend and Araxes River associated with copper. But those ores have more historical and scientific interest rather than industrial importance.

> Some kind of ore is described near Maigri, (Caucasian Armenia) on Araxes associated with molybdenum and in Hejenan where polybdenum associated with pyrites and copper in granulites is found.
>
> The ancient records show that tin, cassiterite ore, was mined near the present towns of Sinous, and also near Aleppo.

This is Karajian's complete statement on tin occurrences in the Near East.

14. Taylor observed: "In the vicinity (of Tillek and Surp Carabet) there are some very rich copper and tin mines and immediately above a large rock composed of loose pieces of an intensely black stone heavier than lead, but shining like marble, which further on is streaked with delicate white veins," Taylor, 1868.

15. One interesting find from the Troad is a handle from one of the so-called frying-pans (Bittel, 1959:2, 34, fig.5). The analysis of the handle showed it to be tin bronze (% Sn: 10) but the double disk end (presumably cast on to the handle) truned out to be arsenical copper (% As: 4.6).

CHAPTER 4

Silver and Lead

A. Types and Characteristics of Silver and Lead Ores

There are two main classes of silver ores. One class comprises the sulfides (i.e. arsenide, antimonide, and argentite) and the chloride (i.e. horn silver). The second is the silver-bearing (or argentiferous) ores of lead, copper, zinc, and other metals. Electrum (gold-silver) is also considered an argentiferous ore. The majority of the modern world's source of silver comes from the argentiferous ores.

Although rare, silver also occurs in the native state, and when it does it is quite pure, with traces of copper, gold, mercury, platinum and bismuth. Native silver appears as a white metal in the form of distorted crystals, massive grains, or aborescent threads. It tends to be located in the contact zones of silver deposits (Rosenfeld, 1965:133). It can also occur in vein form, but it is usually deep-seated and gives no indication on the surface of its presence below.

Specifically, the most common source of silver is from the argentiferous lead ore galena where silver occurs in the form of argentite (Ag_2S) and pyragyrite (Ag_3SbS_3). Silver is hence commonly linked to lead in its occurrences, its mining and its exploitation. Hodges puts the emphasis on argentiferous galena as the principal source of silver in the past:

> There is little evidence that the common ores of silver, <u>horn silver</u> (silver chloride, AgCl), <u>silver glance</u> (silver sulfide, Ag_2S), <u>ruby silver</u> (silver antimony sulfide, $3Ag_2S.Sb_2S$) or <u>silver copper glance</u> ($Ag2S.Cu_2S$) were smelted in antiquity and apart from native silver and electrum, the principal source appears to have been the lead ore <u>galena</u> (lead sulfide, PbS) in which small quantities of silver sulfide are almost invariably present. (Hodges, 1968:91)

Smelting and cupellation are the means by which silver is extracted from galena. We have little idea of the minimum percentage of recuperable silver in ores exploited in antiquity, but it has been said that at least by Roman times it was considered economically worthwhile (and technologically possible) to desilverize lead containing as little as 0.06 % silver (= 20 oz./ton, or approximately 560 g/ton) (Tylecote, 1962:83). Some calculations have put the average ratio of lead to silver in known silver mines in Turkey at 1 to 230, i.e. ca. 0.43 % (Patterson, 1971:288). However, it is not possible to give any meaning to this figure in terms of the quality of silver ore exploited in antiquity. Moreover, it conflicts with the data presented by others (infra) in which only a few silver deposits reached a concentration of more than 0.1 %.

Although lead did not play an important role in the development of ancient metallurgy, its frequent association with silver makes it a useful guideline to the latter's possible location. It is on silver that the ensuing discussion pays most attention. The principal deposits of argentiferous lead in Turkey are described below. In contrast to copper, the lead ore groups seem to be less understood by geologists, probably due to a lack of investigation into ore make-up. General categories have nevertheless been designated by MTA (MTA 1972) and have been followed here (cf. Chart 2). It will be noticed, however, that a fair number of argentiferous lead ore deposits, notably those in Giresun and Gümüşane Provinces, have not been categorized.

B. Nature and Characteristics of Silver-Lead Ore Deposits in Turkey (see Appendix II)[1]

The Akdağmadeni (S-160) silver deposit (not to be confused with Ak Dag in the Anatolian Southwest) has been mentioned by many authors (Karajian, 1920:152; Forbes, 1950:191; MTA, 1972:87-8), but none has provided us with much in the way of details. Forbes enthusiastically stated that the "mines were probably the source of the silver and lead which the Assyrian traders at Kaneş (Kül-tepe) 10 miles north-east of Kayseri buy and send home,"[2] but his claims are unsupported by archaeological evidence. Although there is evidence for smelting and former workings at Akdağmadeni, there is no indication as yet when these took place.

At Denek Md. (Ankara Province, cf. Map 14) silver ore was extracted and reduced in the 19th century A.D. (Ainsworth, 1842, II: 153-4), but no details are known about any earlier workings. Denek Md. is just north of Keskin where another silver deposit has been recorded (MTA, 1972:86).

The ore at Bulgar Maden (S-157) has been reported as high as 1.8 %, but this is quite exceptional.[3] High silver content has been noted in the oxide ores (0.535 %) and in the placers (0.643 %) (MTA, 1972:106). The silver content of the slags at Madenkoy is as high as 0.2357 % (MTA, 1972:104). Reserves in lead ores are quite vast and well studied,[4] but little information is known about the extent of the current silver ore reserves.

It is possible that by the time of the Hittite Empire Bulgar Maden was being exploited for its silver, but it is not as certain as Cary (1932:136) claims. It is true that there are large slag piles near Bulgar Maden at the villages of Maden Köy, Kildere and Gümüş (S-157), but more evidence is necessary before one can venture a date of the workings.

It has been reported that the silver content of the ore deposits at Gümüş (Amasya Province)(S-130) varies between 0.0214 - 0.375 %, and the occurrences are not very uniform (MTA, 1972:21-22). The deposits are considered basically lead ores in limestones and contain varying amounts of argentiferous galena, sphalerite, pyrites and secondary limonite, manganese ore, calamine, cerussite and subordinate amounts of malachite. The present-day veins measure between 100-400 meters in length and between 0.60 - 10 meters in width. The silver content here is considered particularly rich by modern standards. It is tempting to take Cary's suggestion that the Homeric Alybe silver mines could lie near Amasya, in view of the extensive workings recently reported at near-by Gumus (S-130)(Cary, 1932:136). These could be the later mines mentioned by the Islamic author Abul Feda (Vyronis, 1962:7). Simmersbach (1904:534) mentions that the lead workings at Gümüş (i.e. "near Gümüşhaciköy") produced 21 kgs. of silver in 1901.

A few kms. west of Saryer (Sivas Province) and ca. 15 kms. NW of Imrali a lead-silver deposit was exploited by the Asia Mining Company Ltd. at the end of the last century (Gowland, 1920:159) (see Map 16). Gowland referred to this area as Gambibel (Ghemibel) which is the present-day Lulukbaba Tepe. Other deposits in this general area are also reportedly silver-bearing and have remains of "old workings" (Gowland, 1920:159; Forbes, 1950:191 (5); MTA, 1972:71-2). The Asia Minor Mining Company had a smelting complex at Gambibel, but the mining activity there did not last until the time of the Turkish Republic; therefore, the silver reserves must not have been very extensive.

At Balya Maden (Balikesir Province) (S-151) is said to have been one of the most important silver deposits in modern Asia Minor and has been known to geologists for some time. The ore is reported to have contained 63 oz./ton silver (= 0.197 %) (Gowland, 1920:139). Another analysis gave 0.125 % silver (Mining Jour., 1910, Oct. 15:1202). MTA's analysis of the base bullion showed silver to be 1983 g/ton (= 0.1983 %) (MTA, 1972:81-3). It was exploited by a French-owned company between the years 1880-1935, and during these years it produced a yearly average of 7,273 tons of lead, 55 kgs of gold and 18,182 kgs of silver.

Without being specific, Bittel (1934:54) referred to deposits of Mt Ida (Kaz Dağ) and Mt. Olympus (Ulu Dağ) as possibly being the source of Trojan silver. Latching on to this idea, Forbes (1950:192 (18)) stated that the Balya deposit and those of Kaz Dag were the source of Troy II's silver and that these deposits were later worked by the Romans. There is, however, no sound basis for this claim. Gowland (1901:369; idem., 1920:139; idem., 1912:266-7; also Smyth, 1850:297) also refers to silver deposits NE of Mt. Ida. However, he, like Forbes, does not give any locations of these deposits. MTA has recorded a series of lead deposits around Karaaydin (near-by in the Bicki Dere are "old adits",) (MTA, 1972:79), but no silver is mentioned in context with this lead deposit. On the other hand, MTA does state that the deposits in this area "resemble the occurrences at Balya" (S-151) where silver does occur.

The silver deposit mentioned by Gowland (1920:139; idem., 1901:369) as being "near Broussa" (Bursa) may refer to a deposit on Mt Olympus (Ulu Dağ) as yet unknown by MTA. This deposit is also mentioned by Forbes (1950:192 (17)), but again no details are given. This could be the same deposit mentioned by A. Bryer (1970:331). One wonders where original reference came from.

Gowland (1920:139; idem., 1901:369; also Forbes, 1950:192(17)) mentions a site called "Karie-Seunluk" and says that it is in the area of Mt. Ida, but he does not give any information about the nature of this deposit, nor its precise location. According to MTA there is a lead-zinc deposit just north of Kaz Dağ near Evciler (Avcilar), but silver is not mentioned in context with this deposit (MTA, 1972:78).

Still in N.W. Anatolia, MTA records a baryte-galena deposit at Korudere (MTA, 1972:61). The galena at this site contains 600 g/ton silver (i.e. 0.06 %), but no former workings are reported.

Gowland (1920:371) refers to Keban as being a silver deposit, and it apperas that he obtained his informatiom from an earlier study of the last century (Smyth, 1854:297). MTA has likewise referred to the deposit as argentiferous (MTA, 1972:92). Mineralization descends at least 200 meters, but the contents of silver and galena decrease with depth. The deposit was worked, presumably for both lead and silver, from 1728-1877. During the last century, we learn that it was worked by the locals who were well aware of the silver content. Many small operations were opened at that time, but were subsequently abandoned, for only a few were deemed profitable enough. According to one geologist, "in the upper mine , a large quantity of soft iron ochre, or sort of gossan mingled with threads of gypsum, is excavated as ore, being found to contain like the galena from an ounce to an ounce and a half of silver in 100 lbs." (Karajian, 1920:153; cf. also Smyth, 1950:114-115).

There are abundant accounts of the silver deposits in the area of Gümüşane, both from the point of view of their geology and their antiquity (MTA, 1972:53-5; Helmhacker, 1898:635). As MTA reports, there are several deposits in the neighborhood of the Süleymanli district of Gümüşane. MTA further states that the "mineralization consists of pyrites, sphalerite, chalcopyrites, galena and Sb-As (antimony-arsenic)-bearing tetrahedrite, some native silver and secondary enargite" (MTA, 1972:54). The richest ore sample collected contained 2309 g/ton (= 0.247 %) silver. A sample from Dere Madeni contained 2073 g/ton (=.222 %) silver. From the Gümüşane area come some of the richest samples of silver ore in Turkey.

Gowland (1920:159; also Forbes, 1950:191(4)) mentions a silver deposit at Lidjessi near Karahissar (Sebinkarahissar) which is most likely one of the deposits in the area of MTA's Arsarcik-Licese (MTA, 1972:71). Actually, there are two main deposits, one at Asarcik and another at Licese. At the latter site, the deposits occur on both sides of the Ara Dere which flows into the Arslanyurdu Dere which in turn flows into the Eşgüne Dere. Both of these deposits are located ca. 12 kms. north of Sebinkarahissar. No silver content in the ores has been reported precisely, but it is known that before the end of the last century there must have been some indication of silver, for the Asia Minor Mining Co. obtained a concession to mine silver there. Helmhacker (1898:635) mentions that of the deposits in the area of Karahissar the richest carry about 70 % lead and contain from 1.5 - 4.0 kg. per ton of silver (= 0.16 - 0.428 %). According to MTA there are two zones of mineralization, one located in granodorites of Tertiary Age and the other in dark-colored volcanic rocks (MTA, 1972:71).

Helmhacker (1898:635) sums up his information about the deposits in this area as follows: "The District of Kara-Hissar is also known to be rich in silver ores... The Asia Minor Mining Company has a concession covering six square miles where 20 veins have been located and some development done. Most of these discoveries have been based on ancient workings." Gowland (1920:159) seems to refer to this area as Gumush Maden, although Helmhacker, Gowland's chief source, did not mention this name.[5]

From information given by Helmhacker (1898:635; also Gowland, 1920:159) "an English company" was granted a concession to explore silver deposits in the area of Derekoy which is situated ca. 10 kms west of Asarcik-Licese. Near there, ca. 7 kms west of Asarcik-Licese, more modern workings by this same company (Asia Minor Mining Co. Ltd. ?) located three silver veins at Katiralan. Katiralan is also mentioned by Karajian (1920:150) as having been exploited for silver. A modern mine works at Keşhab in the same area proved to be fruitless. No ancient workings are mentioned in the context of these occurrences.

In an early suvey of this area W.J. Hamilton mentions that he found remnants of silver mining at the mouth of the Tirebolu Suyu (N.B. mines are not indicated on Maps 13, 14, 15). He writes:

> The mines appeared to have been neglected for many years, my guide assured me that they had not been opened for thirty years; but he added that they had not been worked since the river ran in its present course, saying that it formerly flowed to the east of the hill above mentioned, and that since its course had been changed the mines had been filles with water. The afterwards confirmed the report that these mines were rich in silver, observing that as they descended, the silver became scarce, and the copper more abundant. (Hamilton, 1842 II:259)

Hamilton's report of silver here is unconfirmed in other studies. MTA, for example, makes no mention of silver deposits in this area.

In the Southwest MTA has recorded a copper-lead-zinc-silver deposit ca. 10-20 kms. west of Gönük at Ağraköy, but little else is known about it (MTA, 1972:109; see also Ryan, 1960:13). Citing Gowland (1920:157), Forbes (1950:191(14)) states that there is a (silver) deposit in the "Ak Dagh South of Kemer." Although Ak Dağ is definitely west of Kemer, the deposit he is referring to is perhaps that of Ağraköy.

Deposits farther East have been noted, but not much is said about them.[6] According to Helmhacker (1898:635): "In several localities near Erzorum old workings exist, and silver-bearing veins are known but are not now worked." Marco Polo (Book I, Chapter IV) made reference to a silver mine at Bayburt, but this claim has not been confirmed by modern research. However, Karajian (1920:150) does mention two deposits in this area of the East: "In Khortan, near Ispir (south of Chorokh river) a rich argentiferous galena is exploited which outcrops in Baiburt, between Trebizond and Erzerum..."[7] This may have been the area Hamilton was referring to when he stated that silver mines had been "reported" in the Çoruh Valley west of Isbir (Hamilton,1842, II:277) and likewise the silver mine mentioned by Marco Polo. Karajian (1920:150) further mentions a silver mine near Baiburt: "About 20 kms. southeast of Baiburt is found Maden Khan mine which occupies about 400 M. It is in the vicinity of green rocks crossing Lower Cretaceous formations. The copper is also associated with these rocks."

Some confusion seems to have arisen about the Tris Maden "silver deposit" cited by Forbes (1950:192) and said to be West of Konya. Forbes took his reference from Gowland (1920:156) who had obtained his reference from Smyth (1850:298) who had obtained his reference from Hamilton (1842, I:339). According to the latter, "The chief occupation of Tris Maden, and from which it derives its name, is the smelting of the lead ore brought from the mountains ten hours to the south," to which he adds, "...a small quantity of silver is also obtained from it." (Hamilton, 1842, I:339). Hence, the silver deposit reported by Forbes appears to be no more than a modern smelting site of the last century. The silver-bearing lead ore would seem to have come from an area in the Southern Taurus, possibly from the Bozkir deposits (S-159).

A few mines have been mentioned in the West. According to Sayce (1880:91) there are silver mines on Gümüş Dağ (Aydin Province) (cf. Map 17):

> I fancied from the Turkish name of the hills that some old silver mines existed in them. One of these I certainly discovered just above the village of Gumush, with its entrance now obstructed by a large fig tree, and I fancied I saw another from the height on which we stood. The view we enjoyed was superb; below lay the plain of the Meander and the ruins of Magnesia, Priene, and Miletus; in front rose the five peaks of Latmos, and behind them the snow-clad summits that look down on Halikarnassos, while the range on which we stood ended in the promontory of Mykale, shut in by the blue sea and the distant shore of Patmos."

There are two mines indicated on the 250,000: 1 map[8] on Gumus Dag (S-169), perhaps the two in question (cf. Map 17). Two more mines are indicated on the map, but it is not known to what they relate. The first of these is situated just a few kms. Southwest of Soke near the northeast base of Samsun Dağ, a few kms. west of Yeni Köy. A second Yeni Köy is situated approximately between Samsun Dag and Gümüş Dağ on the Southeast side of the saddle, and another mine is indicated a few kms. Northeast of this village. The mines here are also mentioned by Gowland (1901:375) and Forbes (1950:192(22)), the latter stating that "the mines failed in Roman times." This is a personal interpretation by Forbes, which, as yet, has no archaeological foundation. It has been reported elsewhere (Mineral Industry 1898:442; also Gowland, 1920:156) that mines in this area produced an ore sample equivalent to 559 oz./ton silver (= 1.7 %). This is an exceptionally rich ore sample. Unfortunately no more information is available.

Paton and Myres (1898) claim to have visited a silver mine and smelting site at Myndos (present-day Gümüşlük, also called Gümüşliliman) on the peninsula of Halikarnassos, but from their description it appears that the exploitation dates from Classical times:

> (At Myndos) the only monument is the 'Clyclopean' wall, which is unique in this part of Karia. Its continuous importance as a silver-working center as is asserted alike by classical and medieval tradition and by its Turkish name of Giumushli (sic.). The beach around the bay south of the harbour is strewn with masses of slag from the silver-furnaces, one of which is well exposed in the hollow way to Kadi Kale, soon after leaving the shore. All that remains is a circular pit some four feet in diameter, the sides of which appear to have been lined with clay, and thoroughly baked into brick. The great silver-mine is to be seen on the range behind the town; The shaft is very irregular, and of great size, and is filled with water to within thirty feet of the surface. There are still veins of silver-lead in this neighbourhood. (Paton and Myres, 1898:204)

If Paton and Myres' evaluation of the site is a correct one, the easy access of both the silver mine and smelting furnace would provide an invaluable opportunity for metallurgical studies. Unfortunately no slag or ore analyses are available, but the site definitely deserves more attention (also mentioned briefly by Gowland, 1901:375; Idem., 1920:156; and Forbes, 1950:192(25)).

Traces of silver in deposits of Northern Anatolia are rare, but Karajian (1920:150) writes that the copper ores of Kure (Kastamonu Province) are argentiferous, though, curiously, there has been no mention of silver exploitation at this deposit (MTA, 1972:7).

At none of the lead-silver deposits mentioned above does the silver content in the ore reach 2 %. The richest silver deposit listed by MTA is that of Bulgar Maden (S-157) which produced a sample containing 1.8 % silver. The second and third richest samples come from Gümüş Dağ (S-169) and Gümüş (Amasya Province) (S-130) having produced ore with silver contents of 1.7 % and 0.375 % respectively. It must be stressed that the quantities of silver in ores cited above are rare examples. In the vast majority of the Anatolian deposits silver in lead ore seldom reaches as high as 0.15 % (= 50 oz./ton). From the point of view of distribution, the lead-silver deposits are wide-spread in Turkey, but they do not seem to have a dense concentration like that of copper or iron. However, there is a tendancy for the deposits to limit themselves to the Northern Anatolian Fold and the Southern Anatolian Fold.

C. Analyses of Silver Slag

From the slag analyses it is not always possible to determine from what types of ore a metal was extracted, and this holds true for other metals as well as for silver. The two heat processes involved for silver refining, smelting and cupellation, both produce wastes (slag and litharge) which can, of course, be analyzed. But what complicates interpretation of analyses of these wastes are the associated impurities which come either from the original ore-body or from entirely different materials added during the refining process. In the smelting stage, different ore types produce a different type of slag, such as at the pre-Roman silver smelting of Riotinto (Blanco and Luzon, 1969). Here a slag and a slag-like material called speiss were simultaneously produced, during the smelting stage, resulting in three layers in the furnace: on top the light slag, then a layer of speiss, then lead (i.e. the silver-bearing lead). Jarosite ($K_2SO_4.3Fe_2SO_6.6H_2O$), a potassium-iron-sulfur compound, was added as a flux to the ore concentrate during smelting (Blanco and Luzon, 1969:128). To make matters complicated for the analyst, jarosite (in this case probably plumbojarosite) is often accompanied by traces of gold, silver, arsenic and antimony. From an analysis of the Riotinto slags it was not possible to determine what the character of the original silver ore-body was, since it had been "covered up," as it were, by the flux (jarosite). The slag layer contained some lead and some of the impurities originating both from the original ore and from the jarosite. The speiss, too, contained an array of impurities from both the ore and the jarosite as well as an alloy of reduced arsenic and antimony with some iron derived from the jarosite. This type of elemental distribution throughout the three layers is particular to a process using jarositic earth as a flux. If another type of flux had been used, a different elemental distribution would have taken place. The lesson to retain from the Riotinto example is that while jarosite may be common to Spanish lead-silver deposits (and lead-silver refining) and was usefully employed as a flux, there is no certainty of its having been used universally elsewhere. This means that each silver smelting operation discovered must be treated as a unique case.

In passing it should be pointed out that plumbojarosite is present in the Bulgar Maden (S-157) lead mineralization, more particularly in the ore placer deposits, but it has not yet been found to be directly associated with ancient silver refining in this area.

D. Silver Ore Processing

Before smelting silver ore, whether silver chloride (AgCl), silver sulfide (Ag_2S), or argentiferous galena the first step is to make up a concentrate. This entails breaking up the ore into small pieces and sorting out the most promising bits. When the ore-sorting action of flowing water was understood, washing the ore probably became common practice in making up the concentrate.[9] Later, washeries (or sluices) were developed to handle larger quantities of ore such as we find at Thorikos in Attica (Mussche and Colophagos, 1970). These washeries no doubt provided a more efficient means of silver-ore recuperation, since the ore could be recycled until a high grade of silver concentrate of silver ore was obtained.

Different washing systems are possible. The earliest example of washing is found in an Egyptian sculptured relief in the tomb of Baqt at Beni Hasan (ca. 2000 B.C.) in which is depicted two large circular (?) basins containing ore and water, a slurry, washed by two pairs of men (Notton, 1974:53). Although here they are washing gold ore, the principle may be equally applied to silver ore. In the relief it looks as though the workers seated at the basins are paddling the water in a whirlpool motion, thereby permitting the separation of the heavy ore (which concentrates towards the center) from the lighter particles in the slurry. The ore concentrate is then passed on to a sluice (a gravity concentrating table) where further separation and concentration take place. Missing from the relief is indication that water is used for the sluice, but the worker at the right of the sluice seems to be holding a small brush with which he may be brushing away the lighter particles, a method which may have common with the use of running water. The washing basins were probably made of wood, as no ceramic examples of this size and shape have ever been found.

Although the date of the workings are still very much in question, the ore washing sluices discovered at Medzamore also illustrate the principal of ore sorting by specific gravity (Vidal, 1969:86). They seem more adapted to heavy ores of tin, silver, gold and lead, rather than to copper ore with which the workings are normally associated. The steep gradient of the sluice and the concentrating features of the raised arcs or ribs suggest that a heavy, rare metal ore was being sought here.[10]

The only pre-Roman washeries east of Spain unequivocally identified with silver ore concentration are those of Thorikos dating to the Late Helladic period (Mussche and Colophagos, 1970). Later examples are known in the area, and there is promise that earlier examples will also be found at Thorikos itself as excavations continue.

The excavators think that the ore slurry was directed over a wooden sluice then down onto a flat, sloping platform. From the platform the slurry flowed into catch tanks in which ore sediment was allowed to form. Modern experiments in ore concentration are going to be carried out soon on a reconstructed version of this type of washery, after which we will have a better idea of the system's efficiency.

If silver is associated with lead ore, i.e. argentiferous galena, as is commonly found, it must undergo concentrating. However, the lead gangue is not as detrimental to the purification process (smelting, then cupellation) as are other impurities, since lead serves as a refining agent, as we shall see below. Hence, during ore concentration lead, if present, would be allowed to accompany the silver ore concentrate into the smelting furnace.

Some alluvial soil may have been exploited for silver at an early stage of history. In Spain the Romans are known to have dealt with such occurrences. According to Rickard (1928:135-6) the absence of lead in most ancient (i.e. Roman) silver bracelets proves that they were made of metal obtained from silver chloride, typical of alluvial deposits. Rickard reports that the ore was sifted and broken five times, after which the concentrate was smelted. Although not specifically stated, Rickard seems to be suggesting that silver was not cupelled in this case, since cupellation demands the use of lead. If this is so, we are uncertain as to what method was used in refining.

D1. Smelting Silver Ore

It has been said that the Romans were able to exploit ore deposits containing as little as 0.06 % silver. (Tylecote, 1962:82; Gowland, 1901:259). Lengthy ore processing was no doubt involved here in order to bring the concentration up to a point where smelting was worthwhile. Only a few deposits in Turkey have silver contents of $0 \geq 0.06$ % (Map 13). Although we have no indication that prior to the Roman period smelters were able to deal with silver-bearing ores of < 0.06 % (Maps 11 and 12), there is no reason to believe that they could not. Once silver ores were recognized, it would seem to be just a question of applying the principles of con to obtain a concentrate of high grade silver ore.

Before cupellation (i.e. the separation of silver from impurities) can take place the silver ore concentrate must be mixed somehow with lead, since it is lead which provides the means of extracting the unwanted impurities. In the case of argentiferous galena the lead is already present, but if silver chloride or silver sulfide concentrates are used the smelter is obliged to add lead (Figure 11). He may add it in the form of crushed galena or even as metallic lead. This process would be performed in a reducing furnace. Some volatile and combustable material would be burned off, the lead would reduce to metal and alloy with the silver, and a slag would form from the other remaining impurities. According to Professor H. Mussche,[11] the lead-silver metal (i.e. alloy) would flow out of the furnace tap first and would be collected for later purification (cupellation), and the slag which flowed out secondly would be diverted away by another tap and discarded.

In the case of silver-bearing galena which already has the requisite lead, the concentrate would still be smelted in order to obtain a good quality of lead-silver alloy. Some accounts describing ancient silver production have not included the preliminary smelting stage, which conflicts with the view expressed here (Hanfmann, 1972:230, fig.174). If only the cupellation stage were used to produce silver from a concentrate, which is theoretically possible, the process would have to be repeated a number of times to obtain a silver of acceptable quantity. This would tend to make the whole process much longer than if the ore were smelted first.

According to Levey (1959:181-2) it is evident from Sumerian and Assyrian texts that a number of processes or steps were employed in the treatment of silver, from its ore stage to its final metallic state. What exactly these steps entailed is not given, but Levey is convinced that they are thermal processes. He also points out that in Assyrian and Neo-Assyrian literature there are at least six different adjectives describing silver. These could be grades of silver after a particular stage of processing. Alternatively, they may have been labels which somehow reflect the nature of the impurities, i.e. copper-silver, lead-silver, etc.

D2. Cupellation

Briefly described, the process of cupellation is the act of separating silver (or gold) from the unwanted impurities using lead as an agent. The oldest surviving description of cupellation is from a Neo-Babylonian document (Fossey, 1935:II-VI), but it is obviously a method handed down from earlier times.[12]

Few cupellation furnaces dating from antiquity have been found. At the end of the last century Gowland investigated a Roman smelting site at Silchester and provided evidence of what he considered to be silver refining furnaces (Gowland, 1901:113-122, figs. 2-3). Gowland's analysis and conclusions were not only cogent but meritous, for his reconstruction of the furnaces is quite similar to the (gold) cupellation furnaces recently discovered at Sardis (6th century B.C.) (Hanfmann, 1972:230, fig.174). Gowland's reconstruction showed that the furnace was lined with bone ash over a clay base. The bone ash served as a lining of the bottom of the furnace, but especially its purpose was to absorb the impurities in the form of molten litharge (lead-bearing slag with impurities). The roof or chimney and walls were never found, but Gowland's reconstruction called for these elements. Hanfmann's Sardian reconstruction does not include sides and roof, but his reconstruction may be a simplification of the process. According to Tylecote a cupelling furnace would reach somewhere between 1000-1100° which would seem to support a reconstruction of a furnace with sides and roof, since a good fire could then be maintained with the assistance of bellows.[13]

Gowland's description of the cupellation process is as follows:

> The shallow cavity in the hearth was filled with charcoal and when this had become sufficiently ignited, the silver to be refined was placed upon it together with a certain aount of lead. More charcoal was then piled up over the metals and the bellows were started. As soon as the metals had melted and the furnace had obtained the requisite temperature, the fire was pushed away and piled around the edge of the metallic bath which now filled the cavity of the hearth. By the combined action of the heat and of the air from the bellows the lead was gradually oxidized forming litharge, the copper and

> other impurities were also converted into oxides at the same time. These oxides, disolved in the metal litharge, were absorbed with it by the hearth.
>
> When the operation was continued sufficiently long and the requisite amount of lead was used the impurities were all removed and a cake of silver remained in the hearth. When, however, the metal treated was chiefly copper, or very impure silver, then pure silver could only be obtained by using a very large amount of lead or by repeating the process." (Gowland, 1901:120-1)

There are other possible methods. Agricola (1950:483) describes one cupelling furnace without roof (i.e. "dome"). The operation is in fact performed in a crucible. In the latter are placed "cakes" of silver-lead alloy over which is piled first dry wood (not charcoal !), then green wood. The fire is aided by bellows. This open fire method, which obviously worked, obliges us to see that cupelling methods do not necessarily require a furnace.

Some silver is inevitably lost in the cupellation process, even though some may be recuperated from the litharge by repeated cupellation. The early silver refiners were aware of this. According to Levey (1959:182-3), a Late Assyrian text indicates the loss of ca. 2.8 % silver in the refining (cupellation ?) process. Other losses are mentioned in Ur III texts as 14 %, 4.2 %, and 10 %. A I st millennium B.C. text records a loss after refining of 2.25 % silver (Levey, ibid.). These figures are, as Levey points out:

> "...the data for the refining process carried out in two stages. The first is probably the smelting operation where most of the lead is oxidized to litharge (PbO) which is volatized at a medium temperature by a mild air blast, perhaps by opening of the door of the muffle. The second 'quantity left over' appears to be that amount which remains in the pores of the cupel, probably the last portion of the lead monoxide, leaving a silver button." (Levey, ibid.)

E. Analysis of Silver Artifacts

Due to the impression of many museum curators that silver objects are too valuable to be submitted for analysis, we have precious little data on silver composition. However, a few analyses available point to some interesting problems to work out when silver artifacts are made more accessible to metal analyst.

The analyses of silver artifacts from the EBA II period at Alaca indicate that silver smiths must have experimented with silver-copper alloys (cf. Appendix III) (Kosay, 1951:189). One silver cup fragment from one of the Royal Tombs contained more than 15 % copper. A simple silver cup would not seem to require strengthening by the addition of copper, and it is because of this that we must seek another reason for its presence here. There are other Anatolian artifacts which reveal this same feature, thereby showing that it is not an isolated occurrence.

Evidence of impure silver also appears on the two-handled silver cup in the Schimmel Collection (Muscarella, 1974:cf. color plate). One can easily see some copper corrosion products (malachite, azurite) on the right handle near the lip, as well as on the fluted body. In spite of the fact that this artifact has not been analyzed these traces of copper are an indication that copper is present in the silver and could be due either to residual copper from the original silver ore deposit or to an imperfect alloying with silver metal.

The silver ingots from Mahmatlar (infra) likewise show traces of copper oxidation on the surface.[14] Although again we are uncertain as to whether copper occurs here as an intentional alloy, there are indications that the ingots are a product of cupellation. First of all, this is suggested by their general plano-convex shape, and secondly, the excavators state that there seem to be traces of lead on the surface of the ingots (Kosay and Akok, 1950:484, fig.16).

From Troy II's Treasure A comes a group of blade-like plaques which Schliemann (Ilios:470-1) described as ingots. The analysis of one of these ingots (not specified which) gave the following constituents:

Silver..................	95.61 %
Copper..................	3.41
Gold....................	0.17
Iron....................	0.38
Lead....................	0.22
Nickel..................	traces
	99.79 (Ilios:470)

The analyst of this piece states:

> The amount of lead present points to the silver having been purified by cupellation. Alloys of silver are known to vary in composition throughout the mass, but it is probable that the results of the analysis fairly indicate the amount of precious metal in the talent. (Ilios:470)

Beyond the confines of Anatolia, another of the rare analyses of silver is a pair of rein rings from the Royal Cemetery at Ur (Plate XXVII (2)):

Silver..................	93.5 %	
Copper..................	6.1	
Gold....................	0.08	
Zinc....................	0.15	
	99.83	(Plenderleith in Woolley, 1934:293)

The conspicuous absence of lead in this analysis suggests that the silver did not originate from an argentiferous galena deposit, unless of course the cupellation operation was particularly efficient in removing all of the lead. Another possible interpretation is that the silver originated from an ore where lead was not present, perhaps a silver-bearing copper ore. However, this interpretation is not without its difficulties, for if the silver did originate from such an ore, how was it extracted ? Scientists normally assume that cupellation was the ancient process employed to refine silver, as explained above (cf. "Cupellation"), but the process requires the presence of lead to "absorb" the impurities. If lead is not present in the silver ore concentrate, it would have to be added at some stage prior to cupellation (cf. Figure 11), in which case some lead trace would be present in the silver. How then is a silver-bearing ore refined without the use of lead ? The state of our knowledge of ancient refining processes does not allow us to deal with this particular point adequately.

Other aspects dealing with silver purity are worth our consideration here. Based on the geological data presented by Patterson (1971: Table 13) copper does not occur naturally in silver chloride ores in quantities above 0.9 %. That being the case, the Alaca silver fragments, the Troy I ingot, and the Ur rein ring contain intentionally added copper. Limet and others (Limet, 1960:47) share the view that copper was added to the Ur rein ring in order to give strength to the silver. But since silver is as hard as copper (HV:2.5), alloying was probably done for another reason. It is possible that a deeper color was desired, or that adding copper was an economical measure.

F. The Archaeology of Silver Artifacts

The beginning of silver working in Anatolia is, like the beginning of so many industries, still frustratingly obscure. We might logically expect that man first became acquainted with silver where it occurs in its native state. But, unlike copper, native silver (also known as silver glance) is rare. Where superficial deposits of native copper probably led man to his acquaintance with copper ores, we cannot readily assume that this was equally the case for silver, for as pointed out earlier native silver normally occurs in deep-seated deposits and hence not visible on the surface.

Other possibilities exist. Perhaps in the course of exploiting lead the ancient metallurgist came across some tiny bits of silver in his smelt. Or, perhaps he obtained some silver as a by-product from copper smelting. One can easily make a good case for both of these possibilities, as lead and copper make their appearance long before silver does.

The earliest silver artifact we know of from Anatolia comes from a small hoard at Beycesultan level XXXIV (ca. 4300 B.C.) in the form of a small silver ring (Stronach, 1959:47-50; Lloyd and Mellaart, 1962:280-3). Our present knowledge of the Chalcolithic being so meager, this ring hardly gives us an indication of the extent of silver production at this time; nor is it known whether the ring is made of native silver or cupeled silver.

We can only speculate on the period which preceded that of the Beycesultan ring. The copper and lead finds at Catal Huyuk suggest a growing metallurgical industry and an awareness of the use of metals as early as the Neolithic (Mellaart, 1967:217-218), but we do not know whether this includes silver. Because of a close association with silver, the presence of lead artifacts at Catal Huyuk may point to silver working in the Neolithic, but until we have actual artifacts of silver from this period we are only speculating.

In EB I silver is known in the East of Anatolia, at Korucutepe Stratum XXXIX (ca. 3000 B.C.) (Van Loon, 1973:360, pls. 4(1), 5(1) (3) (4)). The abundance of silver artifacts here, mostly jewellry pieces, points to a more ambitious production of silver than known previously, a fair indication that silver deposits were being mined and the ore smelted and cupeled. It is highly unlikely that native silver would be found in these amounts in Anatolia. The nearest silver ore deposit to Korucutepe is located near Keban (S-163) where an "ancient" mine is also reported to exist.

In Central Anatolia in EB I silver earrings occur in a tomb deposit at Alishar 14M (OIP XXVIII:9). This suggests a widespread use of silver in this period as a precious metal, and perhaps exploitation of near-by silver deposits (see Maps 14 & 16).

From level I onwards silver artifacts appear at Troy, the first examples being two silver pins with incised heads (<u>Ilios</u>: nos.121, 112), and in Poliochni Azzurro a silver double spiral pin occurs (A-438). Hence, at least by the beginning of the IIIrd millennium B.C. both Eastern and Northwestern Anatolia were using silver, which implies numerous exploitations of silver deposits. It is interesting to note that although Troy I was a small settlement, it nevertheless possessed the technology to produce artifacts in precious metals. A pin mould from Troy I (Figure 16 (1)) supports the view that jewellery-making was a craft practiced here. As for Troy's sources of silver, they may have been local, i.e. in Northwest Anatolia.

In this case Balya Maden (S-151) would seem to be the best candidate. Bergaz (S-146) must also be considered as a possible source. It is not altogether impossible that some ore or silver came to Troy and the Troad via a sea trade operating along the west coast of Anatolia, and possibly extending as far as Cilicia. The Bulgar Maden deposit (S-157), discussed above, is known to be silver-bearing and could have been an important source in antiquity. However, the absence of silver from Mersin and Tarsus in the Chalcolithic and EBA periods does not offer particularly convincing support that Bulgar Maden was exploited quite that early.[15] On the other hand, smaller deposits in Western and Southwestern Anatolia may have been exploited for limited production and trade along the coast (i.e. Ortakonuş, Ağraköy, Gümüşluk, and Gümüş Dağ, cf. Maps 14 and 16). In any case, the technology for the cupellation of silver appears widely practiced in EB I.

Buchholz takes a more cautious view. He places the introduction of cupellation for the East Mediterranean world to the second half of the IIIrd millennium B.C. (Buchholz, 1973:270-81). But even in the absence of silver processing centers, the number of silver objects occurring in Anatolian EB I-II contexts, the discovery of cupellation took place no doubt much earlier.

A few prehistoric silver ingots have been found. What one would expect to be typical types come from a chance find at Mahmatlar. Although their archaeological context is somewhat obscure, they are thought to date from the same time as the other EB III material recovered at the site (Koşay and Akok, 1950:484, fig. 16). These ingots are roughly semi-spheroid in shape (or plano-convex) and vary in weight between 416 grams-494 grams. Apart from these is a single ingot, also from Mahmatlar, which weighs 4.630 kg., the heaviest so far recovered in Anatolia. This large ingot also suggests the shape of the bowl in a cupellation furnace (cf. Figure 11), its maximum diameter being about 22 cms.

The Troy II (i.e. Treasure A, SS 5967 - SS 5972) ingots vary in length between 17.4 - 21.6 cms. and weigh between 170.8 - 173.8 grms.[16] It is evident that some sort of standardization was sought in the manufacture of these pieces. Schliemann states that "they have all been wrought with a hammer" (Ilios:471), perhaps in an effort to wield them into a desired ingot shape. The semi-circular notch at the end could be the result of some metal having been cut or ground away to attain a specified weight. One of Schliemann's collaborators, B.V. Head, suggested that the two largest examples are equivalent to one-third of a Babylonian mina, hence of a standard weight (Ilios:471-2).

In EB II Aegean settlements are better provided with silver artifacts than their Eastern and Southern Anatolian counterparts (Renfrew, 1967:4-7) which shows that silver (presumably Anatolian) was linked to a sea trade. This orientation of silver occurrences may, again, indicate that the Northwest, West, and Southwest silver deposits were exploited more actively than others, or that trade in silver was more intense in the West. By EB II Central Anatolia also becomes more affluent in silver, not only from the point of view of numbers of pieces but in the size of the pieces as well. We need only mention briefly the silver cups at Eskiyapar (A-334-336), the silver ingots from Mahmatlar (Koşay and Akok, 1950), and the abundant silver finds from Alaca (Koşay, 1944; Idem., 1951:passim). This wealth is equaled only at Troy. Even though silver does not become common elsewhere, silver trinkets nevertheless show up in small settlements as at Karataş in Lycia (Mellink, 1969:323, pl.74(17)(18)) and Thermi IV (Lamb, 1936:165), and in the burial at Balikhane (Mitten and Yüğürüm, 1971:193) by the middle of the IIIrd millennium B.C. This wide-spread distribution of silver, although basically Western, does not suggest a single source. The Central Anatolians, themselves, had a number of rich deposits they could have exploited (cf. Map 16). The sites of Gümüş (S-130) and Akdağmadeni (S-160), discussed above, have both shown ample evidence of silver smelting. Other Central Anatolian deposits of lesser silver content have also given evidence of some kind of smelting activity: İşikdağ (S-129), Kurt Maden (S-166), and Arpalik (S-11) (Cf. Map 14).

Perhaps it is significant that silver artifacts have not been found at every EBA site. It could be due to their disappearance by corrosion, chance finds, or for political reasons the ancient silver trade was under some measure of control. Silver has not been reported at Kusura, Mersin, Tarsus, Ahlatlibel, Pulur, Karaz, Gelincik Tepe, Gedikli Hüyük, Tilmen Hüyük, Pekmez, Etiyokuşu, Kayapinar, Polatli or Karaoğlan. The fact that when it does occur it is best represented in the context of a hoard (Beycesultan, Troy and Soli) or as a funerary gift (Balikhane, Karataş, Dorak, Alaca, Horoztepe, Mahmatlar), a fair indication that it was highly prized.

At the beginning of its use in pre-Dynastic Egypt, silver was more highly valued than gold (Partington, 1935:42; C.A.H., 1970:485-6), but its value dropped with respect to gold as it became more abundant, no doubt as a result of improved methods of production and the increased trade in this commodity. Yet, even as late as the XVIIIth Dynasty silver appears to have been more coveted than gold (Partington, 1935:43). The high value put on silver is particular to Egypt which has no silver deposits of its own, whereas in Mesopotamia, which had a more plentiful supply through its trading connections, gold was always valued more highly.

Gold and silver were probably worked by the same smith who may initially have been also the copper smith. All three metals (gold, silver, and copper) are often combined on the same object. On the Hasanoglan silver figure (Plate XV (2)), for example, there is gold overlay. There is a copper or bronze blade from Troy I (Ilios:251, no.120) which has a gold overlay, and from the Alaca tombs there are bronze standards with silver inlay and overlay (i.e. Arik, 1937:no.Al 658, pp.CCII-CCV).

It would seem from the lack of smelting evidence from settlements that silver production centers must have been commonly established outside, in remote areas as yet uninvestigated by archaeologists. The areas which come to mind first are of course those which have provided evidence of silver ore and where slag dumps or traces of ancient mining have been noted.

Whether entire communities were devoted to the production of silver or whether it was just a part-time or seasonal industry of certain members of a settlement is not possible to say.

The silver was probably traded in the form of ingots, either plano-convex type like those found at Mahmatlar (supra); bar ingots, possibly resembling those of Treasure A at Troy (supra); or "torques", the riksum of the Assyrians (Garelli, 1963:265-6). But not all silver was transported in metal form. The Sumerian and Assyrian texts describing the refining processes of silver (supra) point to the fact that ore was brought to the settlements for this treatment. This silver ore would then have been transported as ore concentrate.

In Sumer the earliest-known silver occurs at Uruk during the Jemdet Nasr period (Heinrich, 1936:40, 47) in the form of a silver vase guilded with gold leaf. This exceptional find points to a use of silver at an earlier period. The sophisticated casting technology of such an artifact is surely the result of an earlier development.

It has been suggested that the source of Sumer's silver was Anatolia (Partington, 1935:235), but Limet (1960:94-5) has pointed out that it may not have been the only source. In one Ur III inscription Gudea specifically states that his silver came from the East, from Elam. Sargon I, on the other hand, probably obtained a great portion of his silver from Anatolia (Limet, 1960:95).

The earliest silver artifacts in Northern Syria occur at Tell Brak in the form of silver tacks with gold plate (Mallowan, 1947:93), dated to the Jemdet Nasr period. In the same region, but dating to a later period, a silver bead from Chagar Bazar V (ca. 2500 B.C.) suggests continuing trade for Anatolian silver (Mallowan, 1936:24, 26; and Perkins, 1949:188). Silver artifacts are known at Byblos, dating to about the Jemdet Nasr period (Dunand, 1950:583; idem., 1961:75-82; C.A.H., 1970:421). Closer to Anatolia, at Alalakh, silver rings, pins and pendants were recovered in level XIII which, according to Woolley (1955:273-4, 281-4, 380, and 399), can be placed somewhere between 2900-2400 B.C., but this level is certainly much later.

Northern Mesopotamia was also familiar with silver from as early as the Jemdet Nasr period. Nineveh produced one silver pin (Mallowan, 1930:145-8, pl.LXVIII, pl.LXX,9). From Tell Billa 6 (ca. 2800-2400 B.C.) comes a silver "hairpin" and a finger ring (Speiser, 1931:12; and Perkins, 1949:186). From Tepe Gawra Level VI (ca. 2400-2100 B.C.) come three silver rings, again providing evidence for continuing trade for Anatolian silver.

The appearance of silver artifacts in Northern Mesopotamia and Syria at the same time it occurs in Eastern Anatolia (i.e. at Korucutepe XXXIX) seems to indicate the establishment of a silver-producing industry somewhere in Anatolia by the end of the IVth millennium B.C. It has already been suggested above that Keban Maden (S-163) was a possible source of East Anatolian silver, but smaller lesser deposits may also have been exploited. It is not altogether certain that the source of Syrian and Mesopotamian silver was in Eastern Anatolia. Proximity need not be the safest indication, and the deposits in the West and South of Anatolia, which are by and large bigger and richer in silver, may have been the principal source of supply.

Notes to Chapter 4:

1. For a short discussion on different aspects of the lead industry in the Roman period, Boulikia, 1972.

2. Forbes, 1950:101. Forbes gives as his source, Landsberger AO XIV 1925, No.4, and Bittel, Prae. For. in Klein. (= Ist. For. No.6, 1934): 81.

3. Forbes, 1950:191 (11); Gowland, 1920:157; De Launay, 1911:639-644; Edwards, 1914:197; and Mining Journal, 1910:1202.

4. In addition to the above, Kruse, 1965, a Phd thesis which expounds on the mining potential and nature of the lead deposit at Bulgar Maden.

5. Gowland thought that this area was possibly "ancient Argyria," an idea he likely picked up from Smyth. The latter wrote: "Tirebolu; openings of ancient mines on the western bank of the stream; probably the Argyria of the ancients," Smyth, 1850:298. Smyth, in turn, may have gotten the idea from Hamilton, 1842, II:259, who appears to have been the first to make the association. However, present-day scholars prefer to see Gümüşane as the Homeric Argyropolis, Bryer, 1970:324-5. Forbes, 1950:191, mistakenly understood Gowland's Gumush Maden to be Gümüşane.

6. Gowland, 1920:159, simply states: "Another site is near Erzerum."

7. Karajian also cited by De Launay, 1911:651. Bryer, 1970:331, mentions a mine in the area of Isbir, near the monastery of Surb Hovhannes, which was exploited in the 1830's.

8. Map used for this location: Ordnance Survey. Published in Great Britain 1915. Geolographical Section. General Staff, No.2097. Scale: 1:250,000.

9. A wooden panning bowl (possibly "Late Saxon" according to Davies) was found within the context of an argentiferous lead mine near Etropole, Yugoslavia, Davies, 1937/8:414, fig. 1(2). Its presence in the mine suggests that some sorting was performed at the mine, though this need not have been universally true for all periods and all areas.

10. Agricola, 1950:300-348, discusses many medieval systems which are similar in concept.

11. Personal communication. This description is based essentially on what the excavators at Thorikos (ca. MH I-LH) and in the environs of Laurium have been able to determine from excavated remains of smelting furnaces, ore-washeries and slag, Mussche and Conophagos, 1973:61-72; idem., 1970:1-13 (=16-21).

12. Limet, 1960:143-4; Levey, 1959:182-3; and Hodges, 1968:93-4. Agricola's description of cupellation in a crucible starts with "cakes" of silver-lead alloy, presumably from the preceding smelting stage, Agricola, 1950:483.

13. Gowland, 1901:121, mentioned that one of his Roman furnaces was operated at too high a temperature, which shows that temperature control was no easy matter even for the Romans.

14. This author saw these ingots in the Ankara Museum in 1974 at which time these observations were made. Similar traces of copper oxide have been noted on silver artifacts from EB II Karatas burials, Mellink, 1969:323.

15. Though this is not certain, for EB II black-burnished ware has been reported in the context of the Bulgar Maden silver mines Mellaart, 1965:37.

16. The weights reported by Schmidt are slightly lighter, due perhaps to more accurate weighing. However, Schmidt incorrectly reports the weight of ingot no.792 (<u>Ilios</u>:471 = SS 5970) which should be around 173 grams, not 273.8 grams.

CHAPTER 5

Gold and Arsenic

Contrary to common belief, gold is an abundant element and occurs in many different types of natural materials, albeit minute amounts. Traces of gold can be found in very common rocks, such as limestone, and it is even present in seawater. Gold is commonly found in association with other metals such as nickel, silver, lead, copper, mercury and tellurium. But as far as the exploitable quantities of gold are concerned, there are, generally speaking, two types of gold ore deposits: primary and secondary. Both these types of deposits exist in Turkey.

A. Nature and Occurrences of Gold Deposits in Turkey

A 1 Primary Deposits

This first type of deposit can be subdivided into the following two groups:

1) Auriferous quartz-arsenopyrites deposits. These are located in the mica shists and gneisses of the Menderes Massif in the Western part of Turkey such as at:

Arikbaşi	(Append. IV, no.2)
Bózdağ	(Append. IV, n0.5)
Umurbaba	(Append. IV, no.10)
Sobunca Daği	(Append. IV, no.6)
Ayranci Çakmaği	(Append. IV, no.7)
Sariköy	(Append. IV, no.8)

The gold content is related to arsenopyrites and appears to have originated during hydrothermal activity in Late Paleozoic times. The highest gold content in this group is as Sobunca Dagi, where Au = 128.8 gr/ton (i.e. ca. 0,03 %) is reported (Appendix IV, no.6). For the most part the grades of the ores are ample enough, but the reserves appear to be too small for modern exploitation.

2) The second group of primary ore deposits is associated with silicified shear zones or quartz veins which are in turn associated with volcanic lava flows of Tertiary Age. The gold is present in dacitic breccia (i.e. "reef gold"). The three sites in Turkey representing this type of deposit are:

Arpadağı (Append. IV, no.1)
Madendağı (Append. IV, no.13)
Kartaldağı (Append. IV, no.12)

It should be pointed out that silver occurs with gold in the deposit at Arpadağı, and at the same site native gold has been observed in galena.

A site of considerable interest in Balya Maden (S-151), and although it is not classed as a gold deposit, it did produce in modern times a yearly average of 55 kg. of gold. Silver and lead were by far the most important (see "Silver" supra).

A2 Secondary Gold Deposits

By the action of weathering and water current gold can end up in the form of concentrations of sediments in a riverbed. Since gold has a high specific gravity, it will not move with the current as easily as lighter materials, and, hence, it will tend to collect in pockets. This type of occurrence is called "alluvial" or "placer" gold. The gold itself can exist in the form of muggets or flakes. It is commonly found two or three feet (60-90 cm) above bedrock and tends to concentrate in the middle of the riverbed. Black sand is sometimes an indicator of gold concentrations, but it is not foolproof.

In Turkey, secondary gold deposits are alluvial or are found in conglomerates and sandstones of Neogene age. The sites currently known where secondary gold deposits occur are:

Darphane (Zaraphane) (Append. IV, no.14)
Sart (Sardis) (Append. IV, no.9)
Akilliçay (Append. IV, no.15)

The grades of these deposits are deemed too low for modern exploitation. This was not the case at Sardis in antiquity, for archaeological research has now shown that gold was apparently extracted from the alluvial sands of the Pactolus and purified in refining shops on the bank of the river (cf. infra.).

Karajian conceived of a "western gold belt" which, according to the information now available, appears to be somewhat over-simplified. It is true that there is a preponderance of deposits in the west and southwest of Turkey, but the term "belt" could hardly be applied to these.

In the archaeological literature there are various references to gold deposits. Schliemann, quoting Strabo, offered the suggestion that Trojan gold was from the Troad,[1] and elsewhere he stated that the gold from "Priam's Treasure" (Treasure A) came from Astyra, near Abydos (Troja: 49-50). According to Karajian, "the site of Astyra is supposed to coincide with that of the modern hamlet of Serjiller, about 14 miles south of the Dardanelles. Abandoned workings of considerable extent are known at this point..."[2] No attempts have yet been made by modern field archaeologists to bring new light on the nature and confirmation of the Astyra gold mine.

Pliny (H.N.XXXVII,74) mentions a gold mine at Lampsacus (present-day Lapseki) which Schliemann (Troja:50) describes as being "30 kms north of Abydos and 55 kms from Ilium." Schliemann's friend and geologist, Frank Calvert, had obtained permission from the Porte to investigate these mines, but no report on them had ever been published.

Geological work has not yet turned up either primary or secondary gold deposits on the Central Anatolian Plateau. However, there is a fairly good possibility that gold was once readily available in this part of Anatolia. The abundant gold finds from the Alaca Huyuk tombs point to accessible deposits of gold, perhaps alluvial, in the 3rd millennium B.C.

B. Preparation of Gold Ore

Unfortunately few analyses of gold are available, since many museums are reluctant to allow gold artifacts to be analyzed for trace elements. However, a few analyses are available which, if they do not clear up the question of provenience or smithing techniques, they nevertheless point to exercising caution when attempting to interpret the nature of gold without analyses.

We are uncertain as to whether gold was ever mined by tunnelling in prehistoric times.[3] The earliest written reference to tunnel mining is the description by Agatharchiedes which dates from the second century B.C. (Partington, 1935:35; Notton, 1974). In all likelihood the source of gold in the whole Near East prior to the Second millennium B.C. was native, but as yet no satisfactory guidelines have been established to determine whether the gold is alluvial or vein in origin, or both.

Gold is known since Pre-Dynastic times in Egypt where it is suspected to be of alluvial origin (Partington, 1935:25; Lucas, 1962: 224). In the Eastern Desert at Wadi Allaqi and at Wadi Gabgaba alluvial workings have been reported, possibly dating to as far back as the IIIrd millennium B.C. (Partington, 1935:32-3; Lucas, 1962:225), but details are still lacking.[4] Vercoutter (1959) has pointed out that there are a number of ore-processing sites on both banks of the Nile in the areas of Wawat and Kush, North of Dongola, established there presumably to make use of the water for ore washing. In this same context Vercoutter (1959:120-7) has tentatively identified a gold processing unit, a washery, not totally unlike those found at the silver processing site of Thorikos (Mussche and Conophagos, 1970, 1973). Vercoutter states that the gold of Wawat and Kush does not seem to have been exploited until ca. 1900 B.C. More fieldwork in these regions and at the ore-processing sites would certainly provide a wealth of information on gold processing techniques about which we know so little.

In the second century it is again Agatharchides (via Diodorus Siculus) who gives us an account of ore-processing, and two centuries later so does Pliny (H.N.XXXIII,21). Agatharchides definitely refers to separating gold from quartz rock by crushing and grinding, whereas Pliny makes an allusion to the dredging of river bottoms. To make up a concentrate Agatharchides describes what seems to be the use of the buddle or strake. Such a system is clearly depicted in Egypt on a sculptured relief in the tomb of Bagt at Beni Hassan (ca. 2000 B.C.) (Notton, 1973:53). The system is similar to that illustrated more than two millennia later by Agricola (1950:301, ff.). Pliny makes reference to a kind of screening system where the ore-carrying waters are sent through woven (?) twigs called Ulex (said by Pliny to be similar to rosemary, "rough and prickly") which catch the gold -- in this case native gold particles. These twigs are removed, burned and washed, thereby leaving behind the particles of gold. (Agricola, 1950:314, plate).

Agricola's description of ore-concentrating may be a help to us in understanding earlier techniques. He describes many systems of concentrating, and on one occasion even makes allusion to the Golden Fleece as a system used formerly (Agricola, 1950:330). Many of the systems he describes make use of a cloth-covered buddle across which the ore-bearing waters flow. Due to the high specific gravity of gold tiny particles sink towards the bottom and subsequently become emmeshed in the weave of the cloth. According to Agricola the cloth can even appear golden "because of the particles which adhere to it". It is then "washed in a special tub and the particles are collected in a bowl" (Agricola, 1950:331). The allusion to the Golden Fleece is obvious, in which case woollen skins are used instead of woven cloth. A variation using tightly woven horse hair instead of cloth is also mentioned by Agricola (1950:332). This method, and others similar, are described in the context of concentrating tin ore (Agricola, 1950:307-8), something to bear in mind when evidence of ancient tin workings are brought to light.

Anatolia as yet presents no direct evidence of alluvial workings in prehistoric times. The earliest (and only) gold-processing site so far located in Anatolia is at the 6th century B.C. workings at Sardis (Hanfmann, 1972:26-7; Ramage, 1972:18-24). Although later than the period which concerns us, the simple process of sieving and washing practiced here was probably as equally well understood by the middle of the 4th millennium B.C., when the first gold objects begin to turn up in the Near East.[5]

C. Gold Refining by Heat Treatments

Native gold, either in small nuggets or particles, presents little problem to the goldsmith. It is simply washed to remove all the foreign material and melted into lumps or ingots. Gold nuggets are known in Egypt dating to the XVIIIth Dynasty (Lucas, 1962:228-9). Lucas feels that in the case of Egypt gold was not refined until the Persian period (ca. 525-404 B.C.), stating that the different qualities of gold noted in texts of the XXth Dynasty (ca. 1200-1085 B.C.) "almost certainly refer to different grades of native gold rather than to gold refined or purified in any way." There are, however, serious objections to this view, especially when we consider the advanced gold-refining technology of Egypt's neighbors and in view of the Nubian gold deposits to the south and the ore-processing equipment found there (Vercoutter, 1959).

W. Young (1972:9) has presented an interesting argument stating that the ED Sumerians did not practice gold ore refining. His evidence is based on the analysis of gold material from the Royal Cemetery at Ur. The gold showed traces of free platinum-iridium, thereby indicating that the gold had not been subjected to melting temperature and that it was native.[6] Woolley also claims that all the gold from the Royal Cemetery is "alluvial metal" (Woolley, 1963:556). This opinion could be taken to imply that gold nuggets were panned from rivers and simply melted together. It is more likely that gold ores were brought in their crude state -- possibly originating from alluvial workings -- to the large Mesopotamian city-states for specialized treament.

According to Limet:

> "...il était courant à toutes les époques de l'histoire en Mésopotamie d'importer du minérai d'or que les artisans locaux débaraissaient des métaux vils." (Limet, 1960:85, cf. also 144-5)

And contrary to Young's implication, gold probably underwent some kind of heat treatment for purification, although it is possible that some native gold was still being used in the 3rd millennium B.C. The sculptured relief from the tomb of Baqt mentioned above not only shows the refining process by the use of a horizontal buddle but clearly indicates the use of heat for the refining of gold concentrate (Notton, 1973:53). Martin Levey (1959:193) makes a case for gold refining in the 2nd millennium B.C. in Sumer, and although he uses both the terms "smelting" and "refining" and does not state the distinction he is making between the two, some kind of heat treatment is definitely used in purification.[7]

T.T. Reed has objected to the use of the term "smelt" when referring to the refining of gold in antiquity:

> "Gold occurs only as native metal (there are rare exceptions, quite unknown to the ancients), and therefore it cannot possibly be smelted. When gold occurs in association with lead or copper ores it may be recovered in smelting the lead or copper minerals; indeed the object of smelting the lead or copper mineral may be to recover the gold, but the gold was native metal at the beginning of the process and remained so to the end." (Reed, 1934:382)

Ores from which native gold is obtained by crushing and subsequent amalgamation (i.e. melting the small bits together) are called "free-milling ores," and it is to this category of gold ore that Reed is referring. So far as the archaeological record is concerned, there is no evidence for the smelting of gold-bearing minerals for the purpose of recuperating reduced gold. Hence, when we speak of "gold ores" of antiquity we are referring to minute bits of native gold in mineral gangue which cannot be amalgamated by mechanical means, i.e. crushing, sorting and seiving. These ores must be heat treated in some way to rid the gold of the adhering impurities. Here, then, the term "smelting" is not appropriate, as Reed points out, since the gold does not undergo chemical change.[8]

Gold ore can be refined to a certain extent by cupellation, the process being precisely the same as for the cupellation of silver (supra). However, if any silver is present in the gold ore it will not separate out with the rest of the impurities, and the result will be a gold-silver alloy.

The gold in the Pactolus is silver-bearing by nature, and the 6th century B.C. workships at Sardis appear to have been designed to separate gold from silver, a process known as cementation (Goldstein in Ramage, 1970:26-7). There are variations of this process, one of which is described by Ramage (1970:22-3):

> "The gold is hammered into thin sheets, which are then stacked in a vessel with layers of dry 'pickling mixture' like common salt or alum, and heated for a long time at ca. 700°. Silver especially combines with salts and the gold is left pure. The process can be repeated if necessary."

Tylecote (1962:82) states that it can be done using salt and clay as agents. The salt, clay and gold are mixed together and then subjected to a steady heat in a furnace. Under these conditions and after many hours, the clay absorbes the silver in the form of silver chloride. Afterwards the gold, virtually unchanged, can be washed out and the individual pieces melted together.

Hodges (1968:93) suggests a single step process in which the gold is heated with salt and charcoal in a closed cupel. The silver would combine with the salt to form silver chloride and the other impurities would be converted to oxides and absorbed by the cupel (presumably with the aid of a bone ash lining) and segregate out, leaving behind the purified gold.

The reader will notice that the methods described by Ramage, Tylecote, and Hodges are similar. As gold does not undergo any king of chemical change in these refining methods, we can again accept Reed's objection to the use of the term "smelting."

Agatharchides describes a method which is the first textual account of cementation (in Diodorus Siculus, III, 12-14). The process was repeated in modern experiments which found it to be remarkably efficient (Notton, 1974:54-6). For one experiment small bits of a gold-silver-copper alloy were used. At the outset the gold content was 37.5 %. Salt, brick dust and the alloy were placed in a scorifier and heated at 800^{o} for several hours until no more salt fumes came off. The result was a refined gold of 93 % in purity. A blue, glassy slag was also produced.

It may have been that a combination of cupellation and cementation was used by the ancient metallurgist, as suggested by Hanfmann and Waldbaum, (1970:311-13, pl.34). Their analysis and discussion of the Sardian gold fragments give convincing evidence that the Lydian metallurgist of the 6th century B.C. (i.e. the time of Croesus: 560-547 B.C.) was using both of these processes to refine gold.

Still we are left to speculate as to whether the prehistoric Anatolian metallurgist knew of these methods or not. There are many electrum artifacts as early as Troy II (Ilios:273, 467, 472, 485-6, 493, 488, 494), but other purer artifacts from Troy II (Ilios:297) may serve to indicate that separation of gold from silver was practiced. However, this is far from certain, as the presence of both gold and electrum artifacts may simply mean that there were two sources of supply, one of Pactolean- type and another of purer gold.[9] Many authors (Tylecote, 1962:3-4; James, 1972:40; Lucas, 1962:229) claim that gold refining, using any form of pyrotechnology, was not performed until the Persian period (ca. 525 B.C.) in Egypt or later. Their argument is based on the high amounts of silver found in gold artifacts (Tylecote, 1962:45). As silver commonly occurs in native gold, it is felt that silver separation (ie. using some form of cementation) was not known, and, hence, only native gold (with its naturally-occurring silver) was used.

We must not assume that in every case pure gold (or silver) was desired. From Sumer there are a few 2nd millennium B.C. textual references to the deliberate alloying of gold with copper (Levey, 1959:181), presumably to make it more resistant to wear.

It seems odd to us that one would want to debase gold by intentionally alloying it with a less noble metal, unless it be for the purpose of altering its color or for strengthening. From the few analyses performed on the goldwork from Ur, intentional alloying of gold with silver and/or copper seems to have been common (Plenderleith in Woolley, 1934:294, Table III). As no analyses are available of prehistoric Anatolian gold, it is not known whether similar alloying methods were practiced there.

D. Nature and Occurrences of Arsenic Ore Deposits in Turkey

Arsenic ore occurs mainly as realgar (AsS) or orpiment (As_2S_3). Realgar is orange in color and is found in nature in prismatic crystals. Orpiment is bright yellow in color and occurs either as crystals or foliated. Orpiment is the altered form of realgar and is more abundant. Arsenic also occurs as the mineral arseno-pyrite (FeAs.S), in which case it can be found with gold. This is the case in Turkey, particularly in the west (MTA, 1970:23-6).

There are still other arsenic minerals such as domeykite (Cu_3As), Tennantite($(Cu, Fe)_{12}As_4S_{13}$), olivenite ($Cu_2(AsO_4)(OH)$), and chenevixite ($Cu_2Fe_2(AsO_4)(OH)_4 \cdot H_2O$), but we are not sure whether the ancient miners bothered with them or even whether they are prevalent in Turkey.

Lead-bearing deposits can contain fair amounts of arsenic. Copper ore, as well, can be accompanied by arsenic in small amounts, usually the case of chalcopyrite and arsenopyrite (Fe AsS) occurring together. According to MTA (1970:4-7), such cases have been noted in İzmir Province at Seydiköy (S-117) and at Seki (S-115),[10] and in Denizli Province at Derbent. At Pitkir (S-112 and Append. V) and Kuvarshan Maden (S-77 and Append. V) arsenic is likewise associated with copper ore. Whether the former workings there processed arsenic in any way is not yet known, but it is not incongruous that such an association should occur in the Northeast where the early metalwork there is characterized by an alloy of copper and arsenic.

Elsewhere, at İşikdağ (S-129), at Kurt Maden (S-166), at Balga Maden (S-151) arsenic in some form or other is associated with the lead-ore body. At İşikdağ the slag was also found to be arsenic-bearing. Samples from the ore-body showed arsenic to be strongly-present (As = 11.28 %).

There are two cases of arsenic-copper slags from the Bakir Cay area (S-95), namely at Bahcelidere and at Sakapinar. The arsenic content was found to be o.1 % and 0.4 % respectively. It is possible that these are examples of smelting where the result was an natural arsenical-copper alloy, but from the slags alone it is not possible to confirm this. Enargite is a copper-arsenic mineral (Cu_3AsS_4) which is known to exist near Gümüşane at Hazine Mağara (S-140), but it is not yet known whether this mineral ever received the attention of ancient miners. To date, we have no information indicating that arsenic was exploited at Gümüşane despite the report of "ancient" remains in the area (i.e. at S-140 and S-141).

In addition to the deposits just mentioned and those catalogued by MTA, we can now add the site of Gümüş (S-130).[11] Very high percentages of arsenic were detected in the slag (20-30 %) indicating a rich arsenic content in the original ore-body. From the analyses it is not possible to determine for sure the type of arsenic ore, but it could be arsenopyrite or enargite.

Generally speaking, although arsenic is not abundant in Turkey, the few deposits known are relatively rich.

Notes to Chapter 5 : Gold

1. Schliemann, Ilios:253; Strabo, XIII.1.23. Strabo states "Above the territory of the Abydeni, in the Troad, lies Astyra. This city which is in ruins, now belongs to the Abydeni, but in earlier times it was independent and had gold mines. These mines are now scant, being used up like those on Mt. Tmolus in the neighborhood of the Pactolus River." It has been pointed out by W. Young, 1972:5-13, of the Boston Museum of Fine Arts that other Trojan material in the University Museum, Pennsylvania, does not contain platinum-iridium. This would seem to set it apart from Pactolian gold which commonly carries this impurity. It is considered by some scholars that not all of these pieces are genuine (information supplied by personnal communication from R. Maxwell-Hyslop).

2. Karajian (1920:139), but this may be Kiepurt's interpretation. Cf. Kiepurt Map of Western Asia, Berlin, 1911, ca. N 40° - W 29°75'. For his sources Karajian gives: Diller, J.S., Quart.Jour.Geol.So. X, XXXIX, pp.627-36; and English, T., Quart.Journ.Gold So., 1904, p.236. Curiously, J.M. Cook does not discuss at any great length these important mines, Cook, 1973:290. He does, however, give the following references: Cuinet V., La Turquie d'Asie, 1894, pp.704, 748; and Leaf, W., Strabo on the Troad, 1923, pp.134 f.

3. Levey's reference to "non-placer" mining of the IInd millennium B.C. is not altogether proven (Levey, 1959:181). For the objection, see Limet, 1960:113-114 . For some comments on later gold mining by tunnelling in southern India, F.R, Allchin, 1962.

4. It has been recently reported, Roberts et al, 1975:26-8, that gold deposits exist in SW Saudi Arabia between Medina and Mecca at Mahd adh Dhahab. The deposit is suspected to be the site of Ophir, the source of gold mentioned in the Old Testament, Job, XXVIII:16; and Kings, IX:28, X:11. If this is so, the workings would date from at least the time of Solomon (961-925 B.C.).

The gold of Ophir was brought to King Solomon by "the fleet of Hiram" via the Red Sea, Kings, IX:26-28. One must point out, however, that the Nubian gold deposits are the same distance as the Saudi Arabian deposits from Ezion-Geber, the home port of Hiram's fleet, see Vercoutter, 1959, and Lipinsky, 1975:Map, p.58. Yet another suggestion comes from Balsan, 1970, who provides evidence of Ethiopia's gold reserves.

5. The earliest occurrence so far known in Mesopotamia is a series of gold beads from Tomb 109 at Tepe Gawra Level 10(ca. 3500 B.C.), Tobler, 1950:193, pls LXIII and LIX. The recently-published gold artifacts from SE Europe by Gimbutas, 1977, give conclusive evidence that gold processing was a mastered technology in the 5th millennium B.C.

6. However, it is premature to say -- as Young does -- that Sumerian gold came from the Pactolus on the meager evidence that it contains platinum-iridium, which is a characteristic of Pactolean gold. We will have to reserve conclusions such as this until more analyses of gold from ancient sources are available.

7. Whatever the inferences, Davies, 1932:985, states that gold was formerly worked in the streams in Macedonia (no sites mentioned) and that "gold slag" is found at various sites.

8. Referring to Pliny, XXXIII, 68, geologist C.L. Sagui, 1930:79, states that "auriferous quartz or gangue was <u>smelted</u> twice" (emphasis mine). On the basis of Reed's claim, Sagui should be corrected.

9. Some gold beads from Troy II were shown to be between 16-18 carats (i.e. Au: 68-75.8 %) (<u>Ilios</u>:497), while others could be as high as 20 carats (Au: 85 %). Egyptian gold is known to be both of higher and lower in purity: 9 - 22 carats (i.e. Au: 38.25 - 93.5 %) for the period prior to (and including) the XVIIIth Dynasty, Lucas, 1962:228 and Appen, p.490. One example from the Persian Period in Egypt had a purity of 99.8 %.

Notes to Chapter 5 : Arsenic

10. For Seki, (S-115) MTA, 1972:99. The Seydiköy (S-117) deposit is mentioned by Ryan, 1960:30. Former mining activity has been noted at both of these sites.

11. Also in the unpublished report de Jesus and Kaptan, 1973:111-114. The latter have suggested that the site of Gumus could very possibly be the Mt. Sandaricurgium arsenic mines mentioned by Strabo (XII.3.40). Arsenic mines are not otherwise unknown. In the district of Al Bagh in Hakkari Province at least one mine was exploited in Ottoman times (Layard, 1853:382-3). In these pages see catalog, S-130.

CHAPTER 6

Mining Techniques in Antiquity

It is much too premature to have even a general idea of the development of prehistoric mining practices in Anatolia. The reason is a logical one: there is simply not enough evidence at hand. If prehistoric mines find their way onto the archaeological record it usually is a matter of fortuity, not plan. Old mines have been sealed up by cavings, overgrown by vegetation or worked out to such an extent that they are no longer recognizable. The archaeologist fares much better in plain and open settlements where surface material leads him to the remains of a pre-existing culture. Mining, on the other hand, does not constitute a culture, but an activity of a culture. It is an ancillary industry to life elsewhere.

As far as present-day knowledge dictates, Anatolian mines tend to be located in regions isolated or distant from archaeological sites and, hence, overlooked in the course of normal archaeological field work. If smelting has been performed at a mining site, slag can indicate the general area of the mining operations, such as at the mining and smelting site of Timna (Rothenberg, 1962). Yet, these smelting sites and their slag do not give us any information about mining techniques, though they do provide us with valuable data regarding smelting techniques. However, not in every case was smelting performed at mining sites. In fact, there are indications that mining and smelting at the same site was not a common as one would tend to believe. So, we cannot even use slag deposits as a fool-proof sign that there is a mine close by.

R. Pittioni's (1951) excellent article on the prehistoric mine at Mitterberg near Salzberg has provided much of the theoretical information and concepts in this section. His article must be consulted for details not included here, especially with regards to smelting and for other enlightenments pertinent to European copper mining.

Often references in literature to mines are in the cursorily labled for of "old" or "ancient" workings, but in the absence of archaeological details little else can be said. However, this rough designation of "old" or "ancient" has tempted some authors to consider mines "prehistoric" or "Hittite" or "Classical" to suit their particular needs. Frustrations over our lack of definite information on primary sources of metal for different periods of history and prehistory has, then, driven scholars to make careless attributions. To determine the period of exploitation, others have cited the nearest archaeological site as evidence. This means of dating the mining activities hardly inspires confidence in the reliability of their conclusions.

An old mine, like any archaeological site, should be dated by material found in the contexts of former activity, either in the mine itself or in the context of the mining operations. However, old mines accompanied by datable material are difficult to find. The paucity of our information need not deter us, however, from trying to perceive the problems of early mining operations. The miner is obliged to consider a certain number of natural features which determine the exploitation of deposits. In other words, different types of deposits demand different types of exploitation techniques. Let us now look at some of these _a priori_ factors and cognate techniques.

The mining techniques discussed below are not solely theoretical, for they are illustrated, when possible, with known examples; and although these examples are often drawn from European contexts, they provide us with some notions of how a miner or mining community might have operated in prehistoric Anatolia.

A. The Mining season

The weather must be generally clement. In cold and wet conditions mining can be complicated by excessive seepage of water into the mine or into the mining area and cause difficulty for the transport of ores from the mine. Moreover, daily living conditions simply may not be comfortable. Copper mines, unlike most Eastern Mediterranean archaeological sites, tend to be situated in mountainous regions where the ores have been exposed by erosion, geothermal or geotectonic activity. Often these occurrences do not take place in an area in which human existence is easily adaptable all year round. People who worked mines did so on a seasonal basis, and hence may have seen no need to construct permanent dwellings. It seems likely that due to these factors the early miner, as well as his later counterpart, worked during the driest periods of the year.[1] Smelting also may have followed this same rhythm in many cases.

Our very informative traveller, W.W. Smyth, points out that the mining season at Ergani in his day was only a few weeks long when the deep deposits were being exploited:

> (The deposit) extended to a depth of 10 or 12 fathoms; but the additional 20 or 30 feet which had been excavated were filled with water which had for upwards of a year kept the works almost at a standstill. It is only by waiting patiently until the month of July or August, that access is gained to the lower parts of the mine. The accumulated rains of the winter and spring at that time gradually find their way out through crevices into the valley below, and leave the mines dry for a few weeks. (Smyth, 1845:334-5)

In mid-autumn (ca. Oct. 30th) Ainsworth (1842, I:77) noted that the mine shafts at Kure were filled with water.

B. Transport

Lewy (1958:93) and Veenhoff (1972:1-4) point out that in the Colony Period copper (ore ?) was transported by donkey, even wagon, between major towns, but methods of how copper ore was transported in prehistoric times and over what distances are still unknown. Ore was most definitely transported from some mines to centers where smelting could take place over longer periods of the year, or even all year round. The absence of slag in the area of some mines points to the fact that the ore was taken somewhere else to be smelted, perhaps because of a shortage of fuel in the mining region. It is interesting to note what Smyth observed regarding the ore transport from the copper mines at Ergani:

> The workmen are paid simply to go in and scrape about among old workings til they can fill a basket with ore, which is then roasted in the open air, and smelted to a very impure "black copper." This product is then conveyed to Tocat, a distance of 250 miles, on the backs of horses and mules, to be there refined. One of the chief drawbacks is the scarcity of fuel, for owing to the want of foresight, all the woods in the neighbourhocd have been annihilated, and the charcoal, supplied under the authority of the Pasha, is nothing but charred twigs, which the peasants are forced to bring in from a distance of many miles. (Smyth, 1854:103-4)

The so-called "black copper" to which Smyth referred is undoubtably oxidized copper ore concentrate. As Ergani is basically a sulphide deposit, the miners used what little wood was available to roast the ore to drive off the sulphur. This would not only lighten the loads on the pack animals, but provide a more attractive product for the smelters in Tokat. Smyth later points out:

> A mistake has crept into our gazetteers and encyclopaedias, to the effect that Tocat is situated in the midst of mines. Extensive furnaces have long been worked here by the Porte, but only for the purpose of refining the impure "black copper" which is brought hither on camels and mules from Arghaneh Maden, a distance of eighty-seven "hours", for the advantage of more abundant fuel. The old methods were very defective, and a new edifice has been erected, with blast engins worked by water power, on the whole of which a very large sum has been expended. The trade of the town depends in part upon this refinery, for besides the number of persons engaged in it, the copper smiths are numerous and export a large quantity of their wares in the shape of kettles, dishes, <u>mangils</u> or stoves, coffee pots, etc. (Smyth, 1854:155-6)

Here Smyth writes that camels were also used for ore transportation, in addition to horses and mules he mentioned earlier.

C. Stream Mining

This may have been one of the earliest forms of mining, especially as regards to gold. It has been said that tin ore, cassiterite, could have been obtained in this way in various parts of the Eastern Mediterranean.[2] Copper ores were probably not exploited by streaming, as the solubility of copper would not be favorable to this type of recuperation. Stream mining was preferably employed for heavy minerals and metals such as gold, lead, and tin. Copper ore, if at all detected in a stream, would have been followed up to its primary source where it would be more easily exploited.

D. Open Cast Mining

This is a simple form of land-based mining, and is still used in some areas of the world today.[3] It may have been the prehistoric miner's first attempt at exploiting a copper deposit, especially gossans. This form of mining may have been eventually abandoned, in certain cases, for being too time-consuming, and the more econimical shaft mining was subsequently practices, especially for vein-type deposits. Pittioni has clearly illustrated a case in European mining where open cast exploitation eventually became a tunneling operation (Pittioni, 1951:22-24).

E. Tunneling (adit mining)

When conditions allowed, tunneling was frequently practiced. The tunnel would presumably follow the ore deposit; hence, this type of mining is usually associated with vein-type deposits. The science of mining had to be applied here in the form of digging through rock (soft and hard), disposal of the rubble, supporting the tunnel ceiling with props, drainage of the water arising from seepage and, to a certain degree, ventilation of long tunnels. At present it is not known where these techniques developed first, but it has been noted that some aspects of mining bare close resemblances to quarrying, particularly in the form of cutting the rock.[4] Tunnels had been used by Egyptian miners, as explained by Erman:

> Copper mines which lay in the mountains on the west side of the Sinaitic peninsula, chiefly indeed in the Wadi Nasb, the Wadi Maghara and in the mountain of Sarbut elchadim; with the exception of the first where copper ore is still obtained from one shaft, they were all worked out in old times. The shafts by which they were worked are bored horizontally into the mountain, and are in the form of corridors, the roof being supported by pillars. (Erman, 1971:468-9)[5]

Some mine tunnel makers, then, could have gained their experience in the quarries.

F. Shaft Mining

This type of mine can be simply described as a verticalhole going down into the deposit. Neolithic flint miners often used this type of access to the flint layers. The nature of the copper deposit can affect the structure of the mine shaft. For example, a shaft may be sunk down in order to exploit a mineral outcrop on or near the surface. If the deposit is a gossan the enriched contact zone would be the area of interest for the miner. This zone can vary in depth from a few meters to hundreds. But usually the zone is no more than a couple of meters thick. If the miner has sunk his shaft down far enough he will hit the enriched zone. If his technology is such that he knows how to make galleries he could then follow this deposit in a generally horizontal manner. If, however, he does not possess this technology, he may decide to sink a series of vertical shafts into the deposit as a means of exploitation. This was done, for example, at the Rudna Glava Mine in Yugoslavia (Jovanovic, 1971;1972) and at the Aibunar Mine in Bulgaria (Chernih and Raduncheva, 1972), both ca. 4500-4000 B.C. An early mine shaft dating to the 3rd millennium B.C. has been recently reported near the village of Hristene, Bulgaria (Chernih and Raduncheva, 1972). Its irregular shaft indicates an early phase in this type of mining (see Figure 2).

In vein-type deposits, shafts may also be a starting point, but if the vein dips or turns the use of a simple shaft system is not efficient, for many shafts may have to be sunk before the miner finds the deposit again. In this case, only galleries can effectively follow the deposit. Deep shafts bring their problems, for they oblige the miner to deal with seepage, ventilation, timbering and the like. Hence, if a miner is going to exploit a deep deposit he must have the means and the technology to do so.

G. Struts and Props

The fear of cave-ins in tunnels and galleries was definitely a real one for the early miner. In a few cases we have seen that they proped up the ceiling in certain places as assurance against ceiling collapse or left columns throughout the mine.[6] This was no doubt a practice which grew out of an experience when the ceiling did not hold.[7] In some worked out galleries miners often filled them in with debris or simply walled them up with stones.[8] Other mines have shown us that wood was used extensively as ceiling support,[9] naturally when this material was readily available.

Cave-ins must have been more common in antiquity than today, and judging from the cases of buried miners there does not seem to have been a great amount of effort by their contemporaries to recuperate the bodies of the unfortunate souls.

One ancient (undated) collapsed mine was discovered in Anatolia by the British entrepreneur and mining engineer, Hugh Whithall (Sharpless, 1908:601-3). The mine workings, a cinnabar deposit at Sizma near Konya, had been blocked off from the entrance by a cave-in. More than 50 miners had been trapped inside in the process. Whithall and his workmen discovered the lower chamber when they decided to dig down into the deposit in search of a greater concentration of cinnabar. The discovery of the trapped miners was described as follows:

> A winze was put down into the floor and in doing so the miners broke into another chamber, almost under the first, about the same dimensions, but it was nearly 250 feet long. It was a surprize to find that the first cave was a mine, a greater surprize was in store in the second case. Entering through the opening in the bottom of the winze a weird sight met the eyes of the miners. Scattered over the floor of the chamber in all conceivable positions were seen the remains of more than 50 human skeletons. Many of the bones were imbedded in the secondary deposit of lime on the floor. There were great quantities of stone hammers, several pottery lamps, a fair amount of charcoal, several rubbing stones and some flint arrowheads.
>
> Mining had apparently been done by firing the barren rock, by breaking the softer portion with hammers and by gouging where there were rich seams of cinnabar. Deep grooves followed all high-grade streaks, but the tools for this work were gone.
>
> Working out to the surface, following the floor of the second chamber, 40 to 50 feet of caved ground was penetrated, suggesting that the miners had been entombed by a fall of rock around the portal of the opening. (Sharpless, 1908:602).[10]

H. Drainage

Drainage of water did not pose a problem at all tunneled sites, but only where seepage was a hindrance to ore extraction. In the case of tunnels, a gutter may have provided the means to evacuate the excess water. Of course, if the slope of the tunnel proceeded downward, then water would collect at the head of the workings and constitute an obstacle. In some European flint mines sumps (or pits) were dug in places in order to collect water. Sumps were also used in later European mines, but they were known to be hazardous, as miners had occasionally fallen into them and drowned.

One can logically assume that prior to the use of pumps and mechanical devises that drainage was done simply by bailing by hand whenever other convenient methods were not possible.

I. Ventilation

Ventilation posed the most serious problem for long tunnel and shaft mining. When hard rock had to be broken fire was often used (cf. "Fire setting" infra). Although this was an effective way of breaking up the rock, it had two major disadvantages: 1) it was a slow process and 2) it used up the air in the mine. Unless some system of air replenishment was provided the work in the mine had to be abandoned until the noxious gases had worked their way out and had been replaced by sufficient oxygen to support life again. Even without the use of fire oxygen was used up by the miners themselves. Lamps or candles were the indicators of whether sufficient oxygen still remained in the working area. Ventilation is also necessary to counter-act the stifling effects of heat and dust.

For tunnels the ventilation systems were slightly different from that of shafts. At Timna a small parallel hole was dug and joined the working tunnel at intervals. The excavators feel that the purpose of this parallel shaft was for drought which even today can be felt (Watson, 1975:39-40). In some tunnels air holes may have been pierced from above, but only when the depth from the surface to the tunnel practically allowed. In some cases fires were maintained under one of the air holes, thereby inducing draught.

Particularly in deep mines would ventilation have been a problem, but we have no indication of how the prehistoric miner might have overcome it. In historical and classical times we are a little better off, as documents and essays such as those of Theophrastus, Strabo, Diodorus and Pliny give us a brief sketch of some of the mining methods used in their days. Moreover, many Roman shaft mines have been located in the Meditarranean area, and we have archaeological evidence of their mining techniques.[11]

Regarding ventilation, later sources mentioned above make allusion to the use of bellows, fans and air ducts which may give us iedas of how the problem may have been dealt with in prehistoric times, but these reflections must never leave the realm of "remote possibility" until evidence warrents otherwise.[12]

J. Fire Setting. (Figure 3)

Fire setting was an effective way of breaking up rock too hard for wooden or metal mining tools. Franz Kirnbauer[13] very neatly describes this technique:

> This method consisted in building a fire in order to rapidly heat the rock to be mined up to a high temperature, subsequently letting it cool off naturally or quenching it with water. Thus loosened to some extent in its natural structure, the rock would develop cracks and flaws and unless lumps of rock came tumbling down by their own weight, they had to be loosened and knocked off with suitable tools. The principle of fire setting is based on the different thermal expansion of the individual mineral components of a vein which will cause the structure to loosen when heated.
>
> Pinewood was mostly used for fire setting. The logs were stacked either at the breast of the drifting or of the working place, and the stack was set ablaze as quickly as possible so as to make the flames leap against the roof thereby loosening the rock. At the foot of the stack, where to provide for ample access of air the fire was always started somewhat above the gallery or working level, a wedge of ore would remain untouched by the flames later to be worked off in order to make room for a new fire. Fire setting called for careful control of the smoke escape by providing an appropriate system of ventilation. Hence, fires were either set at night and on Saturdays only, or air shafts and air raises had to be driven up. The fire-warden, at any rate, had to be an experienced miner knowing the ins and outs of the mine's air draught. Fire setting also accounts for the extraordinarily smooth surface of the old drifts. The rough sides of the gallery were intentionally smoothed by the ancient miners so as to allow the air to pass with a minimum of resistance.

The sticks of wood used for the fire were called "beards" in Agricola's time because they were shaved on all sides such that the shavings curled at one end resembling a curly beard. In Figure 3 Agricola has depicted a fire setting scene and illustrated the preparation of the beards.

Quenching the hot rock with water is not mentioned by Agricola, but as Kirnbauer has mentioned it had been since very early times a common practice and remained so until the 19th century A.D. The oldest written account referring to this method is that of Agatharchides, the Greek geographer of the 2nd century B.C. who gave an account of mining in Egypt. His original work does not survive, but he is quoted by Diodurus Siculus (1st century B.C.) and Photius (d. 891 A.D.).[14] R.C. Tompson (1925, Sect. 27, pp.106-7) discusses the use of vinegar for quenching but he comes to no conclusion as to whether it had any effect or not on the breaking up of the rock or whether it was just an ancient belief with no scientific explanation. Vinegar may have been used because it was regarded as being especially cold (Partington, 1935:35).

An Anatolian example of fire setting has been suggested above in the example of the trapped cinnabar miners. Unfortunately we have no date for this mine, but the report on the find very astutely pointed out: "The thick deposit of lime on the floor and walls of the openings in such an arid country as this is positive proof that the bones have been lying there a very long time...".[15]

K. Mining Tools

Tools, as one would logically deduce, are and aid to performing a function that one cannot do, or not do very well, with bare hands. Mining best illustrates this axiom. Rock, being harder than flesh, must be broken by some material at least almost as hard. Although wood is not as hard as rock, using wooden tools with a certain mechanical advantage can make up for this handicap. Mining tools that were made of wood can be listed as follows: shovels or scoops, rakes, gads, hammers, picks, battering rams, and troughs. Wood was also used as hafts, for props and struts, ladders, fuel for lighting as well as for heating the rock. Stone has been used for gads, hammers, mortars, pestles and picks. Basalt was an ideal material for picks, but it must be pointed out that attacking a hard rock face with a stone pick could easily result in a broken tool. Hence, in breaking up hard rock, the gads were probably most effective, in which case the gads were of wood and the hammers of stone or vice versa. As Lucas (1962:63-4) points out, wooden gads (wedges) were used in Egypt for quarrying.

In soft rock antler was used as well as stone picks (Figure 5 (1-3)). In copper ming the earliest tools known come from Rudna Glava (Jovanovic, 1972, 1971), notably deer antlers, used as picks, differently-shaped hammers and pick-axes. These tools were found in situ, erasing all doubts as to their use. No wooden tools or implements survived at Rudna Glava, if indeed there had been any. Horn and bone mining tools have also been found in European flint mines in the form of gads, hammers, rakes and picks (Figure 5).[16] In copper mining these very tools would be equally efficient. Rudna Glava (ca. 4500-4000 B.C.) provides us with early copper mining antler tools, but obviously antler and bone had been used elsewhere as picks long before local copper mining was in practice.[17]

Although undated, the Aramo mines in Northern Spain give an idea of a shaft miner's tools and of his hazardous occupation. In the words of H. Sandars:

> a fall of roof or a 'run in' of the levels buried the miner with his tools... One of the most important of these was again, the deer-horn pick. The deer-horn hoe, or rake, was also employed, while the beams with the burr of the stag's antler was used as a hammer for breaking up the mineral underground. But besides the deer-horn tools the Spanish miner like his neolithic cogener in other parts of Europe, used stone implements for driving his galleries, tines of deer for dislodging the mineral from the gangue or vein, and stone hammers or mauls for breaking it up. (Sandars, 1910:119).

Mining tools are known from mines from which material other than metal ores were extracted. Ancient man has dug or mined for salt, turquoise, lapis lazuli, flint, as well as minerals for coloring or medicinal purposes. Large cavities, even galleries, have been dug in the process (Boshier and Beaumont, 1972). Tools particularly adapted to the mining of these materials would have evolved in the course of use. Soft minerals would not require particularly hard tools. Salt mining, for example, would have requireed only simple wooden picks and gads, and such equipment has been found in European salt mine contexts.[18] But, as one would expect, few wooden tools have survided. No wooden tools are known from Near Eastern mining contexts.

L. Metal Mining Tools

It is extremely difficult to identify metal mining tools from Near Eastern material, for tools had -- more often than not -- multiferious uses. One would not expect the smith to produce specialized tools for all types of manual labor. The making of a mould, the casting of a tool, and its final finishing touches is a long process, and unless the demand were very great the smith would not be encouraged to bifurcate from his regular repertoire. What the miner desired in his tools were simplicity, tensil strength, and hardness. In some cases wood, stone, or antler (as seen above) were adequate, and when metal tools were used the tendancy towards simplicity prevailed, There is, then, a lack of innovative spirit, which makes it difficult to identify the miner's tool kit. What he may be using was likely used by the farmer or wood worker as well. In spite of this, let us look at a few possible mining tools.

1. The Flat Axe

A flat axe, for example, could also serve as a wood chisel, a wedge (or gad) for splitting logs, or -- when properly hafted -- for simple hoeing (Childe, 1969:89, fig.46). In addition to these uses, a flat axe -- especially one with a blunt butt -- would be useful as a mining tool, for not only could it be used in a picking or raking fashion, but it could double as a gad.

Rare are the examples of metal tools abandoned in a mine, but in the Milagro Mine in Northern Spain (Asturia) an un-specified number of flat axes of copper or bronze were found.[19] The fact that this type of axe was found <u>in situ</u> clearly shows that it was used for mining (Figure 5 (4)). Hence, it may be logically postulated that at least some of the flat axes of copper or bronze that have been found in ill-defined contexts in the Near East, and elsewhere, were used as mining tools, though not necessarily exclusively. In Anatolia flat axes are known at a number of sites all prior to or in E.B. II (see catalogue, A-181 ff.). It does not seem likely that the examples from the Troy treasures, and probably from Troy as a whole, were ever used as mining tools. Troy, essentially a citadel, would not have been so concerned with the tools of miners as with the product of the miners. One logically imagines that if mining tools were ever found in a settlement they would not be in a citadel, but in the more humble abodes of the miners. In fact, there is some doubt as to whether any currently-known E.B. A settlements in Anatolia were ever directly involved in mining.[20] This does not discount, however, the use of the flat axe as a mining tool in Anatolia.

2. Chisels

Again, chisels were probably commonly employed for wood working, but where in many cases the act of mining is one of splitting rock, chisels were used at some point in time for mining. If any chisels were used in mining, there would be some distortion of the butt due to blows of a hammer, but no Anatolian example falls into this category. Hence, either the presently-known Anatolian chisels were hafted in some way such that the butts were protected from hammer distortion, or no mining chisels have yet been uncovered.

3. Picks

Few metal picks are known in mining contexts. A copper or bronze pick was found in a salt mine near Salzberg, Austria (Figure 5 (5,6)). It is sharp and tapering in shape and has a deep socket which is at a right angle to a wooden haft. H. Sandars has pointed out that its shape closely resembles "the deer-horn pick from which it was probably derived." (Sandars, 1910:120-1)[21] No prehistoric metal picks have yet been discovered in Anatolia.[22]

4. Axe-Hammers

This is a mining tool par excellence. It can be used as a hammer as a gad and as a pick. A pick-hammer may have been a development out of axe-hammer. Bulgarian axe-hammers of stone are common in the Copper Age, as well as the metal prototype (Renfrew, 1969:32-3, fig.8 (2,3)). At the Ai-Bounar copper mine (3800-3500 B.C.) near Stara Zagora, Bulgaria, was found a copper axe-hammer. (Techerniykh, 1975:153, fig.14). Signs of **wear** and hard use are quite evident on this example. Some broken stone axe-hammers have been found, perhaps indicative of their use on stone. Some fine stone examples are known in Anatolia, (i.e. at Dorak and Troy) but they were not destined for use in a mine (Mellaart, 1959:11, fig.11; SS 6055-6058, from Treasure L in Troy II). However, they may have been inspired by cruder antecedents which were used as mining tools.

Apart from the stone examples there seems to have been little enthusiasm for this type of tool in Anatolia.

5. Adze-Hammers

This tool, like the axe-hammer (supra), is versatile, since it could be used for woodworking, hoeing and mining. No adze-hammers are known in Anatolia until Hellenistic times (Pleiner, 1969:fig,13). This was not a very popular tool, since only three examples are known in the Near East prior to the 1st millennium B.C. (Deshayes, 1960, II:115, nos.2217-2219, pl.XXXVII (11) (12)).

6. Axe-Adzes

This tool is a very versatile one. It is basically a hoe and an axe with a shaft hole. This gives it the features of being solidly hafted and of being able to make vertical and horizontal cuts. As a mining tool, it could be used to widen cracks of different angles without too much contortion on the part of the worker.

Many examples of axe-adzes come from Southeast Europe, which lead us to believe that it is very much at home there. Ultimately it found its way to Greece and Crete.[23] The two Anatolian examples known -- both from Troy -- would seem to be imports.[24] Some axe-adzes appear to have been subjected to rough treatment, as if they had been used against stone surfaces.[25]

M. Lighting

Chalk lamps in the form of small cups seem to have been widely used in European flint mining (Clark and Piggot, 1933:172). In the Aramo mines in Spain it was determined that lighting was provided by inserting bits of resinous wood into clay and setting them afire. These torches were fixed to the sides of the galleries. Other examples of this type of lighting have been found elsewhere in Europe (Sandars, 1910:121). A variation of this method uses animal vertebral bones to fix the torches to the walls (Pittioni, 1951:42). J. Nandris has recently given some interesting suggestions regarding lamps in prehistoric Europe. He points out that the type of earthenware recipient found in the Rudna Glava mine could have been used as a lamp (Nandris, 1973:154, fig.9). In the confined work space, such as in the shafts of Rudna Glava, simple lamps or candles would have sufficed. By the Roman period oil lamps were widely used (Luzon, 1970:231-2).

N. Various equipment.

Leather and rope must also have been used in some mines. If the miners crawled in and out of small openings and worked in confined areas they must have had some sort of protective clothing against sharp rock juttings.[26] Rope would seem to have been required in many cases, especially to haul up baskets of debris and ore. Rope has also been suggested as a means of getting out of the deep, straight shafts (Sandars, 1910:114).[27]

O. Social Structure

There may be a significant underlying difference in the socio-political structure in prehistoric and historical times, a propos to mining as well as to other sectors of society: the artisan vs. the large group. The practice of mining and smelting by small groups in prehistoric times would seem to be the basic social arrangement, at least at the outset. Eventually, small-time operations slowly evolved -- or became incorporated -- into larger and much more organized systems. The state or central power would then have used increased manpower such as slaves, prisoners or other forms of cheap labor to undertake the hazardous or more comprehensive mining operations which the small-time miner would have shunned. The Romans could never have performed their feats of mining engineering without the use of slave labor.

Pittioni supposes that, at least for Mitterberg, the miners and smelters were working of their own free will, mining being the basis of their livelihood. Ownership or administration of the mines may have been concentrated in the hands of a privileged few. Yet, in free mining communities such as this, there seems to have been some sharing of the wealth.

With the advent of more manpower -- whether free or slave -- mines could be more elaborate. Better and wider tunnels and shafts could be dug, and the ore could be more ambitiously exploited. The free small-time miner did not waste his time and effort on difficult deposits, deposits that the Romans, for example, would have exploited with ease.

Using calculations of an earlier study, Pittioni points out that it may take as many as six men for a simple open cast mining operation. For three tunneling operations there may be a need for as many as 180 men. For one shaft mine such as what we have at Kozlu (S-97), there may be a demand for as many as 100 workers. Timbering would take up nearly half of this total. This figure excludes those occupied with activities supplementary to the actual mining operation, such as ore-dressing, smelting, prospecting, trial digging and food-providing. All included, the entire operation at Kozlu may have required between 250-300 workers : a veritable community.

P. Copper Mines in Anatolia (based on Catalog S)

Kozlu (S-97) (Figure 8)

The only confirmed prehistoric copper mine in Anatolia known to us is that of Kozlu, briefly mentioned above. This mine, dated by carbonized wood from the shaft, goes back to at least 2800 B.C. ± 30 (Giles and Kuijpers, 1974:823).[28] It has not been excavated in entirety, but evidence shows that the ancient miners were exploiting a copper sulfide deposit. No tools were located, but the use of timber was definitely detected. This does not surprise us, for Kozlu is located at an altitude of ca. 1300 meters and is in the midst of a lush desiduous forest. No doubt wood was available locally in the IIIrd and IVth millennium B.C. as it is today. Little is known about the mine's layout. It is suspected that the shaft and gallery descend as deep as 50 meters below contemporary surface, perhaps as many as 80 meters. At this depth air ventilation was most certainly artificially provided, but as yet we do not know what system was employed. Depressions in the earth surface throughout the Kozlu mining area cannot be explained geologically. They are perhaps air holes down into the mine that have been filled in since falling into disuse. According to Giles, one of the geologists who made the sounding into the shaft, stoping may have been the manner in which the ancient miners proceded through the deposit (Figure 8), and they probably shored up the resulting roof with wooden beams (Personal communication from D.L. Giles).

We do not know as yet what system of water evacuation was used, but it is probable that one was employed, if only hand bailing.

It is pertinent to note that the site of Horoztepe is only about 15 kms. north of Kozlu, near the town of Erbaa. Until more is known about the Kozlu mine it is not possible to say whether any part of the mining operations are contemporary with Horoztepe.

Another shaft, located a few hundred meters south of the reported mine is yet another shaft, perhaps 10 meters in depth. This shaft has two tunnels, one running N-S and the other E-W, and has one visibly outstanding feature: it has been neatly cut through rock. Throughout the general area of the Kozlu Mine one can see many exploratory cuts into the mountain slopes, which could be contemporary -- though not necessarily -- with the reported shaft.

In conclusion, one can simply say that the miners of Kozlu seem to have employed a technology of surprizing sophistication for the period.

Ağaca Ağaçli (S-98)

A few kms. SE of Karaoluk village is Agaca Agacli Deresi (Tokat Province) and the site of an old copper mine. The deposit was located and opened up by a Karaoluk villager. He took it upon himself to dig through the rubble, whereupon he uncovered remains of an old mine shaft. According to the man, the shaft was lined with logs used as struts and props. The shaft is said to have gone down about 15 meters at which point a sloping tunnel carried on for many more meters.

With the wood from the mine the villager was able to make himself a framework for a small shack on the opposite side of the stream.

While digging out the rubble from the shaft, the villager found a wooden shovel, said to be about 150 cms. long. Unfortunately, he gave this artifact away, and no authoritative eyes were able to examine it. Little is known about this mine's present state, for the villager had filled it in before MTA was able to observe the layout of the shaft and tunnel. Judging from the ore rubble, a series of copper ores were being mined. In varying degrees traces of malachite, azurite, chalcopyrite, cuprite and native copper were noted. The smelters probably dealt with all of these ores, the easiest one being the carbonates and oxides on or near the surface. It was somewhat odd that only one piece of slag was retrieved from this site.

The mine is currently situated on the bank of a stream, the Ağaca Ağaçli, which would seem to be most inconvenient due to the seepage into the mine tunnel. One is led to suspect that this stream was not here in the remote past or, rather, at the time of the mining operations. The presence of this stream today may be due to a number of causes. First, the felling of trees and clearing of vegetation has changed the erosion patterns. Indeed, it has increased the water flow from the higher regions. Secondly, a man-made dam may have given way after it had been abandoned or not properly maintained. Thirdly, cavings of tunnels and similar landfall caused by man may have altered the physiognomy of the land surface. It was further observed that the sharply-cut banks of the Agaca Agacli and the deep erosion patterns which are associated with the stream do not point to a water course of great antiquity.

<u>Bakir Çay</u> (S-95)

About 10 kms. N of Merzifon (Amasya Province) is the east-flowing Bakir Çay (= "Copper Stream"). As much as 100,000 tons of copper slag line both banks of the stream attesting to copper-smelting over an extended period. Although generally it appears that the majority of the workings date from the Late Roman - Early Byzantine Periods,[29] earlier evidence may eventually turn up. There needs to be a thorough search in this area before one can fully understand the beginnings of the metallurgical industry here.

Tunneling was practiced at İnkaya on the right bank of the Bakir Çay (ca. 5 kms, from Büklüce). Small, man-sized tunnels have been dug into the copper deposit. Open cast mining may also have been practiced here due to the ore's proximity to the surface. The deposit had evidently been exposed by the river cutting. Judging from the rubble, the ore extracted seems to have been generally malachite, chalcopyrite and perhaps some native copper. Chalcopyrite is in great abundance. One sample of ore from the rubble yielded more than 10 % Cu (cf. Analysis S-95).[30]

The absence of datable material directly related to the mine workings does not allow one to venture a date of the operations at Inkaya.

Cozoğlu Mahallesi (S-9)

Cozoğlu is located ca. 5 kms. north of Hocavakif (Kastamonu Province). Just behind the village are mine tunnels into the copper deposits. One tunnel is ca. 50 meters long and is crudely dug, having irregularly faced walls and roof with no timbering. Another tunnel is said to be near-by, but it is now caved. It is said by villagers that there are eight open tunnels in the area.

Several tons of slag within sight of the village are scattered about. This is one of the few sites in Turkey where remains of smelting and mining are obviously related.

From the point of view of the quality of the copper ore, the deposit is only mediocre, and the reserves are not considered vast. The types of copper ore available are azurite, malachite and chalcopyrite.

No archaeological finds are yet known from this site, so the date of operations in the past is unknown. However, the accessibility of both mines and slag gives this site a definite value to the archaeologist. With just a superficial excavation useful data pertaining to the history of this site could be easily obtained.

Of the other "old" copper mines listed in Catalog S and shown on Maps 8 and 9, there is little information available. Until they are investigated properly they will be no more than points on a map. The Kozlu (S-97) mine provides the first real insight into the antiquity of mining in Anatolia. At Kozlu we have our only informative document on copper mining of the IIIrd millennium B.C. That Kozlu was discovered under a layer of thick topsoil is indeed foreboding, for great mines of antiquity might be similarly buried.

* * *

For means of comparison let us now look briefly at the evidence for prehistoric mining in the Aegean, Eastern Mediterranean and Middle East.

No doubt some of the mines currently known as Roman or later were also exploited in prehistoric times, but to date little concrete information on the prehistoric phases has come to light. For Greece, O. Davies suggested Early and Middle Helladic for two copper mines near Cirra Maghoula, but strong evidence is lacking there. Moreover, he has given little information on the mining technology at this site (Davies, 1929:89-99).[31] His Early Helladic mine is said to be a "cave mine". Open cast mining is said to be in predominance there, but no dates were proposed for the latter. Davies also mentions a "bronze age" mine at Othrys and states that "some bronze axes were also found in (the) mine." (Davies, 1928-30:80, n..1). Unfortunately, no description of the mine or artifacts accompanies this reference.

Mines are also reported in Cyprus and Syria, but again concrete evidence is lacking as to the methods of exploitation in prehistoric times.[32] Although Syria possesses some copper mining potential, for the most part it seems not to have been exploited in prehistoric times (de Jesus, 1976:n. 35). The often-cited Chrysokamio Cave in Crete is said to be an Early Minoan copper mine, but some doubt has been expressed about the dating evidence (Branigan, 1968:50).

Again, concise information on the mining methods is lacking there. A mine at Lebena is said to be "possible" EBA or MBA, but no datable material has been presented ot support this (Branigan, 1974:66).

Although no dated copper mines have been located in Mesopotamia, we have a brief mention of mining from an Ur III inscription (Limet, 1960:90, 110-11). It states that the earth (im) was extracted and carried out of the mine in baskets (GI.DIRI). It is not known from this inforamtion whether the mine is a shaft mine or a simple tunnel, but the area from which the ore comes is termed "the mountains of Kimas." In addition, the sign understood to be copper mineral (URUDU) has been likened to a schematized image of a mine with an adit[33] (Figure 7). If the latter is, in fact, a true resemblance then we can postulate that at this time tunneling was practiced at Kimas, although the exact location of this area is still a matter of speculation. It could be also that the tunnel was combined with shafts and galleries, but of course we have no evidence to support this. Taking our reasoning a step further we note that Kimas was the supplier of copper to Sumer over a long period.[34] This being the case, and if tunnels were in fact the system employed, these tunnels (and perhaps shafts and galleries as well) could have reached a considerable depth. Hence, it may be inferred in these conditions that special techniques such as timbering, ventilation and the like were employed (cf. Table 4).

Apart from the a priori factors illucidated above and obvious superficial similarities the prehistoric copper mines we know of have little in common. There is no valid way at this point to link them into some sort of related context. Pittioni (1951:35) suggested that prospectors from the Near East may have moved into Eastern and Western Europe by ca. 1700 B.C., or slightly before, and thereby gave rise to advanced mining technology in Europe. In view of the Rudna Glava copper mine, this now seems and unlikely scheme. At different periods throughout its prehistory European metalwork may well have drawn on patterns from afar, but the technology of mining was the contribution from within. Rudna Glava is important not so much because it is early, but because in this case it implies that the metallurgical industry of Early Vinca is much more active than had been previously suspected. For its technology, the simple shaft mine may have drawn on a flint mining tradition.[35] The fact that it was not worked after superficial exploitation of the deposit points out that deep mining techniques were not known. After abandoning the mine, the miners may very well have looked for a similar type of deposit elsewhere and continued their exploitation in the same manner. Until more information is available we can provisionally place the Rudna Glava workings ca. 4500-4000B.C. That smelting was performed by Early Vinca period and that copper artifacts were widely used has already been established elsewhere. The cornerstones to early S.E. European metallurgy have hence been detected, and Rudna Glava represents the extent to which mining technology had participated in that metallurgy. The cultural and chronological implications are beyond the scope of this chapter, but they will no doubt be treated adequately by those more familiar with the complexities of this region.

As for Anatolia, the mining tradition again would seem to have been an internal one. The Kozlu mine (S-97), certainly not an isolated example, gives us only a tantalizing glance of the extent of copper ore extraction in the Early Bronze Age.

Copper artifacts are known in Anatolia since the 7th millennium B.C. The native copper which was made into simple tools, such as at Neolithic Cayönü (Braidwood and Cambel, 1970:50-6), could have been collected from very accessible sources. Native oopper can still be found in rocks and crevices in certain areas of Turkey today and even collected in river beds after a heavy rain. This type of copper recuperation cannot be properly termed mining in the strictest sense of the word.

However the advent of smelted copper presupposes mining. The supply of native metal not being sufficient to demand, smelting was developed. In this case, ore was dug out of the ground, thereby constituting the act of mining. Archaeological research has not yet revealed to us where these early mining areas are, but we do have an indication that smelted copper was being used in the Neolithic (Neuninger et al, 1964:98-110). This is indirect evidence of mining, but for this early stage that is all we have. Analyses of slag and artifacts of the intervening period between the Neolithic and EB I do not give us any information on the development of mining techniques. We can only note that the Central Anatolian inhabitants (especially) had access to greater and greater amounts of smelted copper as the Bronze Age progressed. This indicates that not only was more copper ore being mined, but more was being smelted. In this we see the complexity of the metallurgical industry growing.

Although it is probable that some principal deposits were exploited throughout long periods and witnessed a development of mining techniques because of the increasing difficulty in reaching the ore, we must also consider that more and more deposits were exploited as the Bronze Age advanced. The variety of trace element patterns in especially Early Bronze Age metalwork reflects the inexatitudes and variations in smelting techniques as well as the different types of copper ore being extracted. However, it is not possible from this information to determine mining techniques.

The techniques of extraction were conditional on the knowledge of the miner, as well as on the type of deposit to be worked. The simplest form of mining, open cast, may have been used at any time in the past. The sophistication which we identify with the Kozlu (S-97) workings may have developed quite early, but of course with this one dated example of prehistoric mining, it is not within our means to say just how early. One would assume that simple pits or shafts were at the earliest stage of mining, for not only are they used at a very early mine in Europe (Rudna Glava), but prehistoric flint miners also used this system.

When the different mining techniques, such as fire setting tunneling, drainage and the like, were introduced or developed is anyone's guess. Judging from the high level of craftsmanship which existed at Çatal Hüyük, there can be little doubt that the inhabitants of that Neolithic town were technologically capable of most of the mining techniques described in this Chapter, but at this point of our knowledge of the site there is no direct evidence that they were engaged in such activities.

It would be unwise to try to link up mining in different areas of the Near East, for mining techniques tend to be a local development for local mining problems. These techniques vary throughout time, as is now being revealed at Timna, but the geological formation will invariably come to bear on the types of techniques used. The soft, white sandstone of Timna, where the copper mineralization occurs, did not constitute a difficult technological barrier to early mining. Rudimentary stone hammers and perhaps even wooden tools were used to tunnel through the deposit. Although stones pillars were left inside the Timna galeries to support a potentially weak roof, cave-ins were no real menace there. Water-seepage at Timna was virtually non-existant. In contrast to elsewhere, such as at the gossan type of deposit of Kozlu (S-97) support beams were constantly needed to prevent shafts and galeries from caving in, and water evacuation must have posed a big problem, as pointed out above. The requirements in manpower and materials are additional factors which distinguish one mining area from another.

Hence, it would be premature to propose here a scheme of development of mining techniques, for in the absence of complete data one is tempted to construct a scheme going from a personal interpretation of the simple to the complex. Since we are dealing with several metallurgical traditions (which are a reflection of mining traditions), as we shall see later on in these pages, a simple-to-complex scheme would be forceably too general, inadequate, and misleading.

Notes: Mining Techniques

1. G. Herrmann, 1968:24, makes this same observation for present-day lapis-lazuli mining in Badakhstan, a pattern which was probably followed since mining began there, The mining seasons would be somewhat reversed in Palestine, Glueck, 1940:87.

2. An interesting modern example of stream mining can be seen in Afghanistan, P. Knauth, 1974:cf. photo pp.26-7. For references to tin deposits in the Near East, Muhly, 1973:155-535. Also, Lucas, 1962:225, notes 7,8, and 9; and C.A.H. Vol. I, Pt.2, p.344.

3. The largest open cast mine in the world is the copper mine at Bingham Canyon, Utah which measures more than one mile in diameter. Although the copper content is less than 1 %, modern methods of smelting and refining make this operation economically advantageous.

4. Forbes, 1963:126-8, implies that with the advent of the pyramid builders, greater mining activity took place in the Sinai, first for turquoise, then for copper. Mining and quarrying techniques by that time had developed so that large-scale operations could take place.

5. Erman does not specify his evidence for the date of these mines, but he implies that they were opened in the Old Kingdom and were worked more or less continuously until Ramses III. Hence, operations at Wadi Maghara spanned ca. 2900-1200 B.C. There does seem to be some doubt this view. Recent research shows that there are many mines in this general area, all of which do not date from the same period, see Muhly, 1973:217-20.

6. At the Iron Age mine of Timna, the roof was propped up in places by stones, Watson, 1975:40. An Iron Age mine At Umm el-'Amad near Feinan (the Biblical Punon) left columns, Glueck, 1940:70-1,figs. 30-1; idem, 1934:15. Columns were also left in an undated turquoise

mine a few kms. SW of Sarabit-el Khadem, Petrie, 1909:61, fig.73. In the flint mines of Spiennes, Belgium columns also have been left to support the ceiling, Clark and Piggot, 1933:plate facing p.176.

7. Such as in an early European mine where archaeologists found the crushed body of a flint miner still holding on to his pick, Bromehead, 1956, I:156, fig.373. Another flint miner had apparently been with his 5-year old son at a mine in Strepy, Belgium when the bank where they were working collapsed on them, Sandars, 1910:105.

8. In the Sinai mines the Egyptians filled in the galleries with debris, Forbes, 1963:128. At Rudna Glava a pile of stones supports a suspected weak area of the shaft, Jovanović, 1972:13. Filling in the holes with debris seems to have been a flint mining practice as well. The miners at Obourg, Belgium filled in their trenches, Sandars, 1910:103.

9. Such as at the Anatolian copper mine of Kozlu, Giles and Kuijpers, 1974:823-5. The mine is dated by a piece of carbonized wood to 2800 ± 30 B.C.

10. The excavator provided one grisly photo on p.602 in which 11 miners' skulls are hanging on a house wall. In addition, there seem to be a number of crossed tibia. One shallow pottery bowl, the details of which are unfortunately indistinguishable, is also pictured.

11. The most comprehensive study on Roman mines and mining is Davies, 1935. In other surveys he treats the Balkans, Cyprus and Macedonia, Idem, 1928-30:76-85; Idem, 1937-38:405-418; Idem in Heurtley, 1939:Appendix I. More recently published is La Minera Hispana e Iberoamericana Vol. I, Leon 1970, comprising excellent articles on classical mining in Spain. Cf. especially J.M. Luzon, "Instrumentos Mineros de la Espana Antiqua," (pp.221-258) in which water evacuation methods, hauling systems, and ventilation systems are clearly described. Also, informative are Pittioni, 1951:22-3; and Sagui, 1930.

12. Interesting medieval ventilation systems are described by G. Agricola in his De Re Metallica (N.Y. 1950 trans. by H.C. Hoover and L.H. Hoover) pp.200-212. Shafts, ducts, pumps, windmills, fans, and bellows are illustrated with all their accompanying gadgetry. In pre-Islamic sections of the Talmesi copper mine in Iran there still remains a small ventilation shaft (Bada) made up of earthenware pipes, Wulff, 1966:15. Another Persian system entailed the use of "wind catchers" (bad-gir) placed on the top of the shaft, thereby forcing the wind to blow down into the mine, ibid., p.15, fig.157.

13. F. Kirnbauer, "Copper Mining and Copper Smelting from the Middle Ages until 1900," in Norddeutsche Affinerie (ed.), 1966:42-3.

14. Vinegar is mentioned by Pliny (XXXIII, 21) for quenching to break up hard rock. It seems to be Livy (XXI, 37) who first produced the story of Hannibal's breaking through the Alps by using fire and vinegar. Agricola stated that vinegar was used to help soften ore when assaying it, Agricola, 1950:231.

15. It has been suggested that the mine may date from Neolithic times, but the archaeological reasoning is not very sound, CENTO, 1969:11. No bowls such as the one pictures by Sharpless, 1908, were found in Anatolian Neolithic contexts. Even though the photograph is poor, in no way could the bowl be identified as Neolithic. The absence of iron tools in the mine is no criterion for placing the workings prior to the Phrygian Period. Iron tools were probably not introduced into mining until Hellenistic times.

16. Clark and Piggot, 1933:168, fig.2. Also Sandars, 1910:101-124, for the use of antler in European flint mines. The first copper mining tools were possibly fashioned after antler prototypes. Two antlers from Grimes Graves were definitely used as picks, but at the back of the burr there were traces of their use also as a hammer, Sandars, 1910:117, and fig.16.

The pick-hammer of antler used in flint mining could be the parental antecedant of the copper pick-hammer, hammer-adze, or hammer-axe, see Deshayes, 1960:110-115, pls.XXXVI-XXXVIII.

17. This author did not find examples of flint mining earlier than those mentioned in this study, but the abundance of certain types flint tools in earlier periods may be an indication that such mines did exist, Tringham, 1971:47-8. fig.6 a. At Lepinski Vir shoveling implements did occur, but one need not infer mining from these, ibid., p.56. Childe, 1968:8, fig.5, mentions antler axes from Spain, similar to picks. Sulimirski, 1970:5, 21-3 and fig.5 a, makes interesting comments on this problem. By far the oldest known mining operations known today are those of the Lion Cavern in N.W. Swaziland where the mining of hematite goes back to a remarkable 41, 250 ± 1600 B.C., Boshier and Beaumont, 1972:6.

18. Bromehead, 1956:567 and fig.376, gives an example of European Iron Age salt mining equipment.

19. Sandars, 1910:121, Petrie points out that the chisel marks on the walls of a turquoise mine of the XVIIIth Dynasty indicate metal chisels, Petrie, 1909:60-1. Earlier indirect evidence points to the use of metal tools in the IIIrd Dynasty, ibid., pp.49, 159-60.

20. As pointed out elsewhere, settlements (as we know them) are located distant from copper mines and slag dumps. There is one notable exception: although unexcavated, the site of Karaali Huyuk is located within walking distance of copper deposits and a large mound of slag. The slag amounts to ca. 70,000 tons which indicates a metallurgical activity extending over a long period, de Jesus, 1974a:70-2.

21. Indications are that it is of the Hallstatt period (7th-5th centuries B.C.), Piggot, 1973:171 and fig.94.

22. There is a small trinket pick of electrum from an EBA hoard at Eskiyapar (A-180) which is now on display at the Ankara Museum. This isolated example is interesting, for it indicates that elsewhere in Anatolia full-sized copper or bronze picks were being used. An unpublished shaft-hole pick is known from the Habur region and is now in the British Museum, BM 128803/ 1936.6.13.198. One point of this pick has been hammered into a slight vertical edge, and the opposite point has been hammered into a slight horizontal edge.

23. Deshayes'dating of the axe-adze (hâche-herminette) is very low, which alters the distribution pattern, Deshayes, 1960, I:288-91. Renfrew's chronology for the S.E. European Copper Age is preferable, Renfrew, 1969:12-47, esp. p.28, fig.6. The C-14 dates upon which Renfrew based his chronology were not available when Deshayes compiled his catalog.

24. From Troy II: Deshayes, 1960, II:119, no.2288 and pl.XXXIX (7); from Troy VII (Dorpfeld): Ibid., 120, no.2293, and pl.XXXIX (10).

25. Deshayes, 1960,II:27, nos.2230, 2246, 2277 (see original publications). Also Cook, 1960:10-12.

26. Such clothing has been found in copper and salt mines, Pittioni, 1951:41.

27. Even in the Middle Ages in Europe rope was used as a means of descent and exit, Agricola, 1950:213. See Figure 6.

28. Kozlu may also incorporate later workings as well. The Assyrian "Habura" has been associated with the ancient "Cabira," the Pontic city generally thought to be present-day Niksar, Garelli, 1963:295, citing Lewy, 1958:94. Acoording to Strabo, mines existed in this area. Niksar is about 50 kms. east of Erbaa and Kozlu. Professor D. Oates has, however, suggested that "Habura" should be associated with the Habur in North Syria (personal communication).

29. This estimate is based on one C-14 date from a near-by slag dump at Subaşi (cf. infra "Smelting" at Subaşi (S-96)) and by some scattered pottery fragments, none of which seemed earlier than the Roman period.

30. The analysis of the ore at İnkaya does not correspond to all of the slag analyzed in this area. The slag from Bahçelidere (cf. S-95) carries small traces of Sn and As. likewise some of the slag from Sakapinar in the same area. It would seem, then, that the ore-body in the Bakir Çay area is not uniform.

31. We can provisionally accept Davies's attribution of E.H. for this mine, but one must remember that it is based on one (unpublished) sherd found in the cave. Davies described it as being "red-polished ware," ibid., p.93.

32. For a bibliography and a brief survey of mining and metallurgical problems of the Middle Cypriot period, de Jesus, 1976.

33. Dossin, 1952:436. It has been suggested that Kimaš is east of the Tigris in the Zagros mountains, Limet, 1960:30-1. It has also been indentified with the area around Kirkuk, Falkenstein, 1960:50, somewhere between the Gebel Hamrin and the Lower Zab. Mines are known in the northeastern part of Mesopotamia. In his travels Sir Henry Layard ventured along the Upper Zab and into the Valley of Asheeta (Aşuta ca. N 37°20' - E 43°23') in the Tiyari Mts. In this area locals showed him mines consisting of tunnels and still containing copper veins of bright blue ore (azurite ?). Layard also noted that, "in the heights above Lizan, and in the Valley of Berwari, mines of iron, lead, copper and other minerals abound," Layard, 1850:233; also Maxwell-Hyslop, 1974:139, n. 2. There is no indication that these are the mines of Kimaš. Other authors have argued that Kimas could be the Ergani copper deposit in Turkey, but this seems unlikely in the eyes of some authors, i.e. Limet, 1960:92-3. It has also been identified simply with the Zagros, ibid., 93, n. 1.

34. Limet, 1960:90 and p.16 n. 4. Kimaš is also said to have supplied silver and gold to Sumer, Roux, 1964:155; and Barton, 1929:221. The location of these and other minerals in North Mesopotamia are noted in Thompson, 1925:79-82.

35. Jovanovič, 1972:14, has reached a similar conclusion, though it is not known where this tradition may have originated and thrived. From flint mines in Great Britain, some C-14 dates are now available, the oldest being Church Hill, Sussex, ca. 3390 B.C., Smith, 1974:105-6.

CHAPTER 7

Analyses and Development of Copper and Bronze Metalwork in Anatolia

The analyses of the metalwork from prehistoric Anatolian sites are too numerous to be discussed individually. Graphs appear in Appendix VI which indicate the percentage of occurrences of tin-bronze, arsenical copper, unalloyed copper and arsenic-tin-copper alloys, and are arranged by periods. For convenience, three percentage ranges have been established for both tin-bronzes and arsenical coppers. The first is the percentage of arsenic or tin in copper equal to or greater than 10 % (expressed ≥ 10). The middle range is between less than 10 % and equal to or greater than 5 % (expressed $< 10 - \geq 5$). The third range is between less than 5 % and equal to or greater than 1 % (expressed $< 5 - \geq 1$). All the pieces in these groups are considered intentional alloys. Unalloyed copper is considered to be those pieces which contain less than 1 % tin or arsenic. The percentage of arsenical coppers, tin-bronzes, etc. in the analyzed groups is indicated on top ofthe bar graphs. Their number is indicated in the bar graph. The total number of pieces considered in each graph is indicated beneath the title.

No graphs were made for samples less than 12 analyses, since they would not have been particularly representative of the metalwork of the period. The sites which have contributed most to our corpus of prehistoric metalwork are discussed individually below. These sites allow us to draw the tentative conclusions on the development of metal compositions.

There is a strong tendancy for arsenical-coppers and tin-bronzes to remain distinct. This can be seen by the fact that very few alloys of tin-arsenic-copper occur. Arsenical-coppers are present at every site, and tin-bronzes -- as one would expect -- steadily increase in number throughout time,[1] with some exceptions. What does come as a surprize is the relatively common use of unalloyed copper throughout the Early Bonze Age. Even as late as EB III most of the metalwork at Tarsus is unalloyed copper (see Graph 8). Even when tin-bronze and arsenical-coppers are a common occurrence, such as at Alaca, Ahlatlibel and Alishar, unalloyed copper is used for 20 % or more of the metalwork. The metalwork of Anatolian sites is best viewed regionally. Like the analyses, the metalwork is discussed site by site.

Ahlatlibel

EB II Analyses (Graph 1):

The largest group of alloys in this samples is the arsenical coppers (35 %) where As<5 % - ≥ 1 %. Tin bronze is the next largest group (25 %) where Sn < 10 % - ≥ 5 %. Total arsenical coppers come to 40 %, equivalent to the total of the tin bronzes. Unalloyed copper amounts to 20 % of the sample.[2] There do not appear to be any mixtures of arsenical copper with tin bronze, thereby suggesting to distinct metallurgies, similarly evident in the EB II metalwork of Alaca and Alishar (infra).

EB II Metalwork (Fig. 27):

The amount of material from Ahlatlibel is by no means abundant, but a wide range of metal types is represented. A sword[3] whose blade is copper (A-166) with riveted handle is similar to one from Alaca without rivets (A-164, Tomb S). A shaft-hole axe-hammer (A-225) comes from the same context as the sword. Deshayes (1960, I:198) suggested that this type of axe-hammer was inspired by lithic imitations of Iranian metal prototypes, but it is perhaps more sensibly placed within the context of Central Anatolian metalwork, along with the swords and long daggers.

The macehead (A-172) similar in size and appearance to a gold-gilded one from Alaca (A-178). However, the Ahlatlibel example is technologically different in the sense that it is hollow cast, while the one from Alaca is solid with a simple shaft-hole. The double-knobbed headded pin (or "Hammer headed" pin) (A-532), inspired from bone prototypes, ties in with what we know of the so-called Pontic cultures where this type of pin commonly occurs (Hančar, 1932; Latynin, 1967; Jacobstal, 1956:141). This pin type and the double-sprial pin (Huot, 1969:62,67), link Ahlatlibel with Alaca. Although Ahlatlibel may have been under the peripheral influence of this culture, its sophistication in metallurgy does not reach the heights attained at Alaca.

Ahlatlibel could have obtained its copper from either the Pontic area (i.e. Corum and Tokat Provinces) in which case the flow of the supply may have been governed by Alaca, or from the area of Karaali (S-85) which is closer (cf. Map 16).

Alaca Hüyük

EB II Analyses (Graph 2):

A good selection of the Alaca metalwork has been analyzed, particularly well represented in the study by Esin (1967). Unalloyed copper constitutes the largest group (37.5 %) in the sample of the material, followed by tin bronze (27.5 %) where Sn $< 10\% - \geq 5\%$. The next most abundant group (17.5 %) is tin bronze, where Sn $\geq 10\%$. The last and smallest group (15 %) is the arsenical coppers where As $< 5\% - \geq 1\%$. All told, tin bronze is the most abundant of all the copper types.

There do not appear to be any mixtures of arsenical copper with tin bronze (i.e. remelts of scrap), as in no case does arsenic occur with tin bronze in any amount higher than a trace (i.e. 1 %). Likewise, no tin occurs in any amount higher than a trace in the arsenical coppers. It is evident from the analyses that tin and arsenic are not associated and were not confused by the ancient metallurgists of Alaca. This may be indicative of two distinct types of metallurgies, one based on the production of arsenical copper and the other on tin bronze. Both alloys were used occasionally for the same type of object, but copper as well. There does not seem to be any particular methodological use of one alloy or just copper for any particular type of object. This would seem to invalidate claims by some authors that tin bronze or arsenical copper was necessary for intricate castings or certain types of metalworking.

The Metalwork (Plates VIII-XII)

The majority of the metalwork comes from the tombs the date of which has been much disputed. For reasons given in the "Conclusion" (infra) the tombs are understood here to date from the early part of EB II to the end of EB II, perhaps ca. 3000-2800 B.C. A complete discussion of the metalwork from Alaca would entail yet another thesis. In this short synopsis it is only possible to point out some of the salient features and attempt to situate them in the general context of other EB II sites on the plateau.

There is a strong emphasis on ritual material, standards, lituus, so-called castanets, pins, sistra, vessels, and simple tools.[4] A number of weapons occur, particularly stricking are the swords representing a variety of types. One is a simple falt-bladed example with sloping shoulders and riveted haft (A-163) and two others have a wide flange and are unriveted (A-164, 165).

These swords are similar to those from Ahlatlibel (supra) and an unstratified example from the Çorum area (unpublished but now in the Ankara museum), perhaps all EB II in date. The daggers from Alaca present an even greater variety than the swords, both in material and in form. Two elaborate daggers (A-152, A-153) have (meteoric) iron blades and gold leaf handles and are clear examples of the technological sophistication of the Alaca smiths. Another dagger (A-154) is described as silver (Stronach, 1957:99) and has a pronounced rounded midrib, a characteristic of Central Anatolian blades.

Possibly the earliest examples of bent-tanged spearheads with slotted blade occur at Alaca (A-262, A-263), from where they moved on to other areas. Troy may have been the step-off point to its migration to the aegean, and Cilicia the point of departure to North Syria and the Levant.[5]

From what can be inferred from the manufacture of the Alaca metalwork we can see that the smithing techniques are quite advanced. Both mould-casting and cire-perdue casting appear to have been practiced, although in some cases we may wish to postualte the use of multiple mould casting (cf. "Moulds" supra).

Some, if not much, of the metalwork was coated with a thin arsenical-copper layer, giving the surface a silver appearance. This was first detected on an unstratified bull in the Boston Museum (A-330) said to be from Horoztepe. Eaton and McKerrell (1976) have noted arsenical concentrations on other Alaca metalwork. Examples in museums and from other sites appear to have been similarly treated (A-359 b, 360, 363, 367 a, 367 b, and 368). Seeing the predilection that the Alaca smiths had for silver plating and inlay, it would seem that the arsenical coating process could have been developed as an economy measure. This process, possibly "inverse segregation" (Eaton and McKerrell, 1976:175-7) may have been practiced at a great number of Central Anatolian smithies, and perhaps even as far west as Bayindir (A-134).[6]

Alaca was a major settlement in EB II, and it probably commanded control over a wide area. Its influence certainly extended into the realm of the metallurgical industry, and, in fact, may have even controlled the production and trade of copper from the Pontic Region (i.e. Tokat and Çorum Provinces). Although some small deposits of c copper exist near Alaca (S-94)(de Jesus, 1974 b:201), a large-scale smelting operation does not appear to have taken place anywhere within the loop of the Halys. This would mean that the copper deposits of the Pontic area were important sources to EBA cultures. As a number of unstratified metal artifacts have turned up from Çorum and Merzifon which suggest EB II dates, it would seem possible that some of the smelting sites located in this region (de Jesus, 1974 b) were operative at that time. We must not insist on this interpretation, for there is no direct evidence yet that any of the currently-known smelting sites date from the Early Bronze Age. Only Kozlu (S-97) at the moment has suggested EBA mining and smelting in the Pontic area.

<u>Alishar Hüyük</u>

EB I Analyses (no graph):

Only nine analyses are available from this period. Tin-bronze is known in the high, middle and low ranges. There are three low arsenical coppers and three unalloyed copper. No mixtures of arsenical coppers with tin-bronzes are evident.[7]

EB II Analyses (Graph 3):

There are 24 analyses available of the metalwork from this period. The sample is hence small and the group percentages are possibly not totally representative. The largest group is unalloyed copper (37.5 %), followed by arsenical copper (29.2 %) where As $< 5\% - \geq 1\%$. Low tin-bronzes constitute the third largest group (16.7 %) where Sn $< 5\% - \geq 1\%$. This is followed by the other two tin-bronze groups (8.3 % and 4.2 % respectively). In all, the groups are roughly equivalent, each representing about one-third of the total sample from this period.

The tin-bronze groups are clearly disassociated from the arsenical coppers, except in one case (not included in the above calculations) where there is an obvious mixture of arsenic and tin (As 1.25 % and Sn 2.4 %).

EB III Analyses (no graph):

Only four analyses are available of the metalwork from this period. Three are unalloyed copper and one is a low tin-bronze. No arsenical-coppers are represented.

Metalwork:

In EB I only trinkets and small tools occur, all from the low levels of the city mound (i.e. levels 18-12). Silver earrings occur as funerary deposit (Tomb e X19) in level 14M (OIP XXVIII: 91, fig.43 (e 2238-39)), which shows an awareness of different metals and indirect evidence for cupellation in this period.[8] A fragment of lead also occurs in this horizon. In late EB I (i.e. Levels 13-12M) pins are the most common artifact, though two stamp seals, one of copper (A-599) and the other of lead (A-600), indicate expanding uses of metal. The presence of tin-bronze in this period points to Alishar's link with a sophisticated metallurgy, but it has not yet been specifically identified. There is no indication that it is related to the ancestor metallurgy which was later to emerge at Alaca and Horoztepe in EB II and EB III. Moreover, it is evident that Alishar is not a perveyor of advanced metallurgical technology, but a recipient of it (de Jesus, 1972:136).

In EB II the pins constitute the most abundant type of artifact. The tin bronzes in this period are unidentifiable fragments, pins and a bracelet. The appearance of toggle pins in this period (i.e. Stratum I)[9] links the site with similar pins at Tarsus, thereby revealing Alishar's link with the South, more than with the North. This impression is reinforced by the fact that apart from superficial parallels, the metalwork of Alishar in EB II does not seem to have followed closely the spectacular development of other Central Anatolian or Pontic sites such as Alaca, Kayapinar, and to a certain degree Ahlatlibel. Alishar may have drawn on its own or local ressources for its copper and relied on a technology which was, from the point of view of smithing, inferior to its contemporaries.

In EB III Alishar gains in importance, largely because of the growing settlement and the demands that such expansion entails, but most of all because of its strategic position with regard to the metal-rich Pontic region. It is in this period that a strong cultural bias forms in the southern sector of Central Anatolia, particularly at Alishar and Kültepe (Mellaart, 1967:33; Özgüç, 1963:11-12). This culture is a local development (i.e. the eastern sector of the Halys) which can be equated with Cappadocian Ware. For Alishar, EB III was the period of formation of commercial links with other settlements in Central Anatolia. Although a hybrid, a cultural unity began to form throughout the Plateau. It is quite evident that by EB III Alishar's contacts (and those of Kültepe) were quite far-reaching and continued to expand outwards right up til the establishment of the Assyrian Colonies.

The nature of the metalwork of this period suggests continued varied and practical uses of metal. This is still seen in the common use of pins. A three-riveted dagger (A-155) bears witness of on-going links with Cilicia,[10] as similar blades occur at Tarsus EB III (A-137) and in the Soli hoard.[11] The users of metal artifacts are clearly of a different order than the princely populations of the Pontic culture and to a certain degree those of the West represented by Troy and Dorak. The character of the Alishar metalwork is a perfect expression of the rise of the merchant class.

The closest mines to Alishar would be Menteşe (S-106) and Karaali (S-85). But as no moulds were found at Alishar dating to the EBA, there is every reason to believe that the inhabitants of the settlement were not in any way involved with metal exploitation, and they traditionally obtained their metalwork from elsewhere.

Beycesultan

L. Chalcolithic - EBA Analyses:

Only ten analyses have been made of the metalwork of the Late Chalcolithic period, eight of which are unalloyed copper and two of which are low arsenical coppers where As $< 5\% - \geq 1\%$. The latter happened to be the largest pieces in this group.

Five analyses of EB I metalwork (from Levels XVIII, XVII) are available, three of which are arsenical-coppers where As $< 5\% - \geq 1\%$. The other two are unalloyed coppers. One can note only from these results that there is a tendancy towards a greater use of arsenical copper.

The three analyses of EB II metalwork (from Levels XVI, XIV, XIII) gave two unalloyed coppers and one arsenical where As $< 5\% - \geq 1\%$. From EB IIIa - IIIb period (from Levels XII, IX, VI) only six analyses were made. Two pieces are unalloyed copper and three are low arsenical coppers where As $< 5\% - \geq 1\%$. One mixed tin-bronze occurs (i.e. % Sn 1.0 and % As 1.5), and it is the first appearance of tin in the Beycesultan analyses where Sn $\geq 1\%$.

Metalwork:

Although the amount of Late Chalcolithic metalwork from Beycesultan is small, there is a fairly good indication that copper artifacts in this period were numerous. It must not be forgotten that the deep sounding into the Chalcolithic levels, from where all the Chalcolithic metalwork comes, was extremely limited in area (Stronach in Lloyd and Mellaart, 1962:280). Had the excavation been opened up to incorporate more Chalcolithic levels, certainly more metalwork would have been recovered. With that in mind the few pieces which have been published and analyzed suggest that a regional school of metalworking was possibly active in the Anatolian West at this time. This is mainly indicative through the uniformity of the metal composition (supra) and the practical character of the finds, i.e. borers, punches, awls, etc. The metal hoard from level XXXIV had an unfinished appearance about it and thereby indirectly suggests that some local smithing was done at the settlement (Stronach, ibid., pp. 280-3).

As stated elsewhere (cf. "Silver" supra) the occurrence of the silver ring in the Late Chalcolithic hoard is an indication that the cupellation of silver was practiced this early. But too few Chalcolithic sites have been excavated for us to have more insight into this aspect of the metallurgical industry. Yet, the occurrence of a dagger blade as early as level XXIV (A-107) firmly indicates that a Chalcolithic metallurgy was in full development in the 5th millennium B.C. This is particularly evident when we consider the EB I metalwork which offers such refinements as miniature daggers with riveted tangs. These are not examples of a recent development but the results of a technology which started long before.

The EB I metalwork at Beycesultan does not easily relate to other areas to the East, contrary to what has been expressed before (Stronach, 1962:283). If at all, the daggers from level XVII (Stronach, ibid.: Fig. F.9, nos.1-5 & 9) share common features with daggers from Bayindir (Stronach, 1957: Fig.1, particularly nos. 1-5): the flat midrib and the rounded riveted tang. This association, if legitimate, may push back the date of some of the Bayindir material closser to EB I than to EB III. In any case, the Beycesultan daggers are examples of the competence of western smiths.

The pyramid-headed pin (A-484) from level XVI is a clue that may tie the Beycesultan metallurgical tradition -- although local -- to a wider family which incorporated the West and Northwest (cf. Kusura, infra, n.2), but too little material is known from these regions to see how deep that relation really was.

The knife with twisted handle and with an eyelet at the tip (Stronach, 1962:fig. F.9 (6)) from level XIII has parallels elsewhere, particularly at Karatas (A-102) where it is probably contemporary. A second (unpublished) example is in the Burdur Museum[12] and is probably from the Lake District.

The occurrence of a tuyère in level XVII (A-671) confirms the practice of smithing at the site. The source of metal in the West is still a matter of speculation. Only four copper deposits in the West are known to have been exploited formerly: Seki (S-115), Bülbüler (S-116), Seydiköy (S-117), and Kizilca (S-118) (see Map 8). Any of these would appear to have been accessible to Chalcolithic - EBA miners. The Seki and Seydiköy deposits have both copper and arseno-pyirtes in the ore-body, and it is particularly the arsenical copper which characterizes the metal make-up at Beycesultan.

Horoztepe

EB III Analyses (Graph 4):

More analyses (56) are known of the Horoztepe metalwork than any other EBA site in Anatolia. It is, then, with a certain confidence that we can accept them as being representative, The largest group in the sample is the middle tin-bronze (35.7 %) where Sn $< 10\% - \geq 5\%$. The second largest is the high tin-bronze group (21.4%) where Sn is $\geq 10\%$. This is equal to the low arsenical copper group (21.4 %) where As $< 5\% - \geq 1\%$. The fourth largest group is unalloyed copper (17.9 %), and the lowest is the middle arsenical coppers (3.5 %) where As $< 10\% - \geq 5\%$.

All told the tin-bronze group together represent half of all the metalwork analyzed (i.e. 21.3 % + 35.7 % = 57.1 %) which shows the greater availability of tin supplies in this period. In the previous period (EB II) at Alaca (cf. Graph 2) the total number tin-bronzes constitute just under half of the metalwork analyzed (i.e. 17.5 % + 27.5 % = 45 %). The Horoztepe bronzes outnumber both in proportion and in number all EBA sites, with the exception of Troy II.[14]

Metal work (Figs. 19-24, Plates XIII-XV(I)):

The material from Horoztepe represents almost exclusively grave goods, as the settlement was never fully investigated (Ozguc, 1958: 39-41).[13] A wide range of metalwork was collected from the tombs, some of it intentionally bent and distorted at the time of deposition. A number of pieces became known through the antiquities trade and have made their way into private collections and museums.

Vessels (A-300, 301, 324-326, 331), platters and furniture (A-353-356) make up a fair portion of the metalwork which are excellent examples of sheet-metal technology. Weapons are also well represented, including tanged spearheads with slotted blades (A-264-267, 270) (Figs. 21 (1-4), 22 (3)). A number of these, different in shape, appeared on the antiquities market and are now in the Metropolitan Museum (Özgüç, 1958:58, n.67, pl.XIX) (see "Alaca" supra, n.2). The so-called "Castenets" (A-395-396) are also associated with unstratified finds, and one silver example (A-397) (Fig. 23(4)) is now in the Kocabaş collection in Istanbul.

Ritual material is relatively abundant: a female figurine breast-feeding a child (A-357) (Fig.20) (Plate XIII (3)(4)), bull standards (A-359) (Fig,19(3)) and possibly sistra (A-392-393) Plate XVII (4)(5)). Two bulls show signs of arsenic coating (A-360, 361) Fig.19 (1)(2)), which might also be true of other pieces.[15]

Technologically, the Horoztepe metalwork is quite advanced, but it is distinguished from the Alaca Tomb material in the sense that gold and silver are less used, though they are still represented. What might be considered a distinctive feature of the Horoztepe metalwork is its concept of proportions of the individual pieces. The copper fruitstand (Ozguc, 1958, pl.IV, fig.1) is more than 50 cms. tall, one table (A-353) (Plate XIV (2)) is 67 cms. in length, and the other (A-354) is 50 cms. in length. The so-called mirror (A-290) (Fig.24 (5)) is 21.5 cms. in diameter. The height of the female figure mentioned previously (A-357) is 20.4 cms. Apart from the mere size of these pieces, which indicates a certain abundance of copper available to smiths of this period, there is an indication that the technology was not entirely uniform. This can be seen, for example, in the feet of the female figure which are crudely rendered and are over-sized. This contrasts with the precision of proportions and details on the bulls. It is almost as if the female figure dates from an earlier period and occurs here as an heirloom. On the other hand, it might be argued that this disproportion is willful on human figures whereas animal figures tend almost exclusively towards realism.

The metalwork, taken as a whole, is generally similar to the Alaca material, although Özgüç (1958:57-8) prefers to consider it a century or so later. From the available evidence, including the pottery (Özgüç, 1958:60), there is no inconvenience in placing the Alaca and Horoztepe tombs almost contemporary. One is not obliged at this point of our documentation on Horoztepe to accept catagorically a late EB III date for the site, particularly when Chalcolithic sherds are known there. But until a stratified sequence of the habitation area is available, the Horoztepe finds "float" between middle EB II and late EB III.

Kusura[16]

EB I Analyses:

Only four analyses are available of the metalwork of this period and hence not representative of the whole. However, at least one tin-bronze is know (A-654). The others are unalloyed copper (A-655 and A-425).

EB II Analyses (Graph 5):

A very small sample of 12 pieces were analyzed from this period and hence only roughly indicative of metallurgical practices at this time. The largest group is arsenical copper (58.3 %) where As $< 5\% - \geq 1\%$. Finally only one tin bronze (representing 8.3 % of the total samples) fell into the category Sn $< 10\% - \geq 5\%$.

EB III Analyses:

Only eight analyses are available of metalwork from this period. The largest group is unalloyed copper (5 examples), followed by arsenical- copper $< 5\% - \geq 1\%$. Only one tin bronze was found when Sn $< 10\% - \geq 5\%$.

Metalwork:

The range of metal artifacts recovered at Kusura is quite restricted hardly more than trinkets. In EB I only pins and needles occur and nothing which could be recognized as a tool, unless one wishes to place a needles in this category. Hence, in this period metal was probably looked upon as a curiosity and not indispensable to material life. What little there is was no doubt acquired from elsewhere, as none of the remains at Kusura suggests that the inhabitants were in any way connected with metal production. Unbeknownst to the users of these trinkets, they were benefiting from a sophisticated bronze metallurgy operating somewhere in the West of Anatolia but disassociated from the metallurgy known at Beycesultan (cf. "Beycesultan" supra).

In EB II (i.e. Kusura B) there is no real change in the use of metalwork, except that a few awls and points become common, of which two are tin bronze (A-5, A-26). The appearance of pyramid headed pins in this period indicate that the metalwork is essentially a western one, as this pin type is known in this period mainly in the West along the coast and at Tarsus.[17] The other pin types show no particular regional characteristics.

There is little change in the metalwork in EB III (i.e. Kusura B-C 'Transitional'). This period corresponds to the introduction of wheel-made ware (Lamb, 1938:237) which is a gradual trend in Central Anatolia. The occurrence of a double spiral headed pin could be indicative of the beginning of Central Anatolian influence moving westwards, since this type appears earlier there (A-437, 444, 447).

<u>Mersin</u>

Late Chalcolithic Analyses (Graph 6):

As would be expected the largest group in the sample is the unalloyed (76.2 %) followed by low tin bronzes (14.3 %) where tin is $< 5\% - \geq 1\%$. There were only two arsenical coppers (i.e. 9.5 % of the sample) where As $< 5\% - \geq 1\%$. The small sample (21 analyses) does not permit a secure evaluation of the metal make-up, but the existence of tin-bronzes at this early period shows that some experimentation with alloys was being done by the ancient metallurgists.[18]

Metalwork:

The Chalcolithic at Mersin incorporates the levels XXIV-XVI, and it is in level XXII that a copper artifact first occurs,[19] a pin dating to ca. 5000 B.C. It is not until the Late Chalcolithic levels XVII that any large artifact appears, in this case a chisel. It is to level XVII that the controversal stamp seal is attributed,[20] and in level XVI flat axes are added to the smith's repertoire. Pins become the most common metal artifact in the subsequent levels.

Apart from the analyses (supra) little can be said about the technology of the Chalcolithic metalwork of Mersin. As no abundant sources of copper ore are known on the south side of the Taurus mountains we do not know where Mersin's copper source was. The nearest copper deposit Kizilca (S-125) has given evidence of former exploitation,but the reserves are noted as limited. Mersin could have traded for its copper, and in view of its links with the East, particularly in the Halaf and Ubaid period, its copper source may have been in this direction rather than towards the North or West.

Tarsus

EB II Analyses (Graph 7):

The majority of the metalwork (64 %) of this period is unalloyed copper. There are only three low arsenical coppers (i.e. 12 % of the sample) and two tin bronzes in the two lower ranges (% Sn 6.6 % and 2.5 %). Four of the analyses showed evidence of As-Sn-Cu ternary alloys. As explained elsewhere, it is not possible at this point of our research to determine the cause and nature of these ternary alloys. As opposed to most other sites in the EB II period the occurrence of both As and Sn in the same object may suggest a change in smithing techniques.

EB III Analyses (Graph 8):

Again unalloyed coppers constitute the largest group (65.5 %) followed by arsenical copper (17.2 %) where As < 5 % - ≥ 1 %. The ternary alloys, As-Sn-Cu, again occur and constitute 17.2 % of the sample; otherwise there are no "pure" tin bronzes represented.

Metalwork:

The EB I metalwork from Tarsus tends to be limited to small utility objects, such as a knife, a sickle, an awl, needles and pins. A tanged arrowhead (A-288) comes from this period and is the earliest-known metal example in Anatolia.

In EB II there is a greater array of metalwork. Toggle pins make their appearance and so does a fragment of an early fibula,[21] although fibulae do not become common until the Late Bronze Age. Cilicia appears to have been the area from where the toggle pin was introduced into Anatolia, where it was perhaps a local development and from where it spread (particularly in EB III) to Central, Western and Northwestern Anatolia, the Eastern Aegean, Cyprus and the Levant.[22]

In EB III the most important innovation over the earlier periods are the bent-tanged spearhead with slotted blade (after A-286) and daggers (A-112, A-136, A-137). These items in themselves indicate the ever-growing hostility between peoples, but also the existence of a Cilician school of metalwork, as similar daggers show up in the Soli Hoard.[23]

Cilicia's apparent links with maritime movements did not fail to leave its mark in terms of foreign influence at Tarsus.[24]

Troy

EB I Analyses:

Only seven analyses of Troy I material are currently available. Unalloyed coppers and low arsenical-coppers number three each, and there is one high tin-bronze where % Sn ≥ 10. This is the earliest occurrence of tin bronze in Northwest Anatolia (A-586).

EB II Analyses (Graph 9):

Middle tin-bronzes make up the largest group (29.7 %) in this sample, where Sn < 10 % - ≥ 5 %. This is followed by unalloyed coppers (27 %) and by the low tin-bronzes (24.3 %) where Sn < 5 % - ≥ 1 %. All told, the tin-bronzes outnumber the unalloyed coppers and the arsenical coppers and constitute well over half (i.e. 29.7 % + 24.3 % + 8.1 % = 62.1 %) of all the pieces analyzed. This corrects an original impression held by Blegen (1966:78) who thought that bronzes were not common until the end of the Early Bronze Age (i.e. Troy V).

EB III Analyses (Graph 10):

Unalloyed coppers are the largest group in this period (30.8 %), but it must be pointed out that only 13 analyses have been made, and the results are not confidently taken here as representative. The second and third groups are the low arsenical-coppers where As < 5 % - ≥ 1 %, and the middle tin-bronzes where Sn < 10 % - ≥ 5 %, each representing 23.1 % of the total sample. The last two groups are high tin-bronzes where Sn ≥ 10 % and Sn-As-Cu alloy, each representing 7.7 % of the sample with one analysis apiece.

From this small selection it is not possible to say for sure whether there was any significant change in the alloying practices from the previous period. However, as no single analyses appears incongruous to us, we can tentatively conclude that there are no significant differences in metal compositions between EB II and EB III at Troy.

Metalwork:

We are struck by the relative sophistication of the metalwork from Troy I. Bi-mould casting was apparently practiced, and analyses have shown that tin-bronze was also known.[25] Pins of copper and silver, a bronze bracelet, and knives with curved blades and riveted handles are the outstanding features of this period.[26] Even more surprizing is a knife blade which Schliemann describes as having been gilded with gold leaf (Ilios: 251, no.120). A fragment of a mould of a blade with a pronounced midrib comes from Troy I (middle) (Blegen et al, 1950:43, 150, fig. 221, no.38.100). This, again, clearly indicates that smithing was performed at Troy in the early stages of its existence, Hence, Troy cannot be considered backward, for its own craftsmen could meet some of its needs in metalwork. It can be inferred from this material that a certain number of techniques were known at the time of Troy I:

1. Alloying of copper and tin to make bronze
2. Copper and bronze casting in open and closed moulds
3. Copper and bronze sheet-metal work
4. Use of rivets
5. Cupellation of silver
6. Refining and amalgamation of gold
7. Gilding with gold

In view of this impressive list of metallurgical techniques, the first inhabitants of Troy do not appear to have been as ordinary as the simplicity of their dwellings and pottery might suggest. Although simple, the Troy I pottery does appear to imitate metal vessels, particularly suggestive is the black-burnished carinated bowls with tubular lugs on the rim. The fact that no metal examples were found in Troy I may suggest that the inhabitants had perhaps seen them but were unable to acquire them or manufacture them. In view of the Balkan synchronisms with Troy I (Mellaart, 1971:120-1), it would not be surprizing if one day the metal prototypes of these bowls show up in Southeast Europe in EB I contexts.

Even though Troy I metallurgy may have originally come from the Balkans, towards the end of Troy I it probably gradually came regionalized under the influence of a native Anatolian metallurgy operating somewhere in Northwest Anatolia. The blades with pronounced midrib are an Anatolian feature, which implies that the source of at least some of the smithing technology in Troy I is also coming from the Asian mainland. As we have little information on other EB I settlements in this region, apart from pottery surveys (Lamb, 1932; Mellaart, 1955; French, 1967) it is not yet possible to indicate the area from where this influence might have come.

In Troy II the range of metalwork suggests a uniform development out of Troy I. In addition to the already-known pins, knives and bracelets, flat axes make their appearance.[27] As in Troy I, the absence of smelting equipment (i.e. smelting furnaces, pot bellows, and particularly large quantities of slag) is a firm indication that the processing of copper was a task performed elsewhere, and in all probability, by another people. The craftsmen at Troy were concerned with smithing, not smelting.

In the later phases of Troy II, and particularly Blegen's IIg which we identify with Schliemann's "Burnt City," we find still this increasing proliferation of metalwork. À jour casting and the cire-perdue processes are added to the smith's repertoire.[28] The double-spiral pin is introduced,[29] likewise are the toggle pin,[30] the barbed arrowhead,[31] and the knife with pronounced curve tip.[32] The shaft-hole axe-adze[33] and the shaft-hole axe-hammer[34] make their appearance.

Trojan contacts at this point appear to be both East and West; however, the Eastern contacts are more conspicuous. The most striking is epitomized by the slotted spearhead with hooked tang (A-279-285). It occurs first at Alace (A-262-263), then turns up later at Horoztepe (A-264-266) in a somewhat altered form. The synchronism of this period with Tarsus IIIa appears valid, particularly when we consider the occurrence of a similar spearhead (A-286) from a cache of the Cilician EB III. The Western extension of this type of blade, besides those of Troy, is evidenced by a stray find at Ahirkoy (Aydin Province) and one example with round holes instead of slots from the Southwest (?) and now in the Burdur Museum (unpublished).

The wide-tanged dagger with raised rounded midrib occurs first at Alaca, possibly contemporary with examples at Bayindir[35] and Karataş (A-150). A number of examples show up later in Late Troy II.[36] Particularly interesting is the similar way in which the center midrib is carried right up into the tang area, a feature common to the example at Karataş (A-150) and several from Bayindirkoy (see note 35). This particular type of blade may have originated in Western Anatolia where it is more prevalent. Troy may have become acquainted with this type of weapon via its contact with its neighbors.

The great number of moulds from this period (Branigan, 1974: 77-83) again provides us with the necessary evidence for the manufacture of at least some of these items, if not all, at the settlement itself. Unfortunately, the moulds discovered at Troy were never properly published. Most of those that appear in the Atlas are probably from the late levels of Troy II, judging from the clearly datable examples.

The bulk of the treasures containing metalwork comes from the late phases of Troy II.[37] An attempt at stratifying these finds is as follows:

Treasure	Level
R	I (end ?)
N	II (1st half ?)
G	IIf
L	IIf/g
A, B, C, D, E, F, J, K, M, O, S	IIg
H	IV (late)
P	VI

Without detailed examination of the individual pieces, it is evident that these treasures represent the existence of a wealthy class at Troy which may have had counterparts in other Northwest Anatolian settlements. The metalwork itself is mixed in character: weapons, luxury household items and jewellery. However, they show one underlying link: they are all examples of sophisticated metallurgical technology, which clearly shows us that the users of these items were accustomed to the best. Yet, there were risks. Troy probably controlled (or had access to) rich metal sources. The presence of weapons, not only in the treasures but in the stratified layers of Troy II, suggests that these sources were vulnerable to outside threat. The destruction of Troy IIg clearly illustrates just how vulnerable.

Troy III (= Schliemann's IV) continues in some respects the same type of metallurgical practices of Troy II. We do not find the same variety that was apparent before, nor do we find the same degree of wealth. From the point of view of metalwork, Troy III is definitely impoverished. The destruction of the IIg settlement must have seriously affected copper and precious metal supplies, so much so that Troy never regained its former prominence in metalworking.

Regarding metal sources, we find that there are four copper deposits in Çanakkale Province which are said to have economic value: Balcilar (S-81), Camyurt (S-82), Doğancilar (S-83), and Gümüşçati (S-80). At both Balcilar and Gumuşçati abandoned copper mines have been reported; at Doğancilar copper slag dumps of ca. 10,000 tons are known; and at Çamyurt both copper slag and an abandoned mine have been reported. The slag dumps at Çamyurt have been estimated at ca. 1500-2000 tons. That any or all of these date from prehistoric times is definitely a real possibility; however, it must be pointed out that the amount of slag reported at Dogancilar and Çamyurt does not suggest metallurgical activity in terms of smelting for a very long period. Judging from the amount of slag present, the output of metal at these sites must have been extremely limited. In addition to these deposits and mines is a copper mine mentioned by Strabo (XIII.1.51), which should be somewhere between the ancient town of Cisthese, near the coast, and Pergama (mentioned also in Ilios:253).

As for silver in the Anatolian northwest, there is a very minute trace of it in the lead deposit at Bergaz (S-146) near the coast and just south of Troy. Dumps from former mining operations have been reported at this site, but nothing more is known about them. There is a copper deposit at Korudere (MTA, 1972:61) located ca. 30 kms. west of Çanakkale which contains a small quantity of silver (0.06 %), but no evidence of former working has been reported. Of greater interest is the Balya Maden mine (S-151) east of the Troad and west of Balikesir. In modern times this deposit yielded substantial quantities of lead, gold, and silver (see "Silver-lead ore deposits" supra). It may have been such a deposit which supplied Trojan as well as other Western Anatolian metalworkers with precious metals.

Notes to Chapter 7

1. Eaton and McKerrel, 1977, have reached similar conclusions in their comparison of EBA metalwork with MBA.

2. One piece in this group had Pb > 5 % and Sb > 5 %.

3. Stronach, 1957:94, reported this sword as being 28 cms. in length, while the excavator lists it as being 40 cms. (Kosay, 1934:95).

4. A competent study of the jewellery may be found in Maxwell-Hyslop, 1971:42-6. Some material is also discussed in Mellink, 1956. Sun disks and sistra have been treated in Ortmann, 1966.

5. Tanged spearheads with slotted baldes in Anatolia and elsewhere on the Asian mainland:

   1) Alaca: A-262, A-263. Two examples. Bent tang.
   2) Horoztepe: A-264, A-267. Straight tang.
      A-270. Bent tang.
   3) Ordu: A-277. Bent tang.
   4) Çorum: Ankara Museum (unpublished). Bent tang.
      Ortmann, 1966:176. Bent tang.
   5) Ahirkoy: Stronach, 1957:112, fig.7(3). Tang missing.
   6) Troy EB II: A-280. Bent tang.
      A-281. Bent tang.
      A-282. Bent tang.
      A-283. Bent tang.
      A-284. Straight riveted tang.
      A-285. Bent tang.
   7) Anatolia: Private collection, Stronach, 1957:108-9, 3 exs. Bent tang.
   8) Kültepe: Özgüç, 1956:31-6, fig.3. Bent tang. "Anitta's dagger".

9) Tarsus: after A-256.
10) Gerede: Stronach, 1957:109, fig.9(6). Bent tang.
11) Tell Judeideh: Braidwood and Braidwood, 1960:470, fig.371(5), pl.54(4).
12) Til Barsib: Thureau Dangin and Dunand, 1936:107, pl.XXX(2)
Ibid. :107, pl.XXXI(4)
13) Megiddo: Loud, 1948:183, pl.178(5), no. d 201.
14) For Aegean examples see Renfrew, 1967:10, pl.7.

6. From here originates an EB II dagger blade wrongly interpreted as being coated with lead (Stronach, 1957:98-9).

7. In three cases corrosion products were analyzed and the result may not be totally representative of the objects' original composition. These are A-653, A-623, A-652 (i.e. one arsenical-copper, one tin-bronze, and one unalloyed copper).

8. A handy list of EB I (i.e. "Chalcolithic") metal finds is given for the 1930-32 excavating seasons in OIP XXVIII:91,93.

9. However, there are definitely some corrections to be done in the revised chronology proposed by von der Osten, for the strata 7-11 on the mound do not correspond entirely to Schmidt's level I (OIP XXIX:495, fig.513). Schmidt mentioned that he found toggle pins in his Stratum I (OIP XIX:67) but in von der Osten's corresponding levels on the mound (OIP XXVIII:110) many pins were found, none of which was a toggle pin. This would seem to suggest that Schmidt's Stratum I -- or at least part of it -- is later than von der Osten's mound levels 7-11. This places the appearance of the toggle pins at Alishar slightly later than those of Tarsus, i.e. closer to the end of the EB II or the beginning of EB III.

10. One fibula was found dating to Stratum III, OIP XIX:208, fig.270 (462), and, therefore, roughly contemporary with a similar example from Tarsus. See also "Tarsus" infra.

11. Bittel, 1940: pl.II: S 3437. The "Trefoil" end appears to have been a Cilician development, but it never replaced a more sturdy example which had a medium length with riveted tang and rivets on each shoulder, i.e. Bittel, ibid.: pl.II: S 3440, S 3429, S 3435. This type remained a Cilician type throughout the Bronze Age, as it is still present at Tarsus in MB I and LB I, i.e. Goldman, 1956: fig.428 (103, 104, 106).

12. Museum No. E 1080. This example is approximately the same size and shape as the other two.

13. As Özgüç explains, there are two known areas which have settlement layers. To the Northwest of the cemetery is a small, low EBA mound (Özgüç, 1958: 39). The cemetery itself overlay (and in some cases intruded into) another small EBA settlement. Chalcolithic and EBA pottery was recovered from soundings in the cemetery area (Özgüç, ibid.: 60-1, pl.XVI) which show that Horoztepe was not a one-period settlement.

14. Troy II (EB II) had fewer bronzes (23) but was proportionally higher in tin-bronzes (62.1 %).

15. A process known as "inverse segregation" (see Eaton and McKerrell, 1976: 175-7), was apparently practiced by the Alaca smiths as well. See "Alaca" supra.

16. The dating of Kusura is difficult to assess for two reasons: 1) it is a backwater site which lagged behind its contemporaries in material development, and 2) the dating of the levels was only a general attribution, and does not meet our present-day requirements for clear divisions between periods, Mellaart, 1970: 56 and n.5. However, it is certain that EB I, II, and III periods exist. The following is taken as being <u>roughly</u> indicative, but it must be stressed that there are some overlaps which prevent us from accepting it as an absolute relation:

Kusura A = EB I

Kusura B = EB II

Kusura B-C (Transitional) = EB III

Kusura C = MB I - LBA

According to some authors, Wheeler, 1974:418 and n.33, there are some EB I elements in Kusura B.

17. This pin type occurs first in EB I at Poliochni (Azzurro) (A-489) and at Troy Id (A-488). In EB II they occur at Troy IIg (A-492), at Beycesultan XVI (A-484), and at Poliochni (Verde-Rosso) (A-494, A-495). The Tarsus examples (A-482, A-485, A-486) are EB III in date and fit in with some kind of coastan trade, as similar examples also occur on Samos (EB III) (A-500) and continue at Troy III (A-487-9).

18. The Late Chalcolithic artifacts analyzed by Esin, 1967:145, which contain ≥ 1 % tin are:

1) E-17871, stamp seal (A-596)

2) E-17882, awl (unpublished) (A-29)

3) E-17884, conic-headed toggle pin (unpublished) (A-524).

The stamp seal is attributed to level XVII on the part of the excavators, but they admit the possibility of mis-stratification, Garstang, 1953:108. The awl is not specifically mentioned by Garstang, and Esin may have attributed the find to this level (i.e. XIV) from field notes or a label. The conical-headed toggle pin is also not mentioned by Garstang, and again Esin may have established the dating from notes or a label. Toggle pins do not occur this early, though on that basis alone it does not invalidate the dating. While the awl is a likely occurrence, the other two finds are possible mis-stratifications.

One roll-headed pin (A-388) from level XVI is published by Garstang, 1953:139, fig.85 (R.N.1331), and it contains As 1.1 % and Sn 0.75 % (E-17877). This percentage of tin is lower than what would classify it as a tin-bronze, but this amount of tin does not normally occur in copper ores, Patterson, 1971:314-15, and could be considered an intentional inclusion, though, admittedly, it is a borderline case. Muhly, 1976:89, has opted to disregard these bronzes as valid indication of intentional alloying (but see Muhly's letter in N.Y. Times Magazine, Aug.3, 1974:41,46), even though it is clear from the analyses of other Late Chalcolithic pieces from Mersin that some change in smithing practices is taking place at this time. There is still no reason to reject an earlier view that these are true bronzes from Late Chalcolithic Mersin, de Jesus, 1972:132.

19. For a brief run-down of the copper artifacts at Mersin in the early levels, see de Jesus, 1972:131-2.

20. See n.18 supra.

21. The occurrence of this artifact so early may arouse doubts regarding its correct stratigraphy, as no other fibulae are found at Tarsus until LB II. Nevertheless, Goldman, 1956:286, is sure of her dating. The only other EBA fibula recorded comes from Alishar III (see supra) where the excavator is again sure of its stratigraphical position (OIP XIX:208). Otherwise, no fibulae appear elsewhere until the LBA, Stronach, 1959 b.

22. An EB II example is known from Karatas, Mellink, 1967:255, pl.77(22) right. Toggle pins are perhaps more common in Southern Anatolia in EB II than have heretofore been noted.

23. Compare, for example, Goldman, 1956:fig,428(99-100) with Bittel, 1940:pl.II (S 3437).

24. Mellink, 1964; Mellink, 1965:110-112; Goldman, 1956:97, 109, 121; Easton, 1976:157-8.

25. Bi-mould casting is evidenced by a jewellrey mould attributed by Schliemann to Troy I (A-685). Tin-bronze is shown by the analysis of a bracelet (A-586).

26. Troy I metalwork (N.B. not a complete list):

a. Copper pins: 1) A-556
2) A-488
3) A-505
4) <u>Troja</u>, no.12
5) <u>Troja</u>, no.13

b. Silver pins: 1) <u>Ilios</u>: no.112
2) <u>Ilios</u>: no.121

c. Bronze bracelet: A-586

d. Knives with curved blades:
1) <u>Ilios</u>: no.117
2) <u>Ilios</u>: no.119
3) <u>Ilios</u>: no.118

e. Copper blade with gold gilt : A-100

27. Flat axes in Troy II (N.B. This is not a complete list):

1) <u>Troja</u>: no.81 (Troy II)
2) <u>Troja</u>: no.80 (Troy II)
3) A-187 - 188 (Troy IIg)
4) A-191 - 193 (Troy IIg)
5) A-195 - 198 (Troy IIg)
6) A-202 (Troy IIg)
7) A-205 - 210 (Troy IIg)
8) <u>Ilios</u>: no.810 (Troy IIg)
9) <u>Ilios</u>: no.601 (mould) (Troy IIg)
10) <u>Ilios</u>: no.599 (mould) (Troy IIg)

28. Examples of à jour casting in Troy IIg:

1) <u>Troja</u>: no.83 (Bracelet from Treasure K)
2) SS 6481 (shaft-hole axe with a jour shaft collar)

Cire-perdue cast figure: SS 6054 (=Troja: no.84) from Treasure K.

29. It is not certain from which direction that the double-spiral pins arrived at Troy. Examples of double-spiral pins in Troy IIg:

1) A-439 -442
2) Blegen <u>et al</u>, 1950, IL367, no.37-709

For a wide distribution of this pin type in the Near East, Huot, 1969.

30. The toggle pin seems to be a Syro-Cilician development. Examples of mushroom-headed toggle pins in Troy II:

1) Troja: no.65
2) Troja: no.64
3) Blegen et al, 1950, I:305, no.36-245 (Troy IIf) (Fragment of shank only. Reported as "bent wire").

31. Arrowheads first appear in Troy II, possibly near the end of the period:

1) A-289
2) A-290 (from Temple A)
3) A-291 (ivory)

Three more are listed by Schmidt (SS 6448, 6449, 6450), but he places them in Troy VI and calls SS 6450 undated. A mould (A-689) from the "Burnt City" suggests a barbed arrowhead.

32. Current evidence indicates that this metal type was developed at or in the area of Troy. Examples of knives with curved tip from Troy IIg:

1) A-104
2) Ilios: no.965

33. The only example of the shaft-hole axe-adze from Troy IIg, SS 6481. It is possible that this tool was one of the four that Schliemann found in the "Burnt City" (Ilios:506) and that Schmidt has mis-interpreted this find (see n.34 infra).

34. The only example of the shaft-hole axe-hammer from Troy IIg, SS 6479. It is possible that this tool was one of the four that Schliemann found in the "Burnt City" (Ilios:506, no.958) and that Schmidt has mis-interpreted this find (see n.33 supra).

35. A-134 and Stronach, 1957:fig.1, nos.12, 13, 15.

36. A-113 and SS 6154, 6153, 6146, 5855.

37. My thanks goes to Mr. D. Easton for his advice on the stratification of these finds. For a different view of the dating of the Trojan material, see P. Calmeyer, Iraq 1977:87-97.

CONCLUSION

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A. The Initial Steps

In Anatolia the first awareness of metal is witnessed at Cayönü-tepesi where the copper reamers and awls (A-1) are dated to ca. 7000 B.C. (Braidwood and Çambel, 1970:51). It has been determined that they are made of native copper which was possibly obtained in the area of the Ergani Mine (S-121). It has not yet been established whether these artifacts had been heat treated (i.e. annealed) in any way; so, we cannot yet speak of pyrotechnology at this time. However, the use of fire as a means to forge native copper and later to melt it was probably not long in coming.

At Catal Huyuk a smelting slag is reported (A-612) along with numerous small pieces of copper used as decorative items (de Jesus, 1972:130). These finds span levels IX-VI (ca. 6400-5880 B.C.)[1]. The piece of smalting slag is from House E in Level VIA 1 and appears to be an isolated find in that particular area of the excavation. In view of the absence of piles of slag which we normally associate with a smelting operation, there can be some doubt raised as to whether smelting took place in this part of the town. The piece of slag could have easily been picked up elsewhere and casually dropped where it was found. Speculation aside, the analysts of this artifact claim that it is a smelting slag (Neuninger <u>et al</u>, 1964), and there is no reason at this point to cast any doubts on their conclusions. Production of smelted copper at this stage of metallurgical development was no doubt small, simply because copper as a material had not yet been realized for its full potential, and other materials served quite adequately. Somewhat later in time, Hacilar bears witness of using copper metal much in the same way as other Neolithic settlements, i.e. for decorative items and small tools (Mellaart, 1970:153).

The pace of metallurgical development in the Neolithic and the first part of the Chalcolithic (i.e. ca. 6000-4800 B.C.) appears slow. Even though smelting had been known for more than a millennium by the end of this period, there does not seem to be much of a follow-up. However, this could be due to archaeological chance, since it is only on Çatal Hüyük, Hacilar, Can Hasan and Mersin that we are basing our impression. The full-scale excavation of an important site, such as Çatal Hüyük, could alter the picture considerably.

As far as the archaeological record is concerned we must wait until about the first quarter of the 5th millennium B.C. before we see a hint of some kind of metallurgical progress. From Can Hasan we have Anatolia's first copper macehead (A-168)(Plate XXVII(1)) and possibly the first example of shaft-hole casting, if not simply casting itself. Although the analysis of this object has shown it to be relatively pure copper -- and, hence, considered native copper -- we suspect that smelting, melting and casting are now practiced. But just how wide-spread these techniques are, it is not possible to say. Later in the Late Chalcolithic period (ca. 4300 B.C.), we have more evidence of a quickening pace of the metallurgical industry as a whole. From Mersin XVI-XIII come a number of pins and a seal, attributed to Level XVI (but see Chapter 7 "Mersin" n. 18), which indicate the introduction of bronze. At this moment, we do not know where the source of tin is, nor do we know where the bronze technology originated, but it is likely that we are dealing with a Near Eastern development limited to Anatolia and the fringes of North Syria.[2] Local metallurgical centers are probably common at this time, and it is discernable from this period onwards that Late Chalcolithic cultures of Anatolia continue their steady development of the metallurgical technology which the Early Bronze Age was to inherit. Sadly, it is the Chalcolithic period on which we have so little documentation. Late Chalcolithic copper mines and smelting sites are unidentifiable in our data, but they no doubt existed at this time. The use of copper is wide-spread, and copper objects objects occur at Can Hasan in all the Chalcolithic levels. This shows that a veritable metals trade was in operation.

The southern, southwestern and western orientation of our documents in the Neolithic-Late Chalcolithic suggests that the copper sources of the settlements (i.e. Çatal Hüyük, Can Hasan, Hacilar, Mersin, and Beycesultan) were not outside these areas; yet, apart from a few copper deposits, little is known about the mineral wealth of this part of Anatolia. In the West, the copper deposits at Seki (S-115), Bülbüller (S-116), Seydiköy (S-117), and Kizilca-Afyon (S-118) give evidence of former working. Kizilca-İcel (S-125) in the South likewise has remains of former working. Elsewhere, only deposits are known, such as Haliferler (MTA, 1972:117) in the South, Karakilise (MTA, 1972:104) in the Southwest, and Kocak (MTA, 1972:100) in the West. Future geological prospection may reveal copper deposits which tie in more closely with Neolithic and Chalcolithic metallurgies. Although not impossible, it seems hard to imagine copper metal being traded from the main copper-bearing areas (see Map 21), particularly if we accept the idea that western and southwestern deposits could meet local demands.

From the 7th to the 5th millennium B.C. the rest of the Near East was far from dormant in the field of metallurgy. The copper bead from Tell Ramad I in Syria can be dated to ca. 6500 B.C. (France-Lanord and de Contenson, 1973:107-115), and a similar find in Iran at Ali Kosh (Hole and Flannery, 1967:177) is close to this in date (ca. 6750-6000 B.C.). In North Mesopotamia from Tell Sotto[3] phase III comes a piece of native copper which dates to the pre-Hassuna period; and slightly later, dated to the early Hassuna period, Yarim Tepe VIII yielded pieces of copper ore and a copper bead (Munchaijev and Merpert, 1973:9). From Tell Shemshara Level 12 comes a lump of what seems to be copper ore (Mortensen, 1970:123) which can be placed somewhere in the first half of the 5th millennium B.C. From the lowest level at Tell es-Sawwan (Al-A'dami, 1968:59) come three copper beads and one piece of native copper, and from Level II comes a knife blade with a rivet hole for a handle. These artifacts date from the middle to the end of the 6th millennium B.C. and occur roughly within the period between Tepe Sotto III and Yarim Tepe VIII. Although these finds represent only an awareness of copper and copper ore, they are the only indications we have -- outside of Anatolia -- of the first steps towards regional metallurgies.

The supply of copper to these sites has been put in relation to the obsidian trade which reached, among other, Tell Ramad, Tell Shemshara, and Ali Kosh (Renfrew in Mortensen, 1970:142; Renfrew in Hole et al, 1969:429-433; Mellaart, 1976:82-3). The occurrence of both copper ore or metal and obsidian implicates Anatolia, as both of these materials occur in the eastern part of the country. However, where we can readily accept Anatolia as being the source of obsidian, it is only by inference that we can say that Ergani was the source of Mesopotamian copper, as pointed out by Wright (1969:21-5, esp. 54-6). It is due largely to the unfamiliarity with other Anatolian and Near Eastern copper deposits that authors have consistantly singled out Ergani as the source of early copper. In the case of Tell Ramad the copper could have come from the Timna area. Ali Kosh could have taken advantage of the Western Iran deposits -- in the areas west and south of Kerman, or even closer, on the eastern side of the Zagros in the area west of Kashan (Bazin and Hübner, 1969:pl.XXV).

B. Transition and Assimilation

The period between ca. 4300-3500 B.C. is a crucial phase in Anatolia's metallurgical development, but again we are unfortunately deprived of documents. Our basis for saying that important developments took place in this period relies on what we might call "archaeological reckoning." Using EB II as a reference point, we must account for a certain amount of development prior to that time. There are also a few indices. Kalinkaya, an EB I site just north of Alaca, has provided some pieces of metalwork (as yet unpublished) which suggest a regional development. A shaft-hole axe (A-229) and a mace-head or hammer (A-176) have, as yet, no parallels elsewhere at this time, and it is possible that they are examples of a developed Late Chalcolithic metallurgy in the Pontic region. This metallurgy could be ancestral to what we find at Alaca in EB II.

We may wish to see this period as one of transition and assimilation of metallurgical techniques. The metallurgies which thrived in the Late Chalcolithic - EB I period may have been gradually obliged to gravitate around (i.e. rely on) the large, rich deposits. When only a small output of copper was required, local metallurgies could subsist, even develop a certain number of their own techniques, such as the metallurgical industries which supplied Beycesultan, Can Hasan, and Mersin. But as the use of copper increased, the small metallurgical centers (i.e. mines and smelting complexes) could not satisfy the expanding demand. It was at this point where the massive deposits or the localities of many small deposits took on their importance. Due to the copper-producing potential of these deposits, local and regional Late Chalcolithic metallurgies moved in to develop them, which resulted in a kind of pooling of their respective technologies. The common link between these regional metallurgies would have been, then, their area of supply.

If distance and geographical factors are appropriate criteria, we can isolate certain deposits, or groups of deposits, which might have been areas of intensified exploitation (see Map 21). Ergani, Murgul-Kuvarshan, and Küre are the obvious massive deposits, each with a number of smaller deposits around it. The numerous small deposits of the North Anatolian coast would have constituted another point of gravitation which we will call the Giresun-Trabzon Group; and the Pontic region with Kozlu at its center would be yet another group. The Yaprakli deposits could make up a smaller Central Plateau Group. On Map 21 the arrows represent possible directions of supply or trade paths, but the groups and these trade paths are purely hypothetical and will remain so until tested by archaeological documentation.

The Ergani Group could have had links with both the Mesopotamian plain and the Anatolian interior. The Keban sites could have benefitted from this group, but it must be pointed out that a few small deposits exist north of this area as well. The Murgul-Kuvarshan Group may have been the supply area for Eastern Anatolian cultures, but its proximity with the Causasus may have permitted Caucasian communities to use it as a source also. The Giresun-Trabzon Group is in an ideal position to be the supply for a sea Trade along the coast, otherwise it is hemmed in by the North Pontic Mountain Range. The Tokat Group was probably the area of the Pontic culture copper supply, and after EB III it could have supplied, in part, the Central Anatolian Plateau. It is also somewhat isolated by the physical features of the area; and, therefore, it could have remained an enclave for a long time before being opened up to trade with the Plateau. The early EBA metalwork known to have come from this area, in fact, suggests an internal development.

We may wish to see the Yaprakli Group as an area of supply for some Plateau sites, particularly those on the western side of the Halys in the area of Ankara. We must not forget, too, the important site of Karaali (S-85) which, although off by itself, could also have been a source of copper for the Plateau. The Küre Group, including Cozoğlu (S-9), is in an area about which we know very little archaeologically. As it is cut off from the rest of Anatolia by the İlgaz Dağlari, it probably did not play a role in the supply of copper to the EBA cultures we currently know. Northwest Anatolia is not highly endowed with deposits, as we have seen, but there are a certain number of copper sources which could have been adequate to support some local metallurgies (see Maps 7 &8). However, these deposits were probably not extensive enough to supply the regional metallurgy we associate with Troy and the Troad in EB II. Hence, by this time some importation of raw copper into the Northwest appears likely. This copper could have come from SE European deposits (Gaul, 1942; Maczek et al, 1953; Jovanovič, 1972; Chernih and Raduncheva, 1972) or from the North Anatolian coast (Map 21).

This leaves the rest of Anatolia to fend for itself for the supply of copper. As far as we know, the deposits in the West and Southwest are isolated one and could have satisfied only local demands. By themselves, they could not have sustained a massive trade in copper. How far, then, can we imagine Eastern, Central and Northern Anatolian copper coming westwards? This is a key question which we are not in a position to answer yet. We can only note that there is a conspicuous unbalance in the amount of copper available in the different regions of Anatolia. The copper-producing potential of the West, Northwest, Southwest and South is limited; whereas in the North, Central, and Southeast, it is limitless. This surely must have had a bearing on the development of prehistoric metallurgy. It is the feeling of this author that in the period between ca. 4300-3500 B.C. local copper metallurgies underwent a slow but deliberate development towards bigger output in copper metal, resulting in technological exchange. All this was afforded by their contact at the common sources of supply, as shown on Map 21.

Not in every case did local metallurgies gravitate towards these large sources. Beycesultan could have been such a case (see Chapter 7 "Beycesultan"), for it does not appear to have associated itself with the bronze metallurgy which characterizes the development of EBA metalwork. Beycesultan was probably able to maintain control over its own copper sources, which allowed it to keep a certain autonomy and independence from developments elsewhere.

If we accept this above reconstruction we will be obliged to deal with a much more complex system of development and trade than what prevailed, for example, on the Iranian Plateau (Lamberg-Karlovsky, 1973:17-18). There, the nature of the trade in natural ressources was central in character, what Lamberg-Karlovsky terms the "Central Place Theory." This simply means that goods or materials originated from single or localized sources and were distributed (i.e. traded) to settlements from central points, as in the case of steatite from Tepe Yahya, lapis from Shahr-i-Sokhta, and copper from Tal-i-Iblis.[4] This contrasts with the Anatolian situation, for not only is Anatolia rich in many types of materials (copper, silver, lead, obsidian, etc.) but the locations of these material are widespread, which affords local or regional production to thrive. But the future of metalworking surely lay with the ambitious production of the rich copper-bearing regions we have designated above.

The presence of tin-bronze at Alishar EB I (A-623, A-553, A-552) clearly shows that tin-bronze technology has by this time reached the Central Anatolian Plateau. This technological advance may have been a result of the interaction between metallurgies in the Late Chalcolithic - EB I period, as suggested above. It had been proposed that a tin deposit may have been exploited by Central Anatolians at this time (de Jesus, 1972:135, n.41). The discovery of high traces of tin in the Bakir Cay slag (S-96) in Amasya Province now reinforces this hypothesis (see Chapter 3).

In the Northwest the use of copper is first noted at Kumtepe IB (Sperling, 1977:356) and continues to be used at Troy I and later periods. In Troy I one tin-bronze is known (A-586), which echoes the use of tin-bronze in Central Anatolia. We do not known from where the Trojans obtained this technology, but it is fairly certain that they were not the originators of it. Troy's first tin-bronze, a bracelet, could have been a traded item from some Northwest metallurgical center trading along the Anatolian west coast. As stated above, we doubt whether Northwest Anatolia had enough copper reserves to support such a center. However, further fieldwork in this area might erase those doubts. The tin-bronze at Thermi I (Lamb, 1936L215, no.31,64) points to the wide-reaching trade in tin-bronze. This early Aegean occurrence is related to the same bronze metallurgy evidenced at Troy.

The occurrence of gold and silver artifacts at Troy show that metalworkers were also busy with other types of metallurgy. The gold-gilded knife from Troy I (Ilios:251, no.120) may have a technological parallel in Southeast Europe where the coating of an earthenware bowl with gold paint is known in the late 5th millennium B.C. (Gimbutas, 1977:49). Goldworking seems to have a longer tradition in Southeast Europe than in Anatolia, and the easily accessible sources of gold there (Hartmann, 1968; Maximov, 1974:339, fig.1; Lipinsky, 1975: Map, p.72) could have provided the conditions necessary for its development as early as the 6th millennium B.C. In any case, it is not inconceivable that goldworking was a Southeast European contribution to the wealth acquired by Troy in the early stages of its existence.[5] It is only later(in Troy II) that Troy began to explore the natural wealth of its inner Anatolian neighbors (see Chapter 7 "Troy"). The cupellation of silver was possibly developed at the beginning of this period (i.e. ca. 4300 B.C.),but it was not widely practiced until much later. Intensive search and exploitation of precious metal deposits probably did not take place until EB I (i.e. Troy I, Poliochni Azzurro).

The rest of the Near East does not appear up to the same technological level of EB I Anatolian cultures, although it was not far behind.[6] In the period roughly equal to the Late Chalcolithic in Anatolia (i.e. 4300-3500 B.C.), the Amuq in Northern Syria gives evidence of the use of copper tools, usually no more than awls or reamers (Braidwood and Braidwood, 1960:120, 245), inicating that the use of copper had not been extended into the domain of weapons and heavy tools as it had been in Anatolia. We must wait until the G phase before large artifacts appear. Then, we find the six bronze figures of exceptional workmanship (Braidwood and Braidwood, 1960:300-315).[7]

In the Jemdet Nasr period Tell Brak produces a variety of metal finds, including copper sheet metal (Mallowan, 1949:97), silver tacks covered with gold foil (Mallowan, 1947:93 ff.) and a gold frieze (Mallowan, 1947:93-4, pls. III, IV, L(1)). In Northern Iraq, Tepe Gawra produces some 4th millennium B.C. finds which include awls, a number of flat axes, and small jewellery pieces of copper, electrum, and gold (Tobler, 1950:193, 212-3). Nineveh (Mallowan, 1933:132, 145) and Arpachiya (Mallowan and Rose, 1935:104; and Appendix VII) likewise produced 4th millennium B.C. finds. Other Mesopotamian sites show similar steps towards the common use of metal at this time which point to firmly established metallurgies and trade throughout the land of the two rivers.

In Palestine Abu Matar has given evidence of smelting and metal-working towards the end of the 4th millennium B.C. (Perrot, 1955:79-80). Ore, smelting furnaces, slag, crucibles and some metalwork constitute the full range of equipment. In the Levant the most significant finds are those of the Nahal Mishmar hoard found in a cave in southern Palestine (Bar-Adon, 1962) which as been variously dated from Ghassulian (i.e. 4000-3500 B.C.) (de Vaux, 1966:32) to the "latter part of the 4th millennium B.C. (Muhly , 1976:88) to the first centuries of the 3rd millennium B.C. (Seeden, 1970:48). The C-14 dates suggest that the end of the 4th millennium B.C. is likely (Bar-Adon, 1971). This hoard carries with it its own inherent problems, as it stands out from other Palestinian metalwork and is clearly an intrusive group. The best parallels of the metalwork do no occur until much later, and on ceramic pieces, not metal. In passing one need only point out the stricking similarities between the perching birds on metal "crowns" with the birds that appear on EC I pottery from Vounous (<u>Archéologie Vivante - Chypre</u>, p. 52 (VII)). The bucrania also find close parallels on EC I-II pottery (cf. Ishiguro, 1976:pl. 210; and Karageorghis, 1971: figs. 3 and 4). On the Mishmar metalwork even the incised chevrons and other decorative motifs appear Cypriot in character. It would be difficult to reconcile these parallels unless the date of the Mishmar metalwork were lowered to about the first half of the 3rd millennium B.C., which, in fact, is what Seeden (1970:48) advocates. On the other hand, these parallels aside, it would not be beyond the ability of the metalworkers to produce pieces of this workmanship in the 4th millennium B.C., particularly in view of the advanced metallurgical technology of Anatolian smiths at that time. There is nothing Anatolian about the Nahal Mishmar material, which obliges us to consider the existence of a metalworking center operating somewhere in the Levant. The date of its production will have to wait for clarification by more documentation.

C. The Flourishing

In the EB II period Alaca is the most representative of the southern extension of the Pontic culture.[9] The excavations failed to turn up any moulds or metalworking equipment at the site, which means that none of the artifacts from the tombs was produced there. Alaca holds a special significance for us, since it is, by far, richer than its contemporaries, which suggests a monopoly on the ressources of the Pontic Group deposits (Map 21). This is the same general area where the metallurgical centers may have been located. It was about this time that the copper mine at Kozlu (S-97) was in operation, but it could have been first opened up as early as the Late Chalcolithic. The vast amounts of copper known at Alaca is indicative that many deposits, not only Kozlu, were being worked at this time and that possibly whole communities were involved in the metallurgical industry. As yet, we do not know whether Pontic mines were a direct undertaking of settlements, or whether mining was carried out by another group of people who made it their livelihood to trade with the Plateau settlements.

Gold and silver deposits were also exploited in abundance in EB II, but so far the only silver deposit known in the Pontic region is Gümüş (S-130). The gold may have been traded from the deposits in the West (see Map 11). The gold ear studs from Eski Balikhane (Plate XXV (4)) suggest some kind of East-West link, possibly related to the trade in gold metal from this area; however, other archaeological parallels are lacking. It could be that some gold deposits, as yet unknown to modern geologists, exist in the northern provinces of Tokat, Amasya, Samsun, and Çorum from where Alaca obtained its gold.

Although contemporary in date, Alishar EB II (Levels 10M-8M) was clearly of a different culture which was not endowed with the same degree of wealth. Its affinities lay with the South, possibly as a result of Alaca's powerful dominance over the north side of the Plateau.

Southwest Anatolian metalwork in EB II is represented only by Karatas, and a few stray finds. From this we cannot yet tell whether it was a product of a southwestern metallurgy or whether it was dependent on another regional metallurgy. Karatas relied on trade for all of its metalwork. It is certain that no smithing was performed in the settlement, as no moulds or smithing equipment were found there. This is likewise the case at Kusura farther north and possibly at Pekmez (Aphrodisias) in the West. The present evidence suggests that in the Southwest, and to a certain degree in the West, trade was responsible for bringing metalwork to settlements.

At Karataş, there are some affinities with western metalwork, particularly in the case of the knife with twisted handle (A-101). One also occurs at Beycesultan XIII (see Chapter 7 "Beycesultan") where it is approximately contemporary. The wide-tanged dagger with pronounced midrib (A-150)(Plate XXIV (6)) has parallels with the Bayindir daggers (A-134);and Stronach, 1957:fig.1, nos. 12, 13, 14); but this type also occurs at Alaca (A-154) in silver. The Southwest may have relied on both the West and the Central Plateau for its metalwork, but there seems to be a slightly greater leaning towards the latter. The gold ear studs from Karatas seem to be a Central Anatolian feature, even though they are known elsewhere.[8] The white-on-red painted pitchers from Karataş recall the silver and gold pitchers from Alaca and Mahmatlar tombs.[10] Could these parallels suggest the direction from which some southwestern metalwork was coming? There are many influences at work here, but the evidence does not permit us to unravel them.

In EB II the Northwest provides us with a great abundance of metalwork. Production must have been lively at this time, which suggests a steady supply of metal. As we have stated above, the northwestern sources of copper remains unconfirmed, although in part some copper could have come from the region. Balya Maden (S-151) could have been a northwestern source of precious metal, but this is still just a suggestion. A mixture of styles and elements characterize Trojan metalwork, and it is for this reason that it is thought that a number of metalworking traditions are manifested there (de Jesus, 1972:136-7).

Troy II obviously benefitted from some Central Anatolian and Pontic metal forms, namely the slotted spearhead, the wide-flanged dagger and perhaps even the technique of shaft-hole casting. These innovations would not have reached Troy until after the destruction of Alaca 5, at which time the Central Anatolian and Pontic metallurgical industries possibly looked westwards at an expanding market. It would be, then, in the latter part of EB II (ca. 2700 B.C.) that Northwest Anatolia began receiving the Central Anatolian metal types, and possibly the copper metal, as well. The destruction of Troy IIg must have affected the metal supply to the region. It is possible that another power cut off the main trade route between East and West. Many small kingdoms appear to have existed at this time, and they were not always on the best of terms, judging from their fortifications. After its destruction, Troy was allowed to continue as a settlement (i.e. Troy III), but in a much more impoverished state. It may have been no more than a vassal of a younger, stronger power, such as the one represented by the finds at Dorak. Could a Dorak-type kingdom have cut off Troy's prolific metals trade in the East? Geographically and date-wise it is possible.

The finds of Dorak indicate links which extended farther than Troy's did. The arm chair with gold plate and the cartouche of the Pharaoh Sahure (2487-2473 B.C.) points to the fact that Egypt must have held the Dorak kingdom in high esteem. As Mellaart(1959:754) states,"This piece of Egyptian furniture undoubtedly represents a Royal gift and is the first piece of evidence of contact between the seafaring population of North-West Anatolia and Egypt in the Third Millennium B.C." Judging from the rich tomb material, the

Dorak rulers had access to precious metals and materials, and they may have monopolized by force the prolific East-West trade that was once Troy's source of wealth. Briefly, Dorak was a power to be reckoned with, by virtue of its seapower, its wealth, or both.

In Cilicia it is only in EB II that we have any significant feature in the metalwork; this is the introduction of the perforated pin, or toggle pin. This item found a greater popularity with the Levant than with Anatolia. A few examples do occur on the Central Anatolian Plateau (see Chapter 7 "Alishar)(A-516, A-518), in the West (on Samos, Milojčić, 1961:pl.50(4)), and in the Northwest (Troja: no. 64)(A-517) in EB II, but they are clearly imports from Cilicia.

The turning point in Central Anatolia came with the appearance of a painted pottery in the southern part of the Plateau (Mellaart, 1967:33). This pottery, first monochrome and later polychrome, is termed Intermediate Ware at Alishar III and is the earliest phase of the so-called Cappadocian Ware. It appears to have been a Central Anatolian development out of a simple painted found at Alishar Ib and more particularly at Kültepe which is considered its home (Mellaart, ibid.; Özgüç, 1963:13). The spread of this pottery can easily be interpreted as the growth and spread of a very influencial culture, but which ultimately ran into friction with the powerful state of Alaca. Mellaart (ibid.) suggests that the users of early Cappadocian Ware were possibly responsible for the destruction of Alaca 5 (i.e. the Royal Tomb Culture). The occurrence of early Cappadocian Ware (i.e. Intermediate Ware) in Alaca 4 (Koşay, 1951:142-3) enhances Mellaart's theory.

The consolidation of power by the Cappadocians took place in the course of EB III and was an important phase in laying down the ground work for what was to follow: the Assyrian colonies. Already in the early stages of EB III close relations with Northern Syria and Assyria were being established by Central Anatolian settlements. The sophistication of these southern cultures appealed widely to the Cappadocian people, and they were keen to associate with them.

The hoard of jewellrey from Eskiyapar probably dates from this period (A-334-338, A-405, 406). The material is yet unpublished but is displayed in the Ankara Museum. Information is also conveyed by Mellink (1970:161). The silver bottle (A-337) from this hoard shows North Syrian connections, which is in accordance with the general picture in EB III. There are also one electrum bead (A-405) and one gold bead (A-406), both quadruple spiral in style, which again point to North Syria. By the end of EB III the Assyrian culture had a firm link with Central Anatolia, and in MB I the foreign entrepreneurs arrived.

The metalwork of EB III has a definite commercial look about it (see Chapter 7 "Alishar"). With Alaca out of the way, Central Anatolian settlements may have been able to encroach on some of the copper deposits to the north, i.e. in the Yaprakli Group or in the Pontic Group (see Map 21). Horoztepe represents the EB III continuation of the Alaca culture which, has now returned to its homeland in the Pontic region (de Jesus, 1972:139-140). Commercialism was the rule of the day, and alliances were established throughout Central Anatolia, much to the detriment of small settlements which were neither strategic nor rich in natural ressources. Apart from Horoztepe, this period is but a small reflection of Central Anatolia's former metallurgical accomplishments. Commercialism could not provide the incentive to produce the luxurious items of the Pontic culture of the previous period, which points to the contribution of autocratic rule to the development of metallurgy. Where kingdoms concentrated wealth and power and demanded a high degree of excellence from its craftsmen, trading states thrived on a mass movement of goods, and the incentive came from profit. The latter case left little room for creativity. The Pontic culture was snapped off at its flowering stage by stronger powers, but if it had been allowed to continue freely, the culmination of the Early Bronze Age in Anatolia might have been totally different.

Notes to Conclusion

1. Dates used here are based on Mellaart, 1967:52.

2. It had been previously suggest that the introduction of tin-bronze metallurgy might have come from a "Halaf" area, de Jesus, 1972:134, but the recent analysis of a Halafian chisel from Arpachiya shows it to be unalloyed copper with traces of Ni (see Appendix VII). The absence of tin in this artifact renders a Halafian tin deposit a little more remote, although it is still an outside possibility.

3. See "Excavations in Iraq 1973-4," Iraq XXXVII, pt.1, pp. 65-6.

4. One feels that perhaps in the case of copper, too much emphasis has been placed on Tal-i-Iblis as a central point of distribution. It seems unlikely that Tal-i-Iblis could control all the West Iranian copper deposits (see Barzin and Hubner, 1969: pl.XXV) Despite this, Lamberg-Karlovsky's interpretation may gain in general acceptance, i.e. Beal, 1973.

5. The material from the tombs at Varna is an appropriate indication of what pre-Bronze Age smiths were capable of producing: shaft-hole axes of copper, gold gewellery, gold scepters, and decorative gold plating, Gimbutas, 1977.

6. The only exception to this could be the controversial Nahal Mishmar hoard, see infra. Near Eastern finds are best summarized by Bjorkmann, 1968:17-64 and Perkins, 1949.

7. Seeden, 1970:56-60, feels that these figures should be placed after phase H due to the circumstances of their recovery. This would place them in the region of ca. 2500 B.C.

8. A list of parallels are pointed out by Mitten and Yüğrüm, 1969: 194, n. 3, as follows:

   Karataş-Semayuk, near Elmali, Lycia; M.J. Mellink, AJA 73 (1969) 323, pl. 74, fig. 16, KA 701 N a,b; max. h.:0.022 m;

two pairs were found, both with child burials. Yalincak-Koçumbeli, near Ankara: M.J. Mellink, AJA 70 (1966) 148. Karayavsan, between Polatli and Haymana; M.J. Mellink, AJA 70 (1966) 148. Alaca Hüyük: M.J. Mellink, AJA 73 (1969) 323 n.10; Remzi Öğüz Arik, Les Fouilles d'Alaca Höyük 1935 (Ankara 1937), pl CLXXIX, Al 317-38, from Tomb B. Yortan region, in H. Kocabaş Collection, İstanbul: M.J. Mellink, AJA 73 (1969) 324 n.13: one pair, smaller than the ornaments from Karataş, and an example in stone. Mellink, AJA 73 (1969) 323-324, notes the widespread diffusion of this simple type of Early Bronze Age Jewellery throughout much of Anatolia.

9. The Alaca tombs are considered here EB II in date (i.e. ca. 3000-2700 B.C.). This is nominally higher than many authors normally place them. The stratigraphical position of the tombs definitely limit their deposition to a period prior to the destruction of Level 5, Mellink, 1956:43, n.9, and hence, before the period we designate as EB III. If we accept the two C-14 dates of Level 5 (3390± 58 and 2950±58 B.C.) as being roughly indicative, there is no problem in seeing the Alaca tomb material as corresponding to the middle of Troy II. This equation is reinforced by the C-14 dates from Karataş, their average date in EB II being ca. 2940 B.C. There are parallels between Karataş EB II and the Alaca Tombs in the form of the so-called ear studs. See note 8 supra.

10. Compare, for example, Mellink, 1966: figs. 12, 13, and Mellink, 1968: figs. 32, 33 with the Alaca and Mahmatlar pitchers on Plate VIII (1)(2)(3).

BIBLIOGRAPHICAL NOTE : Sources of Research

The references listed in the following bibliography are too numerous to be considered a manageable starting point for anyone else undertaking the study of ancient mining and metallurgy in the Near East. First of all, the bibliography is mainly concerned with Anatolia, even though some works overlap into other areas. It is hence, desireable to point out here in this Note the significant studies which treat this subject and where other bibliographies can be found. Some works on ancient metallurgy are well-known, but unbeknown to the uninitiated, they are unreliable or seriously outdated. Others are of unequal value. These will be pointed out below, so that any future study may avoid some of the pitfalls propagated by modern scholars.

The study of the geology of Trukey is in full swing, and many excellent works in English, German and French are currently available. The most up-to-date book is that edited by A. Campbell (1971) which brings together a number of good studies on different aspects of the geology of Western Asia, since the founding of the Turkish Mineral Research and Exploration Institute in 1935. Many good studies had also been published before this time when Turkey was still under the Ottoman Empire, such as De Launay (1911) and Cuinet (1894). Early studies on minerology and ore distribution are still valid for the most part, particularly Karajian (1920) and Chaput (1936). An often-cited study on Turkish minerals and ores is Ryan (first published in 1957 and again in 1960), but it has one principal failing in that it does not give specific references to the reports on the deposits it discusses. Ryan obtained much of his information viva voce from geologists who were working in Turkey at the time he was there. One has the impression that some of the information he gives is faulty. Nevertheless, it is a very useful work for an initial approach to the subject.

Some well-informed travellers-cum-geologists have provided much useful information, and they have been often quoted in this thesis. Both Hamilton (1842) and Smyth (1845a, 1845b, and 1850) travelled extensively throughout Turkey and made many observations which are referred to (sometimes erroneously) by later authors. Smyth travelled on horseback in Eastern Turkey and provides us with his impressions of local customs as well as a precious account of post times between points.

The publications of MTA (1964, 1970, 1972) provide us with handy summaries of ore and mineral distribution as well as map references. In this thesis, particularly MTA (1970) and MTA (1972) were used. MTA also publishes annually a geological journal both in Turkish and European languages (International Edition). The most up-to-date geological information can be obtained from this publication (i.e. Bulletin of the Turkish Mineral Research and Exploration Institute (Ankara)). J.C. Dewdney (1971) gives a clear account of the geography of Turkey. A few of Dewdney's maps are used here.

Concerning studies on mining in antiquity, the 16th century monk, Georgius Agricola (1950) provides us with a valuable treatise with wood cut illustrations. The English translation of the 1556 edition by H.C. and L.H. Hoover (N.Y., 1950) is an admirable feat of scholarship. The Hoovers furnish us with half again as much text in terms of footnotes and references. Second to this in terms of sheer bulk of information regarding ancient metallurgical techniques is found in Partington (1935) whose book no doubt provided the basis of another excellent study of a similar nature, Lucas (1962).

Although full of information, the works by Forbes (1950, 1963, 1967) are a good example of how preconceptions and over-zealousness can lead to inaccuracies. From the point of view of this thesis Forbes has been proven to be only about 50 % reliable. Armchair archaeology is definitely useful, but there is no substitute for fieldwork and careful research.[1] Nevertheless, Forbes' studies are a valuable source of bibliography, particularly Forbes, 1940, 1942, 1952 and 1963. Forbes' accounts of ore distribution are very casual and, hence, innaccurate.

More recently published is Muhly (1973; and now the supplement to this volume, 1976) which is a basic study of the problem of copper and tin in antiquity. Muhly's work pulls neatly together practically all the pertinent references to the study of copper and tin ore distribution in Europe and the Old World. It is in itself a mine of information and a concise appraisal of ancient metallurgy. Muhly's study fails to a certain degree in the sense that it deos not take full advantage of the material published on ore distribution in Turkey.

On the technical aspects of ancient metallurgy the most useful (and comprehensible) is Tylecote (1962). Although basically concerned with British metallurgy in historical times, the theory discussed in this book is applicable to other areas of the world. Also good for the introduction to metallurgical principals and practices is Gregory (1943). Although an old book and not concerned with archaeological problems, it is concise and readable. For the analyses of Anatolian metalwork Esin (1967) is the basic publication. Professor Esin provides us with a very good range of materials from some of the earliest known pieces to the latest (Roman), but the bulk of her material is restricted to the Bronze Age. The publication is cumbersome to use as a reference work, and there are many misprints and reference errors, which unfortunately invalidate a number of the analyses. The Troy I material appears in the catalogue, but the analyses are not included. A plate volume was planned for this study, but it never appeared.

The best catalogue of Trojan metalwork is still Schliemann (Ilios), even though Schmidt (1902) catalogued the material which went to Berlin. Schmidt (actually it was Goetze who wrote the metalwork section) for some reason took it upon himself to "re-stratify" the material as it best appeared to him, and obviously did not consult thoroughly Schliemann's accounts. The Samlung contains in the index a concordance of Schmidt's catalogue numbers with those of Schliemann, but it is unfortunately plagued with inaccuracies. Much of what Schmidt placed in the vague stratigraphical period Troy II-V can be recuperated by cross-checking with the works of Schliemann (Atlas, Ilios, and Troja).

Moreover, in his descriptions Schmidt obscured many useful details which are clearly expressed by Schliemann. Unfortunately, the convenience and apparent corrections in Schmidt's catalogue have convinced most scholars of his re-classification.

Schliemann's Atlas Trojanischer Altertümer published in Leipzig in 1874 is a very helpful tool to the stratification of material which is later catalogued by Schmidt but often not mentioned by Schliemann in either Ilios or Troja. The Atlas may, however, be hard to come by; only 500 copies were published, and it was already out of print only three months after its issue.

Przeworski's Die Metallindustrie Anatoliens in der Zeit von 1500 bis 700 vor Chr. was originally published in Leiden in 1939 and later issued under Opera Selecta (Warsaw, 1967:69-351) along with other of his writings. Przeworski had intended to summarize the available data up until his time, but carelessness and oversights unfortunately mar this goal. Apart from the casual dating he attributes to some of the metalwork, his republishing of the available analyses is inaccurate. In some cases he has attributed the wrong analysis to the artifact, and in other cases he erroneously records the figures. In addition, the way in which Prweworski has tablulated his data it is not certain what elements were looked for in the analytical process and which elements were simply absent. To overcome this, the reader must refer to the original publication of the analyses.

From the point of view of archaeological material itself the best and still surprizingly comprehensive study on copper and bronze tools is Deshayes (1960). Although the dating is too general to be used for complex chronological problems, Deshayes' two-volume work is easy to use and is rich in references and illustrations. To a much lesser degree Branigan (1974) is reliable as a basic working manual. The illustrations are much too general to be used for comparative purposes, and the analyses he provides do not include complete information on the range of elements looked for, similar to Przeworski's layout. Branigan's artifact catalogue, however, is fairly complete, except for the fact that he relies on Schmidt's catalogue of the Trojan material with its inherent errors (see supra). Renfrew (1967) gives the best concise appraisal of Aegean metalwork and stresses its many independent aspects from the Near East and Southeast Europe in the early stages of its development. These concepts are followed more or less by Branigan (1974). Although written 20 years ago, the best assessment and catalogue of Anatolian weapons is Stronach (1957). Despite some dating revisions now necessary, the general conclusions expressed by Stronach are still, for the most part, valid.

The intricate problems of literary evidence has not been treated here, as they lie outside the bounds of this thesis, both in time and scope. However, occasionally references were made to basic studies on the Assyrian merchant tablets from Anatolian Karums. Garelli (1963), Orlin (1974), and Larsen (1976) were consulted. They provide information on the Middle Bronze Age Anatolian trading colonies.

For the metallurgist Limet (1960) provides precious data on metal-working in Mesopotamia. It is a basic work for that area of the Near East, and the author rightly suggests that the metallurgy of Sumer is not inextricably linked to that of Anatolia, both from the point of view of metal sources and technology. Limet may be considered <u>le point de départ</u>.

The Cypriot material has not been considered in this thesis, although the occasional reference is made to the metalwork of the island, in which case Catling (1964) is the principal source. It is a very comprehensive catalogue of Cypriot material, but unfortunately the author did not see the value of analyses.

A number of unpublished theses have been written on ancient metalwork,[2] and one of those consulted here was Bjorkman's M.A. dissortation (University of Pennsylvania, 1968). This is a very competent piece of scholarship which treats many aspects of ancient metallurgy as well as the philological implications from written texts. In scope, it surpasses Limet (1960), and it provides the first serious attempt at cataloguing Near Eastern metalwork in the Bronze Age. Passing reference is also made to Helga Seeden's excellent thesis on Phoenician metal figures (Seeden, 1970).

To keep abreast of the latest developments in the field of ancient metallurgy and to have references to the recently published analyses, two journals in particular were consulted in the course of research for this thesis, Bulletin of the Historical Metallurgy Society (formerally, Bulletin for the Historical Metallurgy Group) (Newcastle-upon Tyne) and Art and Archaeological Technical Abstracts (New York). These journals provide the best account of the research that is done world-wide.

Notes to Bibliographical Note

1. A rather stringent review of Forbes, 1950 is given by North, 1955, but he gives useful complementary information to Forbes' treatment of ancient metallurgy.

2. Such as:

L.B. Bordaz	The Metal Artifacts from the Bronze Age Excavations at Karataş-Semayuk, Turkey, and their Significance in Anatolia, the Near East, and the Aegean. (Ph.D. dissertation, Bryn Mawr College, 1973).
U. Esin	M.O. Üçüncü ve Ikinci Binyilda Anadolu iğneleri. Tipplojik ve Kronolojik bir İnceleme. (Second and Third Millennium B.C. Anatolian Pins. A Typological and Chronological Examination.) (Doctoral thesis, University of Istanbul).
C. Hillen	The Early Development of Metal-Working in the Ancient Near East. (Ph.D. dissertation, University of Chicago, 1955).
C.C. Lamberg-Karlovski	The Development of a Metallurgical Technology. Documented Early Finds of Metals in the Near East and the Evidence from Hansanlu, Iran. (Ph.D. dissertation in anthropology, University of Pennsylvania, 1965).

But these were not consulted for this present study.

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APPENDIX I

Copper Ore Groups in Turkey
(After MTA)

GROUP I-1a

Age of Deposits: Late Paleozoic.

Type of Mineralization: Lead-copper-zinc mineralization considered more more as iron deposits than copper. Related to granitic grano-dioritic intrusions. Copper accurs as secondary minerals such as malachite, azurite and chrysocolla.

Area of Deposits: Western Turkey. Small areas such as Ayazmant (69/2) and Samli (53/2)*.

GROUP I-1b

Age of Deposits: Late Paleozoic

Type of Mineralization: Quartz veins, related to quartz diorites with chalcopyrites, secondary copper minerals and molybdenite. Generally considered economically unimportant.

Area of Deposits: NW Turkey, particularly at : Çamyurt (35/4) (S-82)
Gümüşçati (52/1) (S-80)
Balcilar (35/4) (S-81)
Doğancilar (52/3) (S-83)

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* But these deposits were probably not exploited for copper. See MTA, 1972:1. For a discussion of these deposits as an iron deposit cf. MTA, 1964:19, and 33-4.

GROUP I-2

Age of Deposits: Paleozoic formations. The area of mineralization is unknown or doubtful.

Type of Mineralization: In the north and northwest, copper deposits often situated in Devonian shales or limestones. Occasionally associated with lead and zinc. Mineralization of these deposits consists mainly of secondary copper minerals such as malachite, azurite, cuprite and native copper. Also remported are chalcopyrite, bornite, covellite and heamatite.

Area of Deposits: Situated in a belt, Istanbul-Hendek-Mengen-Tascopru (i.e. 8/3, 20/4, 21/3, 22/3, 22/4). Other deposits of this type are scattered throughout West and Central Turkey (35/4, 36/1, 37/1, 54/4, 73/3, 77/1, 89/1, 91/4, 129/1, 143/1, 143/3).

GROUP I-3

Age of Deposits: Late Paleozoic (?).

Type of Mineralization: Lead-zinc-copper mineralization located in the contact aureols of granodioritic intrusions of the Late Paleolithic (?) Age. Sometimes these intrusions are associated with skarn minerals. Mostly lead-dominated deposits, but they also contain sphalerite, chalcopyrite, pyrite, and some silver.

Age of Deposits: West and Central Turkey. Especially :
Karakoca 71/1 (see Map 14)
Denek-Keskin 58/1 (see Map 14)
Saadetköy 55/1

GROUP II-1

Age of Deposits: Mesozoic (Jurassic-Cretaceous).

Type of Mineralization: Copper-lead-zinc deposits. Also copper pyrites of Mesozoic (Jurassic-Cretaceous) Age related to diabases (medium-grained basic igneous rock) or other basic submarine flows. The best example of this type is at Küre (7/3) (S-8).

Area of Deposits: Generally limited to the extreme North (i.e. Kure) or in the Lower Pontus region. Ancient workings gave been noted at some of the sites where this ore group is present (see Map 8) :

Kobalkomu 48/1 (S-111)
Helva Maden 47/1 (S-60, see Map 9)
Maden Köy 44/4 (S-101)
Karaca Hasan 58/1 (S-84)
Karaali 57/4 (S-85)
Deposits are also cited in 45/3, 57/4, and 58/1.

GROUP II-2a

Age of Deposits: Upper Cretaceous

Type of Mineralization: Copper-lead-zinc pyrites in vein deposits. Mineralization consists of galena, sphalerite, chalcopyrite, pyrites and subordinate amounts of tetrahedrite. The predominant direction of the veins is between 120-140° (NW-SE). These are generally small deposits.

Age of Deposits: Typical deposits are found in the Fol-Alacadağ Maden area (29/1). Also west of Giresun and in the area of Fatsa. Other examples are noted in 27/4, 28/3, 29/1 and 39/1. Sites on Map 9 which fall into these areas:

Fol 29/3 (S-55, on Map 9)
Langaz 29/4 (S-56)
Kostere Md. 29/4 (S-57)

GROUP II-2b

Age of Deposits: Upper Cretaceous

Type of Mineralization: Copper ore (principally chalcopyrite) and pyrites. Dissemination in breciated dacites (rhyolites = fine to glassy acid volcanic rocks similar to granits and micro-granits). This type of deposit is sometimes quite rich.

Area of Deposits: Northern area of Giresun Province (28/2) and the lower deposits of Murgul Maden (14/3). Sites on Map 9 which fall into these areas:

Karaerik (S-25 on Map 9)
Ağalik Md. (S-28)
İsrail (S-36)
Kepcelik (S-27)

GROUP II-2c

Age of Deposits: Upper Cretaceous

Type of Mineralization: Border deposits of "Grenzlager" type which are located between surface dacites (below) and tuffites (above). These deposits occur with "yellow ores" or "black ores" and consist of galena, sphalerite, chalcopyrites and pyrites. If the deposits are large they can be improtant, i.e. Lahnos (28/2), Harkköy (28/2), or Murgul Maden (upper deposit) (14/3) (S-75)

Area of Deposits: Generally related to Giresun Province. Sites on Map 9 which fall into this area:

Lahnos (S-26)
Kizilkaya (S-31)
Harkköy (S-35)
Akköy Md. (S-38)
Karagöl Yani (S-39)
Eşeli Md. (S-40)

GROUP II-3

Age of Deposits: Tertiary

Type of Mineralization: Small deposits containing copper-lead-iron-zinc in contact zones. Minerals (Basically chalcopyrite and pyrhotite) are intergrown with skarn minerals as well as in oxices such as magnetite and hematite. Occasionally small amounts of iron-rich sphalerite and galena are also found. In general, these deposits are of little economic importance.

Area of Deposits: Mostly situated in NE Giresun Province and N Gumusane Province. Deposits are cited at :

Deregözü Md. (28/4)

Eğrikar Md. 28/4

Girlak Md. 28/2

Sites on Map 9 which fall into this area:

Giresun Province (28/2) :	Kiran-Gebekkilise (S-29)
	Seku (S-37)
	Karabörk Madeni (S-42)
Gümüşane Province (28/4, 29/3) :	Erikâr Md. (S-44)
	Oyaca Md. (S-45)
	Dandi Sapaği (S-46)
	Nicola Ocak (S-47)
	Kiran Md. (S-48)
	Kuru Md. (S-49)
	Melek Md. (S-50)
	Kozköy-Almacik (S-51)
	Çayirçükür (S-52)
	Çağköy (S-53)
	Karaçukur (S-54)
Trabzon Province (29/1, 29/2) :	Zemberek Yaylasi (S-63)
	Ayman (S-67)
	Büyük Ayven (S-69)
	Erikli (S-70)

GROUP II-4

Age of Deposits: Late Tertiary

Type of Mineralization: Related to Later Tertiary volcanism. Seams and thick veinlets are common. Primary minerals are pyrite, galena, sphalerite, chalcopyrites, lolingite and bornite. Secondary minerals consist of limonite, xantosiderite, cuprite, covellite, malachite, native copper, gypsum and manganese oxide. This mineralization may be related (at Isikdag 40/2) to arsenopyrites, pyrites, sphalerite, jamesonite, boulangerite and galena of the same age.

Area of Deposits: İspit-Otlu-Tortum-Senkaya area in NE Turkey. Deposits are cited in 31/1, 31/2 and 31/4.

GROUP III

Age of Deposits: Upper Cretaceous-Early Tertiary

Type of Mineralization: The most important deposit is at Ergani Md. (80/4). The mineralization consists of a massive sulfide deposit with minor amounts of lead and zinc (especially in 80/4, 83/3 and 107/3).

Area of Deposits: Limited to SE Turkey. Deposits are noted at Keydak (80/1) (S-123), Madenköy (83/3) (S-124) and other deposits are cited in 87/1, 97/1, 127/2, 107/3 and 80/4.

GROUP V

Age of Deposits: Early Tertiary

Type of Mineralization: Lead-copper-zinc. Usually small pockets in contact zones or serpentine. Galena and sphalerite mineralizations are also related.

Area of Deposits: Essentially Central Anatolia in the area west of Keban (79/2).

GROUP VI

Age of Deposits: Tertiary

Type of Mineralization: Lead-copper-zinc mineralization in the form of veins and located along shear zones or metasomatic replacement zones in favorable host rocks. This type of mineralization may be economically important. In the past the Balya Mine (S-151) - now closed - was a rich deposit, and mined essentially for lead.

Area of Deposits: Especially limited to NW Turkey. Principal deposits are cited at:
Balya Md 53/3 (S-151)
Karapinar 52/1
Kocayayla 52/2
Deposits are also located in 35/4 and 53/4.

It can be seen from the outline above that the distribution of the groups is in areas of tectonic activity. Group I, the largest in area, tends to restrict itself to the Northern Folded Zone, whereas the deposits associated with Ergani, Group III, seem to limit themselves to an area near or in the Border Folded Zone and the Southern Anatolian Fold.

Native copper can be found at many deposits which may have been worked in antiquity (cf. Map 11). Native copper has been noted at the following sites: Demir Taş Deresi (Tokat-Niksar) 27/3
Uçoluk 42/1
Nurhak Tepe 42/3 (See S-94)
Ergani Maden 81/4 (S-121)
Derekütüğün 41/2

Near some of the smelting sites currently known native copper has been reported (see Map 8) : Tünkes (Artvin) 31/1 (S-79)
Urvay 41/2 (S-89)
Camili (Sivas) 45/3 (S-103)
İrha (Gümüşane) 46/2 (S-59, Map 9)
Kozlu 26/4 (S-97)

These sources are limited almost entirely to Ore Group I (i.e. North and Northeast), except for Ergani. It is certain, however, that in the past native copper was more common. Indeed, deposits mined in antiquity probably had a certain amount of native copper which was readily collected and used.

APPENDIX II

Silver - Lead Ore Groups in Turkey

(After MTA)

The following is the classification of ore types as conceived by MTA. It is an arrangement by geological age of the deposits which roughly follows geographical lines. The silver-lead ore groups are followed by a list of sites which do not fall into these groups but which nevertheless show evidence of silver. The single "+" following the sites indicates a silver content between 100-560 g/ton (i.e. 0.01 - 0.056 %), and they are plotted on Map 14. The double "++" indicates deposits having a silver content of 560 g/ton (0.56 %) or greater, and they are plotted on Map 16. These are deposits deemed rich enough in silver to have been exploitable in prehistoric times. Where no sign appears, silver is not present as a significant trace element.

GROUP I-3

Age of Deposits: Late Paleozoic (?)

Type of Mineralization: Lead-zinc-copper mineralization in the contact zones.

Area of Deposits: Scattered deposits in the Central and Western Turkey.

Deposits have been noted at:

Bergaz (S-146)	52/1		
Karakoca	71/1	+	
Denek-Keskin	58/1	+	
Lök	59/2	+	
Akdağmadeni (S-161)	60/1	++	(% Ag: 0.155)
Veysel	1/2		
Ortacaköy	54/2		
Derbent	88/3	++	(% Ag: 0.1113)

GROUP I-4a

Age of Deposits: Upper Paleozoic (principally Devonian to Carboniferous) (?).

Type of Mineralization: Lead-zinc mineralization in Upper Paleozoic formations. The age of the mineralization is not known.

Area of Deposits: Located in the areas around Gazipaşa-Bozkir-Anamur.
Deposits are noted at:

Yulari (S-154)	142/1		
Karalar-Gümüşdere	142/1		
Yelmezkoy	125/2	++	(% Ag: 0.32)
Fariske Yayla	125/4		
Bozkir (S-158)	125/1	+	

GROUP I-4b

Age of Deposits: Carboniferous or Devonian/Mesozoic-Early Tertiary.

Type of Mineralization: Lead-zinc deposits of Bulgar Dag Madeni are located in Paleozoic crystalline limestones, but the mineralization may date from late Mesozoic or Early Tertiary.

Area of Deposits: Principally Bulgar Dag Madeni and environs.
Bulgar Maden (S-157) 11/3 ++ (% Ag: 1.8 max.)

GROUP I-4c

Age of Deposits: Paleozoic

Type of Mineralization: Lead-zinc deposits associated with Au and Ag. No further details.

Area of Deposits: Such as those of Aladağ situated northeast of Bulgar Md.
Aladag (S-156) 110/2 ++ (?) (% Ag: not reported)

GROUP I-4d

Age of Deposits: Middle Devonian.

Type of Mineralization: Located in a series of black-colored fetid limestones. Generally speaking mineralization is concordant with the bedding of the limestones and are not considered very important deposits.

Area of Deposits: Akçaparmak (S-155) 77/4

GROUP I-4e

Age of Deposits: Paleozoic. (?)

Type of Mineralization: Only isolated occurrences are known, and the type and date of mineralization is not known.

Area of Deposits: Deposits are cited at:

Sofular Köy	53/1 +
Gumuskoy (S-150)	55/3

GROUP IV

Age of Deposits: Upper Cretaceous-Lower Eocene.

Type of Mineralization: Lead-zinc mineralization of Early Tertiary Age and unknown age. Lead-zinc minerals are strongly oxidized. Galena is primary mineral with some secondary smithsonite, cerussite and copper minerals. There may be a genetic relationship with Group III near-by. Deposits are not considered very important.

Area of Deposits: Examples cited are located in the Southeast.

Pirajman (S-168)	81/3 +
Deri (S-162)	81/1

Other unclassified lead deposits in which silver occurs have also been noted. (MTA 1972).

Lead Deposits containing silver:

Yusuflar Maden	14/1	+	
Gümüş (S-130)	25/4	++	(% Ag: 0.375 max.)
Gözeni-Başköy	27/2	++	(% Ag: 0.064)
Kizilev	28/3	+	
Tuzla	28/4	+	
Civriz-Yeşilkaya	28/4	+	
Dere Madeni (Gumusane)	29/3	++	(% Ag: 0.222)
Öğne-Derebaşi (S-142)	30/3	++	(% Ag: 0.15 max.)
İşikdağ (S-129)	40/2	+	
Saryer	45/3	++	(% Ag: 0.195)
Balya Maden (S-151)	53/3	++	(% Ag: 0.212)
Dağdali	112/1	+	
Ortakonuş (S-159)	143/1	+	
Keban (S-163)	79/2	+	
Maden*	55/1	+	

Copper Deposits containing silver:

Latum Maden (S-72)	13/3	++	(% Ag: 0.0849)
Arpalik (S-11)	27/4	+	
Sucuna Maden (S-73)	14/1	+	
Kaşbaşi (S-3)	21/3	++	(% Ag: 0.0898)
Akköy Maden (S-38)	28/2	+	
Eşeli Maden (S-40)	28/2	+	
Karagöl Yani (S-39)	28/2	+	
Güdül	28/2	+	
Kizilkaya (S-31)	28/2	+	
Karakiraz	28/3	+	
Karanlik Dere	28/3	++	(% Ag: 0.0723)
Dandi (S-46)	28/4	+	
Köstere Maden (S-57)	29/3	+	
Harap Maden	83/3	+	

*After Ryan, 1960:6-7.

Analysis of silver objects from Alaca Hüyük (Koşay, 1944:189)

	Ag	Au	Cu	Pb	Sn	Fe	Ni
<u>From Tomb MC</u>							
Lid (?) fragment, Al.MC 69							
Lab. no. 4125							
Kosay, 1944:130, Pl.Cv	93.6	0.4	6.0	0	0	0	0
<u>From Tomb TM</u>							
Fragment, Al. 1801*							
Lab. no. 4128	96.9	0.11	2.99	0	0	0	0
<u>From Tomb MA</u>							
Cup fragment, Al.MA 75							
Lab. no. 4129							
Kosay, 1944:108	95.5	0.62	3.88	tr	tr	0	0
Cup fragment, Al.MA 8							
Lab. no. 4131							
Kosay, 1944:100	90.82	0.32	8.86	0	0	tr	0
(also traces of Ca, Mg)							
Fragment, Al.MA 73							
Lab. no. 4132							
Kosay, 1944:108	83.76	0.96	15.28	tr	tr	0	0
Cup Fragment, Al.MA 19							
Lab. no. 4133							
Kosay, 1944:101	99.0	0.25	0.75	0	0	0	0
Tooth of a comb, Al.MA 66							
Lab. No. 4135							
Kosay, 1944:108	99.8	0.2	tr	tr	0	tr	0

*N.B. Reference unclear. Possibly Al 1081 (Arik, 1937:CCLVI) which is a silver sheating for some kind of handle.

APPENDIX IV

Gold Deposits in Turkey

1.

Izmir Province: Arpadaği - Alurcaköy 86/2

Type of Deposit : Reef gold. Also present are pyrites of galena, sphalerite and chalcopyrites. With the exception of the pyrites (with poor gold content) all the sulfides have high gold and silver content. Native gold has also been observed in the galena. Maximum gold content was measured to be .001 %.

Location of Deposit : Situated on the western slopes of Yamanlar Daği in Kaşikaya town-ship.

Reference: MTA, 1970:22.

2.

Izmir Province: Arikbaşi 87/3

Type of Deposit: The occurence consists of gold-bearing quartz-arsenopyrite veins. Maximum gold content 0.00106 %.

Location of Deposit: Situated near Ciftcigedigi, ca. 3-4 kms NNW of the village within the township of Bayindir.

References: MTA, 1970:23; Ryan, 1960:8.

3.

Izmir Province: Tire 87/3

Type of Deposit: Gold-bearing quartz-arsenopyrite veins. Maximum gold content 0.00336 %.

Location of Deposit: The deposit is situated ca. 1.5 km WSW of the township of Tire, especially at Beyler Bahçesi.

Reference: MTA, 1970:23.

4.

Izmir Province: Yusuflu 87/3

Type of Deposit: Gold-bearing quartz-arsenopyrite veins. Low grade. Maximum gold content 0.00026 %.

Location of Deposit: The deposit is situated 4.5 kms N of Yusuflu village within the township of Bayindir.

Reference: MTA, 1970:24.

5.

Izmir Province: Bozdağ 87/4

Type of Deposit: Gold-bearing quartz-arsenopyrite veins. Maximum gold content 0.002 1%.

Location of Deposit: The deposit is situated on the SW slope of Bozdag near Mursali village and E of Geneve (Zeytinli) along Tale Aser Oluk Deresi.

Reference: MTA, 1970:24.

6.

Aydin Province: Sobuca Daği 104/1

Type of Deposit: Gold-bearing quartz-arsenopyrites, irregularly distributed in pockets, lenses and veins. Richest sample yielded 128,8 g/ton (=.0128 %), but the average is about 20 g./ton (= 0.002 %).

Location of Deposit: Many deposits distributed throughout a zone 10 kms E-W and 20 kms N-S. All the deposits fall in Kocalari Township.

Reference: MTA, 1970:25-6.

7.

<u>Aydin Province</u>: Ayranci Çakmaği (Tartar Memişler Köyü) 104/2

<u>Type of Deposit</u>: Gold-bearing quartz-arseno-pyrites in lenses. One sample yielded Au 4.6 g/ton (= 0.00047 %) and As 16.01 g/ton (= 0.0016 %).

<u>Location of Deposit</u>: Çine Township. No further details.

<u>Reference</u>: MTA, 1970:26.

8.

<u>Aydin Province</u>: Sariköy 104/4

<u>Type of Deposit</u>: Small gold-bearing quartz-arsenopyrite veins. One sample assayed Au 5.4 g/ton (= 0.00054 %).

<u>Location of Deposit</u>: Çine Township. No further details.

<u>Reference</u>: MTA, 1970:26.

9.

<u>Manisa Province</u>: Sart (Sardis) 87/2

<u>Type of Deposit</u>: Alluvial deposit. Some native gold. Very low grade reported.

<u>Location of Deposit</u>: The River Pactolus.

<u>Reference</u>: MTA, 1970:23; Ryan, 1960:7-8.

10.

Manisa Province: Umurbaba Daği 88/1

Type of Deposit: Small gold-bearing quartz veins. The length of the veins varies from a few meters to 25 meters. The thickness ranges from 7-90 cms. Maximum gold content 52.8 g/ton (=0.0052 %).

Location of Deposit: The deposit is situated along the upper reaches of Yellidere, and on the ridge between Yellidere and Çinarli Dere, within the township of Esme.

Reference: MTA, 1970:24.

11.

Manisa Province: Çavuşlar 88/3

Type of Deposit: Gold-bearing quartz-arsenopyrite veins. One sample yielded Au 37.6 g/ton (= 0.0376 %).

Location of Deposit: Situated in Alashehir Township along Mosoren Deresi, near Serbetçi (Kuzpinar Hill) and N 55° from Cavuşlar.

Reference: MTA, 1970:24-5.

12.

Canakkale Province: Kartoldaği 52/1

Type of Deposit: High grade ore in pyritized zone. It has been noted that earlier exploitation had been carried out.

Location of Deposit: South of Çanakkale-Kirazli road at Kartal Taş (Daği).

References: MTA, 1970:21; Cuinet, 1894:704, 748 ff; Cook, 1974:290, n.2.

13.

Canakkale Province: Madendaği 52/1

Type of Deposit: Reef Gold. Veinlets related to quartz. Generally a poor grade of ore and not suitable for modern exploitation.

Location of Deposit: South of the Çanakkale-Kirazli road. No further details.

Reference: MTA, 1970:21.

14.

Kars Province: Darphane (Zaraphane)-Kazikkaya 49/1

Type of Deposit: Native gold and alluvial deposits along the stream Ortahale Dere. The ore grade is however too low to warrant modern exploitation.

Location of Deposit: Situated in the town of Karadurt and in the stream Ortahale Dere between Darphane and Kazikkaya.

Reference: MTA, 1970:20.

15.

Hatay Province: Akilliçay-Kişçukçayi 145/2

Type of Deposit: Alluvial with native gold. But the grade is too low for modern exploitation.

Location of Deposit: No details.

Reference: MTA, 1970:26.

APPENDIX V

Arsenic-bearing Ore Deposits *

Province	Site	Map Ref.	Mineral Type
Artvin	Kuvarshan Md.(S-77)	14/4	arsenopyrite
Gümüşane	Hazine Mağara (S-140)	29/3	enargite
Sinop	Ovalik-Hasandeğin	25/2	realgar
Erzurum	Pitkir (S-112)	31/3	realgar
Kars	Büyük Zirnik Der.	32/3	orpiment-realgar
	Küçük Zirnik Der.	32/3	orpiment-realgar
	Çikanus	32/3	orpiment-realgar
Bursa	Gözede	37/4	orpiment-realgar
	Lütfiye	37/4	orpiment-realgar
Bolu	Arikdere	39/3	orpiment-realgar
	Akçaalan	39/1	realgar
Ankara	İşikdağ (S-129)	40/2	arsenopyrite
Sivas	Kurt Maden (S-166)	45/3	realgar
Balikesir	Balya (S-151)	53/3	orpiment
Sivas	Bozbeltepe	62/1	orpiment-realgar
Denizli	Derbent	88/3	arsenopyrite
Isparta	Gölbaşi	106/2	realgar
Niğde	Bolgar Dağ (S-157)	110/3	arsenopyrite

* Principal source is MTA, 1970. See Map 11.

APPENDIX VI

Cat. no.	% Cu	% Sn	% Zn	% As	% Pb	% Fe	Total	Metro.Mus.no.	Object	Sample
A-392	90.8	.02	n.d.	3.5	2.5	0.10	96.9	55.137.2	Sistrum	Under foot; bottom of handle.
A-366a	93.4	0.35	n.d.	4.0	0.2	0.07	97.8	55.137.5	Pair of stags	Groin area proper left side of animal.
A-366b	94.2	.02	n.d.	2.1	0.4	0.11	96.8	55.137.5	Pair of stags	Tang, underside base.
A-367	89.5	.02	n.d.	4.0	0.2	0.17	93.9	55.137.6	Two horns	Underside near hole, proper left horn.
A-139	93.7	.02	n.d.	1.4	0.2	0.13	95.2	55.137.25	Dagger	Inside hole in blade.
A-170	80.8	3.6	n.d.	0.6	13.1	0.08	98.1	55.137.10	Axe head	Inside shaft. See Fig.25(3),Pl.XVIII(3)
A-171	86.9	9.8	n.d.	0.5	0.8	0.07	97.6	55.137.7	Axe head	Side of central portion.
A-169	89.1	8.9	n.d.	1.3	0.2	0.16	99.5	55.137.11	Axe head	Rim of shaft. See Fig.25(1),Pl.XVIII(1)

n.d. = not detected

Comments Samples were obtained from the uncorroded metal, whenever possible, by drilling using a hand drill and small (sizes 56-72) shank type high-speed drillbits. The samples were dissolved in 1 ml 1:1 HCl solutions, containing 0.3 % H_2O_2. After dissolution, excess H_2O_2 was removed by heating. Undissolved material, such as metastannic acid, a high tin corrosion product was removed by centrifugation.

.../...

The liquid samples were transferred to sample holders, of hich the bottom consisted of a very thin mylar foil. Samples were counted in a Siemens X-ray fluorescence spectrometer (energy non-dispersive).

Seven different N.B.S. reference bronze materials were used as standards. K α lines were used for copper, zinc, and iron, K β lines for arsenic, L α lines for tin and L β lines for lead.

The accuracy is estimated to be better than 3 percent except when approaching the lower detection limits. For most routine analyses these are 0.02 % for tin, 0.1 % for zinc, 0.3 % for arsenic, 0.2 % for lead and 0.05 % for iron.

Small samples were drilled from the objects. The samples were accurately weighed (5 milligrams). The metal was dissolved in 1 ml 6N HCl containing 3 % H_2O_2. After dissolution the excess peroxide was removed by centrifugation. Wave length dispersive XRF was used for analysis. Comparison with NBS standard bronzes dissolved in the same way allowed for quantitative analysis.

* * *

Chisel from Arpachiya, <u>Iraq</u> II, pt. I, 1933, p.104, pl. X.
Now in British Museum.

%	
Cu	99.0
Sb	0.12
As	0.1
Bi	0.005
Co	0.005
Ni	0.28
Pb	0.02
Ag	0.16
Fe	0.002

Undetected : Au, Sn, Zn, down to .002 %.
Accuracy : ± 1 % for major elements.
± 3 % for trace elements.

The Ag and Ni traces are quite high compared with later metal work. Basically the chisel is copper, the traces coming from the ore used.

Analyst: Dr. Paul Craddock, British Museum.
Analysis performed by X-Ray fluorescence, June 15, 1976.

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***

1.

Type of Deposit: Cu

Province: Istanbul

Name of Deposit: Saryer

Map Reference: 20/3

Ore and Formation: Chalcopyrite. Lenses.

	No.1	No.2	No.3	No.4
% Cu	0.45	4.44	14.32	5.2
Au	Tr	Tr	Tr	Tr

Mine: Ore Dumps. No further details

Slag:

References: MTS, 1972:18-19; Ryan, 1960:25.

Comments: Deposit is located 1.5 kms from Rumeli Kavak. It is said that it was exploited in Byzantine times.

2.

Type of Deposit: Cu

Province: Istanbul

Name of Deposit: Kiliçli

Map Reference: 20/3

Ore and Formation: Chalcopyrite. Veins.

Mine:

Slag: Slags are reported.

References: MTA, 1972:18; Ryan, 1960:26.

Comments: The site is located east of Beykoz on the Asian side. According to Ryan the deposit is valueless.

3.

Type of Deposit: Cu

Province: Istanbul

Name of Deposit: Kaşbaşi

Map Reference: 20/3

Ore and Formation: Bornite and secondary malachite. Also galena. Veins.

	No.1	No.2	No.3
% Cu	1.46	3.55	59.9
Ag	Tr	Tr	Tr

Mine: Remains. No details.
Slag:
References: MTA, 1972:19; Ryan, 1960:26.
Comments: Deposit is situated 12 kms, south of Şile. Relics of former mining activities are said to be found here.

4.
Type of Deposit: Cu
Province: Istanbul
Name of Deposit: Çam Liman - Heybeli Ada
Map Reference: 20/3
Ore and Formation: Chalcopyrite and secondary minerals such as malachite, azurite and limonite. Gossan.
% Cu 3.3 - 6.2
Mine: Pits.
Slag:
References: MTA, 1972:19; Ryan, 1960:26.
Comments: Deposit is situated on Heybeli Island south of the Bosphorus.

5.
Type of Deposit: Cu
Province: Sakarya
Name of Deposit: Hicriye
Map Reference: 39/1
Ore and Formation: Copper ore and malachite. Veins.
% Cu 2.85
Mine: An old adit.
Slag:
References: MTA, 1972:63; Ryan, 1960:26-7.
Comments: Deposit is located near Muradiye. Position on Map is not certain. No details.

6.

<u>Type of Deposit</u>: Cu

<u>Province</u>: Sakarya

<u>Name of Deposit</u>: Nuriye

<u>Map Reference</u>: 39/1

<u>Ore and Formation</u>: Chalcopyrite, bornite, covellite and malachite. Gossan. Veins.

Ore outcroups:

% Cu 1 - 10

Oxidized Zones:

	No.1	No.2	No.3
% Cu	31.0	2.39	0.93

Average:

% Cu 4.0

<u>Mine</u>: No details.

<u>Slag</u>:

<u>References</u>: Ryan, 1960:26-7.

<u>Comments</u>: Deposit is located near Hendek. Outcrops are spread over 2 sq. kms.

7.

<u>Type of Deposit</u>: Cu

<u>Province</u>: Zonguldak

<u>Name of Deposit</u>: Akçabey-Adatepe

<u>Map Reference</u>: 22/3

<u>Ore and Formation</u>: Azurite, malachite. Veins.

% Cu 7.3

Cu 1.3 (average)

<u>Mine</u>: Remains. No details.

<u>Slag</u>:

<u>References</u>: MTA, 1972:21; Ryan, 1960:31.

<u>Comments</u>: These deposits are located ca. 20 kms. southwest of Devrek. Likewise for a third deposit at Eski Tohumlar.

8.

<u>Type of Deposit</u>: Cu

<u>Province</u>: Kastamonu

<u>Name of Deposit</u>: Küre-Nuhas

Map Reference:	7/4
Ore and Formation:	Chalcopyrite, pyrite. Stockwork.
	% Cu 2 - 9.5
Mine:	Pits. No details.
Slag:	Dumps estimated at 1 - 2.5 million tons.
	% Cu 1.556
	CuO 0.93
References:	MTA, 1972:7; Ryan, 1960:31.
Comments:	Deposit is said to have been worked in the Middle Ages. It is an active mine in Turkey today.

9.

Type of Deposit:	Cu
Province:	Kastamonu
Name of Deposit:	Cozoğlu Mahallesi
Map Reference:	8/4
Ore and Formation:	Chalcopyrite. Secondary malachite and azurite. Gossan.
Mine:	Tunnels in the slopes behind the village.
Slag:	Slag dumps near-by. Several tons.
	% Cu 0.81
	Sn nd
	Pb 0.0015
	As nd
	Sb nd
	Ag nd
	Ni nd
	Bi nd
	Au nd
	Zn 0.3
	Co 0.1
	Fe 10
References:	MTA, 1972:8; Ryan, 1960:31; de Jesus and Kaptan, 1974:24-5.
Comments:	Slag analysis shows strong traces of Zn, suggesting sphalerite.

10.

Type of Deposit:	Cu-Pb
Province:	Ordu
Name of Deposit:	Tifi-Hoben
Map Reference:	27/4
Ore and Formation:	Copper and lead ores. No details. Veins.
Mine:	
Slag:	Scattered slag on the surface. No details. % Cu 1.22 Pb 9.1
References:	MTA, 1972:25; Ryan, 1960:36.
Comments:	Deposit is located near Koruk in Ünye County. No further details.

11.

Type of Deposit:	Cu-Pb-Zn
Province:	Ordu
Name of Deposit:	Arpalik
Map Reference:	27/3
Ore and Formation:	Mainly galena with some copper ore. Veins. % Cu 2.44 Pb 7.61 Zn 11.53 Ag Tr
Mine:	"Three old galeries" are reported.
Slag:	Scattered bits. % Cu 0.01 Sn nd Pb 0.0015 As nd Sb nd Ag nd Ni nd Bi nd Au nd Zn 0.15 Co nd Fe 10
References:	MTA, 1972:25; Ryan, 1960:36; De Jesus and Kaptan, 1974:22-3.

Comments: This seems to be a mixed Cu-Pb-Zn deposit with varying degrees of richness of each. High Zn content in the slag suggests sphalerite in the original ore body. The survey (de Jesus and Kaptan, 1974) did not locate the galeries formerly reported.

12.

Type of Deposit: Cu

Province: Ordu

Name of Deposit: Zevli-Okcubel

Map Reference: 27/3

Ore and Formation: Chalcopyrite, malachite. Veins.

% Cu 14.53
Au Tr
Ag Tr

Mine: Tunnels. No further details.

Slag:

References: MTA, 1972:26; Ryan, 1960:37.

Comments: Deposit is located ca. 10 km NW of Gölköy. A series of tunnels are reported, varying in length from 40 - 80 meters.

13.

Type of Deposit: Cu

Province: Ordu

Name of Deposit: Maden Deresi

Map Reference: 27/4

Ore and Formation: Copper ore. No details.

Mine: Remains. No details.

Slag:

References: MTA, 1972:27.

Comments: Deposit is located near the village of Ağizlar, ca. 10 kms N of Gölköy. No further details.

14.

Type of Deposit: Cu
Province: Ordu
Name of Deposit: Kizantman-Ağizlar
Map Reference: 27/3
Ore and Formation: Chalcopyrite. No further details. Veins.
Mine: Remains. No further details.
Slag:
References: MTA, 1972:27.
Comments: No further details.

15.

Type of Deposit: Cu
Province: Ordu
Name of Deposit: Akmecit-Başalan
Map Reference: 27/3
Ore and Formation: Malachite, azurite. Veins.
Mine: Two adits, now inaccessible.
References: MTA, 1972:26; Ryan, 1960:37.
Comments: Deposit is located near Gölköy. Position on map is not certain. Reported that the upper tunnel is 10 meters long and the lower one 50 meters.

16.

Type of Deposit: Cu
Province: Giresun
Name of Deposit: Gedik
Map Reference: 28/3
Ore and Formation: Galena, chalcopyrite and pyrite. Veins
Mine: Caved galleries. No further details.
Slag:
References: MTA, 1972:42.
Comments: There are two deposits, one at Gedik and another at Okcu Madeni. It is not clear from publication whether old workings exist at both. These sites were not plotted on Map no. 9, as their location was not determined.

17.

Type of Deposit: Cu
Province: Giresun
Name of Deposit: Kayabaşi Maden
Map Reference: 28/3
Ore and Formation: Galena, sphalerite, chalcopyrite. No further information.
Mine: Remains. No details.
Slag:
References: MTA, 1972:43; Ryan, 1960:39.
Comments: Former workings are said to be near Kiziltaş. No further details.

18.

Type of Deposit: Cu
Province: Giresun
Name of Deposit: Akkaya-Oren
Map Reference: 28/3
Ore and Formation: Copper ore. No details. Veins.
Mine: Remains. No details.
Slag:
References: MTA, 1972:44.
Comments: Deposit is located SW of Dereli. Other deposits are found in the triangle Ören-Akkaya-Kale. No further details.

19.

Type of Deposit: Cu-Pb
Province: Giresun
Name of Deposit: Duroğlu Maden
Map Reference: 28/4
Ore and Formation: Galena, sphalerite, chalcopyrite and chalcocite. Veins.
% Cu 2.77
Pb 4.17
Mine: Tunnels and dumps.
Slag:

References: MTA, 1972:46; Ryan, 1960:40.
Comments: Ore from dumps seems rich. There is a second deposit near-by at Toğralik.

20.

Type of Deposit: Cu-Pb
Province: Giresun
Name of Deposit: Barça Çakirlişi
Map Reference: 28/2
Ore and Formation: Copper-lead deposit. No details. Veins,
Mine: Seven Tunnels.
Slag: % Cu 0.36
Pb 2.19
References: MTA, 1972:28.
Comments: Deposit is near Kesap. Location on map is not accurate.

21.

Type of Deposit: Cu
Province: Giresun
Name of Deposit: Araca
Map Reference: 28/2
Ore and Formation: Copper ore. No details.
Mine: An abandoned mine.
Slag: Shows signs of copper according to Ryan.
References: Ryan, 1960:40.
Comments: Deposit is situated in Araca Dere. No further details.

22.

Type of Deposit: Cu-Pb-Zn-Fe
Province: Giresun
Name of Deposit: Tahtali
Map Reference: 28/2
Ore and Formation: Galena, sphalerite, chalcopyrite, pyrite. No further details.
Mine: Caved tunnels and dumps.

Slag:

References: Ryan, 1960:41.

Comments: No details.

23.

Type of Deposit: Cu-Pb

Province: Giresun

Name of Deposit: Yivdincik

Map Reference: 28/2

Ore and Formation: Galena, sphalerite, chalcopyrite, pyrite. Veins

Mine: Tunnels and dumps. See "comments".

Slag:

References: MTA, 1972:40; Ryan, 1960:41.

Comments: There are 3 former workings in this general area: at Kikyol (caved tunnel), at Kaşkibi (drift and shaft, now caved, and ore dumps), and at Hanci Creek (drift, now caved). These deposits are said to have been worked previously by the French and Italians before World War I. It is not clear if the mining remains date from that time.

24.

Type of Deposit: Cu-Pb-Zn

Province: Giresun

Name of Deposit: Kizilelma Oruçbey

Map Reference: 28/2

Ore and Formation: At the mill : galena, sphalerite, chalcopyrite, malachite, and azurite. At Cukur Maden: galena, sphalerite, and chalcopyrite.

At the mill:

%	Cu	1.95
	Pb	10.03
	Zn	15.48

At Çurkur Maden:

%	Cu	0.51
	Pb	1.78
	Zn	2.6

Mine: Tunnels.

Slag:

References: MTA, 1972:40; Ryan, 1960:41.

Comments: There are 2 deposits in this general area: at the mill and at Çukur Maden. Tunnels are said to be on both sides of the creek.

25.

Type of Deposit: Cu

Province: Giresun

Name of Deposit: Karaerik

Map Reference: 28/2

Ore and Formation: Pyrite, chalcopyrite. No details.

	No.1	No.2	No.3
% Cu	3.84	2.90	0.31
S	45.55	0.38	50.35
Fe	38.35	34.61	28.33
Se	0.004	0.005	0.0065

Mine: No mine located.

Slag: Dumps estimated at 300,000-400,000 tons.

References: MTA, 1972:38; Ryan, 1960:42.

Comments: Deposit is located near Osman Kiran. Although no ancient mining activities were noted in reports, it is likely that they existed near here in view of the richness of the ore and the presence of so much slag.

26.

Type of Deposit: Cu

Province: Giresun

Name of Deposit: Lahanos

Map Reference: 28/2

Ore and Formation: Copper Ore. No details.

Mine: Remains. No details.

Slag: Dumps are estimated at 40-50,000 tons.

% Cu	0.15
S	38.00
Au	Tr

References: MTA, 1972:39; Ryan, 1960:44.

Comments: Two groups of ancient workings in this area.

27.

Type of Deposit: Cu-Fe and Cu-Pb-Zn.

Province: Giresun

Name of Deposit: Kepçelik

Map Reference: 28/2

Ore and Formation: Copper-lead-zinc ores. No details. Veins (?).

Mine: Trenches.

Slag:

References: MTA, 1972:49.

Comments: This deposit is located S of Kizilkaya. It is reported that present reserves are probably not very extensive.

28.

Type of Deposit: Cu (?) Fe

Province: Giresun

Name of Deposit: Ağalik Maden

Map Reference: 28/2

Ore and Formation: Copper ore (?), iron ore. No further details.

Mine: Remains. No details.

Slag: Dumps amounting to ca. 60,000 tons.

References: MTA, 1972:29; Ryan, 1960:45.

Comments: The deposit is situated SE of Karaerik and ESE of Karilar Maden. This could be an iron-smelting site, but Ryan classes it as a copper mine.

29.

Type of Deposit: Cu-Pb

Province: Giresun

Name of Deposit: Kiran-Gebekkilise

Map Reference: 28/2

Ore and Formation: Contact-metamorphic deposits and sulphidic mineralization located in limestones. No further details.

Mine: Remains. No details.

Slag:

References: MTA, 1972:46.

Comments: This deposit is said to have been small. Location on map is not certain.

30.

Type of Deposit: Cu (?)

Province: Giresun

Name of Deposit: Dikmen

Map Reference: 28/2

Ore and Formation: Traces of pyrite impregnations. No details.

Mine: No details

Slag: Slag piles are visible at Dikmen and at Dikmen Maden.

References: Ryan, 1960:45.

Comments: Dikmen is situated a few hundred meters NE of Kozköy. Alternatively, this site could be an iron-smelting site. Former mining activities are only thought to be in the area.

31.

Type of Deposit: Cu-Pb

Province: Giresun

Name of Deposit: Kizilkaya

Map Reference: 28/2

Ore and Formation: Chalcopyrite (?). No details.

% Cu	7.96
Pb	13.22
Zn	30.59
Fe	27.35
S	8.84

Mine: Remains. No further details.

Slag: Dumps. No details.

References: Ryan, 1960:44; MTA, 1972:41.

Comments: There are 7 deposits and former workings in this general area: Kizilkaya (remains and slag dumps), Killik Maden (malachite, chalcopyrite, slag dumps and old mines), Kavakgüney Maden (caved workings, slag dumps, malachite), Çibril Köy (former smelting activities), and Dikmen (cf. above).

32.

Type of Deposit: Cu-Pb

Province: Giresun

Name of Deposit: Alibaba Maden

Map Reference: 28/2

Ore and Formation: Galena, sphalerite, chalcopyrite. Veins.

%	Cu	1.46
	Pb	37.61
	Zn	23.20
	Ag	Tr

Mine: Tunnels driven into the banks of the stream and elsewhere.

Slag: "A small amount" is reported.

References: MTA, 1972:45; Ryan, 1960:42.

Comments: Position on map is not certain. No further details.

33.

Type of Deposit: Cu-Pb-Zn

Province: Giresun

Name of Deposit: İnköy

Map Reference: 28/2

Ore and Formation: Copper, lead and zinc ores. Pure galena can be found in the mine.

Mine: Four tunnels.

Slag: Dumps. No details.

References: MTA, 1972:38; Ryan, 1960:42.

Comments: Deposit is located at the Harşit River bridge, near the Black Sea and 4 kms. E of Tirebolu. A slag dump at Yalç Madeni, ca. 3.5 kms. SSE of Tirebolu, may be the result of iron-smelting.

34.

Type of Deposit: Cu

Province: Giresun

Name of Deposit: Kân Maden

Map Reference: 28/2

Ore and Formation: Copper ore. No details

% Cu	1.46
Pb	0.25
Zn	5.01
Fe	25.75

Mine: Caved workings. No details.

Slag: Dumps. No details.

References: Ryan, 1960;43.

Comments: Deposit is situated near İnköy, 4 kms. east of Tirebolu.

35.

Type of Deposit: Cu-Pb

Province: Giresun

Name of Deposit: Harkköy

Map Reference: 28/2

Ore and Formation: Sphalerite, chalcopyrite, galena. Some bornite, enargite and covellite.

% Cu	0.845
Pb	3.77
Zn	7.7
S	13.77

Mine: Tunnels. No details.

Slag: Dumps. No details.

	No.1	No.2
% Cu	1.03	7.49
Pb	1.05	0.58
Au	Tr	...
Ag	Tr	...
Zn	Tr	4.44
Fe	Tr	26.08
S	Tr	36.95

References: MTA, 1972:32; Ryan, 1960:43.

Comments: Deposit is located ca. 10 kms SE of Tirebolu. According to Ryan the "mineralization occurs on the east and north slopes of the hill, and numerous old workings attest much activity." Referring to the analysis of the slag (above) Ryan thinks that it "looks more like rich ore than slag." But "several large slag piles are to be seen."

36.

Type of Deposit: Cu

Province: Giresun

Name of Deposit: İsrail

Map Reference: 28/2

Ore and Formation: Chalcopyrite. Veins.

	No.1	No.2
% Cu	1.15	8.10
Fe	30.08	41.5
S	33.74	48.31

Mine: Open cast mine.

Slag: Dumps estimated at ca. 100,000 tons and said to have been produced by the Genoese.

% Cu 1.59

References: MTA, 1972:31-2; Ryan, 1960:43-4.

Comments: Other deposits and former workings have been noted in the area: Yeni Maden (slag), Çiritmeydan, Bekirler, Kişla, Baliboz (caved tunnels).

37.

Type of Deposit: Cu

Province: Giresun

Name of Deposit: Seku

Map Reference: 28/2

Ore and Formation: Galena, sphalerite, malachite. Contact zone.

Mine: Old workings at Şile and Koca Kavanlik. No further details.

Slag: Dumps at Sile and Ocak Kirani.
References: MTA, 1972:37; Ryan, 1960:43.
Comments: These deposits are located 1 km. east of Seku.

38.
Type of Deposit: Cu-Pb
Province: Giresun
Name of Deposit: Akköy Madeni
Map Reference: 28/2
Ore and Formation: Sphalerite, galena, and some chalcopyrite. Lens
Mine: Caved tunnels. Said to have been on a small scale. Rubble.
Slag:
References: MTA, 1972:34.
Comments: Deposit is situated in the valley of Görele. Position on map is not certain.

39.
Type of Deposit: Cu-Pb-Zn
Province: Giresun
Name of Deposit: Karagöl Yani
Map Reference: 29/1
Ore and Formation: Copper-lead-Zinc mineralization. No further details.

% Cu	3.85
Pb	11.01
Zn	25.90
Fe	12.82
S	27.05
Au	Tr
Ag	Tr

Mine: Remains. Dumps.
Slag:
References: MTA, 1972:35-36.
Comments: Deposit is located near Sedegöre. It is said that the ore is similar to that of Eşeli Madeni (below).

40.

Type of Deposit: Cu-Pb

Province: Giresun

Name of Deposit: Eşeli Madeni

Map Reference: 28/2

Ore and Formation: Sphalerite, galena, chalcopyrite. Some bornite. Lens.

	No.1	No.2
% Cu	4.48	6.64
Pb	2.26	0.90
Zn	...	9.02
Fe	...	20.12
S	...	28.66

Mine: Five inclined drifts and shafts have been noted, now caved.

Slag: Dumps estimated at ca. 25,000 tons.

References: MTA, 1972:34-35; Ryan, 1960:46.

Comments: Deposit is said to be located "on the right slopes of the valley of Gömlekçi Deresi, NW of Taşca Tepe and near Çimide Köy. The ore is reportedly the "black and yellow" type, similar to that of Harkköy Madeni (above).

41.

Type of Deposit: Cu-Pb-Zn

Province: Giresun

Name of Deposit: Şadi

Map Reference: 29/1

Ore and Formation: Copper-lead-zinc ores. No details. Veins.

% Cu	16.62
Pb	83.4
Zn	1.02

Mine: Caved workings. No further details.

Slag: "A moderate amount" is reported.

References: Ryan, 1960:45.

Comments: The deposit is located in front of the mill at Şadi. No further details.

42.

Type of Deposit: Cu-Fe

Province: Giresun

Name of Deposit: Karabörk Madeni

Map Reference: 28/2

Ore and Formation: Pyrite, hematite, magnetite, some chalcopyrite, and some malachite.

	No.1	No.2
% Cu	0.08	0.31
Au	Tr	...
S	...	50.77
Fe	...	42.75

Mine: Remains at Girlak. At Karabörk there are shafts and tunnels, now filled with water.

Slag: Dumps at Cecendere:

% Cu	4.82
Pb	3.91

Dumps also at Pelido.

References: MTA, 1972:33-34; Ryan, 1960:45-46.

Comments: Karabörk Mine, situated about 1¼ km. south of Karabork village is said to have been worked by the Genoese and again before World War I by the English.

43.

Type of Deposit: Cu

Province: Giresun

Name of Deposit: Kelete Maden

Map Reference: 29/1

Ore and Formation: Chalcopyrite. Veins (?).

% Cu	4.58
Fe	11.34

Mine: Parts of this deposit are said to have been worked prior to World War I. No details.

Slag: Dumps. No details.

References: MTA, 1972:50; Ryan, 1960:45.

Comments: There is a second mine reported at Demirdere, also said to be for copper. No further details.

44.

Type of Deposit: Cu - Fe

Province: Gümüşane

Name of Deposit: Erikâr Maden (Gelevera Maden)

Map Reference: 28/3

Ore and Formation: Malachite, martite, hematite and chalcopyrite. Contact deposit.

% Cu 2.45
Fe 33.65

Mine: It is inferred that there is a mine in the area due to the amount of slag at this altitude and to the richness of the deposit. No former workings, however, have been specifically noted.

Slag: Dumps are estimated at ca. 20,000-45,000 tons of which 1000-2000 tons are said to be copper slag and the rest iron slag.

References: MTA, 1972:44-45; Ryan, 1960:53.

Comments: This deposit is situated a few kms. SW of Gelevera on Yalyalar Dag.

45.

Type of Deposit: Cu

Province: Gümüşane

Name of Deposit: Oyraca-Maden Kiram

Map Reference: 28/3

Ore and Formation: Chalcopyrite. No details. Veins.

Mine: Relics. Six adits and drifts. No details.

Slag: Dumps estimated at 1000 tons.

References: MTA, 1972:37; Ryan, 1960:52.

Comments: Location on map is not certain.

46.

Type of Deposit: Cu-Pb

Province: Gümüşane

Name of Deposit: Dandi Sapaği-Kahvehane

Map Reference: 28/3

Ore and Formation: Malachite. No further details.

Mine: At Orta Dere: caved tunnel.
At Dandi Sapağı: inclined shaft and a drift.
At Dandi Sapağı-Kahvehane: prospection pits and drifts.

Slag:

References: MTA, 1972:47; Ryan, 1960:53.

Comments: Only at Dandi Sapağı-Kahvehane was malachite noted. At the other two mines (Orta Dere and Dandi Sapağı) copper deposits were inferred because of their proximity.

47.

Type of Deposit: Cu-Pb-Zn

Province: Gümüşane

Name of Deposit: Nikola Ocak

Map Reference: 28/2

Ore and Formation: Copper ore. Sphalerite (?). No further details

% Cu	2.18
Pb	2.06
Zn	1.17
Fe	6.69

Mine: Shaft.

Slag: It is reported that malachite is incrusted on slags. No further details.

References: MTA, 1972:36; Ryan, 1960:52.

Comments: The deposit is located near the town of Çatak. No further details.

48.

Type of Deposit: Cu-Pb-Zn

Province: Gümüşane

Name of Deposit: Kiran Maden

Map Reference: 29/4

Ore and Formation: Pyrite, hematite, some chalcopyrite and traces of galena and sphalerite. No further details.

Mine: Five caved tunnels.

Slag:

References: Ryan, 1960:54.

Comments: Deposit is located N of Taslica at Kizil Ata Mahallesi. The mine is at 1550-1660 m in altitude. Position on map is not certain.

49.

Type of Deposit: Cu-Pb-Zn

Province: Gümüşane

Name of Deposit: Kuru Maden

Map Reference: 29/4

Ore and Formation: Chalcopyrite, cuprite, covellite, sphalerite, galena.

Ore from dumps:

%	Cu	Tr
	Pb	12.38
	Zn	11.61

Ore from shaft:

%	Cu	0.38
	Pb	8.01
	Zn	4.99

Mine: Collapsed tunnels. Ore dumps.

Slag: Large dumps of slag.

%	Cu	7.18
	Pb	1.38
	Zn	18.57

References: MTA, 1972:48; Ryan, 1960:54.

Comments: Deposit is located on the western slopes of Kizilali Dag, 100 m below Belengtepe (elevation: 1900 m).

50.

Type of Deposit: Cu-Pb-Zn

Province: Gümüşane

Name of Deposit: Melek Maden

Map Reference: 29/4

Ore and Formation: Pyrite, chalcopyrite. Contact zone.

Mine: An adit now flooded and several old exploration adits.

Slag:

References: MTA, 1972:48; Ryan, 1960:54.

Comments: Deposit is located in the forest below Delikli Tepe (elevation: 1600 m). The exploration adits, mentioned above, are located on the road from Kapa Yayla to Dere Maden. Ryan vaguely mentions more old workings north of Taslica at 1340-1420 meters elevation, whose workings are said to be "extensive" but "inaccessible". Dumps are also noted at this mine.

51.

Type of Deposit: Cu

Province: Gümüşane

Name of Deposit: Közköy-Almacik

Map Reference: 29/1

Ore and Formation: Pyrite, chalcopyrite, malachite, sphalerite and some lead. Contact-metamorphosed. Vein (?).

% Cu	4.57
Pb	Tr
Zn	0.68
Fe	27.40
S	29.44

Mine: Drift. No further details.

Slag:

References: MTA, 1972:37.

Comments: Location on map is not certain. No further details.

52.

Type of Deposit: Cu

Province: Gümüşane

Name of Deposit: Çayirçukur

Map Reference: 29/4

Ore and Formation: Copper ore. No details. Vein.

Ore from dumps:

% Cu 4.18

Ore from shaft:
% Cu 2.36
Pb Tr

Mine: Five tunnels and several shafts are reported.

Slag: Dumps.
% Cu 0.8

References: MTA, 1972:53; Ryan, 1960:53.

Comments: It seems that there are four deposits mentioned in relation with Çayirçukur. Ryan does not make it clear at which of the four sites (Ulu Kiran, Gömü Kayasi, Perdel and Acisu) the former workings are to be found.

53.

Type of Deposit: Cu

Province: Gümüşane

Name of Deposit: Çağköy

Map Reference: 29/4

Ore and Formation: No information available.

Mine:

Slag: Dumps. No details.

References: Ryan, 1960:53.

Comments: Ryan states that only slag was found at this site.

54.

Type of Deposit: Cu

Province: Gümüşane

Name of Deposit: Karaçukur

Map Reference: 29/4

Ore and Formation: Cupriferous pyrites and malachite. Veins.

Mine: Dumps. No further details.

Slag: Dumps estimated at 5,000 - 8,000 tons near the deposit and another 1,000 - 2,000 tons in the vicinity.
% Cu 1.35 - 1.8
Pb 0.85

References: MTA, 1972:52.

Comments: Deposit is located ca. 5 kms. E of Kutun.

55.

Type of Deposit: Cu-Pb

Province: Gümüşane

Name of Deposit: Fol

Map Reference: 29/3

Ore and Formation: Pyrite, chalcopyrite, galena, sphalerite. Veins.

	No.1	No.2	No.3
% Cu	1.7	2.2	6.8
Pb	n.d.		

Mine: Caved workings. No further details.

Slag:

References: Ryan, 1960:53.

Comments: Deposit is located ca. 20 kms. NE of Kurtun. The principal vein is at Efkâr.

56.

Type of Deposit: Cu

Province: Gümüşane

Name of Deposit: Langaz

Map Reference: 29/4

Ore and Formation: Chalcopyrite, galena, sphalerite.

Ore from dumps:

% Cu	5.18
Pb	15.18
Zn	27.15
Ag	Tr

Mine: Former workings now collapsed. Dumps.

Slag:

References: MTA, 1972:52-53.

Comments: Deposit is located near the village of Sive, at 1600 m. elevation.

57.

Type of Deposit: Cu

Province: Gümüşane

Name of Deposit: Köstere Maden

Map Reference: 29/4

Ore and Formation: Sphalerite, chalcopyrite, pyrite, galena, tetrahedrite. Veins. Ore from dumps:

% Cu	2.17 - 5.80
Pb	0.16 - 16.9
Ag	Tr

Mine: Dumps. Three caved tunnels.

Slag:

References: MTA, 1972:52; Ryan, 1960:55.

Comments: Deposit is located ca. 12 kms. N of Torul at İstala Mahalle. The elevation here is 1900 m. It is reported that the deposit appears exhausted.

58.

Type of Deposit: Cu

Province: Gümüşane

Name of Deposit: Alaca Çayir

Map Reference: 29/3

Ore and Formation: Galena, sphalerite and some chalcopyrite and pyrite. Veins. Ore from dumps:

% Cu	8.9
Pb	12.4
Ag	Tr
Au	Tr

Mine: Ore dumps. No further details.

References: MTA, 1972:55.

Comments: Deposit is situated 1.5 km. SSE of Çakirgök Dag at an elevation of ca. 2800 m. Another old mine is indicated in the general area, ca. 4 kms. NW of Dolek. No details.

59.

Type of Deposit: Cu

Province: Gümüşane

Name of Deposit: İrha (Tizik)

Map Reference: 46/2

Ore and Formation: Native copper, chalcopyrite, malachite, pyrite, carbonate minerals.

	No.1	No.2
% Cu	2.6	2.06

Mine: Remnants of old workings are said to cover an area of ca. 100 m^2. Four shafts and four tunnels, now collapsed.

References: MTA, 1972:74; Ryan, 1960:56.

Comments: Deposit is located ca. 5 kms. W of Köşe. The elevation is 1980 m.

60.

Type of Deposit: Cu

Province: Gümüşane

Name of Deposit: Helva Maden

Map Reference: 47/1

Ore and Formation: Secondary copper mineralization of malachite and azurite, and some chalcopyrite and pyrite.

Mine: Dumps and old galleries. It is suspected that some ore dumps are related to old underground workings which are now caved in.

Slag:

References: MTA, 1972:74-75.

Comments: Deposit is located 3 kms. WSW of Maden. Ore dumps are estimated at 100,000 tons. These dumps are rich enough in copper to be worked in modern times.

61.

Type of Deposit: Cu

Province: Gümüşane

Name of Deposit: Madenhanlar

Map Reference: 47/1

Ore and Formation: Copper ore. No details. Gossan. Cupriferous springs.

Mine: "Old workings" are reported by Ryan. No further details.

Slag:

References: Ryan, 1960:55.

Comments: Deposit is located at Madenköy. Ryan mentions a second copper deposit and cupriferous spring near here. No further details.

62.

Type of Deposit: Cu

Province: Gümüşane

Name of Deposit: Maden

Map Reference: 47/1

Ore and Formation: Pyrite, chalcopyrite. Contact zone (?).
Ore from Dumps:
% Cu 4.5

Mine: Dumps and caved tunnels.

Slag: Dumps. Less than 10,000 m^3.

References: Ryan, 1960:56.

Comments: Deposit is located 1 km. from Maden on the hiway to Erzurum. This deposit could be related to the Helva Maden deposit (above).

63.

Type of Deposit: Cu

Province: Trabzon

Name of Deposit: Zemberek Yaylasi

Map References: 29/1

Ore and Formation:	Magnetite and chalcopyrite in a skarn mineralization.
	Ore from Dumps :
	% Cu 4.0
Mine:	Dumps. No further details.
Slag:	Dumps amounting to 1200 m^3.
	% Cu 1.97
	Fe 25.5
References:	MTA, 1972:51-52.
Comments:	Deposit is located near Macka. Position on map is not certain.

64.

Type of Deposit:	Cu
Province:	Trabzon
Name of Deposit:	Kazikli Tepe
Map Reference:	29/2
Ore and Formation:	Chalcopyrite. Veins and lodes.
	% Cu 3 - 4
Mine:	No details.
Slag:	Dumps situated at 2300 m. elevation.
	% Cu 1.97
	Fe 25.2
References:	Ryan, 1960:47.
Comments:	Deposit is located ca. 12 kms SSE of Kustul-Armenos. The elevation of the mine is estimated between 2300-2600 m. Ryan seems to doubt that the slag analysis was from slag.

65.

Type of Deposit:	Cu
Province:	Trabzon
Name of Deposit:	Uzmesahor
Map Reference:	29/2
Ore and Formation:	Pyrites, chalcopyrite, covellite. Lenses
	Ore from dumps:
	% Cu 1.0

Mine: Remains. Dumps. Could possibly date from Medieval times.

Slag:

References: MTA, 1972:51.

Comments: Deposit is located S of Yomra ca. 15 kms. and at an elevation of 940 m. Deposit was also exploited in modern times.

66.

Type of Deposit: Cu

Province: Trabzon

Name of Deposit: Kalafak Hatipli

Map Reference: 29/2

Ore and Formation: Pyrite and oxidized copper ores. No details. Veins.

Mine: At Arasli Dere there is an old exploration tunnel.

Slag: Dumps.

% Cu	4.42
Fe	26.62

References: MTA, 1972:51; Ryan, 1960:46.

Comments: This deposit is situated about 15 kms. SE of Trabzon on the Araslidere.

67.

Type of Deposit: Cu

Province: Trabzon

Name of Deposit: Ayman

Map Reference: 29/2

Ore and Formation: Pyrite, chalcopyrite. Contact-metamorphic zone.

	No.1	No.2
% Cu	0.14	1.15
Au	Tr	Tr

Mine: "Old workings" are reported. No further details.

Slag: Dumps. No further details.

References: MTA, 1972:56.

Comments: Deposit is situated on both sides of Uzunoluk Deresi mear Dağbaşi and SW of Surmene. The elevation is 1900 m. No further details.

68.

Type of Deposit:	Cu
Province:	Trabzon
Name of Deposit:	Küçük Ayven
Map Reference:	29/2
Ore and Formation:	Chalcopyrite, pyrite. Veins.
Mine:	
Slag:	Dumps of up to 7,000 tons.
References:	MTA, 1972:50-51; Ryan, 1960:47.
Comments:	Deposit is located ca. 5 kms. SW of Dağbaşi. Mine was not located. "Old workings" are mentioned. No further details.

69.

Type of Deposit:	Cu
Province:	Trabzon
Name of Deposit:	Büyük Ayven
Map Reference:	29/2
Ore and Formation:	Pyrite, chalcopyrite and some sphalerite. Skarn. % Cu 0.03 - 11.6
Mine:	Remains. No details.
Slag:	
References:	MTA, 1972:56.
Comments:	Deposit is located at an elevation of ca. 1100 m. Position on map is not certain. Probably near Küçük Ayven (above).

70.

Type of Deposit:	Cu
Province:	Trabzon
Name of Deposit:	Erikli
Map Reference:	29/2
Ore and Formation:	Copper deposit. Contact-metamorphic deposit.

Mine: No mine was located.

Slag: Dumps.

% Cu 0.85

References: MTA, 1972:56.

Comments: Deposit is located at an elevation of ca. 1840 m. No further details.

71.

Type of Deposit: Cu

Province: Trabzon

Name of Deposit: Büyük Harmanhani, Hamzali

Map Reference: 30/1

Ore and Formation: Magnetite, chacopyrite. Contact zone.

Mine: No mine was located.

Slag: Dumps.

% Cu 0.24

References: MTA, 1972:57.

Comments: Deposit is located near Hayrat at 1700 m elevation. Position on map is not certain.

72.

Type of Deposit: Cu

Province: Rize

Name of Deposit: Latum Maden

Map Reference: 13/4

Ore and Formation: Pyrites, chalcopyrite, sphalerite, galena, tetrahedrite, bornite and covellite. Instrusive veins (?). Also, seams rich in copper and zinc alternate. Also lenses.

Ore from gallery:

% Cu 2.0
Pb 10.0
Zn 25.0

Mine: Ore dumps and adits.

Slag:

References:	MTA, 1972:9-10.
Comments:	Tunnels are reported in and around Maden Dere. Some workings are said to be Genoese. Other ore analyses are available in MTA Report No. 1061.

73.

Type of Deposit:	Cu
Province:	Artvin
Name of Deposit:	Sucuna
Map Reference:	14/1
Ore and Formation:	Chalcopyrite, galena, pyrite and sphalerite. Veins. % Cu 9.23 Pb 0.81 Zn Tr Ag Tr Au Tr
Mine:	Four tunnels now filled with water. Deposit is said to have been worked only 60 or 70 years ago.
Slag:	
References:	MTA, 1972:12; Ryan, 1960:50.
Comments:	Deposit is located 2 kms. West of Beğlevan.

74.

Type of Deposit:	Cu
Province:	Artvin
Name Of Deposit:	Beğlevan-Pehlivan
Map Reference:	14/1
Ore and Formation:	Chalcopyrite, sphalerite. Veins. % Cu 2.31 - 4.27 (It was noted that other samples were richer in zinc). Another analysis gave % Cu 6.12
Mine:	"Indications of old workings" have been noted. No further details.

Slag:

References: MTA, 1972:12; Ryan, 1960:50.

Comments: Deposit is said to have been worked before World War I. This deposit is located 9 kms. NW of Borcka. No further details.

75.

Type of Deposit: Cu

Province: Artvin

Name of Deposit: Murgul Maden

Map Reference: 14/3

Ore and Formation: Chalcopyrite, pyrite, some sphalerite, bornite, chalcosite, vovellite, malachite and azurite.
Average grade:
% Cu 2.0

Mine: Tunnels. Malachite and azurite "occur chiefly in the very ancient workings."

Slag:

References: MTA, 1972:13-14; Ryan, 1960:49-50.

Comments: This deposit is located 2 kms. SE of Murgul, on the NW slope of Tiryal Dag, at an altitude of ca. 1100 m. It is reported that, "remnants of old workings from the Middle Ages are sometimes found in the upper parts of the deposit."

76.

Type of Deposit: Cu

Province: Artvin

Name of Deposit: İrsa

Map Reference: 14/4

Ore and Formation: Chalcopyrite. Veins.

	No.1	No.2	No.3	No.4
% Cu	14.8	8.7	7.13	16.8
Fe	22.5	22.0	18.78	30.09
S	25.8	25.4	21.55	34.50
SiO_2	12.3	4.5	32.40	11.90

Mine: "Ancient workings" are reported. No details.

Slag:

References: Ryan, 1960:50.

Comments: Deposit is said to be 6 kms. NW of Çoruh (Artvin) and situated near the Kuvarshan deposit (below). Reserves are thought to be very small. Position on map is not accurate.

77.

Type of Deposit: Cu

Province: Artvin

Name of Deposit: Kuvarshan Maden

Map Reference: 14/4

Ore and Formation: Chalcopyrite, sphalerite, bornite, chalcosite. Lenses.

Ore from modern tunnels:

% Cu	4.65 - 7.1
Fe	34.65 - 37.16
Zn	2.87 - 3.67
Pb	0.52 - 0.72
Bi	Tr
As	1.24 - 1.46
SiO_2	3.10 - 3.54
CaO	0.2
Au	Tr
Ag	Tr

Mine: Modern workings recently abandoned, but deposit was extensively worked in the past. No details.

Slag:

References: MTA, 1972:15; Ryan, 1960:51.

Comments: It is reported that "the ore was suitable for pyritic smelting, but not suitable for the manufacture of sulfuric acid, because of its high arsenic content."

78.

Type of Deposit: Cu

Province: Artvin

Name of Deposit: Hot Madeni

Map Reference: 14/4

Ore and Formation: Chalcopyrites and sphalerites, Many veins.

Mine: Ancient mine works are said to be found in this area at Çeneviz Mağara. No further details.

Slag:

References: MTA, 1972:16-17; Ryan, 1960:51.

Comments: Deposit is located 7 kms. east of the confluence of Hot River and Çoruh River.

79.

Type of Deposit: Cu

Province: Artvin

Name of Deposit: Tünkes

Map Reference: 31/1

Ore and Formation: Native copper, cuprite, malachite. Thin veinlets.

Mine: Open pits.

Slag:

References: MTA, 1972:58.

Comments: Deposit is located ca. 5 kms. S of Ersis and ca. 30 kms. SSW of Yusufeli. Reserves are now considered to be insignificant.

80.

Type of Deposit: Cu

Province: Çanakkale

Name of Deposit: Gümüşçati (or Murab Obasi, or Muratlar)

Map Reference: 52/1

Ore and Formation: Azurite, malachite, chalcopyrite. Outcrops and Veins.

Ore from mine:

% Cu 2 - 25.9

Mine: "Abandoned mine" is reported by Ryan. No further details.

Slag:

References: MTA, 1972:76; Ryan, 1960:28.

Comments: Deposit is located ca. 2 kms. east of Karapinar and less than 5 kms. south of Kirazli. No further details.

81.

Type of Deposit: Cu

Province: Çanakkale

Name of Deposit: Balcilar

Map Reference: 35/4

Ore and Formation: Pyrite, chalcopyrite, galena, sphalerite. Veins.
Ore from dumps:
% Cu 22.18

Mine: A shaft 60-70 m. deep and an adit 30 m. long.

Slag:

References: MTA, 1972:61-2; Ryan, 1960:27.

Comments: Deposit is located ca. 1.5 kms. NW of Balcilar village which is ca. 25 kms. SE of Lapseki.

82.

Type of Deposit: Cu

Province: Çanakkale

Name of Deposit: Çamyurt

Map Reference: 35/4

Ore and Formation: Copper oxide ore. Malachite and chalcopyrite. Cementation zone.

Mine: Shaft 40-50 m deep. "Remains of old workings" reported. No details.

Slag: There are an estimated 1500-2000 tons of slag.
% Cu 0.31

References: MTA, 1972:61; Ryan, 1960:28.

Comments: Deposit is located ca. 28 kms. east of Lapseki. No further details.

83.

Type of Deposit: Cu

Province: Çanakkale

Name of Deposit: Doğancilar

Map Reference: 52/3

Ore and Formation: Malachite, chalcopyrite, sphalerite, galena. Veinlets.

Mine: Former mining activity. No details.

Slag: Dumps estimated at 10,000 tons.

References: MTA, 1972:77.

Comments: Deposit is located 7 kms. NNE of Doğancilar village which is situated near Bakirlik Deresi and Altinlar Suri Deresi. Former mining activity is mentioned at near-by Haci Ibrahim Sayasi. Ore stated above comes from this site.

84.

Type of Deposit: Cu

Province: Ankara

Name of Deposit: Karaca Hasan

Map Reference: 58/1

Ore and Formation: Chalcopyrite and pyrite. Mineralization in shear zone.

Mine:

Slag: Dumps.

	No.1	No.2
% Cu	0.52	18.6
Fe	26.6	...

References: MTA, 1972:85.

Comments: Deposit is located 2.5 kms. from Karaca Hasan at Osman Kavaği Körüklüğü.

85.

Type of Deposit: Cu

Province: Ankara

Name of Deposit: Karaali

Map Reference: 57/3

Ore and Formation: Pyrite and chalcopyrite. Some veins.

Mine: Open pits, caved tunnels and ore dumps N of village.

Slag: Dumps estimated at 70,000 tons.

	Karaali	Karaali	Karaali (on Akkaya)	Karaali (hüyük)	Karaali (at Tomo)
	No.1	No.2	No.1	No.1	No.1
% Cu	0.07	1.0	1	0.3	0.3
Sn	nd	nd	nd	nd	nd
Pb	0.001	0.002	0.001	0.1	0.001
As	nd	nd	nd	nd	nd
Sb	nd	nd	0.01	nd	0.01
Ag	nd	0.001	0.0002	0.001	0.0002
Ni	0.04	0.01	0.015	0.02	0.015
Bi	nd	nd	nd	nd	nd
Au	nd	nd	nd	nd	nd
Zn	nd	0.3	nd	1.5	nd
Co	nd	0.003	0.02	nd	0.02
Fe	10	10	10	1	10

References: MTA, 1972:84; Ryan, 1960:34; de Jesus and Kaptan, 1973:20-36; Ainsworth, 1842;I:150.

Comments: Operations date from at least Byzantine times, probably earlier.

86.

Type of Deposit: Cu

Province: Çankiri

Name of Deposit: Eldivan Mountains

Map Reference: 41/1

Ore and Formation: Chalcosite, chalcopyrite, malachite. Veins.

Mine: No former mining activities were located.

Slag: Dumps are located in the Eldivan Mountains at the following sites:

	Gemilik Mevkiği			Demir Boku	
	No.1	No.2	No.3	No.1	No.2
% Cu	5.52	1.04	1.50	1	0.7
Sn	nd	nd	nd	nd	nd
Pb	0.004	0.002	0.003	0.002	0.002
As	nd	nd	nd	nd	nd
Sb	nd	nd	nd	nd	nd
Ag	0.003	nd	nd	0.0004	0.0001
Ni	–	–	–	0.07	0.15
Bi	nd	nd	nd	nd	nd
Au	nd	nd	nd	nd	nd
Zn	0.07	0.04	nd	nd	nd
Co	0.1	0.004	0.003	nd	0.003
Fe	0.44	0.14	0.14	10	10

	Sari Pinar		Çakmak Tepe	
	No.1	No.2	No.1	No.2
% Cu	1	0.7	1	0.7
Sn	nd	nd	nd	nd
Pb	0.002	0.003	0.0015	0.001
As	nd	nd	nd	nd
Sb	nd	nd	nd	nd
Ag	0.0007	0.0003	0.001	0.0001
Ni	0.07	0.07	0.1	0.1
Bi	nd	nd	nd	nd
Au	nd	nd	nd	nd
Zn	nd	nd	0.1	o.07
Co	0.003	0.003	0.03	0.03
Fe	10	10	10	0.7

	Cuma Camisi Tepesi	
	No.1	No.2
% Cu	1	1
Sn	nd	nd
Pb	0.004	0.007
As	nd	nd
Sb	nd	nd
Ag	0.00015	0.0003
Ni	0.15	0.15
Bi	nd	nd
Au	nd	nd
Zn	0.4	0.3
Co	0.07	0.03
Fe	10	10

References: MTA, 1972:65; de Jesus and Kaptan, 1973:40-54; de Jesus (forthcoming).

Comments: Most of the workings, if not all, may date from Byzantine times or earlier. One C-14 date is available for Gemilik Mevkiği: 427 A.D. ± 155. One C-14 date is available for Demir Boku: 4 B.C. ± 129. Both calculations used the lower half-life. A full report on these sites appears in de Jesus and Kaptan, 1973:40-54.

87.

Type of Deposit: Cu

Province: Çankiri

Name of Deposit: Hisarcikkayi

Map Reference: 41/1

Ore and Formation: Chalcopyrite, sphalerite. No further details.

Mine: Smelting furnace. Judging from the slag analyses chalcopyrite with sphalerite was probably the ore exploited. Site is located a few hundred meters W of the village. Operations could date from Byzantine times or earlier. Furnace could be matting type, cf. text supra.

Slag: Dumps.

	Hisarcikkayi No.1	Hisarcikkayi No.2
% Cu	0.91	3.11
Sn	nd	nd
Pb	0.003	0.003
As	nd	nd
Sb	nd	nd
Ag	nd	0.0007
Ni	-	-
Bi	nd	nd
Au	nd	nd
Zn	0.80	0.49
Co	0.03	0.03
Fe	40.94	27.39
S	0.14	0.55

References: de Jesus and Kaptan, 1973:55-59 and 144-5; de Jesus (forthcoming).

Comments: Ore source was not located, but it was probably close by. More smelting furnaces at the site no doubt exist. Some of the slag had been carted away by the villagers. Hence, there is more slag than can be accounted for by one smelting furnace.

88.

Type of Deposit: Cu

Province: Çankiri

Name of Deposit: Yaprakli

Map Reference: 24/3 and 41/2

Mine: Ore dumps were noted at Armutlu Yelet and possibly at Ahmet Burhan ' in Tarlasi.

Slag: No fewer than 18 sites with dumps have been located in this general area. In none of these cases was the specific ore source located. Amount of slag varied from a few hundred kgs. (Damlu Yurt Basi) to a few thousand tons (Yanyaylasi). A full report is available in de Jesus and Kaptan, 1973.

	Ahmet Burhan Tar I		Ahmet Burhan Tar II		Akyolun Tepe
	No.1	No.2	No.1	No.2	No.1
% Cu	0.02	0.015	0.004	0.004	0.03
Sn	nd	0.002	nd	nd	nd
Pb	0.001	0.003	nd	0.0015	0.04
As	nd	nd	nd	nd	nd
Sb	nd	nd	nd	nd	0.02
Ag	nd	nd	nd	nd	0.0003
Ni	0.04	0.1	0.07	0.07	0.15
Bi	nd	nd	nd	nd	nd
Au	nd	nd	nd	nd	nd
Zn	nd	nd	nd	nd	0.3
Co	0.002	nd	0.002	nd	nd
Fe	10	10	10	10	1

	Asarcik Yaylasi			Damlu Yurt Basi	
	No.1	No.2	No.3	No.1	No.2
% Cu	0.4	0.004	0.004	0.015	0.007
Sn	nd	nd	nd	nd	nd
Pb	nd	0.0015	0.001	0.0015	0.0015
As	nd	nd	nd	nd	nd
Sb	-	nd	nd	nd	nd
Ag	-	nd	nd	nd	nd
Ni	-	0.07	0.07	-	-
Bi	-	nd	nd	nd	nd
Au	-	nd	nd	nd	nd
Zn	nd	nd	nd	0.04	nd
Co	-	nd	nd	0.003	nd
Fe	10	10	10	21.68	22.57
S	-	-	-	0.05	0.14

	Damlu Yurt Deresi			Dipyurt	
	No.1	No.2	No.3	No.1	No.2
% Cu	0.04	0.003	0.003	0.007	0.004
Sn	nd	nd	nd	nd	nd
Pb	nd	nd	nd	0.0015	0.0015
As	nd	nd	nd	nd	nd
Sb	-	nd	nd	nd	nd
Ag	-	0.00015	nd	0.0001	nd
Ni	-	0.04	0.01	0.07	0.07
Bi	-	nd	nd	nd	nd
Au	-	nd	nd	nd	nd
Zn	0.04	nd	nd	nd	nd
Co	-	nd	nd	0.002	nd
Fe	10	10	10	10	10

	Dedeköy			Eyriceova Mevkii	
	No.1	No.2	No.3	No.1	No.2
% Cu	0.007	0.004	0.1	0.004	0.004
Sn	nd	nd	nd	nd	nd
Pb	0.001	0.001	0.0015	0.02	0.002
As	nd	nd	nd	nd	nd
Sb	nd	nd	-	nd	nd
Ag	nd	nd	-	nd	nd
Ni	0.1	0.1	-	-	-
Bi	nd	nd	-	nd	nd
Au	nd	nd	-	nd	nd
Zn	nd	nd	nd	nd	nd
Co	nd	nd	-	nd	nd
Fe	10	10	76.94	14.19	22.47
S	-	-	-	0.05	0.14

	Kapaklik Mev.		Kasyaylasi Mevkiği	
	No.1	No.2	No.1	No.2
% Cu	0.04	0.015	0.01	0.01
Sn	nd	nd	nd	nd
Pb	0.0015	0.002	nd	0.003
As	nd	nd	nd	nd
Sb	nd	nd	nd	nd
Ag	nd	nd	nd	nd
Ni	-	-	0.015	0.015
Bi	nd	nd	nd	nd
Au	nd	nd	nd	nd
Zn	nd	nd	0.04	nd
Co	nd	nd	0.003	nd
Fe	9.85	91.98	10	10
S	0.11	0.08	-	-

	Kiyalti Mev.		K T D D B M *		
	No.1	No.2	No.1	No.2	No.3
% Cu	0.007	0.007	0.15	0.004	0.003
Sn	nd	nd	nd	nd	nd
Pb	nd	0.003	nd	nd	0.0015
As	nd	nd	nd	nd	nd
Sb	nd	nd	-	nd	nd
Ag	nd	nd	-	nd	nd
Ni	0.004	0.01	-	0.01	0.007
Bi	nd	nd	-	nd	nd
Au	nd	nd	-	nd	nd
Zn	nd	0.04	nd	nd	0.07
Co	nd	nd	-	0.003	nd
Fe	10	10	10	10	10

* Karatepe Deki Demir Boku Mevkiği

	Mehmet Tekmen Tar.		Panayir Tepe	
	No.1	No.2	No.1	No.2
% Cu	0.004	0.004	0.7	0.4
Sn	nd	nd	nd	nd
Pb	nd	0.004	nd	0.0015
As	nd	nd	nd	nd
Sb	nd	nd	nd	nd
Ag	nd	nd	nd	0.0004
Ni	0.07	0.007	0.007	0.03
Bi	nd	nd	nd	nd
Au	nd	nd	nd	nd
Zn	nd	0.1	nd	nd
Co	0.002	0.002	0.03	nd
Fe	10	10	10	7.0

	Papurun Kaşi		Yanyaylasi Mev.	
	No.1	No.2	No.1	No.2
% Cu	0.002	0.002	0.007	0.007
Sn	nd	nd	nd	nd
Pb	0.0015	0.0015	nd	nd
As	nd	nd	nd	nd
Sb	nd	nd	nd	nd
Ag	nd	nd	nd	nd
Ni	-	-	0.015	0.015
Bi	nd	nd	nd	nd
Au	nd	nd	nd	nd
Zn	nd	nd	nd	nd
Co	nd	nd	0.002	nd
Fe	15.37	18.13	10	10
S	0.14	0.08	-	-

References: MTA, 1972:66; Ryan, 1960:32; de Jesus and Kaptan, 1973:59-99.

Comments: Most of the sites are located in an area ca. 15 km^2. Operations may have spread over several centuries. Earliest workings could be prior to Byzantine times. Most of the sites are located at an elevation of ca. 1500 m.

89.

Type of Deposit:	Cu
Province:	Çankiri
Name of Deposit:	Urvay
Map Reference:	41/1
Ore and Formation:	Native Copper, malachite, cuprite. Veins.

	No.1	No.2
% Cu	5.0	5.5

Mine:	Caved workings are reported. No further details.
Slag:	
References:	MTA, 1972:66; Ryan, 1960:32.
Comments:	Deposit is located ca. 16 kms N of Çankiri. No further details.

90.

Type of Deposit:	Cu
Province:	Çorum
Name of Deposit:	Örencik
Map Reference:	25/1
Ore and formation:	Copper ore. No further details.
Mine:	Remains of a smelting furnace. Pieces of clay furnace lining were found mixed with the slag. Also mixed with the slag were pieces of quartz and malachite.
Slag:	A few hundred kgs. of copper slag.

	Örencik
% Cu	1.05
Sn	nd
Pb	0.002
As	nd
Sb	nd
Ag	0.0002
Ni	nd
Bi	nd
Au	nd
Zn	0.15
Co	nd
Fe	10

References: de Jesus and Kaptan, 1974:26-7; de Jesus (forthcoming).

Comments: Site is located near Orencik Koyu on the south side of the hill at Karataş Mevkii. Ore source was not located.

91.

Type of Deposit: Cu

Province: Corum

Name of Deposit: Findikoǧlu Deresi

Map Reference: 41/2

Ore and Formation: Copper ore. No details.

Mine: Ore source was not located.

Slag: Scattered dumps.

	Findikoǧlu No.1	Findikoǧlu No.2
% Cu	0.4	0.4
Sn	nd	nd
Pb	0.002	0.002
As	nd	nd
Sb	0.01	0.01
Ag	nd	nd
Ni	0.1	0.15
Bi	nd	nd
Au	nd	nd
Zn	nd	nd
CO	0.0015	0.0015
Fe	10	10

References: de Jesus and Kaptan, 1973:106-7.

Comments: Site is located ca. 10 kms. NW of Bayat, near the village of Tepekuşu.

92.

Type of Deposit: Cu

Province: Çorum

Name of Deposit: Hasan Karaman Tarlasi

Map Reference: 41/2

Ore and Formation: Copper ore. Native copper and malachite.

Mine: Mine was not located, but native copper and copper ore are available in near-by Astar Deresi.

Slag: Scattered bits in the field.

	Hasan Karaman Tar
% Cu	0.4
Sn	nd
Pb	0.003
As	nd
Sb	0.01
Ag	nd
Ni	0.1
Bi	nd
Au	nd
Zn	nd
Co	0.001
Fe	7.0

References: de Jesus and Kaptan, 1973:108-9; MTA, 1972:65.

Comments: Site is located near the confluence of the Astar Deresi and the Koca Çay. The site could date from Byzantine times.

93.

Type of Deposit: Cu

Province: Çorum

Name of Deposit: Hamdi Efendi Çiftliği

Map Reference: 42/1

Ore and Formation: No details.

Mine: Mine was not located.

Slag: Scattered bits throughout the field.

	Hamdi Efendi Çiftliği	
	No.1	No.2
% Cu	0.04	0.03
Sn	nd	nd
Pb	0.01	0.015
As	nd	nd
Sb	0.01	nd
Ag	nd	nd
Ni	0.003	0.002
Bi	nd	nd
Au	nd	nd
Zn	nd	nd
Co	0.002	0.001
Fe	10	7

References: de Jesus and Kaptan, 1973:104-5.

Comments: Deposit is located ca. 5 kms. SW of İskilip. There is some doubt as to whether this is copper slag, or even smelting slag. Sherds suggest Byzantine period.

94.

Type of Deposit: Cu

Province: Çorum

Name of Deposit: Oyaca Köyü

Map Reference: 42/4

Ore and Formation: Copper ore. No details.

Mine: Mine was not located, but native copper has been noted at Ucoluk-Bakirli Deresi and on Nurhak Tepe.

Slag: Small dump. No more than a few hundred kgs.

	Oyaca Köyü
% Cu	0.4
Sn	nd
Pb	0.0015
As	nd
Sb	0.01
Ag	0.00015
Ni	0.15
Bi	nd
Au	nd
Zn	nd
Co	0.03
Fe	10

References: MTA, 1972:66-67; Ryan, 1960:33; de Jesus and Kaptan, 1973:130-1.

Comments: Deposit is located ca. 5 kms. NE of Haciosman Köy in the village of Oyaca.

95.

Type of Deposit: Cu

Province: Amasya

Name of Deposit: Derealan - Bakir Çay

Map Reference: 26/4

Ore and Formation: Chalcopyrite and secondary malachite. Lenses in contact zones. Ore sampled at İnkaya.

	İnkaya
% Cu	10
Sn	nd
Pb	0.015
As	nd
Sb	nd
Ag	0.015
Ni	0.02
Bi	0.003
Au	nd
Zn	3.0
Co	0.007
Fe	1

Mine: The many tons of slag attest to considerable smelting activity. This activity could have spread over many centuries, perhaps as early as the Late Phrygian Period. Probably the bulk of the workings date between Late Roman and Early Byzantine. Mining activities at Inkaya may be modern, but the ancient ore source may have been near-by. From the layout of the smelting sites it looks as if mining may have taken place in the banks of the Bakir Cay itself.

Slag: Thousands of tons of slag in the Bakir Cay area. Samples were analyzed at the following sites:

Bahçelidere

	No.1	No.2
% Cu	1	1
Sn	0.007	0.007
Pb	0.03	0.01
As	0.1	0.1
Sb	0.01	0.02
Ag	0.004	0.004
Ni	0.03	0.02
Bi	0.004	0.004
Au	nd	nd
Zn	0.04	nd
Co	0.0015	nd
Fe	10	10

Kağni Deresi

	No.1	No.2
% Cu	0.7	1.0
Sn	nd	nd
Pb	0.0015	0.03
As	nd	nd
Sb	nd	nd
Ag	0.0004	0.0004
Ni	0.03	0.04
Bi	0.002	0.0015
Au	nd	nd
Zn	0.07	0.1
Co	0.001	0.003
Fe	10	10

	Sakapinar No.1	Sakapinar No.2	Sakapinar No.3
% Cu	1	1	1.0
Sn	0.07	0.004	0.003
Pb	0.03	0.003	0.04
As	0.4	nd	nd
Sb	-	nd	nd
Ag	-	0.001	0.0007
Ni	-	0.015	0.03
Bi	-	0.002	0.0015
Au	-	nd	nd
Zn	0.04	nd	nd
Co	-	0.001	nd
Fe	10	10	10

	Şamelik Dere Mev. No.1	Suluyalak No.1
% Cu	1.0	0.7
Sn	0.007	0.003
Pb	0.015	0.01
As	nd	nd
Sb	nd	0.015
Ag	0.001	0.0007
Ni	0.03	0.04
Bi	0.002	0.0015
Au	nd	nd
Zn	0.07	nd
Co	0.002	0.001
Fe	10	10

<u>References:</u> MTA, 1972:23; Ryan, 1960:33; de Jesus and Kaptan, 1973:116-125.

<u>Comments:</u> Subaşi is also in the Bakir Çay area, but it is treated here separately (cf. S-96).

96.

Type of Deposit: Cu

Province: Amasya

Name of Deposit: Subaşi

Map Reference: 26/4

Ore and Formation: Copper ore, some malachite. No details, but cf. "Derealan-Bakir Çay."

Mine: Mine was not located, but it was probably near-by. One C-14 date is available for Subaşi: 223 B.C. ± 300. Tuyeres were found in this slag, and fragments of tuyeres were found at Suluyalak and Şamelik, thereby linking them with Subaşi. Operations could date as early as the Late Phrygian Period.

Slag: Many hundreds of kgs.

	Subasi No.1	No.2
% Cu	1	1
Sn	0.004	0.007
Pb	0.004	0.01
As	nd	nd
Sb	nd	nd
Ag	0.001	0.001
Ni	0.03	0.03
Bi	0.0015	0.001
Au	nd	nd
Zn	nd	nd
Co	0.001	nd
Fe	10	10

References: de Jesus and Kaptan, 1973:115-117 and 126-129.

Comments: Reconstruction of the smelting operation at Subasi may be found in de Jesus and Kaptan (above) and in de Jesus (forthcoming).

97.

<u>Type of Deposit</u>: Cu
<u>Province</u>: Tokat
<u>Name of Deposit</u>: Kozlu
<u>Map Reference</u>: 26/3
<u>Ore and Formation</u>: Native copper, chalcopyrite, pyrite. Gossan.
<u>Mine</u>: Shafts and tunnels. Most are caved. Dumps. One C-14 date available: 2800 B.C. ± 30 (lower half-life). Currently recognized as the oldest copper mine in Anatolia.
<u>Slag</u>:
<u>References</u>: Giles, Kuijpers:1974; de Jesus (forthcoming).
<u>Comments</u>: Mine is located near the village of Kozlu, southwest of Erbaa ca. 15 kms. Workings seem extensive and may have lasted for many hundreds of years.

98.

<u>Type of Deposit</u>: Cu
<u>Province</u>: Tokat
<u>Name of Deposit</u>: Ağaca Ağaçli
<u>Map Reference</u>: 43/3
<u>Ore and Formation</u>: Chalcopyrite, bornite, chrysocolla, malachite, azurite. Contact zone.
<u>Mine</u>: Tunnel, now caved. Walls and roof were supported with beams.
<u>Slag</u>: One piece of slag is said to have come from this mining site and was analyzed. However, no other pieces at the site were found.

	Ağaca Ağaçli
% Cu	1.10
Sn	nd
Pb	0.003
As	nd
Sb	nd
Ag	0.0001
Ni	0.015
Bi	nd
Au	nd
Zn	1.77
Co	0.002
Fe	10

References: de Jesus and Kaptan, 1974:14-16.

Comments: Deposit and mine are located SE of Karaoluk.

99.

Type of Deposit: Cu

Province: Tokat

Name of Deposit: Bakimli-Gevrek

Map Reference: 44/1

Ore and Formation: Copper ore. No details.

Mine: Ore sourse was not located.

Slag: Scattered bits near the village of Gevrek.

	Bakimli	Gevrek	
	No.1	No.1	No.2
% Cu	0.004	0.015	0.78
Sn	nd	nd	nd
Pb	0.003	0.003	0.002
As	nd	nd	nd
Sb	nd	nd	nd
Ag	nd	nd	nd
Ni	0.004	0.004	nd
Bi	nd	nd	nd
Au	nd	nd	nd
Zn	nd	nd	nd
Co	nd	nd	nd
Fe	7	7	10

References: de Jesus and Kaptan, 1974:17-20.

Comments: Two slag dumps, at Bakimli and at Gevrek, are located on the south side of the Tokat-Almuş road.

100.

Type of Deposit: Cu-Pb

Province: Tokat

Name of Deposit: Kizilev Köprüsü

Map Reference: 44/1

Ore and Formation: Chalcopyrite, pyrite, galena, sphalerite.

Mine: Former workings are reportedly caved.

Slag:

References: Ryan, 1960:33.

Comments: Deposit is one hours's walk from Kizilev Köprüsü.

101.

Type of Deposit: Cu

Province: Sivas

Name of Deposit: Madenköy

Map Reference: 44/4

Ore and Formation: Malachite, hematite. Lens.

Mine: According to reports, there "appears to be... some small-scale underground workings which are now inaccessible.

Slag: Scattered amounts. Indications are that very little ore was smelted.

References: MTA, 1972:68-9.

Comments: The deposit is located 20 kms. N or Haflik and 100 m. NNE of Madenköy at an elevation of 1470 m.

102.

Type of Deposit: Cu

Province: Sivas

Name of Deposit: Golçük Köy

Map Reference: 45/1

Ore and Formation: Malachite. Impregnation.

Mine: Remains. Said to date "from times before World War I." No further details.

Slag: It is reported that "the ore was smelted *in situ*." No further details.
% Cu 3.07

References: MTA, 1972:71.

Comments: Deposit is located ca. 5 kms. south of Koyulhisar at an elevation of 1750 m.

103.

Type of Deposit: Cu

Province: Sivas

Name of Deposit: Camili

Map Reference: 45/1

Ore and Formation: Native copper, malachite and copper carbonates. Veins.

Mine: It is reported that "near the outcrop there are slags from old workings." No further details.

Slag: Said to be near the outcrop. No further details.

References: MTA, 1972:72-3; Ryan, 1960:56.

Comments: It is not certain whether the Camilköy of Ryan is the same site.

104.

Type of Deposit:	Cu
Province:	Sivas
Name of Deposit:	Maden
Map Reference:	45/1
Ore and Formation:	Malachite and some bornite. % Cu 15.0
Mine:	Ryan simply mentions "an abandoned copper deposit." No further details.
Slag:	
References:	Ryan, 1960:56.
Comments:	Deposit is located ca. 25 kms. S of Şuşehri.

105.

Type of Deposit:	Cu
Province:	Sivas
Name of Deposit:	Delice
Map Reference:	45/4
Ore and Formation:	Copper ore. No details.
Mine:	
Slag:	"A slag pile" is reported. No further details.
References:	Ryan, 1960:57.
Comments:	Two copper occurrences are noted, at Kizilmezraa and at Borulu. Both are termed "insignificant."

106.

Type of Deposit:	Cu
Province:	Kayseri
Name of Deposit:	Menteşe
Map Reference:	77/1
Ore and Formation:	Copper mineralization in the form of chalcocite, covellite and malachite. Lenses.
Mines:	"Old workings" are reported. No further details.
Slag:	
References:	MTA, 1972:91.
Comments:	Deposit is located ca. 15 kms. SW of Felahiye and 4 kms. NNW of the village of Menteşe.

107.

Type of Deposit:	Cu
Province:	Erzincan
Name of Deposit:	Çöplerköy
Map Reference:	62/2
Ore and Formation:	Secondary copper minerals such as azurite, malachite, and chrysocolla. Veins.

Ore from dumps:

	No.1	No.2	No.3
% Cu	0.92	3.46	5.40

Mine: It is reported that "about a century ago ... shallow mining was carried out by the Armenians."

Slag: Covers an area of 5500 m^2.

	No.1	No.2	No.3
% Cu	1.6	1.35	2.22
Fe	34.7	-	-
SiO_2	24.5	-	-

References: MTA, 1972:88-89; Ryan, 1960:57.

Comments: Çöplerköy is located ca. 35 kms. S of the Euphrates. Ore reserves in the slag is estimated ca. 25-35,000 tons.

108.

Type of Deposit: Cu-Pb-Zn

Province: Erzincan

Name of Deposit: Ağamcağam

Map Reference: 46/2

Ore and Formation: Pyrite, malachite. Contact zone.

	No.1	No.2	No.3	No.4
% Cu	2.40	1.75	4.07	0.65

Mine: It is reported that "old workings are scattered over an area of 70 x 30 m." No further details.

Slag:

References: Ryan, 1960:58.

Comments: Deposit is located on Kabak Tepe at an elevation of 2063 m.

109.

Type of Deposit: Cu

Province: Tunceli

Name of Deposit: Mamlis

Map Reference: 63/4

Ore and Formation: Malachite, azurite and some bornite. Disseminated in the fissures and seams. One rich ore sample gave: % Cu 4.52

Mine: "A very old copper mine" is reported. No further details.

Slag: Dumps.

	No.1	No.2
% Cu	5.62	8.92

References: MTA, 1972:89-90; Ryan, 1960:59.

Comments: Deposit is located south of Mamlis near Kakbil. Location on map is not certain (Madenköy?).

110.

Type of Deposit: Cu

Province: Erzurum

Name of Deposit: Semherek

Map Reference: 30/3

Ore and Formation: Chalcopyrite, sphalerite and galena. Cementation zone. Also gossan.

Mine: Remnants of old workings are said to exist over an area of ca. 2 km^2. They are thought to date from Genoese times. An open pit still remains.

Slag: Dumps. No further details.

References: MTA, 1972:58.

Comments: Deposit is located at 1310 - 1420 m. in elevation near Norgah. There are not thought to be large reserves. Position on map is not certain.

111.

Type of Deposit: Cu

Province: Erzurum

Name of Deposit: Kobalkomu

Map Reference: 48/1

Ore and Formation: Chalcopyrite, bornite and oxidized copper minerals. No further details.

Mine: Remnants. Shafts and adits are said to have been left by the Russians who worked the deposit during World War I.

Slag: It is reported that 300 tons of slag are visible.

References: MTA, 1972:75; Ryan, 1960:58-59.

Comments: Deposit is located along Maden Deresi at 2500 m elevation.

112.

Type of Deposit: Cu

Province: Erzurum

Name of Deposit: Pitkir

Map Reference: 31/3

Ore and Formation: Chalcopyrite, bornite, pyrite. No further details.

Mine: Dumps, pits and small shafts. Workings cover an area of about 3 hectares.

Slag: Numerous slag dumps are reported.

References: MTA, 1972:60; Ryan, 1960:58.

Comments: Deposit is located to the north and to the east of Pitkir at an elevation of 2000 m. A deposit of arsenic has also been noted at this site. (cf. supra "Arsenic").

113.

Type of Deposit: Cu

Province: Erzurum

Name of Deposit: Terpink

Map Reference: 31/2

Ore and Formation: Chalcopyrite and secondary copper ore. No further details.

Ore from dump:

% Cu 1.3

Mine: Remnants. Mine is now collapsed. Ore dumps.

Slag:

References: MTA, 1972:59.

Comments: Deposit is located 8 kms. east of Otlu. Position on map is not certain. Deposit is located at an elevation of 3,530 m.

114.

Type of Deposit: Cu

Province: Erzurum

Name of Deposit: Mehenk

Map Reference: 14/3

Ore and Formation: Copper ore. No details.

Mine: It is reported that former mining activities were on a small scale and that the mine works are not now accessible.

Slag:

References: MTA, 1972:17.

Comments: Deposit is located south of Mehenk which is 10 kms. NE of Olur.

115.

<u>Type of Deposit</u>: Cu-As

<u>Province</u>: Izmir

<u>Name of Deposit</u>: Seki

<u>Map Reference</u>: 87/3

<u>Ore and Formation</u>: Pyrites, chalcopyrite, arseno-pyrite. No details.

<u>Mine</u>: Ore dump. No further details.

<u>Slag</u>:

<u>References</u>: MTA, 1972:99.

<u>Comments</u>: Deposit is located near Kilise Tepesi in Odemiş county. Position on map is not certain.

116.

<u>Type of Deposit</u>: Cu

<u>Province</u>: Izmir

<u>Name of Deposit</u>: Bülbüller

<u>Map Reference</u>: 87/3

<u>Ore and Formation</u>: Pyrite, chalcopyrite, pyrrhotite. No details.
% Cu 2.53

<u>Mine</u>: "Old workings" are reported. No further details.

<u>Slag</u>:

<u>References</u>: MTA, 1972:99-100.

<u>Comments</u>: Deposit is located ca. 2 kms. N of Bülbüller in Odemiş County. Position on map is not certain.

117.

<u>Type of Deposit</u>: Cu-As

<u>Province</u>: Izmir

<u>Name of Deposit</u>: Seydikoy

<u>Map Reference</u>: 87/3

<u>Ore and Formation</u>: Pyrite, arsenopyrite, chalcopyrite. No further details.

<u>Mine</u>: Ore dumps. No further details.

<u>Slag</u>:

<u>References</u>: Ryan, 1960:30.

<u>Comments</u>: Deposit is said to be located near Seydikoy in Odemiş County. Position on map is not certain.

118.

Type of Deposit:	Cu
Province:	Afyon
Name of Deposit:	Kizilca
Map Reference:	89/1
Ore and Formation:	Malachite and copper carbonates. Veins.
Mine:	Remains. No further details.
Slag:	
References:	MTA, 1972:100.
Comments:	Deposit is located at Bakirli ca. 17 kms. W of Sandikli at 1700 m elevation.

119.

Type of Deposit:	Cu
Province:	Maraş
Name of Deposit:	Suleymanli
Map Reference:	95/4
Ore and Formation:	Copper Deposit. No details.
Mine:	Ore source was not located.
Slag:	Small slag dump located on the slope of the hill in back of the village.

	Süleymanli
% Cu	0.02
Sn	nd
Pb	0.002
As	nd
Sb	nd
Ag	nd
Ni	0.004
Bi	nd
Au	nd
Zn	nd
Co	nd
Fe	10

References:	de Jesus and Kaptan, 1974:10-11.
Comments:	Byzantine coins are said to have come from this village and perhaps the exploitation dates from this time. Workings are considered of short duration.

120.

Type of Deposit:	Cu
Province:	Maraş
Name of Deposit:	Ericek
Map Reference:	95/1
Ore and Formation:	Copper deposit. No details.
Mine:	Ore source was not located.
Slag:	Small slag dump located on the north slope of Karadiçlik Tepe near the village of Ericek. Slag is estimated at less than a few hundred kgs.

	Ericek
% Cu	0.003
Sn	nd
Pb	0.003
As	nd
Sb	nd
Ag	nd
Ni	nd
Bi	nd
Au	nd
Zn	0.04
Co	nd
Fe	10

References:	de Jesus and Kaptan, 1974:12-13.
Comments:	Workings are considered of short duration.

121.

Type of Deposit:	Cu
Province:	Elaziğ
Name of Deposit:	Ergani Maden
Map Reference:	80/3
Ore and Formation :	Pyrite, chalcopyrite. Also some sphalerite, bornite and galena.

Average:

% Cu	5.53
Co	0.231

Massive cupriferous pyrites:

% Cu 10.4

Below massive ore body:

% Cu 4.4

Although no details are given, one analysis of a piece of copper from Ergani (Desch, 1928:437) gave:

% Cu	97.08
Sn	0.27
Ni	0.03
Fe	0.03
S	0.49

Mine: Workings are said to date "from Assyrian times." No details.

Slag: Pieces have been reported.

References: MTA, 1972:93-96; Ryan, 1960:60; Tylecote, 1970:290-2.

Comments: In spite of extensive geological research in this area little is known about former mining and smelting activity.

122.

Type of Deposit: Cu

Province: Elazig

Name of Deposit: Karabek-Süleymanköy

Map Reference: 80/3

Ore and Formation: Pyrite, malachite. Contained in iron hat.

% Cu 2.23

Mine: Underground workings now caved.

Slag:

References: MTA, 1972:96; Ryan, 1960:60.

Comments: Deposit is located ca. 6 kms. E of Ergani Maden.

123.

Type of Deposit: Cu

Province: Elaziğ

Name of Deposit: Kedak (Geydak)

Map Reference: 81/1

Ore and Formation: Copper ore in cementation zone.

Ore from dumps:

% Cu 1.0 -2.0

Au Tr

Ag Tr

Ore from deposit:

% Cu 5.0 - 18.0

Mine: A number of adits are reported plus two smelting areas. Other old galleries are reportedly collapsed.

Slag: Dumps estimated at 10,000 tons.

References: MTA, 1972:97; Ryan, 1960:61; Tylecote, 1970:292.

Comments: Deposit is located ca. 20 kms. SE of Palu and S of Kedak at 1400 m. elevation. The date of these operations is not yet known.

124.

Type of Deposit: Cu

Province: Siirt

Name of Deposit: Maden Köy

Map Reference: 83/4

Ore and Formation: Pyrites, malachite. Dissemination in joints and cracks.

Ore near workings:

% Cu 0.46

Ore from oxidized zone:

% Cu 0.55

Ore from tunnel:

% Cu 0.6

Mine: Tunnel and other caved workings.

Slag: Dumps. Ryan mentions that there are indications of iron smelting in the past, presumably drawing his conclusions from the low copper content of the deposit. According to MTA, "old slags" assay at :

% Cu 1.5 - 3.0

References: MTA, 1972:98; Ryan, 1960:61.

Comments: Deposit is located ca. 11 kms. ENE of Sirvan.

125.

Type of Deposit: Cu-Pb

Province: İçel

Name of Deposit: Kizilca

Map Reference: 127/1

Ore and Formation: Chalcopyrite, bornite, covellite and some pyrite.

Mine: Remains. No details.

Slag:

References: MTA, 1972:113.

Comments: Deposit is located north of Tarsus near the town of Namrun. Position on map is not certain.

126.

Type of Deposit: Pb-Zn

Province: Sakarya

Name of Deposit: Akçukur

Map Reference: 21/3

Ore and Formation: Sphalerite, galena and traces of malachite and azurite.

Mine: Remains of former workings are reported.

Slag:

References: MTA, 1972:20.

Comments: Deposit is situated on the left bank of the Sakarya River. Lead ore seems to be the predominant ore, but reserves are considered negligible.

127.

Type of Deposit: Pb-Zn

Province: Sakarya

Name of Deposit: Kurudere

Map Reference: 21/3

Ore and Formation: Sphalerite, cerussite and galena. Some oxidized copper minerals.

%	Cu	2.21
	Pb	7.69
	Zn	28.18
	As	Tr
	Sb	Tr

Mine: Evidence of former workings are reported.

Slag:

References: MTA, 1972:20; Ryan, 1960:27.

Comments: Several deposits are known in this general area. Characteristic ore is lead-zinc. The western deposits are richer in sphalerite than in lead, and the eastern deposits are poorer in sphalerite.

128.

Type of Deposit: Pb-Zn

Province: Sakarya

Name of Deposit: Kestane Pinar

Map Reference: 22/3

Ore and Formation: Lead-zinc ore. Veins. No further details.

Mine: Remains are reported.

Slag: Slags are reported.

References: MTA, 1972:20; Ryan, 1960:2.

Comments: Deposit is located just south of Kestane Pinar Village. No further details.

129.

Type of Deposit: Pb-As-Zn

Province: Ankara

Name of Deposit: Işikdağ (Salin Yaylasi)

Map Reference: 40/2

Ore and Formation: Arsenopyrite, pyrite, some sphalerite and galena. Veins. Small traces of gold, which seems to be related to the arsenopyrite. Traces of silver are related to boulangerite (Ag = 0.01486 %).

	No.1	No.2
% Cu	11.28	8.96
Sb	1.18	1.7
S	13.53	-
Fe	15.05	12.35
Zn	3.90	6.11
Pb	2.92	5.28
Ag	Tr	Tr
Au	Tr	Tr
SiO_2	-	34.66

Mine: Mine is not mentioned in the report, but it must have been close to the smelting site, given the nature of modern samples.

Slag: Dumps.

% Pb	2.26
Zn	5.18
Sb	0.30
S	13.3

References: MTA, 1972:63-4.

Comments: This deposit is located ca. 12 kms. NE of Guven on the SE slopes of İşik Dağ.

130.

Type of Deposit: Pb-As-Fe

Province: Amasya

Name of Deposit: Gümüş

Map Reference: 25/4

Ore and Formation: Argentiferous galena, sphalerite, pyrites and secondary limonite, manganese ore, calamine, cerussite and subordinate amounts of malachite. Chalcopyrites are extremely rare. Arsenopyrite may also be present. From old workings it is estimated that the % Pb 20-25. Veins.

Mine: There are old tunnels under İnegöl Daği.

Slag: Between 500,000 and one million tons of slag are dispersed throughout the village.

	No.1	No.2	No.3
% Cu	0.36	0.04	0.04
Sn	nd	nd	nd
Pb	0.44	1.0	0.01
As	20.97	1	nd
Sb	-	0.04	0.01
Ag	-	0.015	nd
Ni	-	0.04	nd
Bi	-	nd	nd
Au	-	nd	nd
Zn	nd	1.0	nd
Co	-	nd	0.002
Fe	64.45	10	10.

	No.4	No.5	No.6
% Cu	0.74	0.15	0.93
Sn	nd	nd	nd
Pb	2.61	1	0.87
As	27.76	1	31.50
Sb	-	0.1	-
Ag	-	0.015	-
Ni	-	0.015	-
Bi	-	nd	-
Au	-	nd	-
Zn	nd	1	nd
Co	-	nd	-
Fe	54.46	10	59.71

References: MTA, 1972:21-22; Ryan, 1960:10; de Jesus and Kaptan, 1973:111-114; de Jesus (forthcoming).

Comments: Deposit and slag dumps are located in the village of Gümüş, ca. 5 kms. south of Gümüşhaciköy. This site has been identified with the Roman arsenic mines mentioned by Strabo, XII-3, 40.

131.

Type of Deposit: Pb-Zn

Province: Sivas

Name of Deposit: Muradin Mahallesi (Kân Köy)

Map Reference: 45/1

Ore and Formation: Galena, sphalerite, with some hematite and chalcopyrite. Veins.

Mine: "Old workings" are reported. They were re-investigated in 1954. Dumps from these investigations.

Slag:

References: MTA, 1972:70-1.

Comments: Deposit is located W of Aksudere at an elevation of 1530-1785 m.

132.

Type of Deposit: Pb

Province: Ordu

Name of Deposit: Kiraztepe

Map Reference: 27/1

Ore and Formation: Lead ore. No details.

Mine: "An old adit" is reported. No further details.

Slag:

References: MTA, 1972:23.

Comments: Deposit is located 21 kms, east of Ünye. Position on map is not certain.

133.

Type of Deposit: Pb-Cu

Province: Ordu

Name of Deposit: Kumarli

Map Reference: 27/1

Ore and Formation: Galena, sphalerite, chalcopyrite and pyrite.
Veins.
Ore from dumps:
% Pb 27.74
Au Tr
Ag Tr

Mine: Ore dumps and galleries. Galleries range 10-20 m. in length. Located on both sides of Kurudere.

Slag:

References: MTA, 1972:23-4; Ryan, 1960:35-6.

Comments: At near-by Sari Gecit (Sarigaerik ?) there are more galleries, one of which measures 90 m. in length. Position on map is not certain.

134.

Type of Deposit: Pb-Zn

Province: Ordu

Name of Deposit: Sariyakup

Map Reference: 27/4

Ore and Formation: Lead-zinc-copper deposit. No details.
Mine: "An old copper mine near the village of Sariyakup" is reported. No details.
Slag:
References: MTA, 1972:28; Ryan, 1960:36.
Comments: Other lead deposits are reported at Uzun Ali, Taşoluk, Çaranşa and Keçili. Position of Sariyakup on map is not certain.

135.
Type of Deposit: Pb-Zn.
Province: Giresun
Name of Deposit: Karabulduk
Map Reference: 28/2
Ore and Formation: Galena, sphalerite, chalcopyrite and pyrite. Veins.
Mine: Caved tunnel and shaft. Small open pits.
Slag:
References: MTA, 1972:46; Ryan, 1960:40.
Comments: Deposit is located S of Kesap.

136.
Type of Deposit: Zn-Cu
Province: Giresun
Name of Deposit: Killik-Akköy
Map Reference: 28/2
Ore and Formation: Pyrite, chalcopyrite, sphalerite, galena. Deposits in faulted zones.
Mine: Ore dumps and "three small mines" are reported.
Slag:
References: MTA, 1972:41; Ryan, 1960:44.
Comments: Deposit is located south of Lahanos, ca. 15 kms. south of Esbiye.

137.

Type of Deposit: Pb

Province: Giresun

Name of Deposit: Asarcik-Licese

Map Reference: 45/2

Ore and Formation: Pyrite, galena and sphalerite. Veins.

% Pb	3.42
Fe	6.69
Zn	2.29
S	4.21

Mine: "Numerous old exploration workings" are reported as well as "old adits". The latter are now inaccessible.

Slag:

References: MTA, 1972:71.

Comments: Deposit is situated at Asarcik-İlicak Tepesi. Earliest exploration and exploitation may date from the beginning of this century, but this is not certain.

138.

Type of Deposit: Pb

Province: Giresun

Name of Deposit: Sisordu

Map Reference: 45/2

Ore and Formation: Lead ore. No details.

Mine: Remains. It is estimated that ca. 1600 tons of ore were extracted. No further details.

Slag:

References: MTA, 1972:70.

Comments: Deposit is located ca. 10 kms. N of Şebinkarahisar, near Seldere.

139.

Type of Deposit: Pb-Zn

Province: Giresun

Name of Deposit: Sucak

Map Reference: 45/1

Ore and Formation: Galena, sphalerite, pyrite and chalcopyrite. No further details.

Mine: "Remnants of old working" are reported. No further details.

Slag:

References: MTA, 1972:69.

Comments: Deposit is located ca. 12 kms. SW of Şebinkarahisar.

140.

Type of Deposit: Pb-Ag

Province: Gumusane

Name of Deposit: Hazine Mağara

Map Reference: 29/3

Ore and Formation: Lead-silver deposits and some zinc. Some native silver and secondary enargite. Lenses.

Average ore:

	No.1	No.2
% Pb	8.04	3.78
Zn	8.46	2.20
Sd	13.86	3.40
Ag	Tr	Tr

Mine: Numerous vague references to former workings. No specific details. Deposit was worked at the end of the last century and between World War I and World War II.

Slag:

References: MTA, 1972:54; Ryan, 1960:19.

Comments: Deposit is located in the area of Süleymanli, an outlying district of Gümüşane city. The name of this deposit may refer to former tunnels (mağara = cave). Another lead deposit is located at Kirkpavli Maden.

141.

Type of Deposit: Pb-Cu-Zn

Province: Gümüşane

Name of Deposit: Artabil (Ertabil)

Map Reference: 46/1

Ore and Formation: Calamine (smithsonite) and chrysocolla. No further details.

	No.1	No.2	No.3	No.4
% Cu	0.78	0.77	0.11	0.79
Pb	0.63	1.87	1.86	3.38
Zn	45.42	2.04	5.53	1.25
Ag	Tr	Tr	Tr	Tr

Mine: "Very ancient workings" are reported. Eight old adits are reportedly still visible.

Slag: Dumps spread over an area ca. 200 x 300 m.

References: MTA, 1972:73-4; Ryan, 1960:54.

Comments: Deposit is situated near the village of Livene and near the water shed of the Harşit and Kelkit rivers. The elevation of the deposit is 2450 m. Position of this deposit on the map is not certain.

142.

Type of Deposit: Pb-Ag

Province: Trabzon

Name of Deposit: Öğne Derebaşi

Map Reference: 30/3

Ore and Formation: Galena with some subordinate amounts of pyrites, chalcopyrites, sphalerite and cerussite. Lenses.

	No.1	No.2
% Cu	0.08	7.66
Pb	45.19	52.25
Zn	1.87	1.25
Au	Tr	Tr
Ag	Tr	Tr

Mine: Remains. No further details. An adit 30 m long.

Slag:

References: MTA, 1972:57-8.

Comments: Deposit is located 8 kms. S of Öğne and 15 kms. S of Kadahor. Silver content is quite high at this deposit, 1,247 gr/ton. (= 0.125 %).

143.

Type of Deposit: Zn

Province: Artvin

Name of Deposit: Peronit-Albana

Map Reference: 13/2

Ore and Formation: Sphalerite with subordinate amounts of galena, copper minerals, pyrites and tetrahedrite. Veins.

Mine: Tunnels driven at two levels, now collapsed. Ore dumps.

Slag: According to Ryan, "the ore was smelted locally," but no mention is made of slag dumps.

References: MTA, 1972:8; Ryan, 1960:49.

Comments: Workings may date from Genoese times according to Ryan.

144.

Type of Deposit: Zn

Province: Artvin

Name of Deposit: Yukara Kutunit

Map Reference: 13/2

Ore and Formation: Sphalerite and some chalcopyrite. No further details.

Mine: Ore dumps. No further details.

Slag:

References: MTA, 1972:8.

Comments: Deposit is said to be near Artvin. Position on map is not certain.

145.

Type of Deposit:	Pb-Zn
Province:	Artvin
Name of Deposit:	Nukâvur
Map Reference:	14/1
Ore and Formation:	Galena, sphalerite and some chalcopyrite. Veins.
Mine:	Abandoned tunnels. No further details.
Slag:	
References:	Ryan, 1960:51.
Comments:	Deposit is located near Nukavur in Berta County, ca. 12 kms. NE of Coruh. Position on map is not certain.

146.

Type of Deposit:	Pb
Province:	Çanakkale
Name of Deposit:	Bergaz
Map Reference:	52/1
Ore and Formation:	Galena, sphalerite, magnetite, pyrite and some chalcopyrite, Veinlets. Ore from dumps: % Pb 23.15 Zn 27.76 Fe 4.23 S 19.42 Ag 0.001 % (ie 32 gr/ton)
Mine:	Small shafts and adits, now inaccessible. Ore dumps.
Slag:	
References:	MTA, 1972:76.
Comments:	Deposit is located 1.5 kms. east of Bergaz on the road to Ezine.

147.

Type of Deposit: Pb-Zn

Province: Çanakkale

Name of Deposit: Kocayayla

Map Reference: 52/2

Ore and Formation: Sphalerite with some galena and small quantities of chalcopyrite. Contact zone.

% Zn 36.0
Pb 12-15
Cu 1.5

Mine: Eight adits, two shafts, now inaccessible.

Slag:

References: MTA, 1972:77.

Comments: Deposit is situated N of Kocayayla. Mineralization is said to have continued down for at least 80 meters. Similar mineralization is noted at Dana Pinari, a few kms. NE of Kocayayla. Remnants of old mining activities are also mentioned there. The deposit also seems to be basically zinc and lead.

148.

Type of Deposit: Pb

Province: Çanakkale

Name of Deposit: Karaaydin

Map Reference: 52/2

Ore and Formation: Galena, sphalerite, chalcopyrite, pyrite. Veins and lenses.

Mine: Old adits, now collapsed.

Slag:

References: MTA, 1972:79-80; Ryan, 1960:2.

Comments: Deposit is situated SW of Karaaydin in Biçki Dere. Karaaydin is located ca. 18 kms. SSW of Yenice. This deposit had been formerly worked by a French company in this century.

149.

Type of Deposit: Pb-Zn

Province: Bursa

Name of Deposit: Kirazliyayla

Map Reference: 38/3

Ore and Formation: Galena and Sphalerite. No further details.

Mine: It is reported that "there are remnants of old workings of lead and zinc ore."

Slag:

References: MTA, 1972:62.

Comments: There are two deposits at this site, one rich in galena and the other rich in sphalerite. These deposits are located S of İznik Göl. Elevation is reportedly 700 m.

150.

Type of Deposit: Pb

Province: Kütahya

Name of Deposit: Gümüşköy

Map Reference: 55/3

Ore and Formation: Galena, sphalerite, Pyrite. Veins.

Mine: "Signs of old workings" are reported. No further details.

Slag:

References: MTA, 1972:84.

Comments: Deposit is located south of the village of Gümüş which is ca 20 kms. NW of Kütahya. No further details.

151.

Type of Deposit: Pb-Cu-Ag-Zn

Province: Balikesir

Name of Deposit: Balya Maden

Map Reference: 53/3

Ore and Formation: Galena, sphalerite, pyrite, some chalcopyrite, and arsenopyrite. According to MTA reports, the quantity of chalcopyrites and burnonite increases with depth. Galena is predominant in the upper parts of the primary zone. Sphalerite increases downwards, and at about 200-250 m. below the surface sphalerite and pyrite become predominant. Average composition of base bullion of the lead produced from the ore :

% Cu	0.54
Pb	97.76
Sb	0.53
Sn	0.11
BiO	0.1
Fe	0.03
Ni	0.004
Cd	0.01
As	0.25
S	0.47
Au	0.0002 %
Ag	0.062 %

Mine: It is reported that "shafts have been sunk down to 300-330 m." From 1880 to 1935 this deposit was worked by a French-owned oompany and produced a yearly average of 7,273 Tons Pb, 55 kg Au, 18,182 kg Ag. The mine was closed down shortly before World War II because of extraction difficulties. A great portion of the former workings date from this period.

Slag: Slag has been reported at Kepsut nearby (Ryan, p.3), but no details are available.

References: MTA, 1972:81-83; Ryan, 1960:3; Gowland, 1920:139.

Comments: In the Balya area many lead deposits are konwn.

152.

Type of Deposit: Pb

Province: Balikesir

Name of Deposit: Alibey (Alibey Ada)

Map Reference: 69/2

Ore and Formation: Lead Ore, OUtcrops. No further details.

Mine:	"Old lead workings" are reported. No further details.
Slag:	
References:	Ryan, 1960:6.
Comments:	Site is located on Alibey Island opposite Ayvalik. Newly discovered outcrops are reported. It is not clear from the report (Ryan, p.6) whether "old lead workings" refers to smelting or mining. Possibly the latter.

153.

Type of Deposit:	Pb-Zn
Province:	İzmir
Name of Deposit:	Gümüldere
Map Reference:	86/3
Ore and Formation:	Lead and zinc. No details.
Mine:	"Old lead-zinc workings" are reported. No further details.
Slag:	
References:	Ryan, 1960:7.
Comments:	No further details.

154.

Type of Deposit:	Pb
Province:	Antalya
Name of Deposit:	Yulari
Map Reference:	142/2
Ore and Formation:	Lead deposit. No further details.
Mine:	"Old workings" are reported. No further details.
Slag:	
References:	MTA, 1972:113-114; Ryan, 1960:13.
Comments:	Deposit has recently been re-opened. Located 12 kms. NW of Gazipaşa. Position on map is not certain. At one time this deposit was worked by the French before World War I. Perhaps "old workings" refers to his time.

155.

Type of Deposit: Pb

Province: Kayseri

Name of Deposit: Akçaparmak

Map Reference: 77/4

Ore and Formation: Galena, cerussite. Veins.

Mine: Remains and shafts and adits, now caved.

Slag:

References: MTA, 1972:91-2.

Comments: Deposit is located N of Pazarviran. Location on map is not certain (Altiparmak?).

156.

Type of Deposit: Pb-Ag-Au

Province: Niğde

Name of Deposit: Aladağ

Map Reference: 110/2

Ore and Formation: Lead-silver-gold ores. Principally plumbojarosite. Veins,

Mine: "Very old gold-silver-lead workings" are reported. No further details.

Slag:

References: Ryan, 1960:12.

Comments: Three sites are mentioned in this context: Madanoba, Katirkiri, and Akçay. All are reportedly on Aladağ.

157.

Type of Deposit: Pb

Province: Nigde

Name of Deposit: Bolgar Dağ Maden

Map Reference: 110/3

Ore and Formation: Primary and altered zones. Deepest primary sulphidic ores (i.e. sphalerite, galena, pyrites, arsenopyrites) have been altered to carbonates and oxides. Lead content decreases with depth. Veins. Many analyses are available (MTA, 1972:107-8). Silver is present in oxide deposits up to % 0,005. In ore placer silver has been noted at more than .006 %. Placer deposits with secondary lead-zinc minerals is also unusually high. Plumbojarosite is present in placer gangue as well as some native gold and copper.

<u>Mine</u>: Tunnels, many caved. Ore dumps.

<u>Slag</u>: Many large dumps are known among which are:

1. Madenköy: ca. 40,000 tons of lead slag of 6 % Pb.
2. Kildere: ca. 5,000 tons of lead slag.
3. Gümüş: 15,000 tons of lead slag.

<u>References</u>: MTA, 1972:104-9; Ryan, 1960:11-12.
A very technical and complete analysis of the geological setting of the Bolgar Md. deposit has been written by Dr. Gerhard Kruse of Technische Universität, München (cf. Bibliography).

<u>Comments</u>: The Büyük Toyislam deposit is said to have been worked by the Greeks and Romans. No further information available.

158.

<u>Type of Deposit</u>: Pb-Ag

<u>Province</u>: Konya

<u>Name of Deposit</u>: Bozkir

<u>Map Reference</u>: 125/1

<u>Ore and Formation</u>: Lead-silver ore. Some traces of copper and zinc. Thin veins.

% Pb	26.85
Fe	53.00
Ag	Tr

<u>Mine</u>: "A number of small-scale old mine works on lead-silver ores" are reported near Bozkir. Many small caves (tunnels?) are reported the ore from one of which is analyzed above ("Büyük Mağara"). At Asalide near Sorgun Yayla "old workings" are reported, and they seem to relate to a "dome-like gossan" which covers an area of 350 m^2. Samples from this gossan were analyzed to contain % Pb 1-7.

Slag:
References: MTA, 1972:109-110.
Comments: No further details.

159.

Type of Deposit: Pb
Province: Içel
Name of Deposit: Ortakonuş
Map Reference: 143/1
Ore and Formation: Lead-zinc. Generally galena, cerussite, anglesite and plubo-jarosite. The ore bodies are generally lens-shaped.
Mine: Old adits are reportedly caved.
Slag: No mention of slag, but smelting was performed here.
References: MTA, 1972:115-117; Ryan, 1960:13-14.
Comments: There are several mines in this area. All the principal ore-bodies are said to be mined out.

160.

Type of Deposit: Pb-Zn
Province: Yozgat
Name of Deposit: Akçakişla
Map Reference: 60/3
Ore and Formation: Lead-zinc mineralization. Instrusions and veins.
Mine: Mining activities in this area are not reported.
Slag: Dumps, estimated at ca. 3,000 tons. % Pb 7.5.
References: MTA, 1972:88.
Comments: Deposit is located ca. 2 kms. NE of Akçakişla.

161.

Type of Deposit: Pb-Zn

Province: Yozgat

Name of Deposit: Akdağmadeni

Map Reference: 60/1

Ore and Formation: Lead-zinc mineralization located in fault zones.
Many deposits in this general area:

1. Evcininboyun Tepe
2. Çukurmaden
3. Boğatepe
4. Çiçekdağ. Ore % Pb 27, Ag Tr
5. Çikrik. Ore % Pb 18, Ag Tr
6. Ziyaret Tepe
7. Tatderesi

In all, 14 separate occurrences are known.

Mine: It is reported that mining in this area had started more than a century and a half ago and was ceased at the time of World War I. Indications of older exploitation are not known.

Slag: At Akdağmadeni dumps are estimated at 25,000 tons.
% Pb 6.2

References: MTA, 1972:87-88; Ryan, 1960:10-11.

Comments: Deposit is spread over a considerable area, ca. 5 kms x 1.5 km.

162.

Type of Deposit: Pb-Zn

Province: Elaziğ

Name of Deposit: Deri

Map Reference: 80/3

Ore and Formation: Secondary lead-zinc minerals such as calamine.

% Pb	70 - 12
Zn	28 - 40

Mine: Remains. No further details.

Slag:

References: MTA, 1972:96-97; Ryan, 1960:24.

Comments: Deposit is located near Karaçor, 1 km. NNE of Deri on both sides of Ruzvan Creek. Position on map is not certain.

163.

Type of Deposit: Pb

Province: Elaziğ

Name of Deposit: Keban Madeni

Map Reference: 79/2

Ore and Formation: Pyrite, sphalerite, galena. Some chalcopyrite. Contact zone and intrusive lenses. Mineralization continues downwards for at least 200 m., but contents of galena and silver decrease with depth. Ore exploited in modern times:

% Pb 10.0

Mine: It is reported that some lead oxides "were exploited by ancient people," but no details are available.

Slag:

References: MTA, 1972:92-3; Gowland, 1901:371; Smyth, 1854:114-115.

Comments: Mine was worked from 1728 to 1877. It was re-opened by Etibank in 1952.

164.

Type of Deposit: Pb

Province: Sivas

Name of Deposit: Deredam

Map Reference: 45/3

Ore and Formation: Galena, sphalerite and much pyrite. Veins.

Mine: It is reported that "the deposit has been exploited by the Romans; however, at present the old workings are inaccessible and covered by a great amount of debris."

Slag:

References: MTA, 1972:72.

Comments: Deposit is located ca. 15 kms. NE of Zara and 3 kms. NW of the village at Mezarlik Yaylasi. The elevation here is 2000 - 2300 m.

165.

Type of Deposit: Pb

Province: Sivas

Name of Deposit: Kaplan

Map Reference: 45/3

Ore and Formation: Galena with some sphalerite and chalcopyrite. Veins.

Mine: It is reported that "there are remnants of old Roman workings; however, only a few outcroups can be seen at present."

Slag:

References: MTA, 1972:72.

Comments: Deposit is located 13 kms. ENE of Zara on the Papaz Dere.

166.

Type of Deposit: Pb-As

Province: Sivas

Name of Deposit: Kurt Maden

Map Reference: 45/3

Ore and Formation: Galena, chalcopyrite, sphalerite, and some realgar. Veins.

Mine: Secondary minerals here are malachite, azurite and limonite. It is reported that "these veins have already been exploited by the Romans and now very little ore is left on the surface."

Slag: No direct reference is made to slag, but "remnants of a Roman smelting oven" is mentioned.

References: MTA, 1972:71-2.

Comments: Deposit is located N of Umraniye. Position on map is not accurate (Maden ?). The presence of realgar at this deposit is an interesting point to retain, especially in view of the presence of chalcopyrite and other copper ores.

167.

Type of Deposit: Pb-Cu

Province: Maraş

Name of Deposit: Kayiş

Map Reference: 95/2

Ore and Formation: Copper and lead ore. No details.

Mine: Caved tunnels.

Slag: Dumps estimated at 300 tons. Slag has malachite coatings.
% Pb 4.3

References: Ryan, 1960:62.

Comments: Deposit is located ca. 35 kms. East of Göksun. Elevation is 1100 m.

168.

Type of Deposit: Pb-Ag-Zn

Province: Diyarbakir

Name of Deposit: Pirajman

Map Reference: 81/4

Ore and Formation: Argentiferous lead-zinc ore with some copper. Galena, azurite, malachite, calamine and cerussite.
Ore from Çağiroğlu Mine:

%	Pb	2.57 - 27.63
	Zn	1.14 - 32.18
	Ag	Tr

Mine: It is reported that "there are several mines in the area, all worked in the past in a small way."

Slag:

References: MTA, 1972:97-8; Ryan, 1960:24.

Comments: Deposit is located ca. 10 kms. N of Eğil. Reserves today are considered medium-sized at best.

169.

Type of Deposit:	Pb-Ag
Province:	Aydin
Name of Deposit:	Gümüş
Map Reference:	104/1
Ore and Formation:	Argentiferous galena. One sample yielded: % Ag 1.7
Mine:	"Old silver mines" are reported.
Slag:	
References:	Sayce, 1880:91; Gowland, 1901:375; Forbes, 1950: 192(22); Mineral Industry, 1898:442; Gowland, 1920: 156
Comments:	This deposit does not seem to have been studied extensively by geologists. Information dates from the last century and is vague. See Map 17.

CATALOGUE A

CATALOGUE A

Artifacts*	A-
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* N.B. When cited by number in the text the catalogued artifacts carry the prefix A-

Globular-Headed Pins 449-455
Semi-Globular-Headed Pins 456-459
Conical-Headed Pins 460-465
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POINTS, BORERS, AWLS, PUNCHES

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
1	Cayönütepesi	Neo.	Unpublished. (After Esin, 1967:147)	E-18431		Cu/tr: As, Sn, Ni, Fe.
2	Etiyokuşu	EB II	Kansu, 1937:102, fig.91 (93) (EY.208)	E-17738		Cu-As/tr: Sn, Sb, Ag, Ni, Fe.
3	Mersin XIII	L.Chal.	Unpublished. Adana Museum. No. M.38.1165 (After Esin, 1967:147)	E-17887		Cu/tr: Pb, As, Sb, Ag, Ni, Fe.
4	Alishar	EB III	OIP XXVIII:261, fig.272 (e.2261)	E-17750		Cu-Sn-As/tr: Pb, Ag, Ni.
5	Kusura B	EB III	Unpublished. Afyon Museum. No. 1768, M.37.89 (After Esin, 1967:147)	E-18043		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Co.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
6	Kusura B	EB III	Unpublished. Afyon Museum. No. 1461, M.37.29 (After Esin, 1967:148)	E-18044		Cu-As/tr: Sn, Pb, Sb, Ag, Ni.
7	Kusura B-C	EBA	Lamb, 1936:40, fig.18 (23)	E-18045		Cu/tr: Sn, Pb, As, Ag, Ni.
8	Alishar	EB I	OIP XXVIII:93, 2/3 (c. 552)	E-17745		Cu-As/tr: Ag, Ni.
9	Beycesultan XXXIV	L Chal.	Lloyd and Mellaart, 1962: 281, fig.F.8 (4)	E-11774		Cu-As-Pb/tr: Sb, Ag, Ni, Bi.
10	Beycesultan XXXIV	L.CHal.	Lloyd and Mellaart, 1962: 281, fig.F.8 (5)	E-11776		Cu/tr: Pb, As, Sb, Ag, Ni, Bi.
11	Beycesultan XXXIV	L.Chal.	Lloyd and Mellaart, 1962: 281, fig.F.8 (8)	E-11779		Cu/tr: Pb, As, Sb, Ag, Ni, Bi, Fe.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
12	Beycesultan XXXIV	L.Chal.	Lloyd and Mellaart, 1962: 281, fig.F.8 (10) pl.34	E-11781		Cu-As/tr: Pb, Sb, Ag, Ni, Bi.
13	Beycesultan XXXIV	L.Chal.	Lloyd and Mellaart, 1962: 281, fig.F.8 (6)	E-11778		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi, Co.
14	Mersin XII	L.Chal.	Unpublished. Adana Museum. No. M.38, 1104 (After Esin, 1967:148)	E-17909		Cu-As-Ni/tr: Sb, Ag, Au, Co, Fe.
15	Tarsus	EB II	Goldman, 1956:289, fig.425 (30)	E-17927		Cu/tr: Sn, Pb, As, Sb, Ni, Au, Zn.
16	Alaca Tomb S	EB II	Koşay, 1951:75	E-6873		Cu-As/tr: Sb, Ag, Ni, Bi.
17	Beycesultan XXXIV	L.Chal.	Lloyd and Mellaart:1962: 281, fig.F.8 (9), No.687, pl.34	E-11780		Cu/tr: Pb, As, Sb, Ag, Ni, Bi.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
18	Alishar	EB II	OIP XXVIII:197, fig.197	E-17747		Cu/tr: Sn, As, Ag, Ni. Esin does not specify which piece she analyzed.
19	Tarsus	EB II	Goldman, 1956:289 (After Esin, 1967:149)	E-17928		Cu-As/tr: Sn, Pb, Sb, Ag, Ni. Esin does not specify which piece she analyzed.
20	Tarsus	EB II	Gddman, 1956:289, fig.425 (32)	E-17929		Cu/tr: Sn, As, Sb, Ag, Ni, Co.
21	Pulur	EB II	Koşay and Vary, 1964:32, P. 79	E-17711		Cu-As/tr: Sb, Ag, Ni, Fe.
22	Tarsus	EB II	Goldman, 1956:289, fig.425 (33)	E-17930		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Zn, Co.
23	Tarsus	EB II	Goldman, 1956:289, fig.425 (35)	E-17932		Cu/tr: As, Sb, Ag, Ni, Au, Zn.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
24	Tarsus	EB III	Goldman, 1956:289, *fig*.425 (36)	E-17933		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Au, Zn.
25	Kusura B	EB III	Unpublished. Afyon Museum. no. 1534, M.37.34 (After Esin, 1967:149)	E-18042		Cu-As/tr: Pb, Sb, Ag, Ni, Bi.
26	Kusura B	EB III	Lamb, 1937:258, *fig*.21 (6)	E-18047		Cu-Sn/tr: Pb, As, Ag, Ni, Zn.
27	Kusura B-C	EB A	Unpublished. Afyon Museum. No. 1774, M.37.89 (After Esin, 1967:150)	E-18046		Cu/tr: Pb, As, Ag, Ni.
28	Tarsus	EB III	Goldman, 1956:290, *fig*.425 (37)	E-17934		Cu-As/tr: Sn, Pb Sb, Ag, Ni, Zn, Co.
29	Mersin XIV	L.Chal.	Unpublished. Adana Museum. M.38.1169 (After Esin, 1967:150)	E-17882		Cu-Sn-As/tr: Pb, Sb, Ag, Ni.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
30	Alishar I	EB II	OIP XXVIII:197, fig.197 (c. 364)	E-17748		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi.
31	Tarsus	EB II	Goldman, 1956:289, fig.425 (34)	E-17931		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Au.
32	Mersin XIV	L.Chal.	Unpublished. Adana Museum. M.38.1166 (After Esin, 1967:150)	E-17881		Cu/tr: Sn, Pb, As, Ag, Ni, Bi.
33	Karaz	EB II	Koşay and Turfan, 1959:410, (Kz.90)	E-17629		Cu-As/tr: Sb, Ag, Ni.
34	Kültepe	EBA	Unpublished. Ankara Museum. Kt. n/t 168, (After Esin, 1967:151)	E-17638		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Co.
35	Beycesultan XXII	L.Chal.	Lloyd and Mellaart, 1962: 291, fig.F.11 (7)	E-11740		Cu-As/tr: Sb, Ag, Ni, Bi, Au. Esin's reference is somewhat confused. Possibly this artifact.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
36	Beycesultan XXI	L.Chal.	LLoyd and Mellaart, 1962: 291, fig.F.11 (9)	E-11741		Cu-As/tr: Sb, Ag, Ni. Esin's reference is somewhat confused. Possibly this artifact.
37	Alishar I	EB II	OIP XXVII:197, fig.197 (d. 1965)	E-17746		Cu/tr: Pb, As, Sb, Ag, Ni, Bi.
38	Alishar 13 M	EB I	OIP XXVIII:93 (c. 1887)	E-17761		Cu-As/tr: Ag, Ni.
39	Alaca Tomb MC	EB II	Koşay, 1938:124 (Al.A.72)	E-6849		Cu-Sn-Pb/tr: As, Ag, Ni, Bi.
40	Alaca Tomb MA	EB II	Koşay, 1938:114 (Al.M.A.9)	E-6848		Cu-Sn/tr: As, Ag, Ni, Fe.

NAILS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
41	Troy II	EB II	_Troja_:105, no.3; Przeworski, 1967:no.45	Tr-105-3		Cu/tr: Sn, Fe. From Temple A.
42	Troy II	EB II	_Troja_:105, no.4; Przeworski, 1967:no.46	Tr-105-4		Cu/tr: Sn, Fe. From Temple A.

CHISELS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
43	Beycesultan IX	EB III	Lloyd and Mellaart, 1962: 287, fig.9 (8) (No. 572)	E-11759		Cu-As/tr: Pb, Sb, Ag, Ni, Co.
44	Alaca Tomb S	EB II	Koşay, 1951:75 (Al.B.5)	E-6864		Cu/tr: Ag.
45	Alaca Tomb MA	EB II	Koşay, 1938:114, (Al/a M.A.16)	E-6860		Cu/tr: Sn, Pb, As, Ag, Ni.
46	Ahlatlibel	EB II	Koşay, 1934:77 (A.B.403)	E-6757		Cu-As/tr: Ag, Ni, Bi.
47	Tarsus	EB II	Goldman, 1956:290, fig.426 (51)	E-17936		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Au.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
48	Alaca Tomb MA	EB II	Koşay, 1938:114, (Al/A.MA.14)	E-6857		Cu/tr: Sn, Pb, As, Ag, Ni.
49	Karaz	EB II	Koşay and Turfan, 1959:410 (Kz. 110)	E-17630		Cu-As/tr: Sn, Pb, Sb, Ag, Ni.
50	Pulur	EB II	Koşay and Vary, Pulur, 1964, s.32 (p. 78)	E-17710		Cu/tr: Pb, As, Sb, Ag, Ni.
51	Alaca Tomb MA	EB II	Koşay, 1938:114, (Al.A.MA.15)	E-6859		Cu/tr: Sn, Pb, As, Ag, Ni.
52	Tarsus	EB II	Goldman, 1956:210, fig.426 (53)	E-17938		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Co.
53	Tarsus	EB III	Goldman, 1956:290, fig.426 (54)	E-17939		Cu-Sn-Pb-As/tr: Sb, Ag, Ni, Bi.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
54	Tarsus	EB III	Goldman, 1956:290, fig.426 (58)	E-17943		Cu-Sn-Pb-As/tr: Sb, Ag, Ni, Bi, Au.
55	Tarsus	EB III	Goldman, 1956:299, fig.426 (59)	E-17944		Cu-As-Ni/tr: Pb, Sb, Ag, Au, Co.
56	Tarsus	EB III	Goldman, 1956:290, fig.426 (60)	E-17945		Cu/tr: As, Ag, Ni, Co.
57	Tarsus	EB III	Goldman, 1956:290 (62) (38.476)	E-17946		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi, Au, Co.
58	Kusura B-C	EBA	Lamb, 1937:258, fig.21 (7)	E-18048		Cu-Sn-As/tr: Pb, Ag, Ni, Zn.
59	Alaca Tomb MA	EB II	Koşay, 1938:102 (Al.M.A.8)	E-6852		Cu/tr: As, Ag, Ni.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
60	Tarsus	EB II	Goldman, 1956:290, fig.426 (52)	E-17937		Cu-Sn/tr: Pb, As, Sb, Ag, Ni, Bi, Au.
61	Tarsus	EB III	Goldman, 1956:290, fig.426 (57)	E-17942		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi, Au.
62	Alaca Tomb S	EB II	Koşay, 1951:75, (Al.B.S.30)	E-6871		Cu-As/tr: Sb, Ag, Ni, Bi.
63	Alaca Tomb S	EB II	Koşay, 1951:75, (Al.B.S.31)	E-6872		Cu/tr: Sn, Pb, As, Sb, Ag, Bi.
64	Alaca Tomb S	EB II	Koşay, 1951:75, (Al.B.S.34)	E-6874		Cu-As/tr: Sb, Ag, Bi.
65	Alishar I	EB II	OIP XXVIII:197, fig.197 (e. 702)	E-17760		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Bi.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
66	Alaca Tomb MC	EB II	Koşay, 1951:124 (Al.71)	E-6847		Cu-Sn/tr: Pb, As, Ag, Bi, Fe.
67	Alaca Tomb MA	EB II	Koşay, 1951:102, (Al.M.A.18)	E-6851		Cu-Sn-Pb/tr: Ag, Ni, Bi.
68	Horoztepe	EB III	Özgüç and Akok, 1958:8 (5) (Ht. 29)	E-6738		Cu-As/tr: Pb, Ag, Ni.
69	Tarsus	EB III	Goldman, 1956:290, fig.426 (55)	E-17940		Cu/tr: Sn, Pb, As, Sb, Ag, Ni.
70	Karaz	EB II	Koşay and Turfan, 1959:410, (Kz. 40)	E-17628		Cu/tr: Pb, As, Sb, Ag, Ni.
71	Troy	EB II	Inv. No. 617 (After Esin, 1967:155)	E-11807		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
72	Tarsus	EB III	Goldman, 1956:290, (56) (38.502)	E-17941		Cu/tr: Pb, As, Sb , Ag, Ni.
73	Troy II	EB II	<u>Troja</u>:104, no.5; Przeworski, 1967:202-3, no.40	Tr-104-5		Cu/tr: Sn, Pb, Fe. Reported as "quadrangle weapon".
74	Troy IIg Treasure A	EB II	<u>Ilios</u>:482, no.816; SS 5823; Przeworski, 1967:202-3, no.47;	SS-5823		Cu-Sn/tr: S, Pb, Fe, As.
75	Troy II-V	EBA	SS 6231 o; Przeworski, 1967: 204-5, no.53	SS-6231 o		Cu-Sn/tr: Pb, As.

SICKLES

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
76	Karaz	EB II	Koşay and Turfan, 1959:409, (Kz. A.179)	E-17625		Cu/tr: As, Ag, Ni.
77	Mersin	EBA (?)	Garstang, 1953:232, (M.38.1110) fig. 149 (9)	E-17915		Cu/tr: Sn, Pb, As, Sb, Ag, Ni.
78	Mersin	EBA (?)	Garstang, 1953:238, (M.38.1130) fig. 149 (10)	E-17916		Cu-As-Zn/tr: Sn, Pb, Sb, Ag, Ni.
79	Pulur	EB II	Koşay and Vary, 1964:81 (76), pl.L.	E-17708		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Fe.

HOOKS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
80	Alaca Tomb S	EB II	Koşay, 1951:75, (Al.B.S.10)	E-6868		Cu-As/tr: Sb, Ag, Ni, Bi.
81	Alaca Tomb S	EB II	Koşay, 1951:75, (Al.B.S.11)	E-6869		Cu-As/tr: Sb, Ag, Ni, Bi.
82	Alaca Tomb S	EB II	Koşay, 1951:75, (Al.B.S.9)	E-6867		Cu-As/tr: Sb, Ag, Ni, Bi.
83	Alaca Tomb S	EB II	Koşay, 1951:75, (Al.B.S.8)	E-6866		Cu-As/tr: Sb, Ag, Ni, Bi.
84	Alaca Tomb S	EB II	Koşay, 1951:75, (Al.B.S.7)	E-6865		Cu-As/tr: Sb, Ag, Ni, Bi.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
85	Alaca Tomb MA	EB II	Koşay, 1951:102, (Al.M.A.26)	E-6855		Cu/tr: As, Ag, Ni.
86	Alaca Tomb MA	EB II	Koşay, 1951:102, (Al.M.A.5)	E-6853		Cu/tr: As, Ag, Ni.
87	Alaca Tomb MA	EB II	Koşay, 1951:102, (Al.M.A.6)	E-6854		Cu/tr: As, Ag, Ni;
88	Alaca Tomb MA	EB II	Koşay, Alaca 1936, s.102 (Al.M.A.23)	E-6856		Cu/tr: As, Ag Ni.
89	Tarsus	EB II	Goldman, 1956:293, fig.429 (120)	E-17953		Cu-As/tr: Sn, Pb, Sb, Ag, Ni.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
90	Alaca Tomb TM	EB II	Arik, 1937:CCLIX, no.1103 (?); Koşay, 1938:181	K-4127		Cu-Sn. Tin content: 16.73 %.
91	Alaca Tomb S	EB II	Koşay, 1955:170 (no.S6), pl.CCIII		XI(3)	

FISH HOOKS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
92	Tarsus	EB II	Goldman, 1956:293, fig.429 (121)	E-17954		Cu/tr: Sn, Pb, As, Sb, Ag, Ni.
93	Tarsus	EB II	Goldman, 1956:293, fig.429 (122)			

KNIFE BLADES AND SCRAPERS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
94	Tarsus	EB III	Goldman, 1956:288, *fig*.423 (2)	E-17924		Cu/tr: As, Sb, Ag, Ni, Au, Fe.
95	Alishar I	EB II	OIP XXVIII:197, (c. 2477) Esin, 1967:158	E-17751		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi,Co Called a tweezer frag. by the excavators and blade by Esin.
96	Troy		SS No. 6191 (After Esin, 1967:158)	E-9879		Analysis not reported.
97	Troy		SS No. 6189 (After Esin, 1967:158)	E-9877		Analysis not reported.
98	Etiyokuşu	EB II	Kansu, 1940:102, *fig*.91 (93)	E-17740		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Bi.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
99	Tarsus	EB II	Goldman, 1956:289, fig.423 (16)	E-17925		Cu-Sn-As/tr: Pb, Ag, Ni, Bi, Au.
100	Troy I	EB I	Ilios:251, no.120; SS 6190; Przeworski, 1967:202-3, no.27	I-120		Cu. Reported "no appreciable quantity of tin", According to Schliemann this blade was gilded with gold. Ilios, ibid. Esin (1967:158, no.9878) lists this in her catalog but does not include her analysis.
101	Karataş	EB II-III	Mellink, 1967:255, pl.77 (19) No. KA 445.		XXIV(1)	Knife.
102	Karataş	EB II-III	Mellink, 1967:255, pl.77 (16) No. KA 448. From Tomb 152.		XXIV(2)	Knife/spatula.
103	Karataş	EB II-III	Mellink, 1969:325, pl.74 (20) No. B 103. From Area AQ.		XXIV(3)	Knife/spatula.
104	Troy IIg	EB II	Ilios: no.966; SS 6209			Knife with curved tip.

SPINDLE WHORLS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
105	Horoztepe	EB III	Özgüç and Akok, 1958:16, pl.VIII(3), fig.25	E-6745	23(1)	Cu-Sn/tr: Pb, Ag, Ni, Bi. Reported as "spindle".
106	Horoztepe	EB III	Özgüç and Akok, 1958:51, fig.26, pl.VIII (1-2)		23(2)	Reported as "spindle".

DAGGERS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
107	Beycesultan XXXIV	Chal.	Lloyd and Mellaart, 1962: 291, F 8 (14)	E-11775		Cu-As/tr: Pb, Sb, Ag, Ni, Bi.
108	Beycesultan XVIII	EB I	Lloyd and Mellaart, 1962: 284, fig. F 9 (1)	E-11742		Cu-As/tr: Ag, Ni, Bi
109	Karaz	EB II	Koşay and Turfan, 1959:409 (Kz. A. 178)	E-17624		Cu-As/tr: Pb, Sb, Ag, Ni.
110	Polatli	EB II	Lloyd and Gökçe, 1951:61, fig. 14 (12)	E-11731		Cu-Sn-Pb/tr: As, Sb, Ni, Bi, Au, Fe.
111	Kültepe	EB II	Unpublished. Ankara Museum. no. Kt. i/T 291 (After Esin, 1967:160)	E-6790		Cu/tr: As, Ag, Ni, Bi, Fe.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.no.	FIG./PL.	REMARKS
112	Tarsus	EB III	Goldman, 1956:291, fig.427 (77)	E-17947		Cu-As/tr: Pb, Sb, Ag, Bi, Au, Fe.
113	Troy II	EBA	SS 6153; <u>Atlas</u>, pl.93, no.1900	E-9875		Analysis not reported. Because of find depth (9-10 ms.) taken here to be Troy II.
114	Karaz	EB II	Koşay and Turfan, 1959:377, 409 (Kz. A. 177)	E-17623		Cu/tr: As, Sb, Ag, Ni.
115	Yazilikaya	EB III	Unpublished. Afyon Museum. No. 139, 2712 (Y.K.49, M.31) (After Esin, 1967:161)	E-18100		Cu-As/tr: Pb, Sb, Ag, Bi, Fe.
116	Karaz	EB II	Koşay and Turfan, 1959:410 (Kz. 107)	E-17627		Cu-As-Ni/tr: Pb, Sb, Ag, Co.
117	Yazilikaya	EB II	Unpublished. Afyon Museum. No.34, 2824 (Y.K.50 M.34) (After Esin, 1967:131)	E-18099		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
118	Yazilikaya	EB II	Unpublished. Afyon Museum. No. 2.3039 (Y.K.40 M.32) (After Esin, 1967:161)	E-18098		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi.
119	Bayindirköy	EB II	Bittel, 1955:114, fig.6; Stronach, 1957:fig.1(1)	E-3191	31(4)	Cu/tr: As, Ag, Bi.
120	Yortan	EB II	Unpublished. Istanbul Archaeological Museum. No. 6349 (After Esin, 1967:161)	E-11801		Cu-As/tr: Pb, Sb, Ag, Ni, Bi.
121	Kayapinar	EB III	Temizer, 1954:327, fig.17	E-17616		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi.
122	Troy II-V	EBA	SS. 6161 (After Esin, 1967:161)	E-9876		Analysis not reported.
123	Bayindirköy	EB II	Bittel, 1955:114, fig.5; Stronach, 1957:fig.1(10)	E-3192	31(5)	Cu-As/tr: Ag, Ni.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
124	Ahlatlibel	EB II	Koşay, 1934:75, (AB.363)	E-6767	27(2)	Cu-As/tr: Sb, Ag, Ni, Bi.
125	Beycesultan	EB I	Lloyd and Mellaart, 1962: 291, *fig*.F 9 (2)	E-11743		Cu-As/tr: Ag, Ni.
126	Yortan	EB II	Istanbul Archaeological Museum. No.6742 (After Esin, 1967:162)	E-11796		Cu-As/tr: Ag, Ni, Fe.
127	Alishar	EB I	OIP XXVIII:93, *fig*.96 (C.289)	E-17741		Cu/tr: As, Ag, Ni.
128	Ahlatlibel	EB II	Koşay, 1934:75 (AB.585)	E-6765		Cu-Sn/tr: Pb, As, Ag, Ni, Fe.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
129	Bayindirköy	EB II	Bittel, 1955:114 (7); Stronach, 1957:fig.1(4)	E-3190	31(3)	Cu-As/tr: Ag, Ni, Bi.
130	Yortan	EB II	Istanbul Archaeological Museum. No. 6743 (After Esin, 1967:162)	E-11798		Cu-As/tr: Ag, Ni, Fe.
131	Yortan	EB II	Istanbul Archaeological Museum. No. 6348 (After Esin, 1967:162)	E-11802		Cu-As/tr: Ag, Ni, Bi, Fe.
132	Yortan	EB II	Istanbul Archaeological Museum. No. 6744 (After Esin,1967:162)	E-11797		Cu-As/tr: Ag, Ni, Fe.
133	Karaz	EB II	Unpublished. Ankara Museum. No. Kz 16g. (After Esin, 1967:162)	E-17631		Cu-As/tr: Pb, Ag, Ni.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
134	Bayindirköy	EB II	Bittel, 1955:114 (1); Stronach, 1957:fig.1(14), anal. p.99.	E-3188 Str-1	31(1)	Cu-As/tr: Ag, Ni. Cu-As/tr: Bi, Fe, Ag. Esin's and Stronach's results differ slightly.
135	Bayindirköy	EB II	Bittel, 1955:114 (4)	E-3189	31(4)	Cu-As/tr: Ag, Ni.
136	Tarsus	EB III	Goldman, 1956:292 (101); Esin, 1967:163.	E-17950		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Bi. Esin calls this a knife.
137	Tarsus	EB III	Goldman, 1956:292 (100), fig.428 (100); Esin, 1967: 163.	E-17949		Cu/tr Sn, Pb, As, Sb, Ag, Ni, Bi, Au, Zn, Co. Esin calls this a knife.
138	Troy II-V	EBA	SS-6148; Przeworski, 1967: 204-5, no.58	SS-6148		Cu-Sn/tr: Pb, Fe.
139	Anatolia	EB III	Tezcan, 1969:41, pl.XXIX (6 left ?); Met. Museum no. 55.137.25.	BI-8		Cu-As/tr: Sn, Pb, Fe. Sample taken from "inside hole in blade".

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
140	Yerten	EB III	Moorey and Schweizer, 1974: 114, no.1911.304; Stronach, 1957:fig.2 (18)	1911.304		Cu-Sn-As/tr: Pb.
141	Yerten	EB III	Moorey and Schweizer, 1974: 114, no. 1911.305.	1911.305		Cu-Sn-As/tr: Pb, Sb.
142 a)	Soli	EB III	Bittel, 1940:185, 201, pl.III, no. S 3400, fig.3	So-3400	28(6)	Cu-Sn/tr: Pb, Sb. Analysis of blade.
b)	Soli	EB III	Ibid.	So-3400	28(6)	Cu-Sb/tr: Pb, Sn. Analysis of handle of above.
143	Soli	EB III	Bittel, 1940:185, fig.2, pl.III, no. S 3441; Stronach, 1957:100, fig.2 (19)	So-3441	28(2)	Cu-Sn-Pb/tr: Sb, As, Ag.
144	Soli	EB III	Bittel, 1940:187, fig.5, pl.III, no. S 3418; Stronach, 1957: 98, fig.2 (12)	So-3418	28(3)	Cu/tr: Sn, Pb, Sb, As, Ag.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
145	Soli	EB III	Von Luschan, 1902:301; Bittel, 1940:185, pl.III, S 3443; Buchholz, 1967: 238, no.2.	So-3443		Cu-Sn.
146	Soli	EB III	Bittel, 1940:187, fig.4, pl;III, S 3431; Stronach, 1957:100.		28(4)	
147	Soli	EB III	Bittel, 1940:fig.1, pl.II, S 3420 (nos. S 3424 and S 3426 are also represented by this fig.); Stronach, 1957:96, fig.2(7)		28(1)	
148	Karataş	EB II-III	Mellink, 1967:255, pl.77(18), No. KA 446 N. From Tomb 156.		XXIV(4)	
149	Karataş	EB II-III	Mellink, 1969:322, pl.74(22), No. B 85. From Tomb 329.		XXIV(5)	
150	Karataş	EB II-III	Mellink, 1969:322, pl.74(21), No. B 86. From Tomb 335.		XXIV(6)	

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
151	Eski Balikhane	EB II	Mitten and Yüğrüm, 1971:193, fig.5 (M 69.5:7972)		XXV(3)	
152	Alaca	EB II	Koşay, 1944:189, pl.C II; Stronach, 1957:102, fig.3(5)			Iron Dagger.
153	Alaca Tomb K	EB II	Koşay, 1951:167, pl.CLXXXII(4) Al.10/K.14; Stronach, 1957: 103, fig.2(27)			Iron Dagger.
154	Alaca Tomb K	EB II	Koşay, 1951:pl.CLXXXIII(fig.2); Stronach, 1957:99, fig.3(4)			Silver with gold rivets.
155	Alishar III	EB III	OIP XIX:208, fig.270(b 3); Stronach, 1957:101, fig.2(23)			
156	Alishar I	EB II	OIP XIX:59, fig.65(b 921)			

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
157	Alishar "Chal."	EB I	OIP XXVIII:fig.96(c 419); Stronach, 1957:90, and n.7.			Fragment.
158	Karaz "Copper Age"	EB II	Koşay and Turfan, 1959:409, nos.177-8.			
159	Korucutepe XXXVII	EB I	Van Loon, 1973:360, pl.4(5);			
160	Asarcik Hüyük V	EB II-III	Ortmann, 1966a:38, pl.6(4)			

SWORDS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG.PL.	REMARKS
161	Soli	EB III	Bittel; 1940:189, pl.IV, S 3414.		28(5)	
162	Anatolia	EB III	Unpublished. Tokat Museum.		30(4)	Short sword (?). L. ca. 30 cms.
163	Alaca Tomb A'	EB II	Koşay, 1944:84, 120, pl.LXXXI; Stronach, 1957: 94, fig.2(5)			L. 82.4 cms.
164	Alaca Tomb S	EB II	Koşay, 1951:pl.CCIII; Stronach, 1957:94, fig.3(1)			L. 53.5 cms.
165	Alaca Tomb K	EB II	Koşay, 1944:84, pl.CLXXXIII; Stronach, 1957:94.			L. 61.6 cms.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
166	Ahlatlibel Tomb X	EB II	Koşay, 1934:95, no.AB 579; Stronach, 1957:94, fig.3(2)			L. 40 cms. Tip broken. Stronach reported L: 28 cms.
167	Horoztepe	EB III	Özgüç, 1958:58, n.67, pl.XVIII (15-19). Now in Met. N.Y. Also, Özgüç, 1963:15.			Said to be from Horoztepe. Five exs. L: 26-65 cms.

MACEHEADS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
168	Can Hasan	L.Chal.	French, 1962:33	E-17635	XXVII(1)	Cu/tr: Ag.
169	Ankara Prov.	EB II-III	Özgüç and Akok, 1958:57-8, pl.XVIII(6); Tezcan, 1960: 40-1, pl.XXVIII(3); Met. Museum No. 55.137.11	BI-7	25(4) XVIII(1)	Cu-Sn-As/tr: Pb, Fe. Sample taken from rim of shaft. Cf. Appendix VI. Said to come from "near Nallihan."
170	Ankara Prov.	EB II-III	Özgüç and Akok, 1958:57-8, pl.XVIII(4); Tezcan, 1960: 40-1, pl.XXVIII(1); Met. Museum No. 55.137.10	BI-9	25(2) XVIII(3)	Cu-Sn-Pb/tr: As, Fe. Sample taken from inside of shaft. Cf. Appendix VI. Said to come from "near Nallihan."
171	Ankara Prov.	EB II-III	Met. Museum No. 55.137.7. Unpublished.	BI-6		Cu-Sn/tr: As, Pb, Fe. Cf. Appendix VI. Thought to come from "near Nallihan."
172	Ahlatlibel	EB II	Koşay, 1934:76, 91, no.AB.577 and plates.	AB-577	27(1)	

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
173	Ankara Prov.	EB II-III	Ozgüç and Akok, 1958:57-8, pl.XVIII(3); Tezcan, 1960: 40-1, pl:XXVIII(4); Met. Museum No. 55.137.12		25(1) XVIII(2)	Said to come from "near Nallihan."
174	Ankara Prov.	EB II-III	Ozgüç and Akok, 1958:57-8, pl.XVIII(5); Tezcan, 1960: 40-1, pl.XXVIII(2); Met. Museum No. 55.137.13		25(3) XVIII(4)	Said to come from "near Nallihan."
175	Ankara Prov.	EB II-III	Ozgüç and Akok, 1958:57-8, pl.XVIII(7); Tezcan, 1960: 40-1, pl.XXVII(3); Met. Museum No. 55.137.13		25(5) XVIII(5)	Said to come from "near Nallihan."
176	Kalinkaya	EB I	Unpublished. Ankara Museum. No. KL 123-73			Could also be a metalworkers' hammer.
177	Alaca	EB II	Kosay, 1951:167, no. K 29, pl.CLXXXIV(1). Tomb K		IX(2)	Could also be a metalworkers' Hammer.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
178	Alaca	EB II	Koşay, 1951:166, no. K 9, pl.CLXXXII(2). Tomb K		IX(5)	Gold gilded.
179	Anatolia	EBA	Tezcan, 1960:40, pl.XXVII(4); Met. Museum No. 55.137.15.		XXIII(3)	Possibly a metalworkers' hammer.

PICK

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
180	Eskiyapar	EB III	Unpublished. Ankara Museum.			Electrum pick with shaft hole. L: ca. 16 cms.

FLAT AXES

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
181	Büyük Güllücek	Chal.	Koşay and Akok, 1957:47, pl. 35 (Gl. 18); idem, 1966:107, no. 6755; Esin, 1967:130, 164.	E-6755		Cu/tr: Pb, As, Ag, Ni, Bi.
182	Büyük Güllücek	Chal.	Koşay and Akok, 1957:35, (Gl. 19); Idem, 1966:107, no. 6756; Esin, 1967:130, 164.	E-6756		Cu/tr: As, Sb, Ag, Ni, Bi, Au.
183	Pulur	EB II	Koşay and Vary, 1964:32, pl. L (P.76,77,110)	E-17709		Cu-As/tr: Pb, Sb, Ag, Ni, Fe.
184	Mersin XVI	Chal.	Garstang, 1953:132-133, (M. 38, 1123)	E-17873		Cu/tr: As, Sb, Ag, Ni, Fe.
185	Mersin XVI	Chal.	Garstang, 1953:132-133, (M. 38, 1334)	E-17874		Cu/tr: As, Sb, Ag, Ni, Bi.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
186	Ahlatlibel	EB II	Koşay, 1934:76 (A.B.583)	E-6758		Cu/tr: Sn, Pb, As, Sb, Ag.
187	Troy	EB II	Unpublished. Istanbul Archaeological Museum. No. 622 (After Esin, 1967:165)	E-11810		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Co.
188	Troy	EB II	Unpublished. Istanbul Archaeological Museum. No. 630 (After Esin, 1967:165)	E-11811		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi, Au.
189	Karaz	EB II	Koşay and Turfan, 1959:409 (Kz. a.179)	E-17626		Cu-As/tr: Pb, Sb, Ag, Ni.
190	Troy	EB II	Unpublished. Istanbul Archaeological Museum. No. 612 (After Esin, 1967:165)	E-11806		Cu/tr: Sn, Ag, Ni.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
191	Troy	EB II	SS. 6835 (XIb, 1010)	E-9873		Analysis not reported.
192	Troy	EB II	Unpublished. Istanbul Archaeological Museum. No. 607 (After Esin, 1967:165)	E-11805		Cu-Sn/tr: Pb, As, Sb, Ag, Ni, Bi.
193	Troy	EB II	Unpublished. Istanbul Archaeological Museum. No. 99/2 (After Esin, 1967:165)	E-11803		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Zn, Co.
194	Alaca	EB II	Koşay, 1951:75 (Al.b.s.4)	E-6863		Cu-Sn/tr: Pb, As, Sb, Ag, Ni, Bi, Fe.
195	Troy	EB II	Unpublished. Istanbul Archaeological Museum. No. 621 (After Esin, 1967:165)	E-11809		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi, Au.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
196	Troy	EB II	Unpublished. Istanbul Archaeological Museum. No. 620 (After Esin, 1967:165)	E-11808		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi, Au, Co.
197	Troy	EB II	Unpublished. Istanbul Archaeological Museum. No. 965 (After Esin, 1967:165)	E-11812		Cu-Sn/tr: Pb, As, Sb, Ag, Ni, Bi.
198	Troy	EB II	Unpublished. Istanbul Archaeological Museum. No. 11 B, 1008 (After Esin, 1967:165)	E-9871		Analysis not reported.
199	Tarsus	EB III	Goldman, 1956:289, fig.424 (18)	E-17926		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi, Au.
200	Beycesultan X	EB III	Lloyd and Mellaart, 1962: 292, 286, fig.F.9(7), pl.XXXV(1).	E-11739		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi, Co.
201	Bayindirköy	EB II	Bittel, 1955:114, fig.2	E-3187		Cu/tr: As, Ag.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
202	Troy	EB II	Unpublished. Istanbul Archaeological Museum. No. 105 (After Esin, 1967:165)	E-11804		Cu/tr: Ag, Ni.
203	Mersin XVI	Chal.	Garstang, 1953:137, fig.80b (1329)	E-17872		Cu/tr: Sb, Ag, Fe.
204	Mersin XV B	Chal.	Garstang, 1953:167, fig.95(b)	E-17880		Cu/tr: As, Sb, Ag, Ni, Bi, Fe.
205	Troy II	EB II	<u>Troja</u> : 104, no.1; Przeworski, 1967:202-3, no.37	Tr-104-1		Cu-Sn/tr: Pb, Fe.
206	Troy II	EB II	<u>Troja</u> :104, no.2; Przeworski, 1967:202-3, no.38	Tr-104-2		Cu-Sn/tr: Pb, Fe.
207	Troy II	EB II	<u>Troja</u> :104, no.3; Przeworski, 1967:202-3, no.39	Tr-104-3		Cu-Sn/tr: Pb, Fe.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
208	Troy II	EB II	Troja:105, no.2; Przeworski, 1967:202-3, no.43	Tr-105-2		Cu-Sn/tr: Fe.
209	Troy II g Treasure A	EB II	Ilios:478; Przeworski, 1967: 202-3, no.35	I-1		Cu-Sn. One of 14 axes from Treasure A but not reported in SS. Cf. gen. view, Ilios:42.
210	Troy II g Treasure A	EB II	Ilios:478; Przeworski, 1967: 202-3, no.36	I-2		Cu-Sn. One of 14 axes from Treasure A but not reported in SS. Cf. gen. view, Ilios:42.
211	Troy II g Treasure A	EB II	Ilios:477, no.806(?); Przeworski, 1967:202-3, no.33; SS 5830; Atlas:pl.193, no.3492	SS-5830		Cu-Sn. One of 14 axes from Treasure A, Ilios:477. Not specified which, cf.Ilios:42.
212	Troy II g Treasure A	EB II	Ilios:477, no.809(?); Przeworski, 1967:202-3, no.34; SS 5827; Atlas, pl.193, no.3495e	SS-5827		Cu-Sn. One of 14 axes from Treasure A, Ilios:477. Not specified which, cf.Ilios:42.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
213	Troy II g Treasure A	EB II	Ilios:478; Przeworski, 1967: 202-3, no.48; SS 5831; Atlas,pl.201, no.3597	SS-5831		Cu-Sn/tr: Pb, As, Ni, Fe, Sb, Ni, Co. One of the 14 axes from Treasure A. Cf. gen. view, Ilios:42
214	Pinarbaşi Göl	EB II	Moorey and Schweizer, 1974: 113, no.1911.117; Przeworski, 1966:pl.IX(5); Deshayes, 1960:no.338.	1911-117		Cu/tr: Sn, As, Pb.
215	Pinarbaşi Göl	EB II	Moorey and Schweizer, 1974:113, no.1911.118; Przeworski, 1966:pl.IX(4); Deshayes, 1960:no.250.	1911-118		Cu-As/tr: Sn, Pb, Sb.
216	Soli	EB III	Bittel, 1940:194, fig.12, S 3462; Buchholz, 1967:214, no.201; Deshayes,II:1960: 12, no.212.	So-3462		Cu-Sn/tr: Pb, Sb.
217	Soli	EB III	von Luschan, 1902:301, no. S 3469; Buchholz, 1967: 238, no.99	So-3469		Cu-Sn-Pb/tr: Ni, Fe.
218	"Kayseri Region"	EBA(?)	Przeworski, 1967:206-7, no.126, pl.X(5); Deshayes, 1960,II:28, no.528	Prz-126		Cu:99.7 %.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
219	"Bodrum Region"	EBA(?)	Tezcan, 1960:39, pl.XXVII(2). Ankara Museum.		XXIII(1)	

SHAFT-HOLE AXES

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
220	Ahlatlibel	EB II	Koşay, 1934:76 (A.B.584)	E-6759		Cu-As/tr: Ag.
221	Güzelova	EB II	Atatürk University Museum. No. G 263 (After Esin, 1967:167)	E-17725		Cu-As/tr: Pb, Sb, Ag, Ni, Fe.
222	Kayapinar	EB III	Temizer, 1954:327, fig.18	E-17615		Cu-As/tr: Sb, Ag, Ni, Fe.
223	Polatli	EBA	Lloyd and Gökçe, 1951:60, fig.13	E-11732		Cu-As/tr: Sb, Ag, Ni.
224	Mahmatlar	EB III	Koşay and Akok, 1950:pl.XL,4.	E-6781	18(3)	Cu-As/tr: Ag, Ni.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
225	Ahlatlibel	EB II	Koşay, 1934:76 (A.B.354)	E-6760	27(3)	Cu-As/tr: Sb, Ag. L:12 cms.
226	Karaz	EB II	Erzurum Museum. No.69 (After Esin, 1967:167)	E-17726		Cu-As/tr: Pb, Sb Ag, Ni.
227	Karaz	EB II	Koşay and Turfan, 1959:409 (Kz. a/174)	E-17622		Cu -As/tr: Sb, Ag, Ni.
228	Horoztepe	EB III	Özgüç and Akok, 1958:46, pl.XIII, (10); Idem, 1957: 215-16, figs.15 a-b, 37.	E-6735	21(5)	Cu-Sn/tr: Pb, As, Ag, Ni, Bi.
229	Kalinkaya	EB I	Unpublished. Ankara Museum. No. KL 25-73.			May be classed also as an axe-hammer.
230	Anatolia	EBA(?)	Tezcan, 1960:40, pl.XXVII(1); Metropolitan Museum No.55.137.14		XXIII(2)	

HALBERDS *

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
231	Mahmatlar	EB III	Koşay and Akok, 1950:481-5, pl.XLI (15)	E-6780		Cu-Sn-As/tr: Pb, Ag, Ni.
232	Mahmatlar	EB III	Koşay and Akok, 1950:481-5, pl.XLI (15)	E-6783		Cu/tr: Pb, Ag, Ni, Bi.
233	Mahmatlar	EB III	Koşay and Akok, 1950:481-5, pl.XLI (15)	E-6782		Cu-Sn-As/tr: Sb, Ag, Ni.
234	Mahmatlar	EB III	Koşay and Akok, 1950:481-5, pl.XLI (15)	E-6785		Cu-Sn/tr: As, Ag, Ni.
235	Mahmatlar	EB III	Koşay and Akok, 1950:481-5, pl.XLI (15)	E-6784		Cu-Sn/tr: Pb, As, Ag, Ni.

* N.B. : In the publication of the Mahmatlar group, Esin did not indicate in her catalogue which analyses go with which "crescentic axes" (ie. halberds). Hence, they all carry the same reference. Only E-6779 was identified.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
236	Mahmatlar	EB III	Koşay and Akok, 1950:481-5, pl.XLI (15)	E-6787		Cu-S /tr: Pb, Ag, Ni, Fe.
237	Mahmatlar	EB III	Koşay and Akok, 1950:481-5, pl.XLI (15)	E-6786		Cu-Sn/tr: Pb, As, Ag, Ni.
238	Mahmatlar	EB III	Koşay and Akok, 1950:481-5, pl.XL (3)	E-6779	18(4)	Cu-Sn/tr: Pb, As, Ag, Ni, Bi, Au, Zn, Fe.
239	Mahmatlar	EB III	Koşay and Akok, 1950:484, pl.XL (2)		18(1)	
240	Mahmatlar	EB III	Koşay and Akok, 1950:484, pl.XL(1)		18(2)	

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
241	Anatolia	EB III	Stronach, 1957:121, fig.12(2), pl.VIIIa(1) and n.215. Private collection.		XXII(1)	
242	Anatolia	EB III	Stronach, 1957:121, fig.12(3), pl.VIIIa(2) and n.216. Private collection.		XXII(2)	

CRESCENTIC AXES

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
243	Soli	EB III	Bittel, 1940:192, 201, pl.IV, no. S 3398; Stronach, 1957: 125, fig.3(7)	So-3398		Cu-Sn/tr: Pb, Sb, As, Ag.
244	Soli	EB III	Stronach, 1957:124, fig.13 (6); Bittel, 1940:192-3, pl.IV (S 3397)			
245	Ankara Prov.	EB III	Ozgüç and Akok, 1958:57-8, pl.XVIII(1); Tezcan, 1960: 37-39, pl.XX(4)		25(7)	Said to come from "near Nallihan".
246	Ankara Prov.	EB III	Ozgüç and Akok, 1958:57-8, pl.XVIII(2); Tezcan, 1960: 37-39, pl.XX(2)		25(6)	Said to come from "near Nallihan".
247	Satir Hüyük	EB III	Stronach, 1957:124, fig.14, pl.VIIIb(1) and n.233. Adana Museum.		XXII(4)	

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
248	Bayindirköy	EB III	Stronach, 1957:124, fig.14(2), pl.VIIIb(2) and n.235. Private collection.		XXII(5)	
249	Til Barsib	EB III	Dunand and Thureau-Dangin, 1936: 106, 114-116, pl.XXVIII(6)			

SPEARHEADS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
250	Yortan	EB II	Unpublished. Istanbul Archaeological Museum. No. 5825 (After Esin, 1967:168)	E-11795		Cu-Sn/tr: Pb, Sb, Ag, Ni, Bi, Fe.
251	Alishar II	EB III	OIP XIX:154, fig.193 (b 1228) Stratum II	E-17807		Cu/tr: Pb, As, Ag, Ni.
252	Güzelova	EBA	Atatürk University Museum. No. G 278 (After Esin, 1967:169)	E-17724		Cu-As/tr: Ag, Bi, Fe.
253	Horoztepe	EB III	Ozgüç and Akok, 1958:46, pl.VIII (4), fig.27; Esin, 1967:169	E-6734	22(4)	Cu-As/tr: Ag, Ni. Esin does not specify which of the four spear-heads she analyzed. Possibly this blade fragment.
254	Troy II	EB II	<u>Troja</u>:104, no.6; Przeworski, 1967:202-3, no.41	Tr-104-6		Cu-Sn/tr: Pb, Fe.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
255	Troy II	EB II	Troja:105, no.1; Przeworski, 1967:202-3, no.44	Tr-105-1		Cu-Sn. From Temple A
256	Pinarbaşi Göl	EB II	Moorey and Schweizer, 1974: 113, no.1911.114; Przeworski, 1967:pl.IX(3); Stronach, 1957:fig.4(2); Watkins, 1974: fig.1(c)	1911-114		Cu-As/tr: Sn, Pb, Sb.
257	Pinarbaşi Göl	EB II	Moorey and Schweizer, 1974: 113, no.1911.115; Przeworski, 1967:pl.IX(2); Stronach, 1957: fig.9(5); Watkins, 1974:fig.1(b)	1911-115		Cu/tr: Sn, As, Pb.
258	Pinarbaşi Göl	EB II	Moorey and Schweizer, 1974: 113, no.1911.116; Przeworski, 1967:pl.IX(1); Watkins, 1974: fig.1(a)	1911-116		Cu/tr: Sn, As, Pb, Sb.
259	Soli	EB III	Bittel, 1940:192, 201, pl.IV, no.3406, fig.9; Stronach, 1957:114, fig.8(3)	So-3406	29(3)	Cu-Sn/tr: Pb, Sb.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
260	Soli	EB III	Bittel, 1940:190, 201, pl.IV, no.S 3405, fig.8	So-3405	29(2)	Cu-Sn/tr: Pb, Sb, As, Ag.
261	Troy II g	EB II	SS 5855. Ilios:453, no.13; Przeworski, 1967:202-3, no.49	I-13		Cu-Sn/tr: Pb, As, Sb, Ni, Co, Fe. Przeworski has erroneously re-copied this analysis. Specific example not mentioned. Could also be A-284.
262	Alaca Tomb T	EB II	Arik, 1937:CCLXXIV, pl.CCLXXV, no. Al. 1086.			
263	Alaca Tomb T	EB II	Arik, 1937:CCLXXIV, pl.CCLXXV, no. Al. 1087.			
264	Horoztepe	EB III	Özgüç and Akok, 1958:46, pl.VIII(9); Idem, 1957:216, figs. 14, 30.		21(1)	
265	Horoztepe	EB III	Özgüç and Akok, 1958:46, pl.XVIII(7); Idem, 1957:216, figs. 18, 31.		21(2)	

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
266	Horoztepe	EB III	Özgüç and Akok, 1958:46, pl.XVIII(8); Idem, 195 :216, figs.17, 32		21(3)	
267	Horoztepe	EB III	Özgüç and Akok, 1958:46; Idem, 1957:216, figs;16, 33		21(4)	
268	Horoztepe	EB III	Özgüç and Akok, 1958:46, pl.VIII(6); Idem, 1957:216, figs. 13, 34		22(1)	
269	Horoztepe	EB III	Özgüç, 1964:10, fig.8		22(2)	
270	Horoztepe	EB III	Özgüç, 1964:10, fig.7. Now in Istanbul Archaeological Museum.		22 (3)	Said to come from "Tokat-Samsun Region".
271	Soli	EB III	Bittel, 1940:190, fig.7, pl.IV, S-3408		29(1)	

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
272	Soli	EB III	Bittel, 1940:192, fig.10, pl.IV, S.3407; Stronach, 1957:114, fig.8(2)		29(4)	
273	Silifke	EB III	Bittel, 1955:118, fig.10; Stronach, 1957:115, fig.8(5)		30(1)	
274	Anatolia	EB III	Unpublished. Kastamonu Museum. Sketch only.		30(2)	
275	Ordu	EB III	Bittel, 1944/45:53, fig.4; Stronach, 1957:109, fig.5(4)		30(3)	
276	Kalinkaya	EB I	Unpublished. Ankara Museum. No. KL 185-71			
277	Anatolia	EB III (?)	Stronach, 1957:108, fig.6(2) From a private collection.			Bent tang. Slotted blade.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
278	Anatolia	EB III (?)	Stronach, 1957:109, *fig*.6(4)			Bent tang with button end. Slotted blade.
279	Troy Treasure A	EB II	Ilios: no.801;			Straight tang.
280	Troy	EB II	Ilios: no.901; SS 6149			Silver. Bent tang. Slotted blade
281	Troy Treasure A	EB II	Ilios: no.812; SS 5842			Bent tang. Slotted blade.
282	Troy Treasure A	EB II	Ilios: no.813; SS 5844			Bent tang. Slotted blade.
283	Troy Treasure A	EB II	Ilios: no.814; SS 5845			Bent tang. Slotted blade.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
284	Troy Treasure A	EB II	Ilios:453; SS 5848			Straight riveted tang. Slotted blade. Specific ex. not mentioned Could also be A-261.
285	Troy Treasure K	EB II	Troja:no.34; SS 6050			Bent tang. Slotted blade.
286	Tarsus	EB III	Goldman, 1956:284, 292(93), fig.428(93).			Bent tang. Slotted blade.
287	Corum	EB II (?)	Ankara Museum. Unpublished.			Bent tang. Slotted blade.

ARROWHEADS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
288	Tarsus	EB I	Goldman, 1956:291,fig.427(76) No. T.48.83.			L: 5.6 cms. W (max): 2.2 cms.
289	Troy II g	EB II	_Ilios_: no.955			
290	Troy II g	EB II	_Troja_: 104 (mention only) From Temple A.			
291	Troy II (early)	EB II	_Troja_: 117, no.44			Ivory.

"FRYING PANS" / "MIRRORS" *

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
292	Troad	EB II	Bittel, 1959:1, 34(1) figs. 1,2	E-3793		Cu-Sn/tr: Pb, As, Ag, Ni, Bi, Fe.
293	Troad	EB II	Bittel, 1959:1, 34(5) fig. 6	E-3802		Cu-Sn/tr: Pb, As, Ag, Bi, Fe. Handle of "frying pan."
294	Troad	EB II	Bittel, 1959:2, 34(3) fig. 4	E-3810		Cu-Sn-Fe/tr: Pb, As, Ag, Bi.
295 a)	Troad	EB II	Bittel, 1959:2, 34(4a) fig. 5	E-3811		Cu-Sn/tr: Pb, As, Ag, Ni, Bi, Fe. Handle of "frying pan."
b)	Troad	EB II	Bittel, 1959:2, 34(4b) fig. 5	E-3812		Cu-As-Pb-Bi-Fe/tr: Ag, Sb, Sn, Ni. Knob of "frying pan" of above.

*N.B.: It is not sure for what purpose these objects were intended. Mellink, 1956:52-3, calls them mirrors. An unfounded interpretation is offered by Barnett, in Weinberg, 1956:222, who refers to them as cult objects.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
296	Horoztepe	EB III	Özgüç and Akok, 1958:44, fig. 19, pl.VII(1)	E-6751	24(5)	Cu/tr: Ag.
297	Alaca	EB II	Koşay, 1944:108 (Al/a MA 60), pl.LXXXIII(60). Tomb MA.		IX(3)	
298	Alaca	EB II	Koşay, 1944:108 (Al/a MA' 27), pl.LXXXIX(27). Tomb MA'.		IX(4)	

VESSELS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
299 a)	Kayapinar	EB II	Temizer, 1954:325-326, fig.16a	E-17618		Cu/tr: Sn, Ag, Ni, Fe. Same artifact as below but upper part.
b)	Kayapinar	EB II	Temizer, 1954:325-326, fig.16b	E-17620		Cu-Sn/tr: As, Ag, Ni. Same artifact as above but lower part.
300	Horoztepe	EB III	Ozgüç and Akok, 1958:44, fig.18, pl.VI (6)	E-6750		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Zn, Fe.
301	Horoztepe	EB III	Ozgüç and Akok, 1958:43, fig.4	E-6752		Cu/tr: Sn, Ag, Fe.
302 a)	Kayapinar	EB II	Temizer, 1954:325-326, fig.15	E-17612		Cu-As/tr: Sn, Sb, Ag, Ni. Same artifact as below. Body.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
302 b)	Kayapinar	EB II	Ibid.	E-17614		Cu-As/tr: Sb, Ag, Ni. Same artifact as above. Volute.
c)	Kayapinar	EB II	Ibid.	E-17613		Cu-As/tr: Sb, Ag, Ni. Same artifact as E-17614 and E-17612. Handle.
303	Ahlatlibel	EB II	After Esin, 1967:172	E-6778		Cu-Fe/tr: Pb, As, Ag, Ni, Bi. Esin's reference to this artifact is erroneous: "rim fragment".
304	Troy	EB II	Berlin Museum. No.XIB 1696 (After Esin, 1967:172)	E-9899		Analysis not reported. "Cup fragment".
305	Alaca	EB II	Arik, 1935:CCLXVIII-CCLXIX (AL 1829)	E-6838		Cu-As/tr: Sn, Sb, Ag, Ni, Bi, Au, Fe. Spout.
306	Troad	EB II	Bittel, 1959:34 (18), fig.20	E-3799		Cu-Sn-Pb-Bi/tr: As, Sb, Ag, Ni, Fe Spout.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
307	Troad	EB II	Bittel, 1959:34 (16), fig.18	E-3796		Cu-Sn/tr: Pb, As, Ni, Fe. Spout.
308	Troad	EB II	Bittel, 1959:34 (15), fig.17	E-3797		Cu-Sn-Bi/tr: Pb, As, Sb, Ag, Ni, Fe. Spout.
309	Troad	EB II	Bittel, 1959:34 (17), fig.19	E-3798		Cu-Sn-Sb-Fe/tr: Pb, As, Ag, Ni, Bi. Spout.
310	Troad	EB II	Bittel, 1959:34 (12), fig.14	E-3814		Cu-As-Fe/tr: Sn, Pb, Sb, Ag, Ni, Bi Spout.
311	Troad	EB II	Bittel, 1959:34 (14), fig.16	E-3813		Cu-As-Fe/tr: Sn, Pb, Sb, Ag, Ni, Bi Co. Spout.
312	Troy II g	EB II	SS. 5975. Berlin Museum. XIb, 1695. Treasure B; <u>Ilios</u>: no.796.	E-9896		Analysis not reported. Esin's reference is erroneous. Possibly this one. Spout.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
313	Troad	EB II	Bittel, 1959:34 (13), fig.15	E-3804		Cu-As/tr: Sn, Pb, Ag, Ni, Bi, Fe. Spout.
314 a)	Alaca Tomb TM	EB II	Arik, 1937:CCLXVI, (1822)	E-6835		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi, Au, Fe. Same artifact as below but different volute.
b)	Alaca Tomb TM	EB II	Arik, 1937:CCLXVI, (1822)	E-6834		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi, Fe. Same artifact as above but different volute.
315	Troad	EB II	Bittel, 1959:4, 34 (11), fig.13	E-3801		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Bi, Fe. Volute.
316 a)	Troad	EB II	Bittel, 1959:34(9 l), fig.11 (left)	E-3805		Cu-As/tr: Sn, Pb, Ag, Ni, Bi, Fe. Left volute. Same vase as below.
b)	Troad	EB II	Bittel, 1959:34(9 r), fig.11 (right)	E-3806		Cu-As/tr: Sn, Pb, Ag, Ni, Bi, Fe. Right volute. Same vase as above.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
317 a)	Troad	EB II	Bittel, 1959:43 (8 1) fig .10 (left)	E-3807		Cu- Sn/tr: Pb, As, Ni, Bi, Fe. Left volute. Same vase as below.
b)	Troad	EB II	Bittel, 1959:34 (8 r) fig.10 (right)	E-3808		Cu-Sn-Pb/tr: As, Ni, Bi, Fe. Right volute. Same vase as above.
318	Troad	EB II	Bittel, 1959:34 (6), figs.7, 8	E-3794		Cu-Sn-Pb-Bi/tr: As, Ag, Ni, Fe. Vase.
319	Troad	EB II	Bittel, 1959:34 (10), fig.12 (left)	E-3795		Cu-Sn-Pb-Bi/tr: As, Ag, Ni, Fe. Volute.
320	Troy II g	EB II	SS. 5975. Berlin Museum. XIb, 1695. Treasure B (After Esin, 1967:173)	E-9898		Analyses not reported for the following three. Esin's refs. to E-9898, 9904, 9897 are erroneous. These do not correspond to the voluted handle attachments she has apparently analyzed. Her analysis numbers may refer to the volute frags. mentioned under SS 5975. Three of these volutes are possibly those pictured in *Ilios*:nos.795,797, and 798.
321	Troy II g	EB II	SS. 5975. Berlin Museum. XIv, 1695. Treasure B (After Esin, 1967:173)	E-9904		

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
322	Troy II g	EB II	SS. 5975. Berlin Museum. XIb, 1695. Treasure B (After Esin, 1967:173)	E-9897		See remarks above (i.e. 320, 321).
323	Troy II g	EB II	SS. 6147a. Berlin Museum. XIV, 1694. Treasure S (After Esin, 1967:173)	E-9893		Analysis not reported. Not specified which volute was analyzed.
324	Horoztepe	EB III	Özgüç and Akok, 195 :43, fig.6, pl.IV (5)	E-6749	24(1) XIV(1)	Cu/tr: Sn, Pb, As, Sb, Ag, Ni.
325	Horoztepe	EB III	Özgüç and Akok, 1958:43, fig.7, pl.IV (6)	E-6754	24(4)	Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Fe.
326	Horoztepe	EB III	Özgüç and Akok, 1958:44, figs.15, 16, pl.VI (1,2) Esin, 1967:173	E-6731	24(2) 24(3)	Cu-Sn/tr: Pb, As, Ag, Ni, Bi. There is some confusion here. Esin puts two cups under this analysis.
327	Troad	EB II	Bittel, 1959:5, 34 (19) fig.21	E-3800		Cu-Sn/tr: Pb, As, Sb, Ni, Fe. Spout.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
328	Troy II g	EB II	SS. 5975. Berlin Museum. XIb 1695. Treasure B (After Esin, 1967:174)	E-9895		Analysis not reported. Esin's reference is erroneous. Possibly this one.
329	Troad	EB II	Bittel, 1959:34 (8 b) fig.10	E-3809		Cu-Sn/tr: Pb, As, Ni, Bi, Fe. Handle.
330	Troy	EB II	SS. 6147. Berlin Museum. 11b 1694. Treasure S (After Esin, 1967:174)	E-9889		Analysis not reported.
331	Horoztepe	EB III	Özgüc and Akok, 1958:43, fig.3, pl.IX (1)	E-6729		Cu-Sn-Pb/tr: As, Ag, Ni, Bi, Fe.
332	Alaca Tomb TM	EB II	Arik, 1937:CCLXVI, no.1823; Kosay, 1944:189, no.4126	K-4126		Cu-Sn. Tin content: 14.07 %.
333	Troad	EB II	Bittel, 1959:34, no.20	E-3803		Cu-Sn/tr: Ag, Ni, Fe. Bowl.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
334	ESkiyapar	EB III	Unpublished, Ankara Museum.			Silver cup. H : ca.8 cms. D : ca.8 cms.
335	Eskiyapar	EB III	Unpublished. Ankara Museum.			Silver cup. H : ca.9.2 cms. D : ca.8 cms.
336	Eskiyapar	EB III	Unpublished. Ankara Museum.			Silver cup. H : ca.7 cms. D : ca.6 cms.
337	Eskiyapar	EB III	Unpublished. Ankara Museum.			Silver bottle. H : 10.4 cms. D : ca.3.6 cms (widest point).
338	Eskiyapar	EB III	Unpublished. Ankara Museum.			Silver dish. H : ca.1.5 cms, D : ca.10 cms.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
339	Alaca	EB II	Koşay, 1951:160, no.H 120, pl.CXXXII. Tomb H		VIII(1)	Silver pitcher.
340	Mahmatlar	EB II	Koşay and Akok, 1950:483, pl.XXXVIII(8); Ankara Museum. No. 15076; Smithsonian, 1966:no.20		VIII(2)	Gold pitcher.
341	Alaca	EB II	Koşay, 1951:160, no.H 118, pl.CXXXII. Tomb H		VIII(3)	Silver pitcher.
342	Alaca	EB II	Koşay, 1951:166, no. K 2, pl.CLXXVI		IX(1)	Gold vase.
343	Anatolia	EB III	Tezcan, 1960:31, pl.VII(1); Metropolitan Museum No.55.137.38		XIX(1)	Said to come from "near Nallihan."

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
344	Anatolia	EB III	Tezcan, 1960:31, pl.XVII(2); Metropolitan Museum No.55.137.39		XIX(2)	Said to come from "near Nallihan."
345	Anatolia	EB III	Tezcan, 1960:31, pl.XVII(3); Metropolitan Museum No.55.137.40		XIX(3)	Said to come from "near Nallihan."
346	Anatolia	EB III	Tezcan, 1960:31, pl.XVII(4); Metropolitan Museum No.55.137.41		XIX(4)	Said to come from "near Nallihan."
347	Anatolia	EB II	Tezcan, 1960:30, pl.XV; Muscarella, 1968:195, fig.2; Metropolitan Museum No.51.67		XIX(5)	Gold pitcher. Said to come from Amasya region.
348	Anatolia	EB III	Muscarella, 1974:no.2 Schimmel collection.		XX(1)	Two-handled silver cup with gold overlay.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
349	Anatolia	EB II	Muscarella, 1974:no.1; Schimmel collection.		XX(2)	Two-lugged electrum vase with lid.
350	Anatolia	EB III	Muscarella, 1974:no.3; Schimmel collection.		XXI(1)	Silver omphalos bowl.
351	Anatolia	EB II	Muscarella, 1974:no.4; Schimmel collection.		XXI(2)	Silver cup.
352	N.W. Anatolia	EB II	British Museum no.132150; Renfrew, 1967:pl.10(c)			Silver depas.

FURNITURE

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
353 a)	Horoztepe	EB III	Özg üç and Akok, 1958:42, fig.2, pl.III(3)	E-6726		Cu-Sn/tr: Pb, As, Ag, Ni, Bi. Table. Same artifact as below.
b)	Horoztepe	EB III	Özgüç and Akok, 1958:43, fig.2, pl.III (4) (Upper frag.)	E-6725		Cu-Sn/tr: Pb, As, Ag, Ni, Bi. Same artifact as above and below. Leg.
c)	Horoztepe	EB III	Özgüç and Akok, 1958:43, fig.2, pl.III (4) (Lower frag.)	E-6727		Cu-Sn-Zn/tr: Pb, As, Sb, Ag, Ni, Au, Fe. Same artifact as above. Leg.
354	Horoztepe	EB III	Özgüç and Akok, 1958:43, fig.1, pl.III (2)	E-6728	XIV(2)	Cu-Sn/tr: Pb, As, Ag, Ni, Bi, Zn, Fe. Leg of table. Not specified which.
355	Horoztepe	EB III	Özgüç and Akok, 1958:49, pl.XIII 10	E-6730		Cu-Sn/tr: Pb, As, Ag, Ni, Bi, Au, F . Sheetmetal.
356	Horoztepe	EB III	Özgüç and Akok, 1958:43, fig.2, pl.IV (1-2)			Fruitstand.

FIGURINES

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
357	Horoztepe	EB III	Özgüç and Akok, 1958:46-7, pl. X (1a b)	E-6737	20 XIII(3) (4)	Cu-Sn/tr: Pb, As, Ag, Ni, Bi.
358	Alaca Tomb TM	EB II	Arik, 1937:CCLXX-CCLXXI (Al. 1080)	E-6839		Cu-Sn/tr: Pb, As, Sb, Ag, Ni, Bi, Fe.
359 a)	Horoztepe	EB III	Özgüç and Akok, 1958:47, fig.28, pl.XI (1b-c)	E-6732	19(3)	Cu-Sn-Pb/tr: As, Ag, Ni, Bi, Fe. Same artifact as below . Some confusion in Esin's ref. Possibly this one.
b)	Horoztepe	EB III	Özgüç and Akok, 1958:47, fig.28, pl.XI (1b-c)	E-6733	19(3)	Cu-As/tr: Ag, Ni, Au. Plating on bull figurine. Same artifact as above.
360 a)	Horoztepe	EB III	Özgüç and Akok, 1958:47-48, pl.XI (2)	E-6741	19(1)	Cu-Sn/tr: Pb, As, Ag, Ni, Bi. Same artifact as below.
b)	Horoztepe	EB III	Özgüç and Akok, 1958:47-48, pl.XI (2)	E-6742	19(1)	Cu-As/tr: Sb, Ag, Ni. Same artifact as above.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
361	Horoztepe	EB III	Ozgüç and Akok, 1958:47-48, pl.XI (3)	E-6743	19(2)	Cu-Sn/tr: Pb, As, Ag, Ni, Bi.
362	Horoztepe	EB III	Ozgüç and Akok, 1958:48, pl.XIV (1)	E-6744	19(4)	Cu-As/tr: Sn, Sb, Ag, Ni, Au.
363	Troy	EBA	Berlin Museum. No. 11b 1968. (After Esin, 1967:175)	E-9903		Analysis not reported.
364	Alaca	EB II	Arik, 1937:CCLIX, no.1757(?) or 1103(?); Koşay, 1944:189, no.4127	K-4127		Cu-Sn. Described as a "horn-shaped object."
365	Anatolia	EB III	Smith, 1973:96, fig.1. Boston Museum.	CSS-1		Cu-As/tr: Sn. Surface analysis only. Said to come from Horoztepe.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
366 a)	Anatolia	EB III	Tezcan, 1960:33-34, pl.XIX; Metropolitan Museum No.55.137 5	BI-3	XVII(1)	Cu-As/tr: Sn, Pb, Fe. Sample taken from left side of animal in groin area. Same object as below. Cf. Appendix VI.
b)	Anatolia	EB III	Tezcan, 1960:33-34, pl.XIX; Metropolitan Museum No.55.137. 5	BI-4	XVII(1)	Cu-As/tr: Sn, Pb, Fe. Sample taken from tang, underside base. Same object as above. Cf. Appendix VI.
367	Anatolia	EB III	Tezcan, 1960:34, pl.XX(1); Metropolitan Museum No.55.137. 6	BI-5	XVII(3)	Cu-As/tr: Sn, Pb, Fe. Sample taken from left horn, underside near hole. Cf. Appendix VI.
368	Anatolia	EB III	Unpublished. Oriental Inst. Mus. Chicago. No.A 30797		26(1) XVI(1)	
369	Anatolia	EB III	Unpublished. Oriental Inst. Mus. Chicago. No.A 30798		26(2) XVI(2)	
370	Anatolia	EB III	Tezcan, 1960:32, pl.XVIII(1); Boston Museum No.58.14		XVI(3)	

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
371	Soli	EB III	Bittel, 1940:197, fig.14, pl.VI, S.3399		29(5)	Horn only.
372	Hasanoglan	EB II	Tezcan, 1960:37, pl.24, figs.2-3		XV(2)	Electrum with gold overlay.
373	Alaca	EB II	Koşay, 1951:157 (no. H 7), pl.CXXIX; Ankara Museum, No.6044; Smithsonian, 1966: no.28		X(3)	
374	Anatolia	EB III	Unpublished. British Museum. No. 135851, 1973-1-20			Silver bull with gold inlay.
375	Alaca	EB II	Koşay, 1944:128 (no. MC 1), pl.XCVI (MC 1); Smithsonian, 1966:no.30		XI(1)	Bull standard.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
376	Alaca	EB II	Koşay, 1951:167 (nos. K 27, K 26, K 25), pl.CLXXX		XI(2)	Horns only. Hollow cast.
377	Horoztepe	EB III	Ozgüç and Akok, 1958:50, pl.XIV (2), fig.50		XIII(1)	Scepter (?) with birds.
378	Horoztepe	EB III	Lloyd, 1967:28, fig.18		XV(1)	This bull standard does not seem to be published elsewhere.
379	Troy II g	EB II	<u>Ilios</u>: no.226; SS 6446			Lead female figure.
380	Hasanoglan	EB III	Tezcan, 1960:37, pl.24, figs.2-3. Ankara Museum. No. 13922		XV(2)	Silver figurine with gold overlay.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
381	Anatolia	EB III	Muscarella, 1974:no.122; Schimmel collection.		XXI(3)	Twin bulls on staff with stone base.
382	Eski Balikhane	EB II	Mitten and Yüğrüm, 1971:193, fig.6 (M 69.6:7973)		XXV(1)	Silver ram pendant.

SUN DISKS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
383	Alaca Tomb S	EB II	Koşay, 1951:75 (Al.S. 3) pl.CCIII	E-6858		Cu-Sn/tr: Pb, As, Ag, Ni, Zn, Fe.
384	Alaca Tomb TM	EB II	Arik, 1938:CCLXII-CCLXIII (1071)	E-6876		Cu-As/tr: Sn, Sb, Ag, Ni, Bi.
385	Alaca Tomb TM	EB II	Arik, 1938:CCLXIV-CCLXV (Al. 1075)	E-6875		Cu-Sn/tr: Pb, As, Ag, Ni, Fe.
386	Horoztepe	EB III	Özgüç and Akok, 1958:44-45, pl.VII (2)	E-6740		Cu-Sn/tr: Pb, As, Ag, Ni, Bi.
387	Alaca Tomb S	EB II	Koşay, 1951:75 (Al.b.s. 23), pl.CCIII	E-6870		Cu-Sn/tr: Pb, As, Sb, Ag, Ni.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
388	Alaca Tomb MA'	EB II	Koşay, 1944:118 (Al/a. MA'3), pl.XCI		XII(1)	
389	Alaca Tomb MC	EB II	Koşay, 1944:129 (Al/q. MC 31), pl.CI		XII(2)	
390	Alaca Tomb E	EB II	Koşay, 1951:164 (No. E 3), pl.CLXIV. Ankara Museum. No. 7129; Smithsonian, 1966:no.31		XII(3)	

SISTRA

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
391	Horoztepe	EB III	Özgüç and Akok, 1958:48, pl.XII (1a-b)	E-6748		Cu-As/tr: Ag, Ni.
392	Horoztepe (?)	EB III	Tezcan, 1960:35-6, pl.XXII; Metropolitan Museum No.55.137.2	BI-1	XVII(5)	Cu-As-Pb/tr: Sn, Fe. Sample taken from under foot, bottom of handle. See Appendix VI.
393	Horoztepe (?)	EB III	Tezcan, 1960:34-5, pl.XXI; Metropolitan Museum No.55.137.1		XVII(4)	

"CASTANETS"

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
394	Alaca Tomb TM	EB II	Arik, 1937:CCLXXVI-CCLXXVII, (Al. 1816)	E-6840		Cu-Sn/tr: Pb, As, Ag, Au.
395	Horoztepe (?)	EB III	Özgüç and Akok, 1958:45, pl.VII (4,5). From a private collection in Turkey. (After Esin, 1967:176)	E-6739	XXII(3)	Cu-As/tr: Sn, Sb, Ag, Ni, Bi. It is not indicated which of the two was analyzed.
396	Horoztepe	EB III	Özgüç and Akok, 1958:45, pl.VII (3); idem, 1957:215, figs.12, 36	E-6746	23(3) XIV(3)	Cu-As/tr: Ag, Ni, Au.
397	Horoztepe	EB III	Özgüç, 1964:7-8, fig.5		23(4)	Silver.
398	Soli	EB III	Bittel, 1940:198, fig.16, pl.VI, S. 3395		29(6)	

LITUUS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
399	Alaca Tomb TM	EB II	Arik, 1937:CCLXXII-CCLXXIII (Al. 1100)	E-6836		Cu-As/tr: Pb, Sb, Ag, Ni, Bi, Au.
400	Alaca Tomb BM	EB II	Arik, 1937:CCVIII-CCIX (Al. 660)	E-6837		Cu-Sn/tr: Pb, As, Ag, Ni.
401	Alaca Tomb BM	EB II	Arik, 1937:CCVIII-CCIX (659)	E-6841		Cu-Sn/tr: As, Ag, Ni, Bi, Fe.
402	Alaca Tomb MA'	EB II	Koşay, 1951:114 (MA 17)	E-6846		Cu-Sn/tr: As, Ag, Fe.
403	Alaca Tomb TM	EB II	Arik, 1937:CCLXXII-CCLXXIII (1099)	E-6842		Cu/tr: As, Ag, Ni, Bi, Au.

BEADS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
404	Ahlatlibel	EB II	Koşay, 1934:70, 90 (A.B. 577)	E-6777		Cu-Pb-As/tr: Ag, Ni.
405	Eskiyapar	EB III	Unpublished. Ankara Museum; Mellink, 1970:161			Electrum. Four incised circles. A solid piece. The incised (punched ?) circles suggest an abreviated version of quadruple spiral.
406	Eskiyapar	EB III	Unpublished. Ankara Museum; Mellink, 1970:161			Gold. Quadruple spiral. L: 1.3 cms. Similar to a silver example from Brak, Mallowan, 1947:171, fig.9; and Maxwell-Hyslop, 1971: 31, fig.22(a)

NEEDLES

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
407	Tarsus	EB II	Goldman, 1956:294, pl.429, (132)	E-17956		Cu-Sn-As/tr: Pb, Sb, Ag, Ni.
408	Beycesultan XVII	EB I	Lloyd and Mellaart, 1962:292, fig. F 11 (12), pl.XXXV (9)	E-11744		Cu-As/tr: Sn, Ag, Ni.
409	Beycesultan XVII	EB I	Lloyd and Mellaart, 1962:288, fig. F 11 (13), pl.XXXV (10)	E-11746		Cu-As/tr: Ag, Ni.
410	Beycesultan XIII	EB II	Lloyd and Mellaart, 1962:288-292, fig. F 11 (15), pl. XXXV (5)	E-11749		Cu-As/tr: Ag.
411	Yortan	EB II	Unpublished. Istanbul Archaeological Museum. No. 6746 (After Esin, 1967:177)	E-11800		Cu-As/tr: Pb, Ag, Ni, Bi, Zn, Fe.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
412	Kusura B-C	EBA	Afyon Museum. No. 37, 22. 1453 (After Esin, 1967:177)	E-18041		Cu/tr: Sn, Pb, As, Ag Ni.
413	Beycesultan XXXIV	Chal.	Lloyd and Mellaart, 1962:291, fig. F 8 (1)	E-11777		Cu/tr: As, Ag, Ni, Bi.
414	Beycesultan XIII	EB II	Lloyd and Mellaart, 1962:288-292, fig. F 11 (11)	E-11748		Cu/tr: As, Ag, Ni, Bi.
415	Tarsus	EB II	Goldman, 1956:294, fig.429 (131)	E-17955		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Au.
416	Mersin XIII	Chal.	Garstang, 1953:172, fig.108 (M 38, 1168)	E-17885		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
417	Mersin XIII	Chal.	Garstang, 1953:172, fig.108 (M 38,1167)	E-17886		Cu/tr: As, Ag, Ni, Fe.
418	Troy II-V	EBA	SS 6413 a; Przeworski, 1967: 204-5, no.55	SS-6413 a		Cu/tr: Ni, Fe. Reported as a needle fragment.
419	Troy II-V	EBA	SS 6423 a; Przeworski, 1967: 204-5 , no.56	SS-6423 a		Cu/tr: Ni.

ROLL-HEADED PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
420	Mersin XVI	Chal.	Garstang, 1953:139, fig.85, pl.XXI (M 38, 1332)	E-17879		Cu/tr: Pb, Sb, Ag, Ni, Fe.
421	Mersin XVI	Chal.	Garstang, 1953:139, fig.85, pl.XXI (M 38, 1130)	E-17878		Cu/tr: Sb, Ag, Fe.
422	Mersin XVI	Chal.	Garstang, 1953:139, fig.85, pl.XXI (M 38, 1325)	E-17875		Cu/tr: As, Sb, Ag, Ni, Bi, Fe.
423	Mersin XVI	Chal.	Garstang, 1953:139, fig.85, pl.XXI (M 38, 1333)	E-17876		Cu/tr: Pb, As, Sb, Ag, Ni, Bi, Fe.
424	Mersin XVI	Chal.	Garstang, 1953:139, fig.85, pl.XXI (M 38, 1331)	E-17877		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Au.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
425	Kusura A	EB I	Lamb, 1936:39 (13), fig.18 (3)	E-18031		Cu/tr: Pb, As, Ag, Ni, Zn.
426	Polatli VI	EB II	Lloyd and Gökce, 1951:61, fig. 14 (4)	E-11729		Cu-Sn/tr: Pb, As, Sb, Ag, Ni.
427	Tarsus	EB III	Goldman, 1956:295, fig.430 (183)	E-17970		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Bi, Au, Co.
428	Tarsus	EB III	Goldman, 1956:295, fig.430 (187)	E-17969		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi, Au, Co.
429	Beycesultan XIV	EB II	Lloyd and Mellaart, 1962:288, (Bs/57/706); (After Esin, 1967:179).	E-11750		Cu/tr: As, Ag, Ni, Co. Apparently unpublished.
430	Beycesultan XIV	EB II	Lloyd and Mellaart, 1962:290, fig. F 11 (4); Esin, 1967:179	E-11747		Cu/tr: Sn, Pb, As, Sb, Ag, Ni. Esin's reference is erroneous. Possibly this one.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
431	Tarsus	EB III	Goldman, 1956:295, *fig*.430 (184)	E-17971		Cu/tr: Pb, As, Sb, Ag, Ni.
432	Kültepe	EB III	Ankara Museum. No. KT.i/T 303 (After Esin, 1967:179)	E-6793		Cu-As/tr: Sb, Ag, Fe.
433	Beycesultan VI	EB III	Lloyd and Mellaart, 1962:288, *fig*. F 11, 5	E-11753		Cu-As/tr: Sn, Pb, Sb, Ag, Ni.
434	Kusura B-C	EB III	Lamb, 1936:39 (13), *fig*.18 (13)	E-18037		Cu-As/tr: Sn, Pb, Sb, Ag, Ni.
435	Tarsus	EB II	Goldman, 1956:295, *fig*.430 (181)	E-17968		Cu-As/tr: Sb, Ag, Ni, Au, Fe.
436	Troy II-V	EBA	SS 6398 a; Przeworski, 1967: 204-5, no.54	SS-6398 a		Cu/tr: Sn, Pb.

DOUBLE-SPIRAL PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
437	Alaca	EB II	Kosay, 1951:167, pl.CLXXXVII, no. Al. d/k.13; Huot, 1969: 62, 70-1			Gold and silver.
438	Poliochni Azzurro	EB I	Bernabo-Brea, 1964:220, 591, 592, pl.LXXXVI (e)			Silver
439	Troy II g	EB II	Ilios, no.850, Treasure D; Istanbul Museum. Smithsonian, 1966:no.38		XXVI(4)	Gold.
440	Troy II g	EB II	Ilios: no.848, Treasure D; Istanbul Museum. No.684; Smithsonian, 1966:no.35		XXVI(1)	Gold.
441	Troy II g	EB II	Ilios:no.849, Treasure O; Istanbul Museum. No.685; Smithsonian, 1966:no.36		XXVI(2)	Gold. Two sets of spirals.
442	Troy II g	EB II	Ilios:no.932; SS 6401 (?)			Copper.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
443	Troy II g	EB II	Blegen, 1950,I:367, figs.356-357, no.37.709; Smithsonian, 1966:no.37. Istanbul Museum, No.5551		XXVI(3)	Gold.
444	Alaca	EB II	Koşay, 1951:150, pl.CXII(1), No.Al.d. 265			Copper.
445	Troy II (?)	EB II (?)	SS 6402			Copper.
446	Kusura B-C	EB III	Lamb, 1938:259, fig.21, no.24			Copper.
447	Ahlatlibel	EB II	Koşay, 1934:77, 93, no.355			
448	Troy II (?)	EB II (?)	SS 6402			

GLOBULAR-HEADED PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
449	Alishar I	EB II	OIP XXVIII: 196, fig.196 (C 212)	E-17754		Cu-As/tr: Sn, Sb, Ag, Ni, Fe
450	Yazilikaya	EB II	Unpublished, Afyon Museum No.2711, (Y.K.49, M.30, 138) (After Esin, 1967:180)	E-18102		Cu-Sn/tr: Pb, As, Sb, Ag, Ni, Au
451	Kultepe	EB II	Unpublished, Ankara Museum No.Kt.n./T.205, (After Esin, 1967:180)	E-17641		Cu-As/tr: Pb, Sb, Ag, Ni, Bi
452	Alishar I	EB II	OIP XXVII: 147, fig.153 (d.2761)	E-17769		Cu-Sn-Pb/tr: As, Ag
453	Alishar III	EB III	OIP XXVIII: 145, fig.150 (d.2977). From burial d X27	E-17770		Cu-Pb/tr: Sn, As, Sb, Ag, Ni, Bi Classed here by Esin, but photo does not give good likeness.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
454	Etiyokusu	EB II	Kansu, 1940:102-103, *fig.* 91,93 (Ey.207)	E-17739		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Co
455	Alishar I	EB II	OIP XXVIII: 195, *fig.*195 (E 573); Esin, 1967:180	E-17753		Cu-As/tr: Pb, Sb, Ag, Ni Esin's reference is erroneous. Possibly this one.

SEMI-GLOBULAR-HEADED PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
456	Beycesultan	EB III	Lloyd and Mellaart, 1962:288, fig. F. 11.3	E-11751		Cu-As/tr: Pb, Sb, Ag, Ni, Co
457	Tarsus	EB II	Goldman, 1956:294, fig.430 (161)	E-17961		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Bi, Co. Esin makes a separate classification of this pin. Head is fitted on.
458	Yazilikaya	EB III	Unpublished. Afyon Museum No.2796 (Y.K.50,M.6) (After Esin, 1967:181)	E-18101		Cu-As/tr: Pb, Sb, Ag, Ni, Bi, Au, Fe
459	Tarsus	EB III	Goldman, 1956:294, fig.430 (165); Esin, 1967:181	E-17963		Cu-As/tr: Pb, Sb, Ag, Ni. Considered by Goldman to be "conical headed."

CONICAL-HEADED PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
460	Alishar	EB II	OIP XXVIII:196, fig.196 (d 1745)	E-17759		Cu/tr; Sn, Pb, As, Sb, Ag, Ni, Bi.
461	Alishar	EB II	OIP XXVIII;196, fig.196 (d.140)	E-17757		Cu-Sn-As/tr; Pb, Sb, Ag, Ni.
462	Yortan	EB II	Unpublished. Istanbul Museum. No.6746, (After Esin, 1967: 182)	E-11799		Cu-As/tr; Ag, Ni, Zn, Fe.
463	Kusura B	EBA	Lamb, 1936:40, fig.18 (5)	E-18035		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi
464	Yazilikaya	EB III	Unpublished. Afyon Museum. No.35, 2825 Y.K.50, M 35 (After Esin, 1967:182)	E-18104		Cu-As/tr: Sb, Ag, Ni, Bi, Fe.
465	Alishar I	EB II	OIP XIX: fig.68 (b 2680)			

ROUNDED CONICAL-HEADED PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
466	Alishar	EB II	OIP XXVIII;195, fig.195 (c 315)	E-17758		Cu-As-Ni/tr: Sn, Pb, Sb, Ag, Bi, Co.
467	Kusura	EBA	Afyon Museum. No.1457, M. 37. 25 (After Esin, 1967:181)	E-18040		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Zn.
468	Kayapinar	EB II	Temizer, 1954:327-328, fig.19.	E-17617		Cu-As/tr: Sn, Sb, Ag, Ni, Fe.
469	Hashoyuk	EB II	Unpublished. Ankara Museum. No. 52. S. 119 (After Esin, 1967:181)	E-17636		Cu-As/tr: Pb, Sb, Ag, Ni, Bi.
470	Tilmen	EBA	No. Tb-K/122, (After Esin, 1967:181) From Tomb M III	E-17608		Cu-Pb/tr: Ag, Fe.

DOUBLE CONICAL-HEADED PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
471	Kusura B	EBA	Unpublished. Afyon Museum. No. 903, M. 36, 35 (After Esin, 1967:181)	E-18033		Cu-As/tr: Pb, Sb, Ag, Ni, Co.
472	Kusura B	EBA	Lamb, 1936:40, gif.18 (7)	E-18038		Cu-As/tr Sn, Pb, Ag, Ni, Co.
473	Kultepe	EBA	Unpublished. Ankara Museum. No. Kt.i./T.308 (After Esin, 1967:181)	E-6792		Cu-As/tr: Sn, Pb, Ag, Ni, Fe.
474	Yazilikaya	EB II	Unpublished. Afyon Museum. No.2799, Y.K. 50, N.9 (After Esin, 1967:181)	E-18103		Cu-Sn-Pb/tr: As, Ag, Ni, Bi.
475	Beycesultan VI	EB III	Lloyd and Mellaart, 1962: fig. F 11,2	E-11752		Cu-As/tr: Pb, Ag, Ni.
476	Alishar	EB II	OIP XXVIII:196, fig.195 (c 285); Esin, 1967:181	E-17755		Cu-As/tr: Pb, Sb, Ag, Ni. Esin classed this under "Knot-headed pins," but it is clearly not.

CONCAVE-HEADED PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
477	Alishar	EB II	OIP XXVIII:196, fig.196 (d. 935)	E-17756		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi. Classed here by Esin. Photo does not give good likeness.
478	Tarsus	EB II	Goldman, 1956:294, fig.430 (159)	E-17960		Cu/tr: As, Ag, Zn.
479	Tarsus	EB III	Goldman, 1956:295 (168)	E-17966		Cu-As/tr: Pb, Sb, Ag, Ni.
480	Alishar	EB II	OIP XIX:61, fig.69, (b. 705)			
481	Alaca	EB II	Koşay and Akok, 1966:pl.59, no. Al.h 66			

PYRAMID-HEADED PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
482	Tarsus	EB III	Goldman, 1956:294, fig.430, (167)	E-17965		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi, Au, Co.
483	Alishar	EB III	OIP XXVIII:230, fig.229 (c 1275). From burial c X16	E-17768		Cu/tr: Sn, Pb, As, Sb, Ni, Bi, Fe. Possibly MB I.
484	Beycesultan	EB II	Lloyd and Mellaart, 1962: 288, fig. F 11 (1)	E-11745		Cu-As/tr: Sn, Pb, Sb, Ag, Ni.
485	Tarsus	EB III	Goldman, 1956:294, fig.430, (166)	E-17964		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi.
486	Tarsus	EB III	Goldman, 1956:294, fig.430, (164)	E-17962		Cu/tr: As, Ag, Ni, Co.
487	Yazilikaya	EBA	Unpublished. Afyon Museum. No.154. 2943. Y.K. 50. M. 57 (After Esin, 1967:183)	E-18105		Cu-As/tr: Pb, Sb, Ag, Bi, Fe.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
488	Troy Id (middle)	EB I	Blegen *et al*, 1950, I:136, fig.215 (34-502)			
489	Poliochni Azzurro	EB I	Bernabo-Brea, 1964:pl. LXXXVI(1) (2) (6) 3 exs.			
490	Kusura B	EB II	Lamb, 1937:fig.18 (9)			
491	Kusura B	EB II	Lamb, 1938:fig.21 (23)			
492	Troy IIg	EB II	Blegen *et al*, 1950, I: fig.358 (36-33) 4 exs.			
493	Poliochni Verde-Rosso	EB II	Bernabo-Brea, 1964:pl. CLXXVI(6)			

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL/No.	FIG./PL.	REMARKS
494	Poliochni Verde-Rosso	EB II	Bernabo-Brea, 1964:pl. CLXXVI(3)			
495	Poliochni Verde-Rosso	EV II	Bernabo-Brea, 1964:pl. CLXXVI(11)			
496	Poliochni Rosso	EB III	Bernabo-Brea, 1964:pl. CLXXVI(9)			
497	Troy IIIa	EB III	Blegen et al, 1950, II: fig.47 (34-504)			
498	Troy IIIb	EB III	Blegen et al, 1950,II: fig.47 (34-207) More exs. in this period.			
499	Troy IIId	EB III	Blegen et al, 1950, II: fig.47 (33-208 and 33-207). 2 exs.			
500	Samos	EB III	Milojčič, 1961:pl.50(7)			

KNOT-HEADED PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
501	Kusura B	EB III	Unpublished. Afyon Museum. No. 982 M. 36. 60 (After Esin, 1967:183)	E-18039		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi.
502	Troy III (middle)	EB III	Blegen *et al*, 1950, II:fig.47, no. 37-739			

CUBE-HEADED PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
503	Tarsus	EB II	Goldman, 1956:294, fig.430, (158)	E-17959		Cu/tr: As, Sb, Ag, Ni, Zn.
504	Kusura B	EB III	Lamb, 1937:258, fig.21 (19)	E-18036		Cu-As/tr: Pb, Ag, Ni, Bi.
505	Troy I	EB I	Blegen et al, 1950:fig.215 (37-735)			
506	Alishar I	EB II	OIP XIX:fig.69 (b 381 k)			
507	Alaca	EB II	Koşay and Akok, 1966;pl.59 (Al.h.9)			
508	Poliochni Azzurro	EB II	Bernabo-Brea, 1964:pl. LXXXI(1)			

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
509	Troy II	EB II	SS-6352			
510	Tarsus	EB III	Goldman, 1956:294 (163), mention only.			

ELONGATE-HEADED TOGGLE PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
511	Tarsus	EB II	Goldman, 1956:296, fig.218 (38.1661)	E-17976		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Au.
512	Kusura B	EB III	Lamb, 1936:39 (3), fig.18 (3)	E-18034		Cu/tr: Pb, As, Sb, Ag, Ni, Bi.
513	Tarsus	EB II	Goldman, 1956:296, fig.431 (214)	E-17974		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Au.
514	Tarsus	EB II	Goldman, 1956:296, fig.431 (213)	E-17973		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Co.
515	Tarsus	EB II	Goldman, 1956:296, fig.431 (215)	E-17975		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Au.

GLOBULAR-HEADED TOGGLE PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
516	Kültepe	EBA	Unpublished. Ankara Museum. No. Kt. i/T 304 (After Esin, 1967:183)	E-6791		Cu/tr: Sn, Pb, As, Ag, Ni, Fe.
517	Poliochni Rosso	EB II	Bernabo-Brea;1964:pl. CLXXVII(4)			
518	Alishar I	EB II	OIP XIX:61, fig.69 (b 512)			

MUSHROOM-HEADED TOGGLE PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
519	Tarsus	EB III	Goldman, 1956:296, fig.431 (227)	E-17982		Cu-Pb-As/tr: Sn, Sb, Ag, Ni, Co.
520	Tarsus	EB II	Goldman, 1956:296, fig.431 (210)	E-17972		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Bi.
521	Tarsus	EB III	Goldman, 1956:296, fig.431 (223)	E-17980		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi.
522	Tarsus	EB III	Goldman, 1956:296, fig.431 (222)	E-17979		Cu/tr: Pb, As, Ag, Ni, Bi.
523	Karataş Tomb 152	EB II	Mellink; 1967:255, pl.77, fig.22 (right), no.KN 430 N			L.13cm.

CONICAL-HEADED TOGGLE PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
524	Mersin XIII-XIV	L.Chal	Garstang, 1953:167 (M 38.1313) (After Esin, 1967:184)	E-17884		Cu-Sn-As/tr: Pb, Sb Ag, Ni, Bi, Au. Find not specifically mentioned by Garstang. Possibility of intrusion or error. See chapter 7, n.18.
525	Tarsus	EB II	Goldman, 1956:296, fig.431 (221)	E-17978		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi, Au.
526	Karaz	EB II	Koşay and Turfan, 1959:410	E-17621		Cu-As/tr: Sb, Ag, Ni.
527	Kusura	EBA	Lamb, 1936:40 (953 M.36.52)	E-18032		Cu-As/tr: Sb, Ag, Ni, Bi, Fe.
528	Kusura	EBA	Unpublished. Afyon Museum. No. 3338 (After Esin, 1967:184)	E-18094		Cu-Sn/tr: Pb, As, Sb, Ag, Ni, Fe.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
529	Tarsus	EB II	Goldman, 1956:296, fig.431 (219)	E-17977		Cu-Sn-As/tr: Pb, Sb, Ag, Ni.
530	Tarsus	EB II	Goldman, 1956:296, fig.431 (225)	E-17981		Cu-As/tr: Pb, Sb, Ag, Ni, Bi, Co.
531	Alishar I	EB II	OIP XIX:61, fig.68 (b 2680) From burial b X69.			

HAMMER-HEADED PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
532	Ahlatlibel	EB II	Koşay, 1934:77 (AB 580)	E-6762		Cu-Sn/tr: Pb, As, Ag, Fe.
533	Ahlatlibel	EB II	Koşay, 1934:77 (AB 355)		27(3)	Copper.
534	Alaca	EB II	Arik, 1937:CCXLI (Al. 1760 and Al. 1761)			Gold.
535	Alaca	EB II	Koşay; 1951:pl.CXXXV (H 68, H 69)			Silver.
536	Troy IIg	EB II	Blegen _et al_, 1950: fig.357 (37-528)			Gold.

POINT-HEADED PIN

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
537	Pulur	EB II	Koşay and Vary, 1964:32 (P 80). Not illustrated. After Esin, 1967:185.	E-17712		Cu-As-Ni/tr: Ag, Co.

BIRD-HEADED PINS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
538	Tilmen IIId	EB III	Alkim, 1961:5-6 (1518)	E-17603		Cu-Sn-Pb-As-Ni/tr: Sb, Ag, Co, Fe.
539	Tilmen IIId	EB III	Alkim; 1969:288 (No. TB-K/121). From tomb M III.	E-17602		Cu-Sn-Pb-As-Ni/tr: SB, Ag, Co, Fe.
540	Thermi I	EB I	Lamb, 1936:pl.XXV (31-18) (31-39) 2 exs.			

PINS - VARIOUS STYLES

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
541	Mersin XXI	L.Chal.	Garstang, 1953:fig.50 (1589)			Disk-headed.
542	Alaca	EB II	Koşay, 1944:101 (no.Al/a MA 28), pl.LXXXII(28)		X(1)	Gold pin with embossed plaque.
543	Karatas	EB II	Mellink, 1967:255, pl.77 (22, left) (KA 452 N)			Silver. Rippled head.
544	Tarsus	EB III	Goldman; 1956:295, fig.430 (171)			Cluster of 3 balls.

PIN SHANKS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
545	Mersin XIII	L.Chal	Unpublished. Adana Museum. No. M. 38, 1164. (After Esin, 1967:186)	E-17888		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi.
546	Mersin XIV	L.Chal	Unpublished. Adana Museum. No. M. 38, 1189. (After Esin, 1967:186)	E-17883		Cu/tr: Pb, Sb, Ag, Ni, Fe.
547	Ahlatlibel	EB II	Unpublished. Ankara Museum. No. AB 439 (After Esin, 1967:186)	E-6770		Cu-Sn/tr: Pb, As, Sb, Ag, Fe.
548	Polatli VII	EB II	Unpublished. Ankara Museum. No. PO. H.C.VII, 213, 451 (After Esin, 1967:186)	E-11735		Cu-As/tr: Sn, Pb, Sb, Ag, Ni.
549	Alaca Tomb MA	EB II	Koşay, 1938:104, no.64.	K-4136		Cu-Sn.

UNINDENTIFIED PINS AND PIN FRAGMENTS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
550	Alaca Tomb MA	EB II	Koşay, 1944:189, no. Al M.A. 64	K-4136		Cu-Sn.
551	Alishar 12 M	EB I	OIP XXX:338, no. c 523; OIP XXVIII:93	c 523		Cu/ tr: Sn, Pb.
552	Alishar 13 M	EB I	OIP XXVIII:93; OIP XXX:338, no. c 2465	c 2465		Cu-Sn.
553	Alishar I	EB I	OIP XIX:29, no no.; OIP VII:4; OIP XXX:338	OIP-X3		Cu-Sn.
554	Alishar Ib	EB II	OIP XXX:338, no. B 381	B 381		Cu/tr: Sn, Pb, Zn.
555	Alishar Ib	EB II	OIP XXX:338, no. c 1081	c 1081		Cu-Sn/tr: Fe.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
556	Troy I	EB I	Ilios:251, no. 105; Przeworski, 1967:202-3, no.28	I-105		Cu/tr: Sn, Ni, Co, Fe.
557	Troy II	EB II	Troja:104, no. 4; Przeworski, 1967:202-3, no.42	Tr-104-4		Cu-Sn/tr: Pb, Fe.
558	Troy II	EB II	Ilios:251, no. 115; Przeworski, 1967:202-3, no.29	I-115		Cu/tr: S, Sn, Fe. Analysis erroneously reported in Przeworski, 1967:202-3, cf. Ilios:250, n.4
559	Alishar III	EB III	OIP XXX:338, no. c 1754	c 1754		Cu: 88,5 % Fe: 3,95 %
560	Kusura A	EB I	Lamb, 1936:64. From burial II	L-1		Cu/tr: As, Ni.

EARRINGS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
561	Tarsus	EB III	Goldman, 1956:297, fig.432 (250)	E-17983		Cu/tr: Sn, Pb, As, Sb, Ag, Ni.
562	Tarsus	EB III	Goldman, 1956:297, fig.432 (251)	E-17984		Cu/tr: Sn, Pb, As, Sb, Ag, Ni.

EAR PLUGS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
563	Eski Bahkhane	EB II	Mitten and Yügrüm, 1971:193–4, fig.7a (M 69.7:7974 and M 69.8:7975)		XXV(4)	Gold. 2 exs. Hollow.
564	Alaca	EB II	Arik, 1937:CLXXIX, no. Al.317-318. From Tomb B.			Solid gold.

RINGS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG.PL.	REMARKS
565	Mersin	EB III	Garstang, 1953:232-233 (M 38. 1116)	E-17890		Cu/tr: Sn, Pb, As, Ag, Sb, Ni, Bi, Zn, Co.
566	Karaz	EB II	Koşay and Turfan, 1959:381 (kz. 52)	E-17632		Cu-As/tr: Ag, Ni.
567	Tarsus	EB II	Goldman, 1956:297, fig.432 (259)	E-17985		Cu/tr: As, Ag, Ni.

BRACELETS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
568	Ahlatlibel	EB II	Koşay, 1934:76 (A.B.576)	E-6761		Cu/tr: As, Ag, Fe.
569	Polatli	EBA (?)	Unpublished. Ankara Museum. No. PO. 208, 452, (After Esin, 1967:187)	E-11733		Cu-Sn-Zn/tr: Pb, As, Sb, Ag, Ni, Bi.
570	Alishar	EB I	OIP XXVIII:38, fig.43 (2236)	E-17743		Cu-As/tr: Ag, Ni, Fe.
571	Tarsus	EB III	Goldman, 1956:298, fig.432 (268)	E-17986		Cu/tr: Sn, Pb, As, Sb, Ag, Ni.
572	Tilmen IIIe	EB III	Unpublished. Gaziantep Museum. No. T.C. -K/151 (After Esin, 1967:188)	E-17605		Cu-Sn-As/tr: Pb, Sb, Ag, Ni, Bi.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
573	Ahlatlibel	EB II	Koşay, 1934:76 (A.B 362)	E-6773		Cu-As/tr: Pb, Sb, Ag, Ni.
574	Ahlatlibel	EB II	Koşay, 1934:77 (A.B 404)	E-6774		Cu-As/tr: Ag.
575	Ahlatlibel	EB II	Koşay, 1934:76 (A.B 539)	E-6769		Cu-Sn/tr: Pb, Ag, Bi, Fe.
576	Ahlatlibel	EB II	Koşay, 1934:77 (A.B 581)	E-6775		Cu-As/tr: Ag.
577	Ahlatlibel	EB II	Koşay, 1934:77 (A.B 582)	E-6776		Cu-Sn/tr: Pb, As, Sb, Ag, Ni, Fe.
578	Alaca	EB II	Arik, 1937:CCLXXVI-VII (Al. 1101)	E-6843		Cu-Sn-Pb/tr: As, Sb, Ag, Ni, Bi.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
579	Tilmen IIIe	EB III	Unpublished. Gaziantep Museum. No. T.C. -K/152 (After Esin, 1967:188)	E-17604		Cu-As/tr: Pb, Sb, Ag, Ni, Co.
580	Alishar	EB II	OIP XIX:57, fig. 66 (6923)	E-17744		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi, Zn.
581	Ahlatlibel	EB II	Koşay, 1934:77 (A.B 544)	E-6771		Cu-As/tr: Sn, Pb, Sb, Ag, Ni.
582	Guzelova	EBA (?)	Unpublished. Ataturk University Museum. No. G.256 (c) (After Esin, 1967:189)	E-17723		Cu-Sn/tr: Pb, As, Sb, Ag, Ni, Co.
583	Tilmen III	EB III	Alkim, 1961:5-6	E-17606		Cu/tr: Sn, Pb, As, Ag, Ni.
584	Alishar Ib	EB II	OIP XXX:339, no. e 833; Desch, 1933:305	e 833		Cu-Sn/tr: As, Ni.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
585	Alishar 14 T	EB III	OIP XXVIII:93, fig.43; Desch, 1935:342, no. e 2037	e 2037		Cu.
586	Troy I	EB I	Ilios, no.116; SS 6667, anal. p.262 ; Przeworski, 1967:202-3, no.30	SS-6667		Cu-Sn/tr: Pb, As, Ni, Fe.

ANKLETS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
587	Ahlatlibel	EB II	Koşay, 1934:77 (A.B 433)	E-6763		Cu-Sn/tr: As, Ag, Ni, Bi, Co, Fe.
588	Karaz	EB II	Koşay and Turfan, 1959:410 (Kz.a 180)	E-17634		Cu-As/tr: Sn, Pb, Sb, Ag, Ni.

NECKLACES

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
589	Ahlatlibel	EB II	Koşay, 1934:76 (A.B 361)	E-6768		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Bi.
590	Ahlatlibel	EB II	Koşay, 1934:76 (A.B 577)	E-6764		Cu/tr: Sn, As, Sb, Ag, Ni.
591	Ahlatlibel	EB II	Koşay, 1934:76 (A.B 578)	E-6772		Cu-Sn-Pb/tr: Ag.
592	Troy	EB I-II	Unpublished. Berlin Museum. No. XI b, 1697, (After Esin, 1967:190)	E-9970		Analysis not reported.
593	Alaca	EB II	Koşay, 1951:165 (no. F 1-3), pl.CLXIX (fig.2), Al/a F 1-3		X(2)	String of embossed gold disks.

BELT BUCKLES

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
594	Troad	EB II	Bittel, 1959:34, no.20, figs.23,24; Esin, 1967:190.	E-3803		Cu-Sn/tr: Ag, Ni, Fe. Some confusion here. Bittel refers to this artifact as an open bowl. In Esin this analysis is referred to as a buckle.
595	Horoztepe	EB II	Özgüç and Akok, 1958:16, pl.14 (5)	E-6736		Cu-Sn/tr: Pb, As, Ag, Ni, Bi.

SEALS

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
596	Mersin XVII-XVI	L.Chal	Garstang, 1953:108, 109, fig. 70	E-17871		Cu-Sn-Pb-As/tr: Sb, Ag, Ni, Bi, Au, Zn.
597	Soli	EB III	Bittel, 1940:198, 201, pl.IV, no. S 3394	S-3394		Cu-As/tr: Pb, Sb, Ni.
598	Soli	EBA (?)	Bittel, 1940:199, 201, pl.IV, no. S 3393	S-3393		Cu-Pb-Sb/tr: Sn.
599	Alishar 13 M	EB I	OIP XXVIII:fig.87, no.1481			Copper.
600	Alishar 12 M	EB I	OIP XXVIII:fig.87, no.576			Lead.

SHEET-METAL WORK

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
601	Kayapinar	EB II	After Esin, 1967:191.	E-17613		Cu-As/tr: Sb, Ag, Ni. Reported as "scales", but there is no such item mentioned in the reference Esin gives.
602	Horoztepe	EB II	Özgüç and Akok, 1958:44, fig. 14, pl.V (4)	E-6753		Cu-Sn-Pb/tr: As, Ag, Ni, Bi, Fe. Reported as "tray".
603	Alaca Tomb RM	EB II	Arik, 1937:LXXXIII; Koşay, 1944:189.	K-4124		Cu-Sn. Tin content: 16.3 %. Rim of plate or tray.
604	Troy II (f)	EB II	Tylecote, 1966:25, no. 37.9	TY-37.9		Cu-As/tr: Pb, Ni.

WIRE

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
605	Alishar I	EB II	OIP XIX:57, pl.66 (b 789)	E-17771		Cu/tr: Sn, Pb, As, Sb, Ag, Ni, Bi.
606	Mersin XI	EB III-MB I	Unpublished. Adana Museum. No. M 38, 1091 (After Esin, 1967:191)	E-17889		Cu-As/tr: Sn, Pb, Sb, Ag, Ni, Bi.
607	Troy IIg	EB II	Tylecote, 1966:26, no. 37.17	Ty-37.17		Cu-Sn/tr: Pb, As, Ni, Fe.
608	Troy III	EB III	Tylecote, 1966:26, no. 37.19	Ty-37.19		Cu/tr: Sn, As, Ni, Fe. Reported as "wire and knob."
609	Troy IV	EB III	Tylecote, 1966:26, no. 37.22	Ty-37.22		Cu-As/tr: Ni, Fe.
610	Troy IV	EB III	Tylecote, 1966:26, no. 37.23	Ty-37.23		Cu-As/tr: Pb, Ni.

SLAGS *

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
611	Alishar	Date (?)	Unpublished. Ankara Museum. (After Esin, 1967:192)	E-17767		Cu/tr: Pb, Ag, Ni, Zn.
612	Çatal Hüyük VI	Neo.	Neuninger, Pittioni and Siegl, 1964:99, fig.1; Mellaart, 1964:114.	AA-3866		Cu/tr: Ag, As, Fe, Ni, Zn, Cr, Co, V, Al, Ca, Mg, Si.
613	Korucutepe XI	EB I	Van Loon, 1973:361			
614	Norşuntepe	Chal-EBA	Hauptmann in Mellink, 1975: 207; Zwicker, 1977:16, tables 3 and 6. Numerous samples.			Cu/tr: Al, Ca, Cl, Cr, Fe, K, Mg, Ni, S, Si, Zn.

* N.B. Hittite slags have been noted (Koşay and Akok, 1973:see pl.XLVI (AL.n.180)) and analyzed by Bachmann(1968:419-422) and Esin (1967:192, no.18394).

NATIVE COPPER

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
615	Ergani		Istanbul University. Prehistory Department. (After Esin, 1967:192).	E-18030		Cu/tr: Fe.
616	"Ankara Area"		Desch, 1928:437	D-1928A		Cu/tr: Sn, Fe. Specific site is not reported.
617	Ergani		Desch, 1928:437. See "Mining and Smelting Sites" (S-121).	D-1928B		Cu-Fe/tr: Sn, Ni, S. In this sample % Sn 0.27.
618	Ergani		Tylecote, 1970:291-2			Cu/tr: Ag, Zn, Fe.

UNIDENTIFIABLE PIECES

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
619	Troy	EBA	Unpublished. Berlin Museum. No. XI b, 1698 (After Esin, 1967:191)	E-9885		Referred to as "Cast piece". Analysis not reported.
620	Troy	EBA	Unpublished. Berlin Museum. No. XI b, 1698 (After Esin, 1967:191)	E-9882		Referred to as "Cast piece". Analysis not reported.
621	Troy	EBA	Unpublished. Berlin Museum. No. XI b, 1698 (After Esin, 1967:192)	E-9886		Possibly a ring. Analysis not reported.
622	Troy	EBA	Unpublished. Berlin Museum. No. XI b, 1698 (After Esin, 1967:192)	E-9884		A stem fragment. Analysis not reported.
623	Alishar	EB I	OIP XXX:339, no. e 1801; Desch, 1935:342	e-1801		Cu-Sn.
624	Polatli VI	EB II	Lloyd and Gökçe, 1951:75, no.165	LG-165		Cu tr: C, Pb, As, Sb, Ni, Bi, Zn, Fe. Reported as a "Corroded piece".

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
625	Polatli XII	EB III	Lloyd and Gökçe, 1951:75, no.169	LG-169		Cu/tr: C, Pb, As, Sb, Ni, Bi, Zn, Fe. Reported as a "Corroded piece".
626	Polatli XII	EB III	Lloyd and Gökçe, 1951:75, no.170	LG-170		Cu/tr: C, Pb, As, Sb, Ni, Bi, Zn, Fe. Reported as a "Corroded piece".
627	Troy I	EB I	Tylecote, 1966:25, no.37.4	Ty-37.4		Cu/tr: S, Pb, As, Ni.
628	Troy I	EB I	Tylecote, 1966:25, no.1; Przeworski, 1967: 202-3, no.31; Desch, 1936:1, no.1	Ty-1		Cu-As/tr: Ni.
629	Troy I	EB I	Tylecote, 1966:25, no.2; Przeworski, 1967: 202-3, no.32	Ty-2		Cu-As/tr: Ni.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
630	Troy II	EB II	Tylecote, 1966:25, no.3; Desch, 1936:1, no.3	Ty-3		Cu-As/tr: Ni. Analysis erroneously copied in Przeworski: 1967:202-3, no. 50.
631	Troy II	EB II	Tylecote, 1966:25, no.4; Desch, 1936:1, no.4	Ty-4		Cu-As/tr: Ni. Analysis erroneously copied in Przeworski: 1967:204-5, no. 51.
632	Troy II	EB II	Tylecote, 1966:25, no.5; Desch, 1936:1, no.5	Ty-5		Cu-Sn/tr: As, Ni. Analysis erroneously copied in Przeworski: 1967:204-5, no.52.
633	Troy II (late)	EB II	_Ilios_: 478; SS-6169	SS-6169		Cu/tr: S, Fe. Reported as "sling bullet." Analysis erroneously copied in Przeworski, 1967:204-5, no. 57.
634	Troy II	EB II	Tylecote, 1966:25, no.37.8	Ty-37.8		Cu/tr: Pb, As, Ni. Reported as a "nugget."
635	Troy IIg	EB II	Tylecote, 1966:25, no. 37.10	Ty-37.10		Cu-Sn-Fe/tr: Pb, As, Ni. Reported as a "rod."

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
636	Troy IIg	EB II	Tylecote, 1966:25, no. 37.12	Ty-37.12		Cu-As/tr: Pb, Ni. Reported as "granules."
637	Troy IIg	EB II	Ilios: 477-8; SS-6169	SS-6169		Cu-S/tr: Fe. Reported as a "sling bullet." Incorrectly recorded by Przeworski, 1967:204-5, no. 57.
638	Troy III	EB III	Tylecote, 1966:26, no.13; Desch, 1936:1, no.13.	Ty-13		Cu-Sn-As/tr: Pb, Ni.
639	Troy III	EB III	Tylecote, 1966 26, no.14; Przeworski, 1967:204-5, no. 60; Desch, 1936:1, no.14	Ty-14		Cu-As/tr: Sn. Analysis erroneously copied in Przeworski, 1967:204-5, no. 60.
640	Troy III	EB III	Tylecote, 1966:26, no.37.21	Ty-37.21		Cu-Sn/tr: Pb, As, Ni, Fe.
641	Troy IV-V	EB III	Tylecote, 1966:26, no.37.24	Ty-37.24		Cu-Sn/tr: Pb, As, Ni.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
642	Troy V	EB III	Tylecote, 1966:26, no. 37.25	Ty-37.25		Cu-As/tr: Ni.
643	Troy V	EB III	Tylecote, 1966:26, no. 6; Przeworski, 1967:204-5, no.61; Desch, 1936:1, no.6	Ty-6		Cu-Sn
644	Alishar III	EB III	OIP XXX:338, no. c 1997	c-1997		Cu-Sn.
645	Alishar Ib	EB II	OIP XXX:339, no. e 963; Desch, 1933:305; Idem, 1935:345	e-963		Cu/tr: Sn, Pb, As, Ni, S.
646	Alishar Ib	EB II	OIP XXX:338, no. c 1082	c-1082		Cu-Sn/tr: Fe.
647	Alishar Ib	EB II	OIP XXX:339, no. e 962; Desch, 1935:342	e-962		Cu/tr: Sn, Ni, S.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
648	Alishar Ib	EB II	OIP XXX:339, no. e 936; Desch, 1935:342	e-936		Cu-Sn/tr: Pb, As, Ni.
649	Alishar Ib	EB II	OIP XXX:339, no. e 860; Desch, 1935:342	e-860		Cu-Sn-Pb/tr: As, Ni, S.
650	Alishar Ib	EB II	OIP XXX:339, no. 700; Desch, 1933:305; Desch, 1935:342			Cu-Sn-Pb/tr: As, Ni.
651	Alishar Ib	EB II	OIP XXX:339, no. e 832; Desch, 1935:342	e-832		Cu/tr: Sn, Pb, As, Ni.
652	Alishar 17	EB I	OIP XXX:339, no. e 2058; OIP XXVIII:93	e-2058		Cu/tr: As, S.
653	Alishar 12	EB I	OIP XXX:339, no. e 1554; OIP XXVIII:93	e-1554		Cu-S-As.

No.	SITE - LEVEL	PERIOD	REFERENCE	ANAL.No.	FIG./PL.	REMARKS
654	Kusura A	EB I	Lamb, 1936:64. From burial II.	L-3		Cu-Sn-Pb/tr: As, Ni.
655	Kusura A	EB I	Lamb, 1936:64. From burial II.	L-2		Cu/tr: As.
656	Çatal Hüyük	Neo.	Neuninger, Pittioni, and Siegl, 1964:99, fig.1; Mellaart, 1964:114	AA-3862		Cu/tr: Ag, Fe, V.
657	Çatal Hüyük	Neo.	Neuninger, Pittioni, and Siegl, 1964:99, fig.1; Mellaart, 1964:114	AA-3863		Cu/tr: Ag, Fe, Cr, V.
658	Çatal Hüyük	Neo.	Neuninger, Pittioni, and Siegl, 1964:99, fig.1; Mellaart, 1964:114	AA-3864		Cu/tr: Ag, Fe, V.
659	Çatal Hüyük	Neo.	Neuninger, Pittioni, and Siegl, 1964:99, fig.1; Mellaart, 1964:114	AA-3865		Cu/tr: Ag, V, Al, Mg, Si.

CRUCIBLES

No.	SITE - LEVEL	PERIOD	REFERENCE	FIG./PL.	REMARKS
660	Troy II (late)	EB II	_Ilios_, no. 470	14(1)	D: ca. 10 cms. Clay
661	Troy II (late)	EB II	_Ilios_, no. 469	14(2)	D: ca. 12 cms. Clay
662	Troy II (late)	EB II	_Ilios_, no. 512		D: ca. 7 cms. Reported as a clay scoop, but possibly a crucible.
663	Troy III	EB II	_Ilios_, no. 1197; SS 6819		D: ca. 8 cms. Clay
664	Troy III	EB II	_Ilios_, no. 1199	14(3)	D: ca. 8 cms. Clay

No.	SITE - LEVEL	PERIOD	REFERENCE	FIG./PL.	REMARKS
665	Arslantepe	EB III B	Palmieri, 1973: 110, Figs. 45-6 (1)	14(4)	D: ca. 8 cms. Clay
666	Alishar	MB I	Schmidt, 1931:157, fig.118	14(5)	D: ca. 13.5 cms. Clay
667	Thermi I	EB II	Lamb, 1936:157, fig.44 (31-72)	14(6)	D: ca. 6.7 cms. Clay
667-1	Alaca	EBA	Koşay and Akok, 1966:86, pl.59 (K 139)		Dimensions given are: W: 4 cms. L: 7.4 cms. Clay

TUYERES

No.	SITE - LEVEL	PERIOD	REFERENCE	FIG./PL.	REMARKS
668	Troy II (late)	EB II	Ilios: 410-11, no. 476. SS 6779	13(1)	L: ca. 7cms.
669	Troy IV-V	EB III	Ilios: 582-3, no. 1339. Atlas; pl.21, no. 591	13(2)	L: ca. 8 cms.
670	Troy IV-V	EB III	Ilios: 582-3, no. 1338.	13(3)	L: ca. 7 cms.
671	Beycesultan XVII	EB I	Lloyd and Mellaart, 1962:276, fig. F4(2), no. 606	13(4)	
672	Poliochni Rosso	EB I	Bernabo-Brea, 1964:pl. LXXXIII(r). From Megaron 832	13(5)	

No.	SITE - LEVEL	PERIOD	REFERENCE	FIG./PL.	REMARKS
673	Poliochni Rosso	EB I	Bernabo-Brea, 1964:pl. LXXXIII(t). From discarica nord.	13(6)	
674	Poliochni Rosso	EB I	Bernabo-Brea, 1964:pl. LXXXIII(s). From Muro S.	13(7)	
675	Thermi III	EB I	Lamb, 1936:161, pl.XXIV (31-57)	13(8)	L: 6 cms.
676	Thermi III	EB I	Lamb, 1936:161, pl.XXIII (30-30)	13(9)	L: 8 cms.
677	Thermi II-III (late)	EB I	Lamb, 1936:161, pl.XXIII (30-33)	13(10)	L: 7 cms.
678	Subaşi	Iron Age (?)	De Jesus and Kaptan, 1973: 115-117 and 126-129	III(1,2)	Fragments of ca. ten examples found in slag dump.

BELLOWS

No.	SITE - LEVEL	PERIOD	REFERENCE	FIG./PL.	REMARKS
679	Tell-edh Dhubai	EB III	al-Gailani, 1965:37, pl.4, no. 614/2	12(1)	D: ca. 50 cms.
680	Tello	ED	Cros, 1910:151, fig.D	12(2)	D: ca. 50 cms.
681	Kültepe	MB I	Özgüç, 1955:79, fig.25	12(3)	D: ca. 46.5 cms.
682	Tell Asmar	ED III	Delougaz, 1952:100, pl.190, no. 301.112	12(4)	D: ca. 50 cms.
683	Alalakh	LBA I	Woolley, 1955:324, pl.CXI, no.38		D: ca. 27.5 cms.
684	Mari	EB III	Parrot, 1958:260, fig.315		D: 47 cms.

MOULDS

No.	SITE - LEVEL	PERIOD	REFERENCE	FIG./PL.	REMARKS
685	Troy I	EB I	_Ilios_: 248, no. 103; SS 6774	16(1)	L: 7.3 cms. W: 0.5 cms. Pin mould.
686	Troy II (late)	EB II	_Ilios_: 433, no. 600 and 599 (?); SS 6726	XXVI(7) 16(2)	L: 26 cms. W: 12.5 cms. Open multiple mould. Flat axes, chisels, spearheads and round ingot (?).
687	Troy II (late)	EB II	_Ilios_: no. 602; SS 6766 _Atlas_, pl.69, no. 1553	16(3)	L: 15.5 cms. W: 9.0 cms. Open mould. Hammer and round ingot (?).
688	Troy II (late)	EB II	_Troja_: no.95; SS 6755	16(4)	L: 13 cms. W: 8.5 cms. Two-piece mould fragment. Dagger or spearhead.
689	Troy II (late)	EB II	_Ilios_: no. 604; SS 6773	16(5)	L: 7.5 cms. W: 5.0 cms. Two-piece mould fragment. Arrow-heads.

No.	SITE - LEVEL	PERIOD	REFERENCE	FIG./PL.	REMARKS
690	Norşuntepe VIII	EB IIIb	Hauptmann in Mellink, 1975: 206-7, pl.39(8)		
691	Troy III	EB II	Ilios: no. 1266; SS 6729	16(6)	L: 23 cms. W: 15 cms. Two-piece mould. Pin (?)
692	Troy IV	EB III	Ilios: no. 1267; SS 6776 Atlas: pl. 142, no. 2812	16(7)	L: 12 cms. W: 5.3 cms. Two-piece mould fragment. Blade with midrib.
693	Thermi II	EB I	Lamb, 1936:159, fig.44 (31-67)	17(1)	L: 6.0 cms. Blade with midrib.
694	Thermi I	EB I	Lamb, 1936:157, fig.44 (30-23 A)	17(2)	L: 10 cms. Solid object. Ingot (?)

LOST-WAX MOULDS

No.	SITE - LEVEL	PERIOD	REFERENCE	FIG./PL.	REMARKS
695	Poliochni Azzurro	EB I	Bernabo-Brea, 1964:pl. LXXXV d	15(1)	L: ca. 14.7 cms. Shaft-hole axe.
696	Thermi IV	EB II	Lamb, 1936:121, fig.37 (367)	15(2)	L: 11.5 cms. Shaft-hole tool (?)
697	Thermi	EB II	Lamb, 1936:134 (601) pl.XXIII	15(3)	Unstratified. L: 8.0 cms. Shaft-hole tool (?)

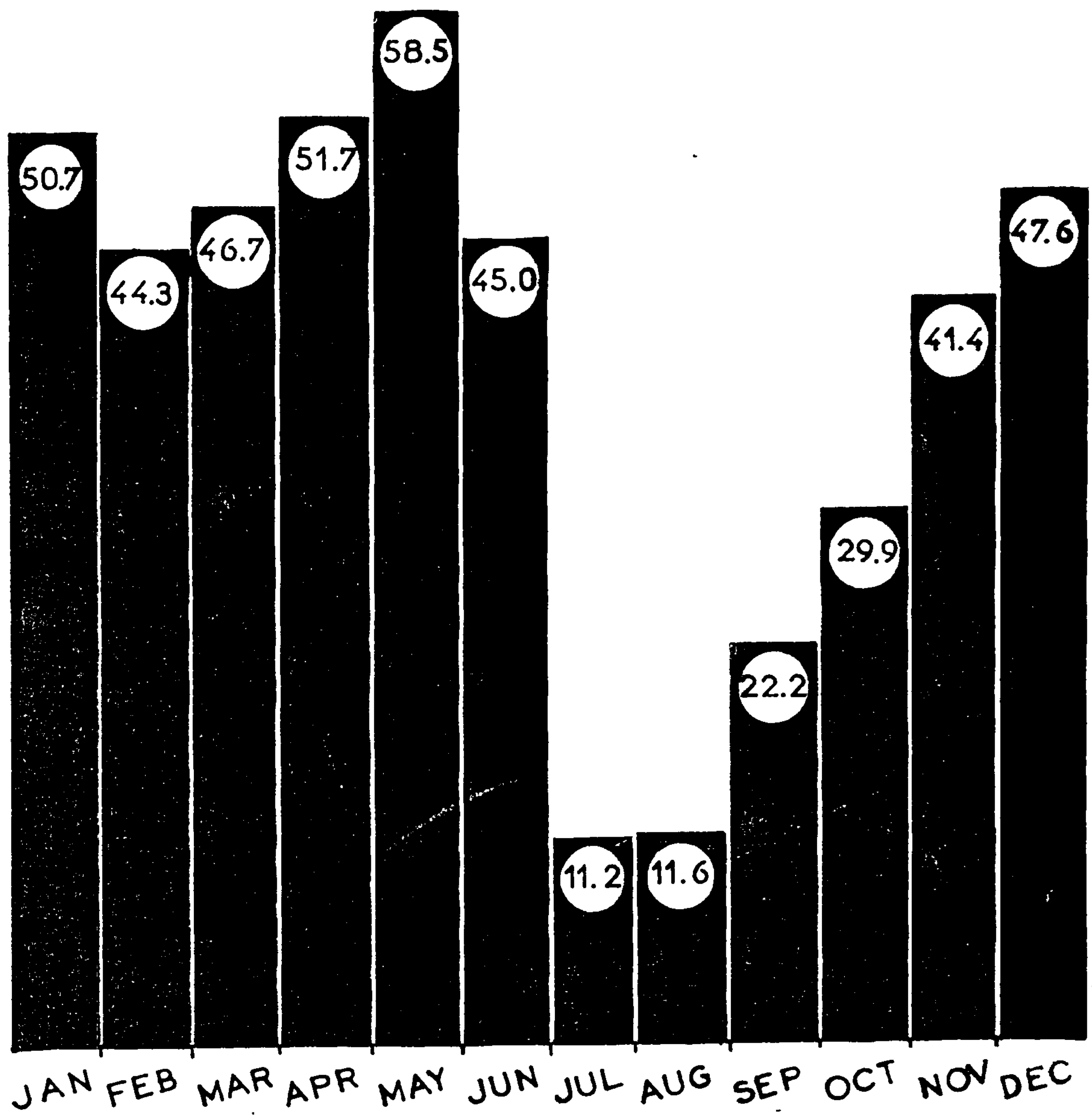
MINING TOOLS (all non-Anatolian)

No.	SITE - LEVEL	PERIOD	REFERENCE	FIG./PL.	REMARKS
698	Rudna Glava	Chal.	Jovanovič, 1972:13, pls.VI(3), V(1), V(3).	XXVII(1)	Stone hammers. Three exs.
699	Rudna Glava	Chal.	Jovanovič, 1972:13	XXVII(2)	Antler pick.
700	Greece	Iron Age	Pleiner, 1969:fig.11	XXVII(3)	Iron gads and hammers.
701	Belgium	Neo.	Sandars, 1910:fig.16	5(1)	Antler pick.
702	Grimes Graves	Neo.	Sandars, 1910:fig.16	5(2)	Antler pick.
703	Belgium	Neo.	Sandars, 1910:fig.16	5(3)	Antler rake.

No.	SITE - LEVEL	PERIOD	REFERENCE	FIG./PL.	REMARKS
704	Spain	Roman	Sandars, 1910:121	5(4)	Flat axe.
705	Austria	Roman	Sandars, 1910:121	5(5)(6)	Same hafted.
706	France	Neo.	Sandars, 1910:pl.XVII(5)	5(7)	Antler hammer.

TABLE 1

TOKAT



Average Monthly Precipitation
(expressed in mm.)

TABLE 2

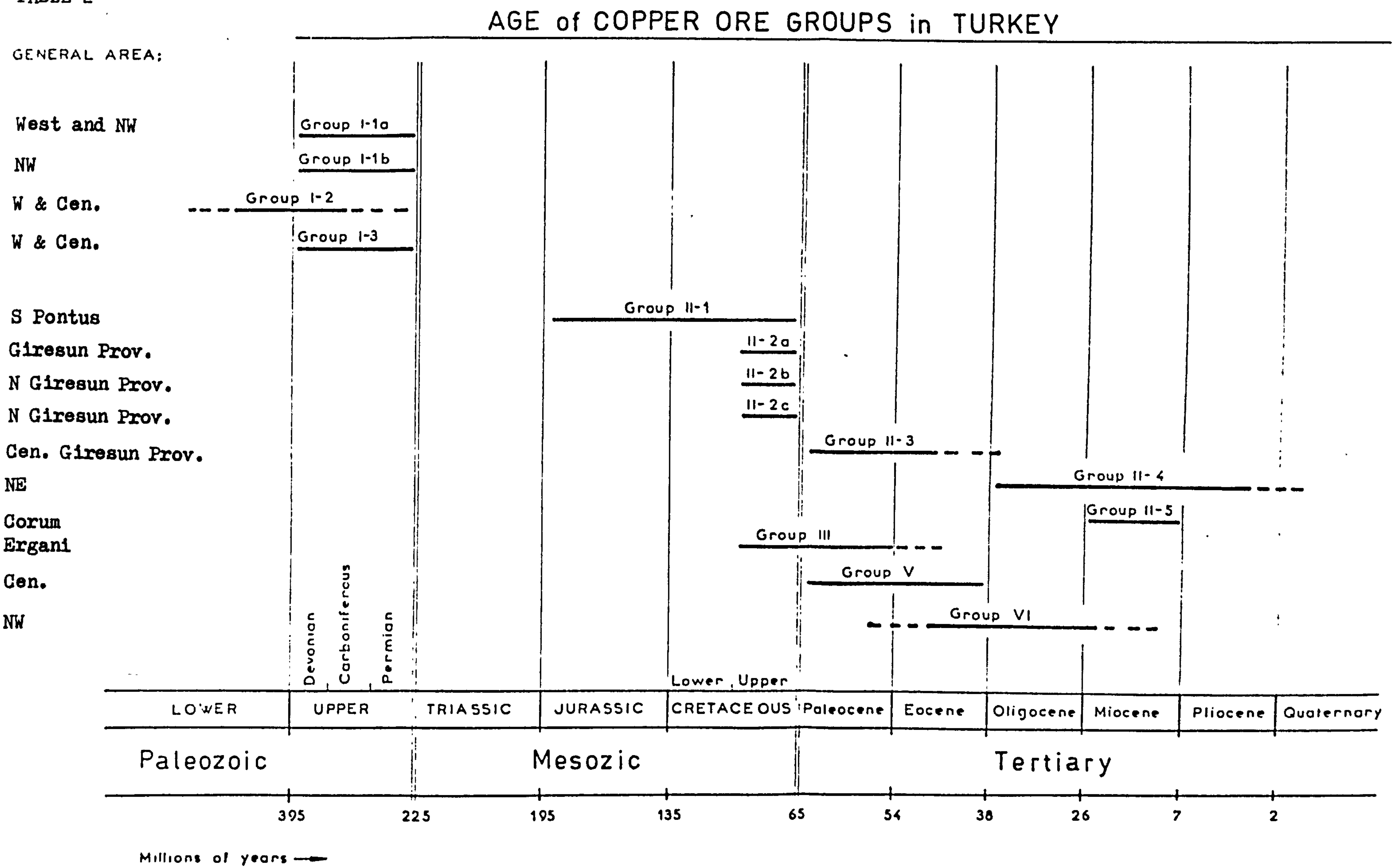

AGE of COPPER ORE GROUPS in TURKEY
GENERAL AREA:
West and NW
NW
W & Cen.
W & Cen.
S Pontus
Giresun Prov.
N Giresun Prov.
N Giresun Prov.
Cen. Giresun Prov.
NE
Corum
Ergani
Cen.
NW
Group I-1a
Group I-1b
Group I-2
Group I-3
Group II-1
II-2a
II-2b
II-2c
Group II-3
Group II-4
Group II-5
Group III
Group V
Group VI
Devonian
Carboniferous
Permian
Lower , Upper
LOWER
UPPER
TRIASSIC
JURASSIC
CRETACEOUS
Paleocene
Eocene
Oligocene
Miocene
Pliocene
Quaternary
Paleozoic
Mesozic
Tertiary
395
225
195
135
65
54
38
26
7
2
Millions of years

TABLE 3

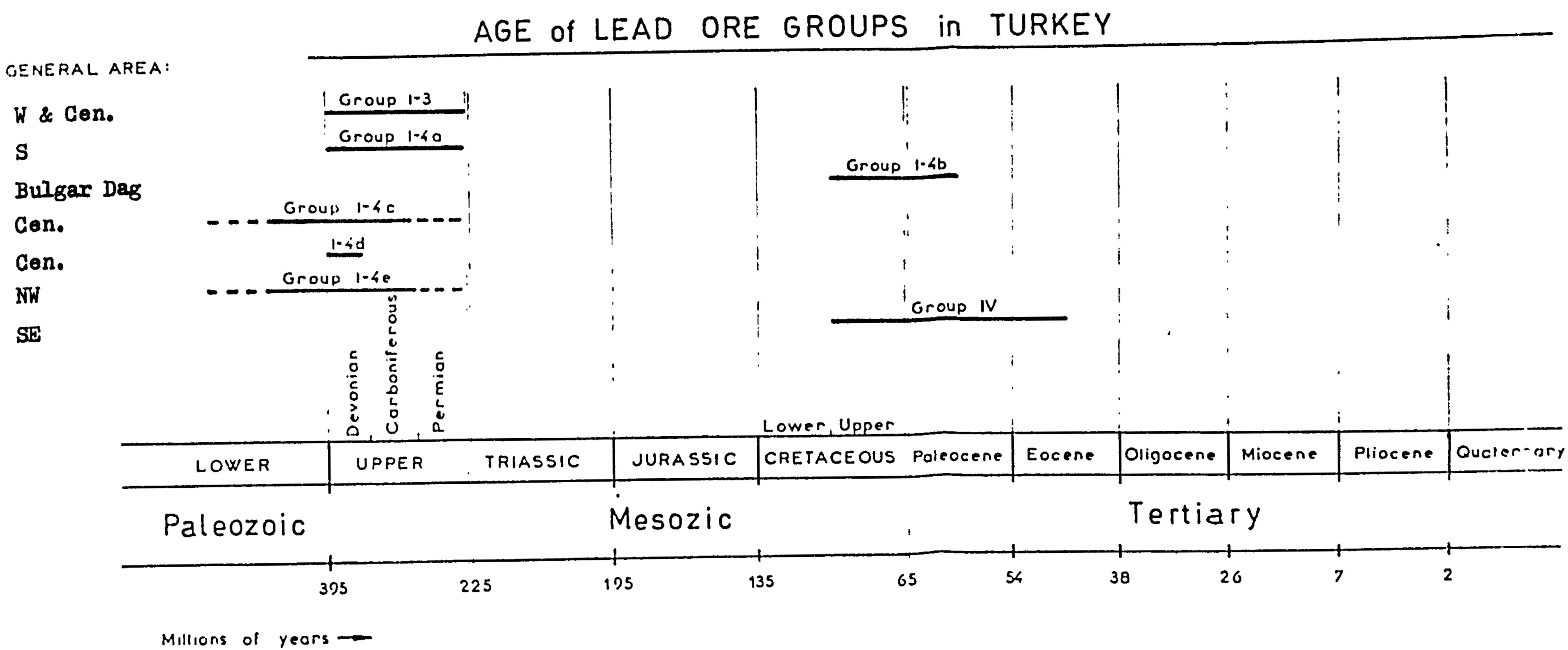

AGE of LEAD ORE GROUPS in TURKEY
GENERAL AREA:
W & Cen.
S
Bulgar Dag
Cen.
Cen.
NW
SE
Group I-3
Group I-4a
Group I-4b
Group I-4c
I-4d
Group I-4e
Group IV
Devonian
Carboniferous
Permian
Lower Upper
LOWER
UPPER
TRIASSIC
JURASSIC
CRETACEOUS
Paleocene
Eocene
Oligocene
Miocene
Pliocene
Paleozoic
Mesozic
Tertiary
395
225
195
135
65
54
38
26
7
2
Millions of years

TABLE 4

GENERAL SCHEME OF MINING TECHNIQUES AND MATERIALS

Mine Type	Surface Mining*	Stream Mining	Open Cast Mining	Tunnel Mining	Shaft Mining	Shafts and galleries
Material Mined	Native Copper Native Gold Obsidian Flint Stones	Tin Gold	Metal ores: Iron Copper Lead Silver Gold Tin Arsenic Zinc Flint	Metal Ores: Iron Copper Lead Silver Gold Tin Arsenic Zinc Flint Turquoise Salt Lapis Lazuli	Metal Ores: Iron Copper Lead Silver Gold Tin Arsenic Zinc Flint Turquoise Salt Lapis Lazuli	Metal ores: Iron Copper Lead Silver Gold Tin Arsenic Zinc Flint Turquoise Salt Lapis Lazuli
Special Techniques		Diversion of water course or comparable system.		Fire-setting Timbering Water run-off or evacuation system Lighting system Ventilation System	Fire-setting Water evacuation system Lighting system	Fire-setting Timbering Water evacuation system Ventilation system Lighting system
Tools and Equipment	Hammers (stone, antler, wood) Scoops (wood, bone)	Washing troughs (wooden) Hammers (stone, wood, antler) Mortars+ (stone) Pestles+ (stone, bone) Scoops (wood, bone)	Picks (antler, wood) Scoops (wood, bone) Mortars (stone) Pestles (stone, bone) Baskets (wicker, grass) Rope (fibers, grass) Hammers (stone, wood, antler) Gads (bone, stone, wood) Shovels (wood)	Picks (antler, wood) Scoops (wood, bone) Mortars (stone) Pestles (stone, bone) Baskets (wicker, grass) Rope (fibers, grass) Gads (antler, bone, stone, wood) Hammers (stone, wood, antler) Rakes (bone, antler, wood) Leather garments Buckets (wood, pottery) Lamps (stone, pottery) Torches (wood chips) Shovels (wood)	Picks (antler, wood) Scoops (wood, bone) Mortars (stone) Pestles (stone, bone) Baskets (wicker, grass) Rope (fibers, grass) Gads (antler, bone, stone, wood) Hammers (stone, wood, antler) Rakes (bone, antler, wood) Leather garments Buckets (wood, pottery) Lamps (stone, pottery) Torches (wood chips) Shovels (wood)	Picks (antler, wood) Scoops (wood, bone) Mortars (stone) Pestles (stone, bone) Baskets (wicker, grass) Rope (fibers, grass) Gads (antler, bone, stone, wood) Hammers (stone, wood, antler) Rakes (bone, antler, wood) Leather garments Ladders (wood) Shovels (wood) Buckets (wood, pottery) Lamps (stone, pottery) Torches (wood chips)

* This is not discussed in the text. It refers to simple gathering of surface materials.

\+ Mortars and Pestles are not used for mining itself, but they may be found within the context of a mine.

TABLE 5

Approximate range of some natural-occurring impurities in copper oxide (expressed in %) (after Fields et al, 1971:139, table 9.6)

Ag	3.2×10^{-5}	-	0.32
Hg	1.0×10^{-5}	-	0.01
Fe	0.01	-	32.0
Sc	3.2×10^{-7}	-	0.032
Co	1.0×10^{-5}	-	0.032
Sb	3.2×10^{-5}	-	0.32
Se	1.0×10^{-5}	-	1.0
Au	3.2×10^{-6}	-	0.01
Ce	0.001	-	0.32
Cr	3.2×10^{-5}	-	0.001
Hf	1.0×10^{-4}	-	0.01
In	0.001	-	0.32
Ir	3.2×10^{-8}	-	3.2×10^{-5}

N.B. Other data is also given by Fields: impurities in reduced ore, in native copper, in Middle Eastern artifacts, in South American artifacts, in European artifacts, and in North American artifacts. (Fields et al, 1971; Friedman et al, 1966:1504-5)

TABLE 6

Approximate range of some natural-occuring impurities in Copper.
(After Friedman et al, 1966) (Here expressed in %)

Impurity	Native Cu	Oxidized ore	Reduced ore
Ag	.004 - .1	.004 - 1.0	.004 - 10
As	.004 - .4	.004 - 0.1	.004 - 10
Fe	.004 - .1	.004 - 10	.004 - 10
Bi	< .004	.004 - 0.1	.004 - .1
Pb	< .004	.004 - 10.0	.004 - 10
Sb	< .004	.004 - 0.4	.004 - 4

CHRONOLOGY

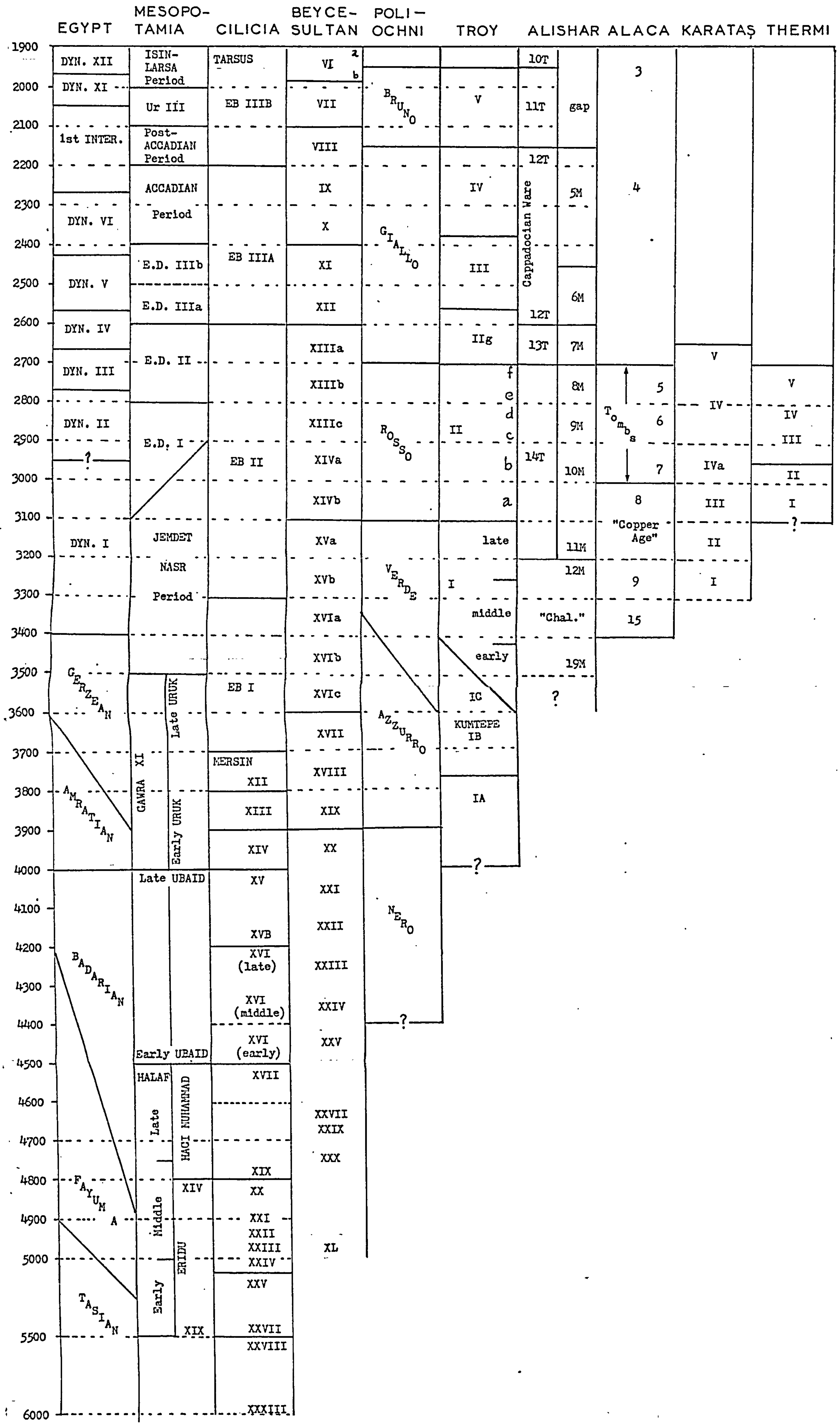
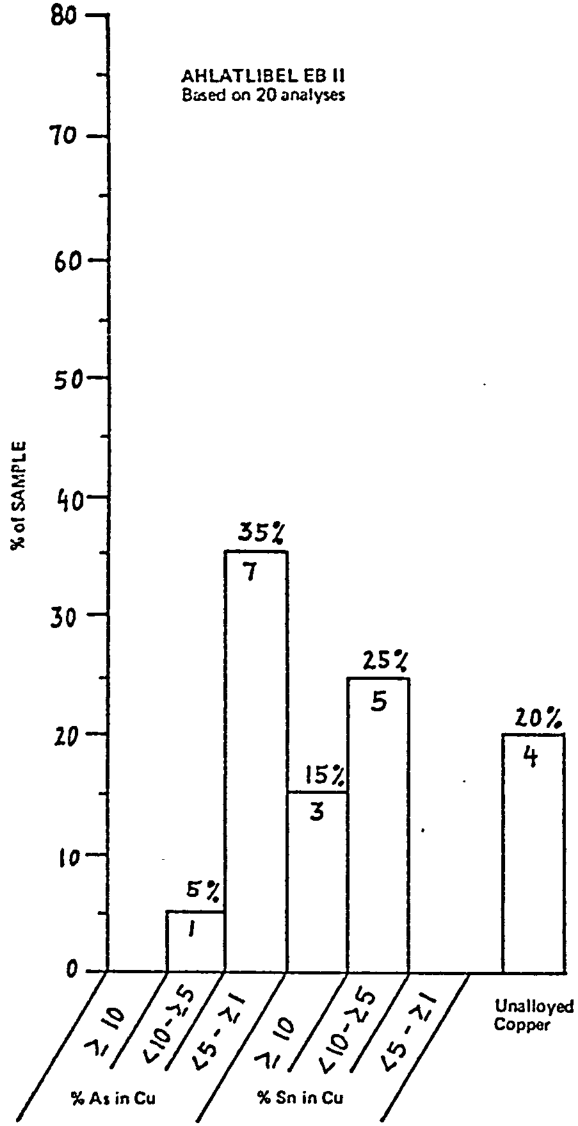
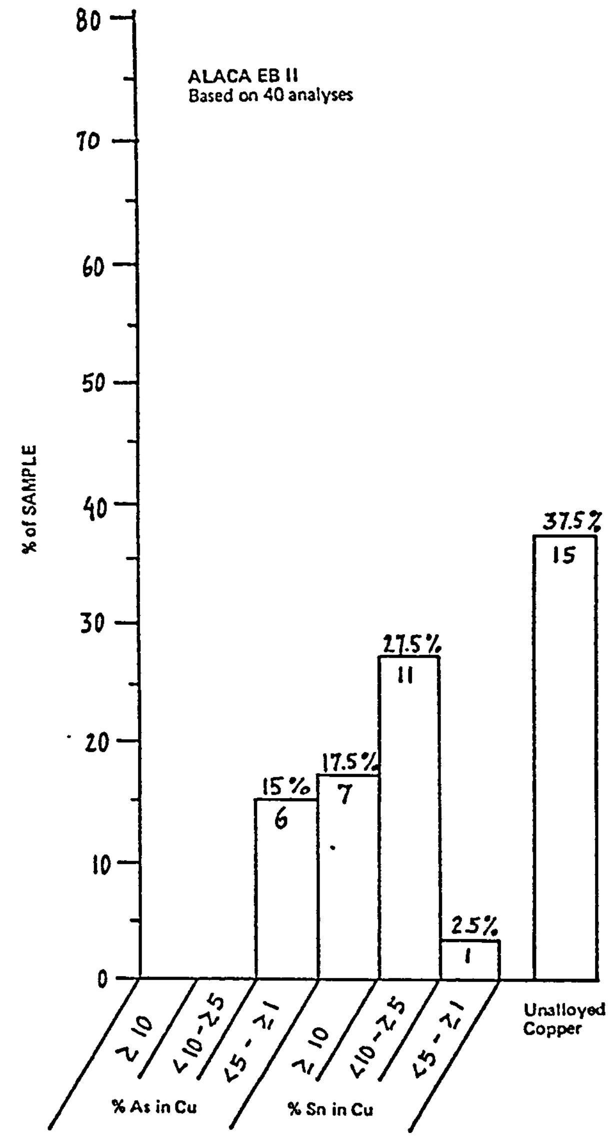


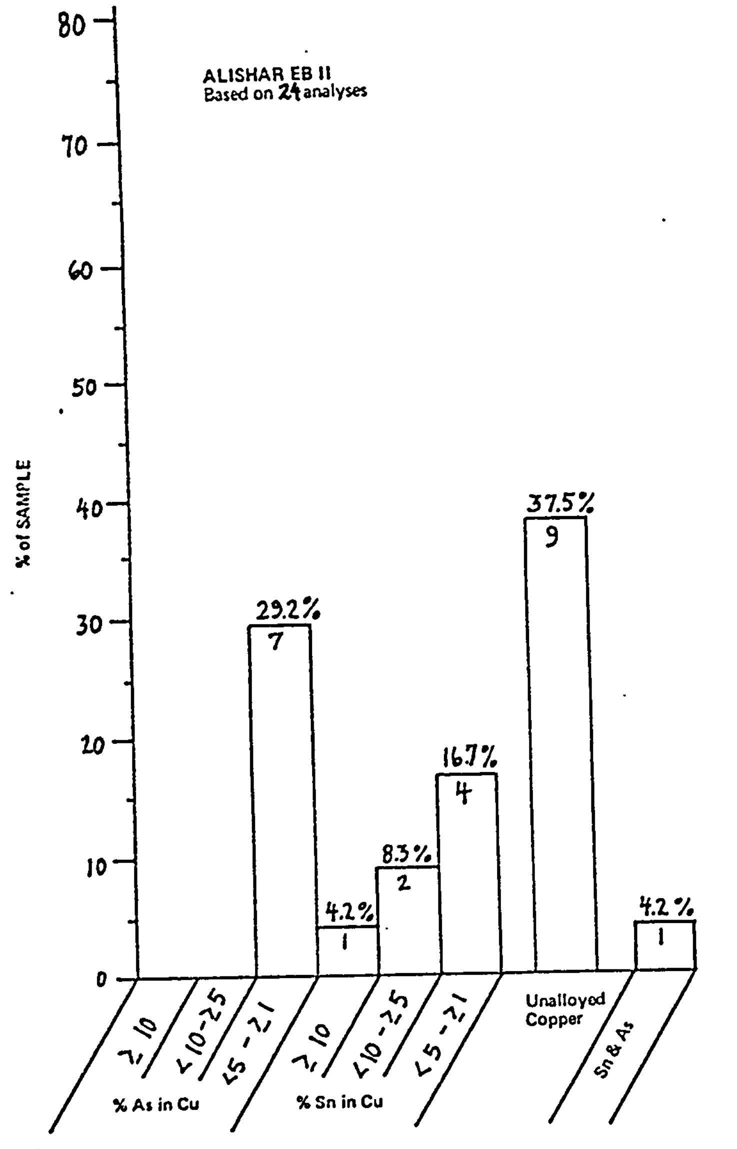
TABLE 7



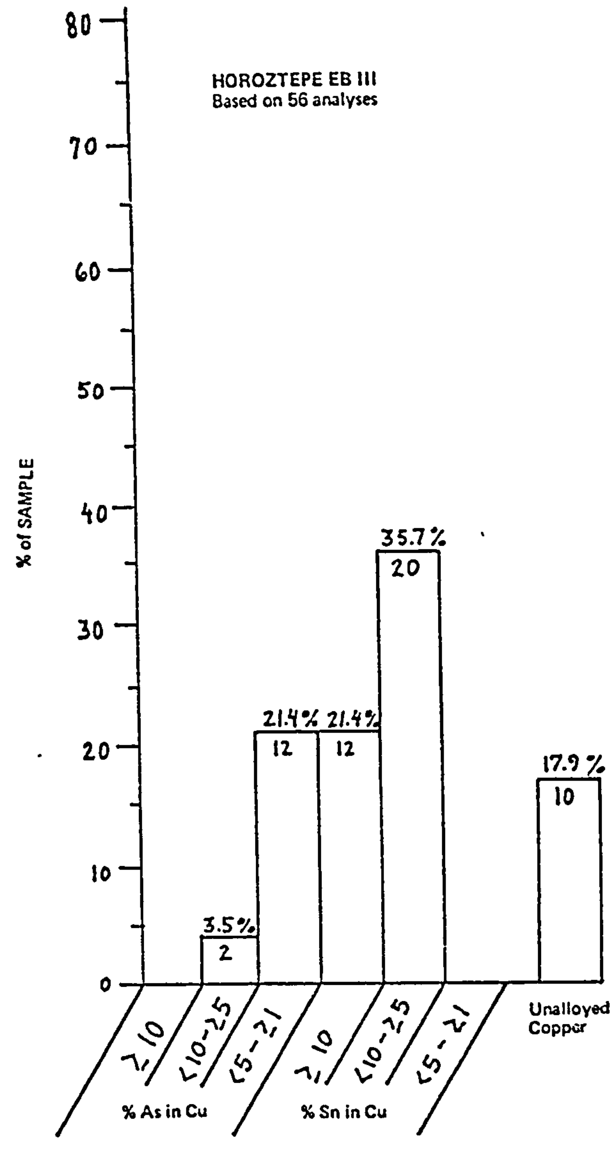
GRAPH no. 1



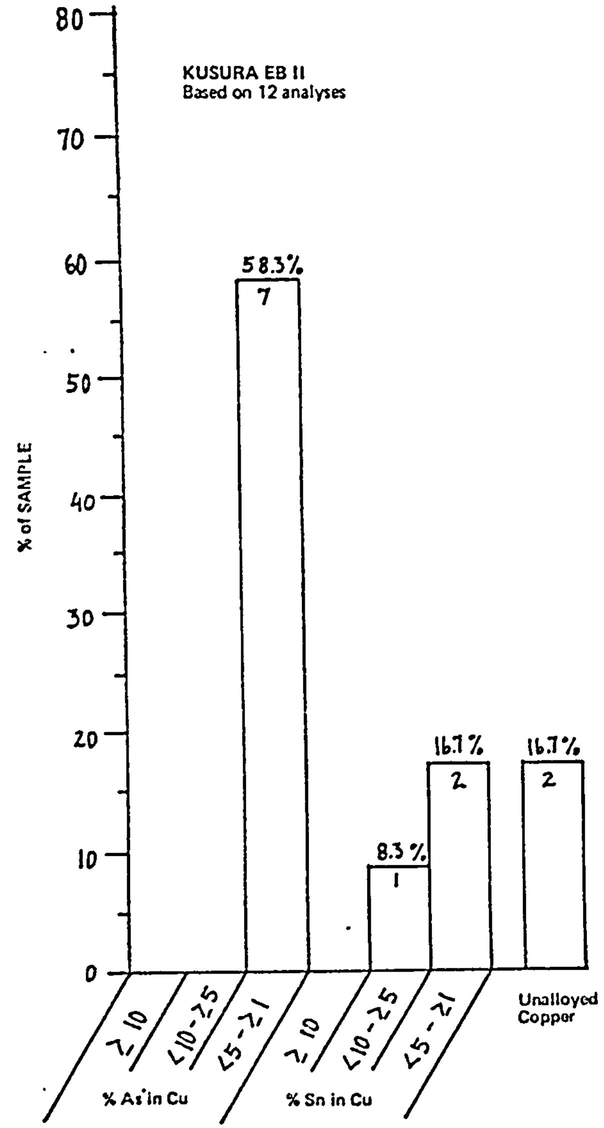
GRAPH no. 2



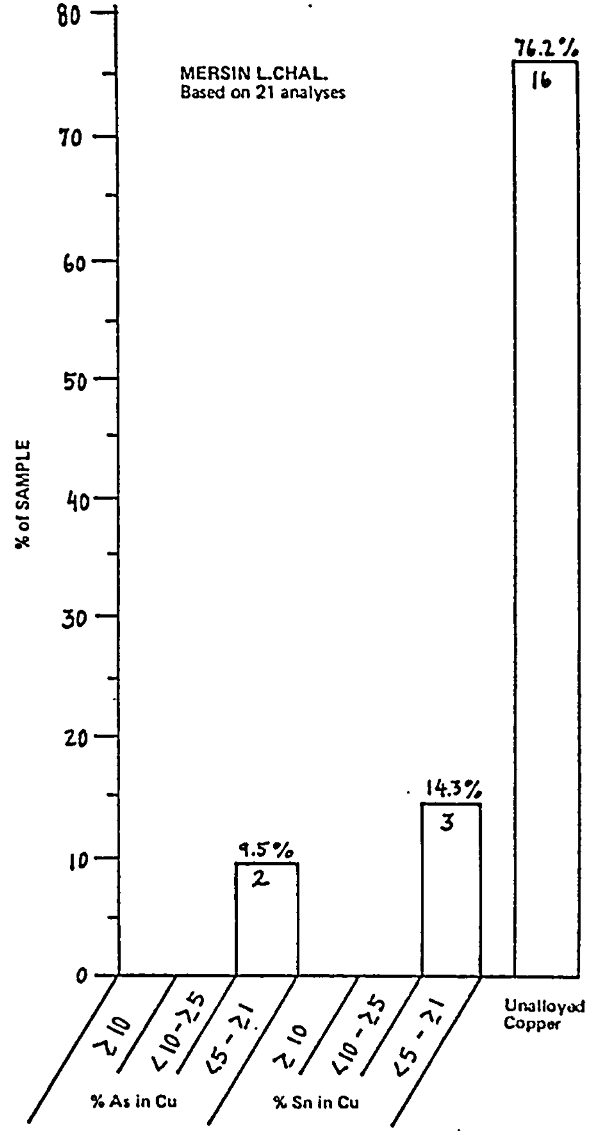
GRAPH no. 3



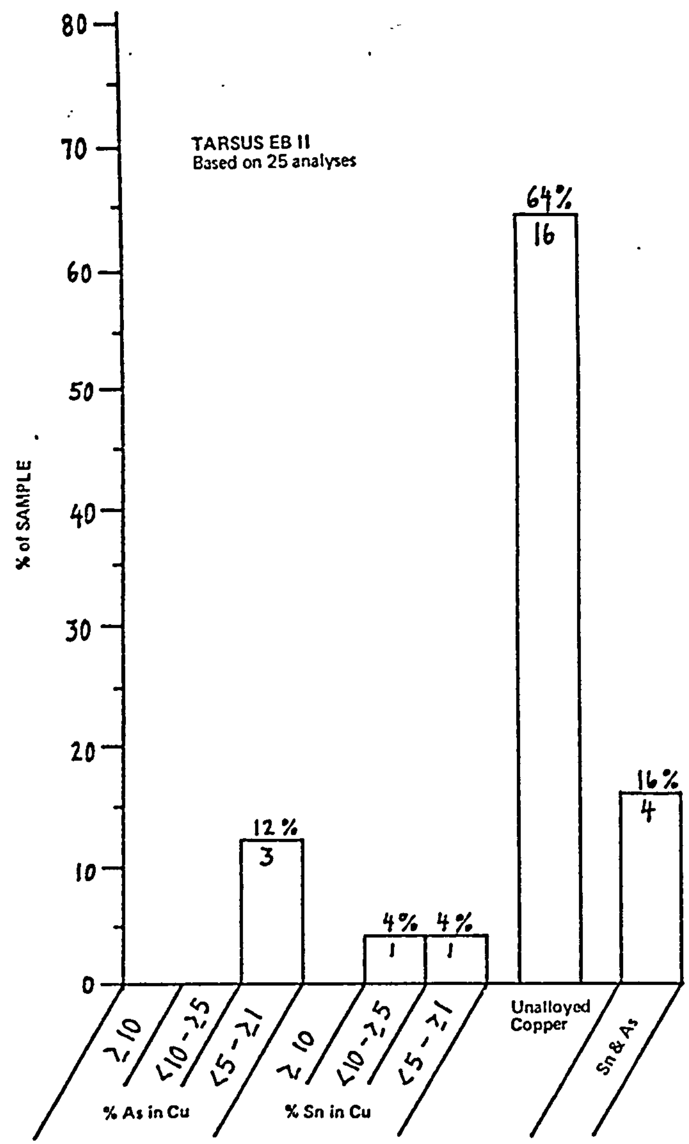
GRAPH no. 4



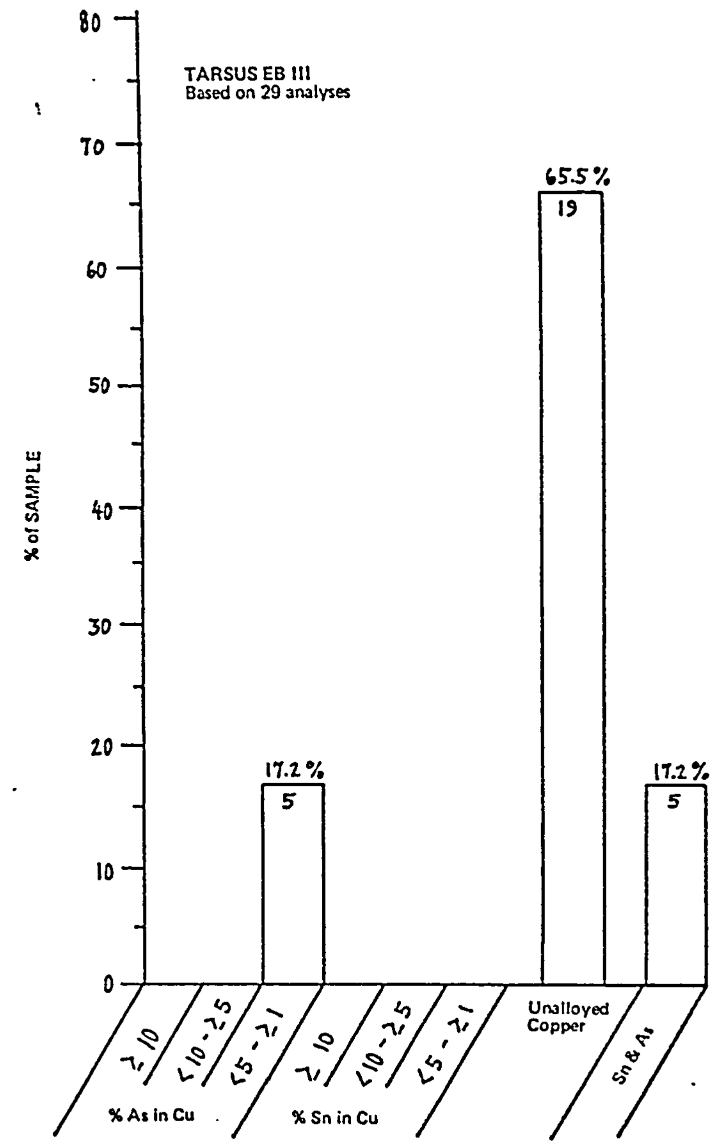
GRAPH no. 5



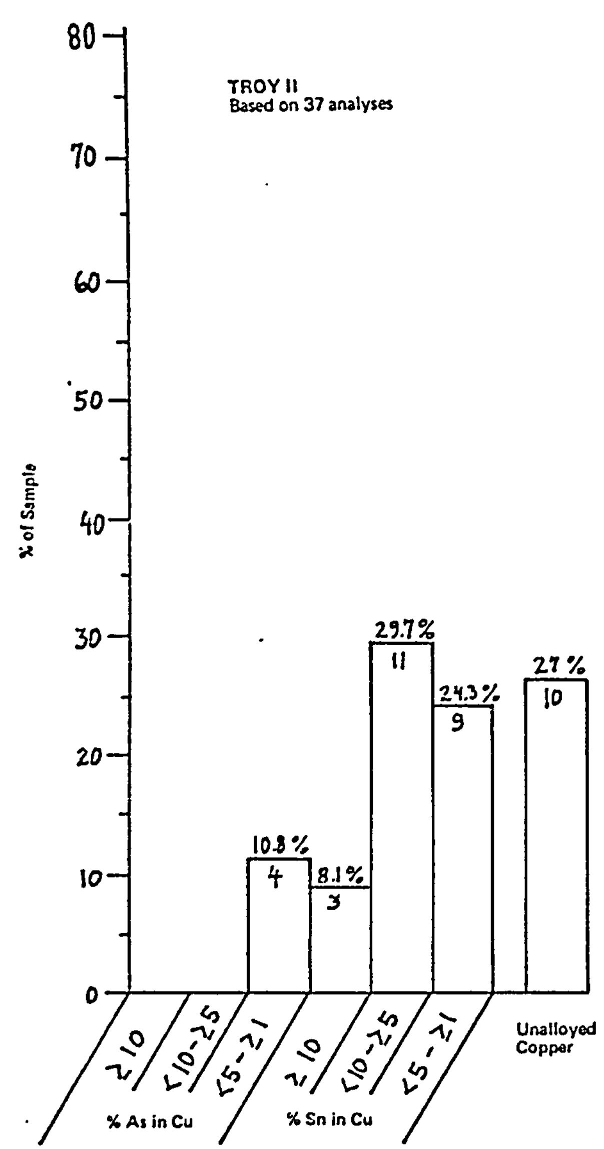
GRAPH no. 6



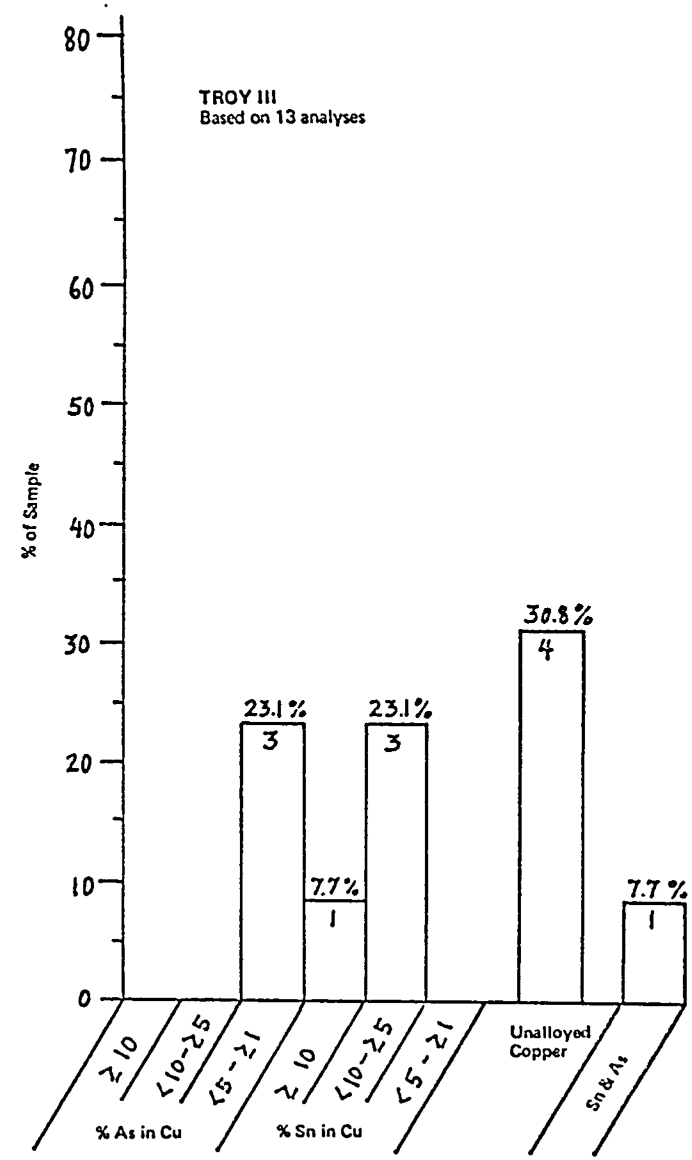
GRAPH no. 7



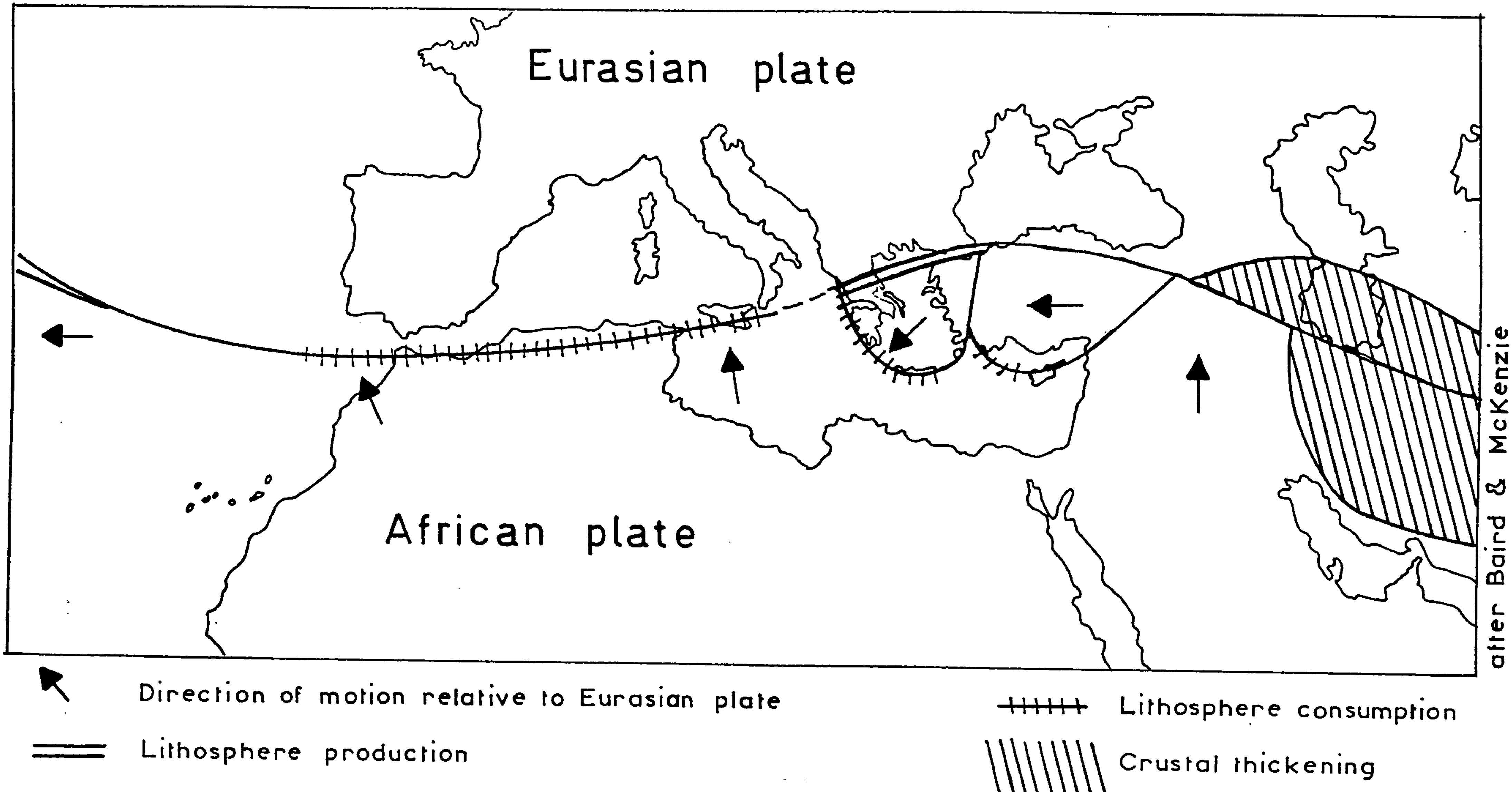
GRAPH no. 8



GRAPH no. 9



GRAPH no. 10

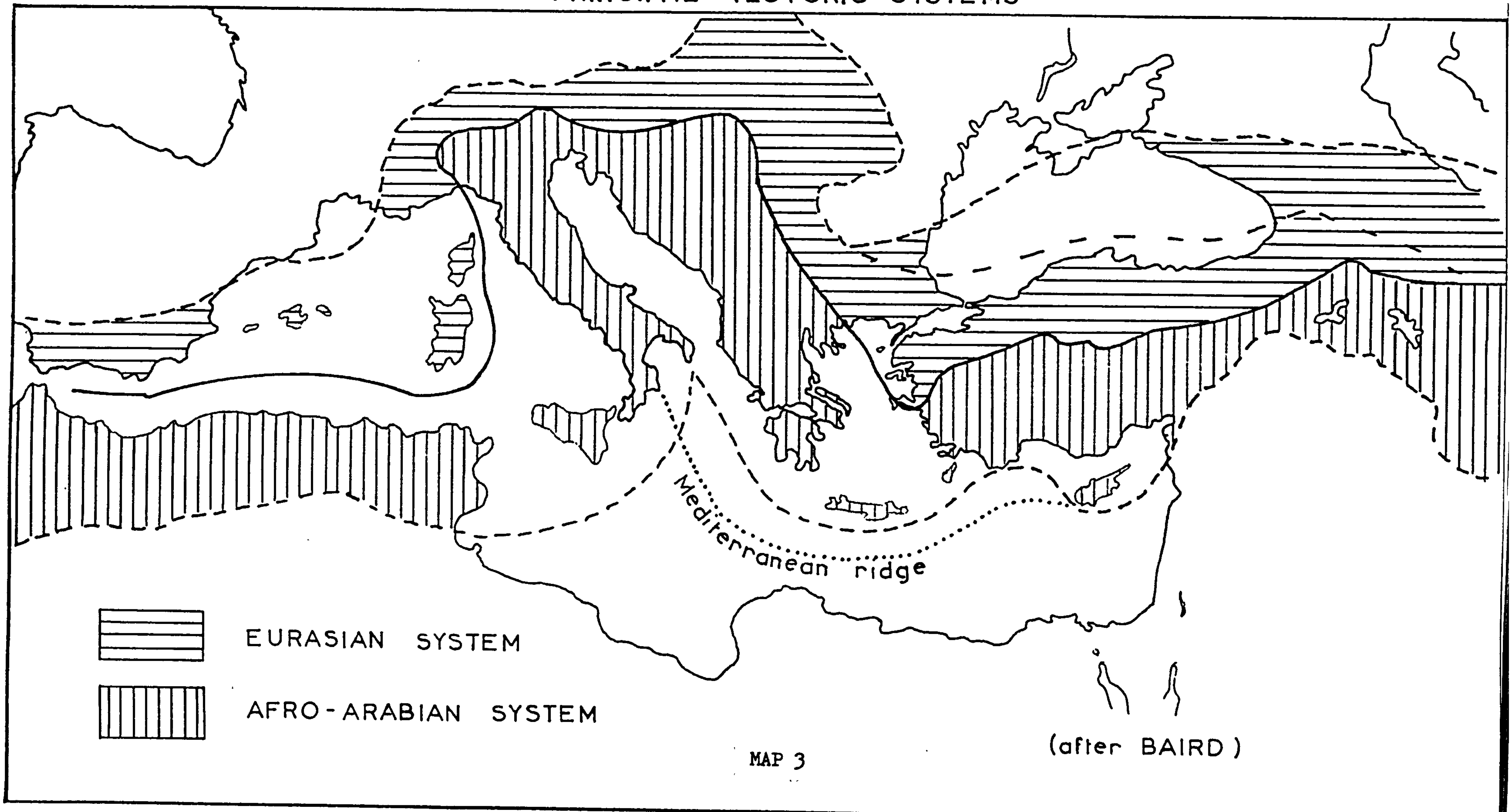

Eurasian plate
African plate
after Baird & McKenzie
Direction of motion relative to Eurasian plate
Lithosphere production
Lithosphere consumption
Crustal thickening

MAP 1

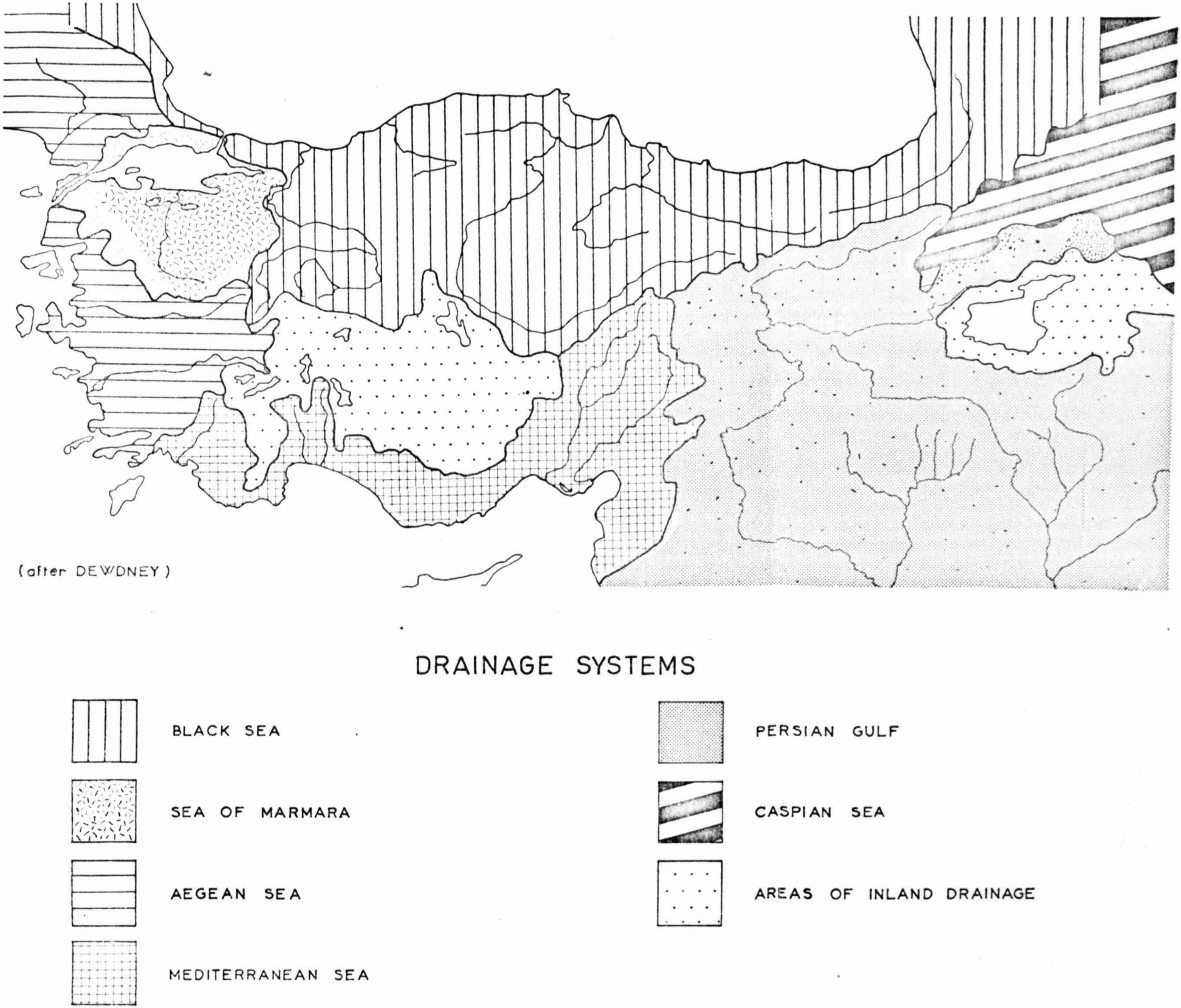
Image removed due to third party copyright

MAP 2

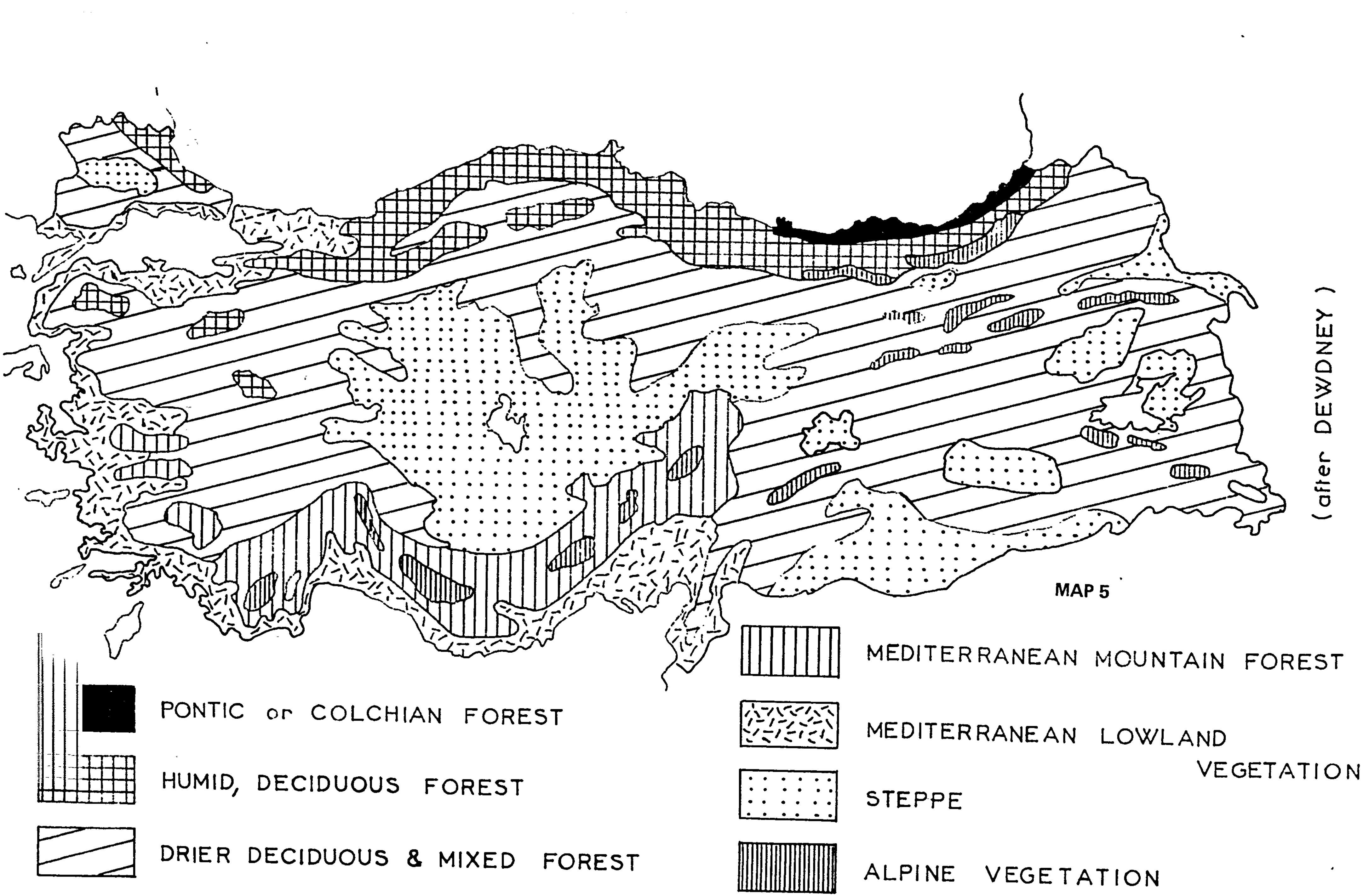
PRINCIPAL TECTONIC SYSTEMS

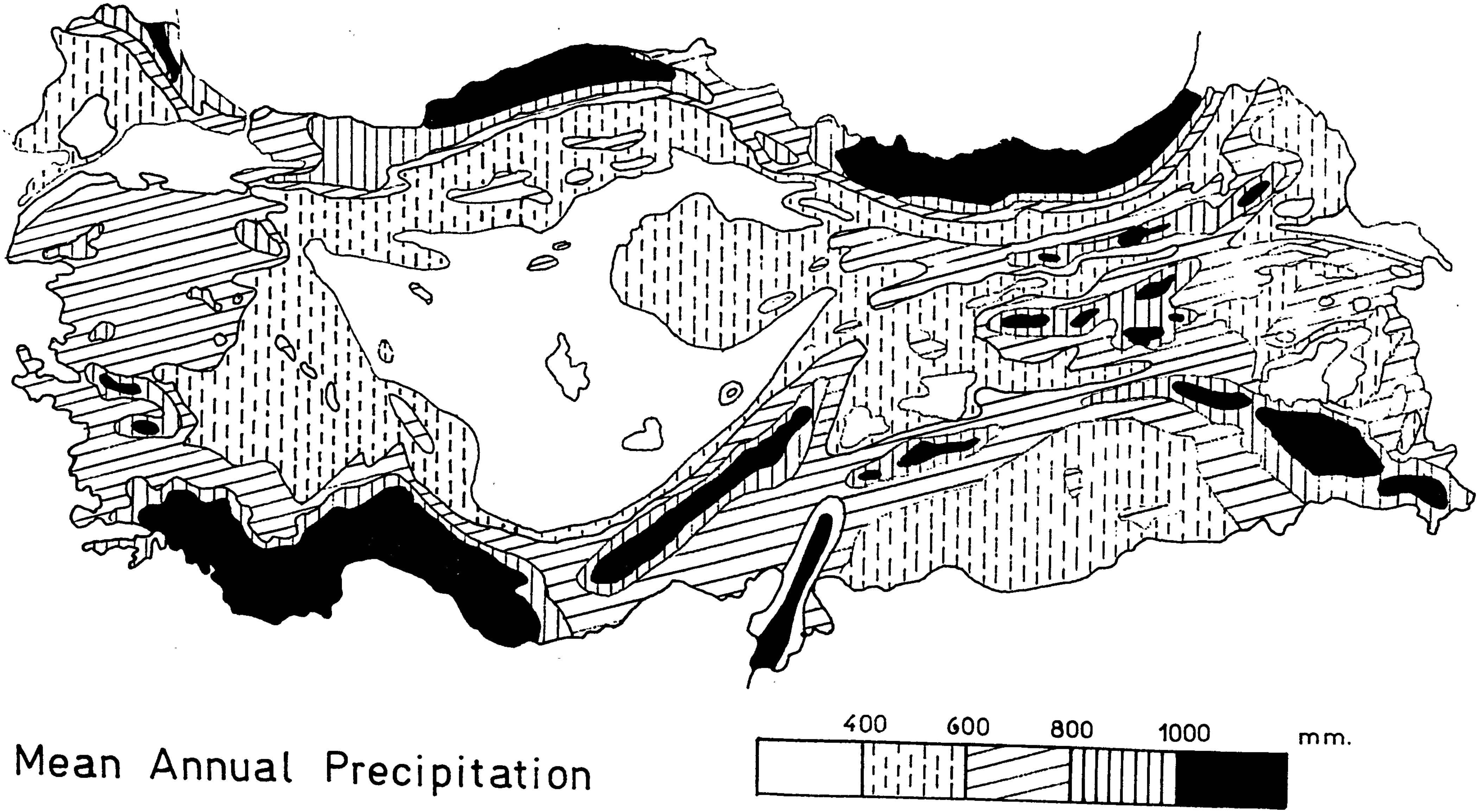


MAP 3

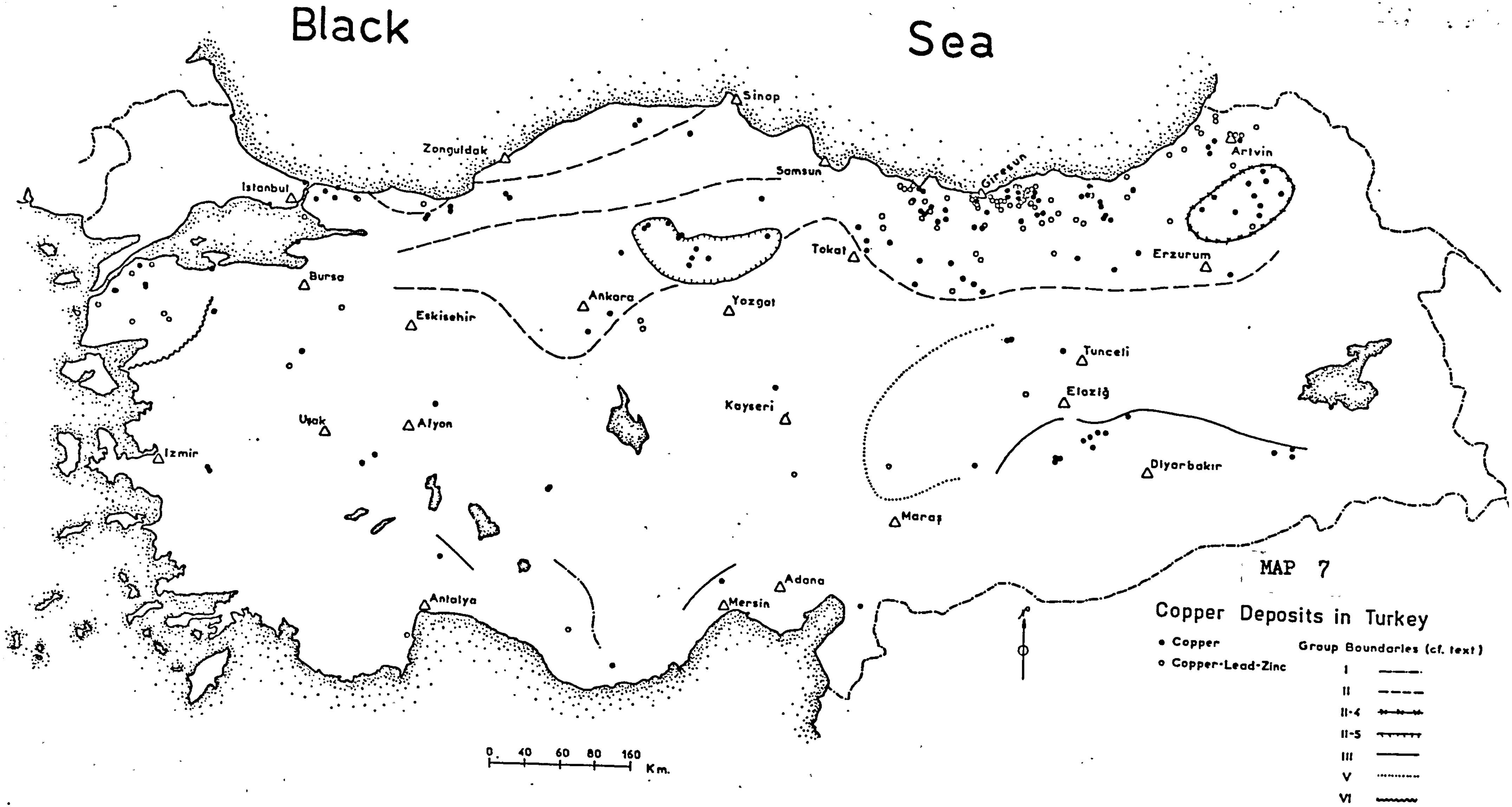


DRAINAGE SYSTEMS


MAP 5
(after DEWDNEY)
PONTIC or COLCHIAN FOREST
HUMID, DECIDUOUS FOREST
DRIER DECIDUOUS & MIXED FOREST
MEDITERRANEAN MOUNTAIN FOREST
MEDITERRANEAN LOWLAND VEGETATION
STEPPE
ALPINE VEGETATION

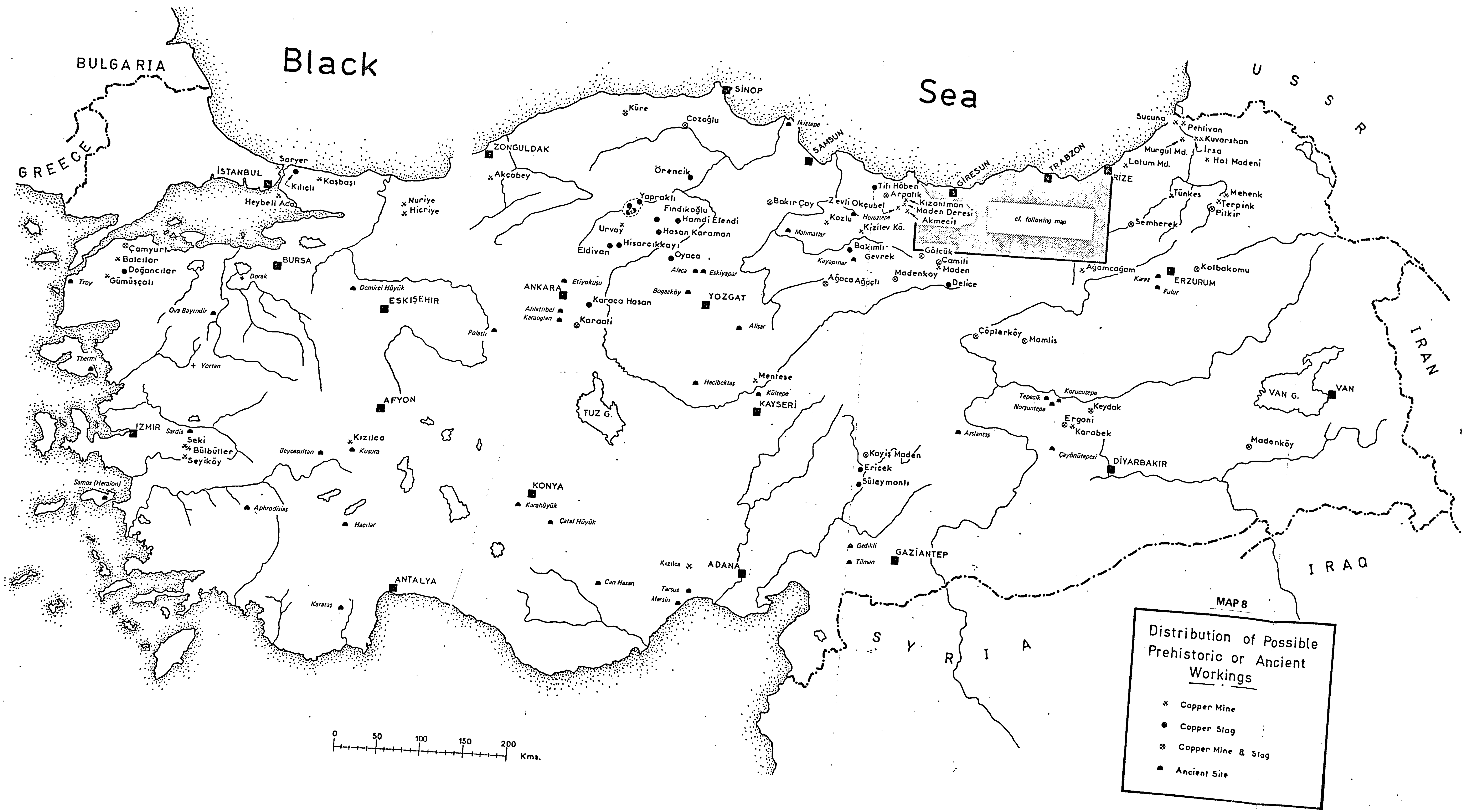

Mean Annual Precipitation
400
600
800
1000
mm.
(after DEWDNEY)

MAP 6



MAP 7

Copper Deposits in Turkey

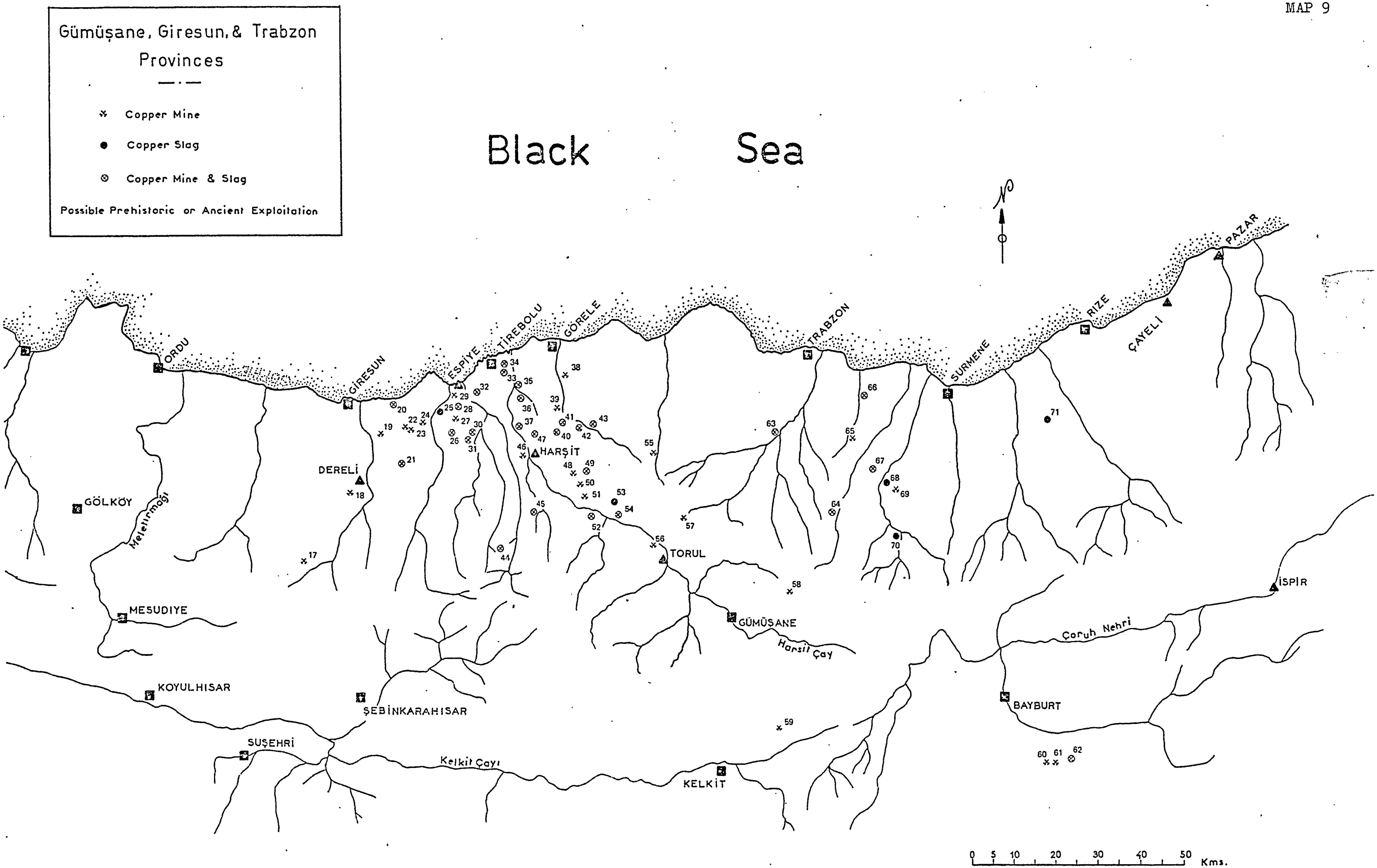


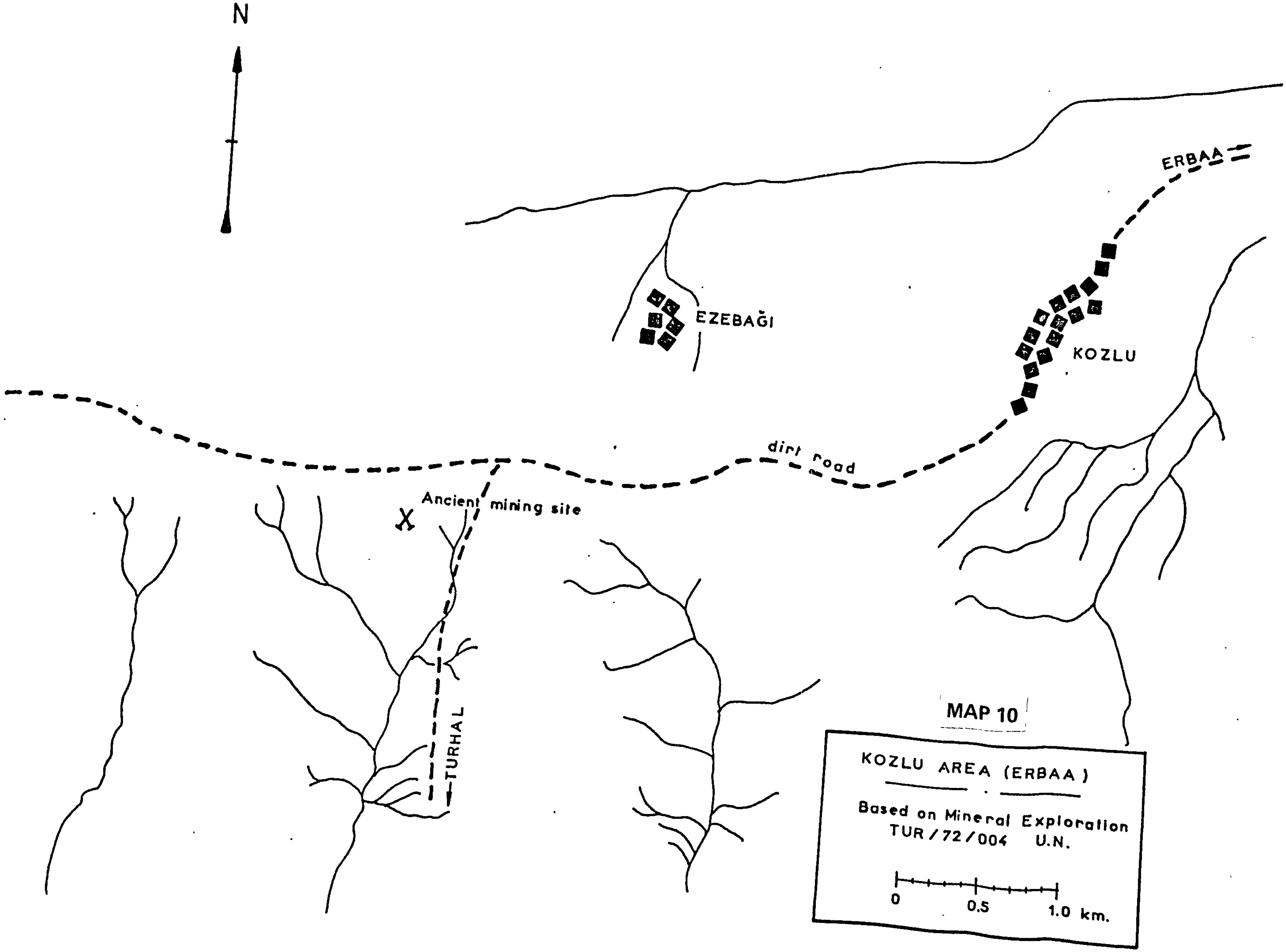
MAP 8

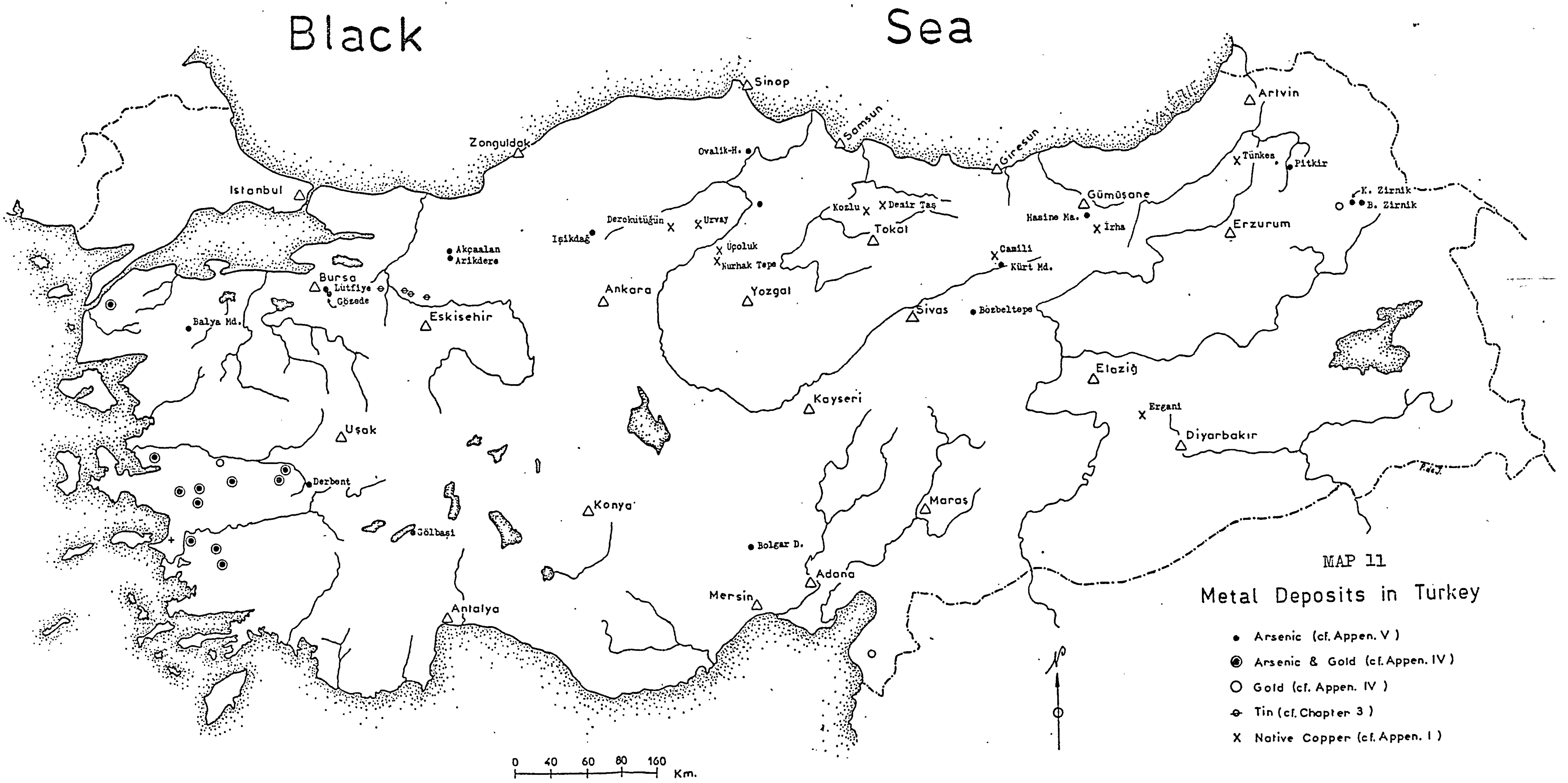
Distribution of Possible Prehistoric or Ancient Workings

MAP 9

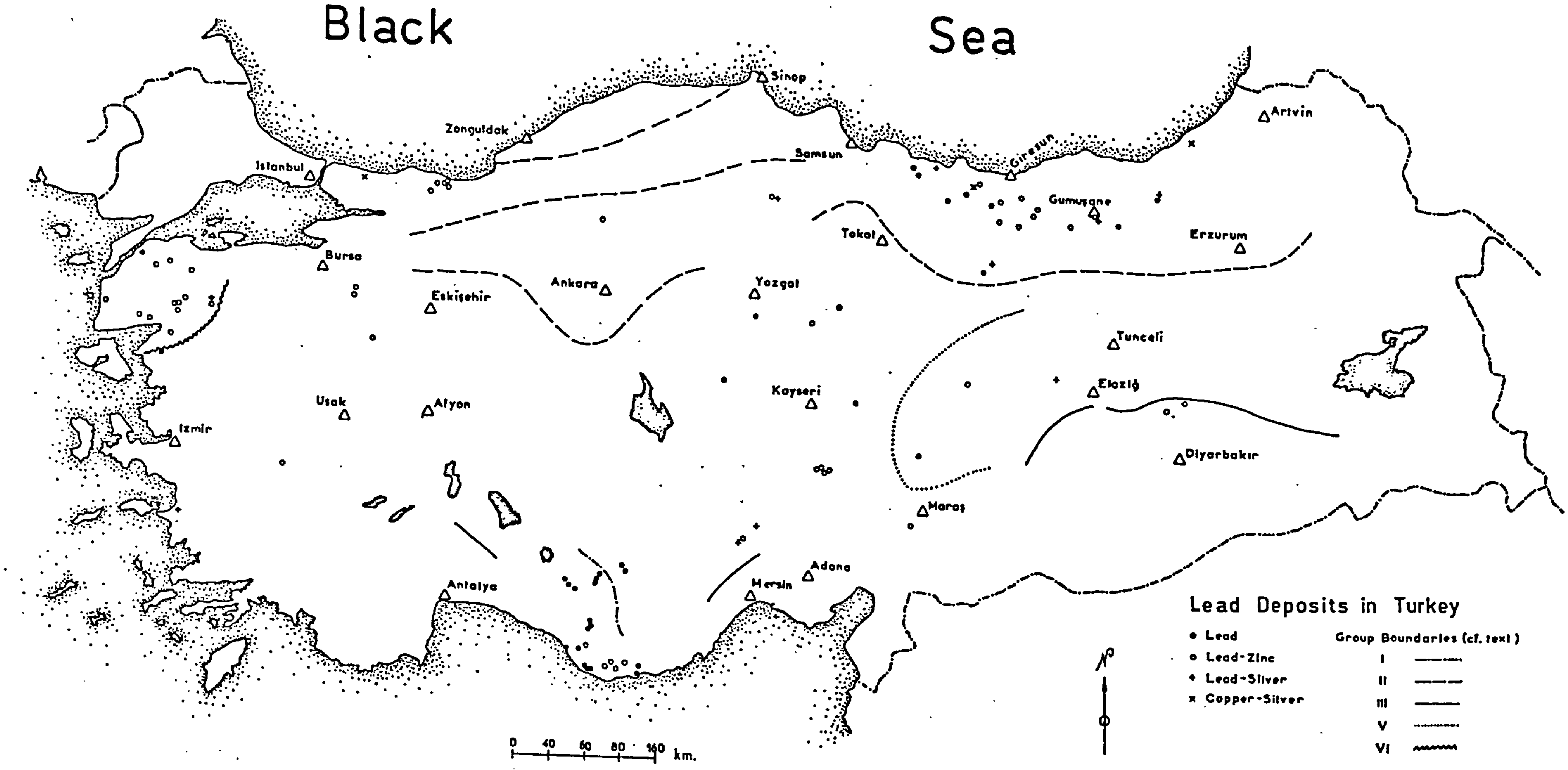
MAP 9


Gümüşane, Giresun, & Trabzon Provinces
Copper Mine
Copper Slag
Copper Mine & Slag
Possible Prehistoric or Ancient Exploitation
Black Sea
ORDU
GİRESUN
ESPİYE
TİREBOLU
GÖRELE
TRABZON
SURMENE
RİZE
ÇAYELİ
PAZAR
GÖLKÖY
Meletirmaği
MESUDİYE
KOYULHISAR
SUŞEHRİ
ŞEBİNKARAHISAR
DERELİ
HARŞİT
TORUL
GÜMÜSANE
Harsit Çay
Kelkit Çayı
KELKİT
BAYBURT
Çoruh Nehri
İSPİR
0 5 10 20 30 40 50 Kms.

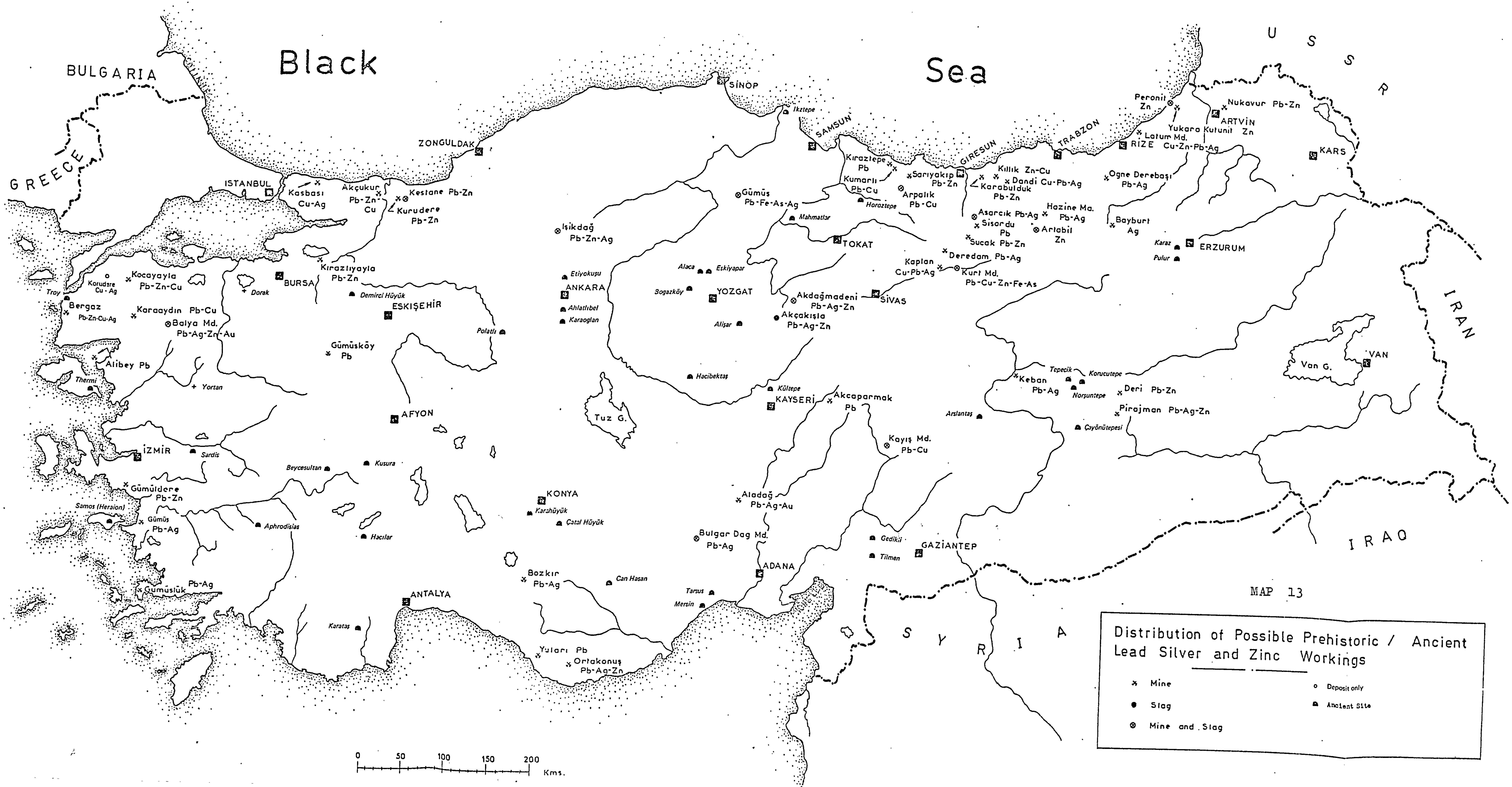

N
ERBAA
KOZLU
EZEBAĞI
dirt road
Ancient mining site
TURHAL
MAP 10
KOZLU AREA (ERBAA)
Based on Mineral Exploration
TUR/72/004 U.N.
0
0.5
1.0 km.



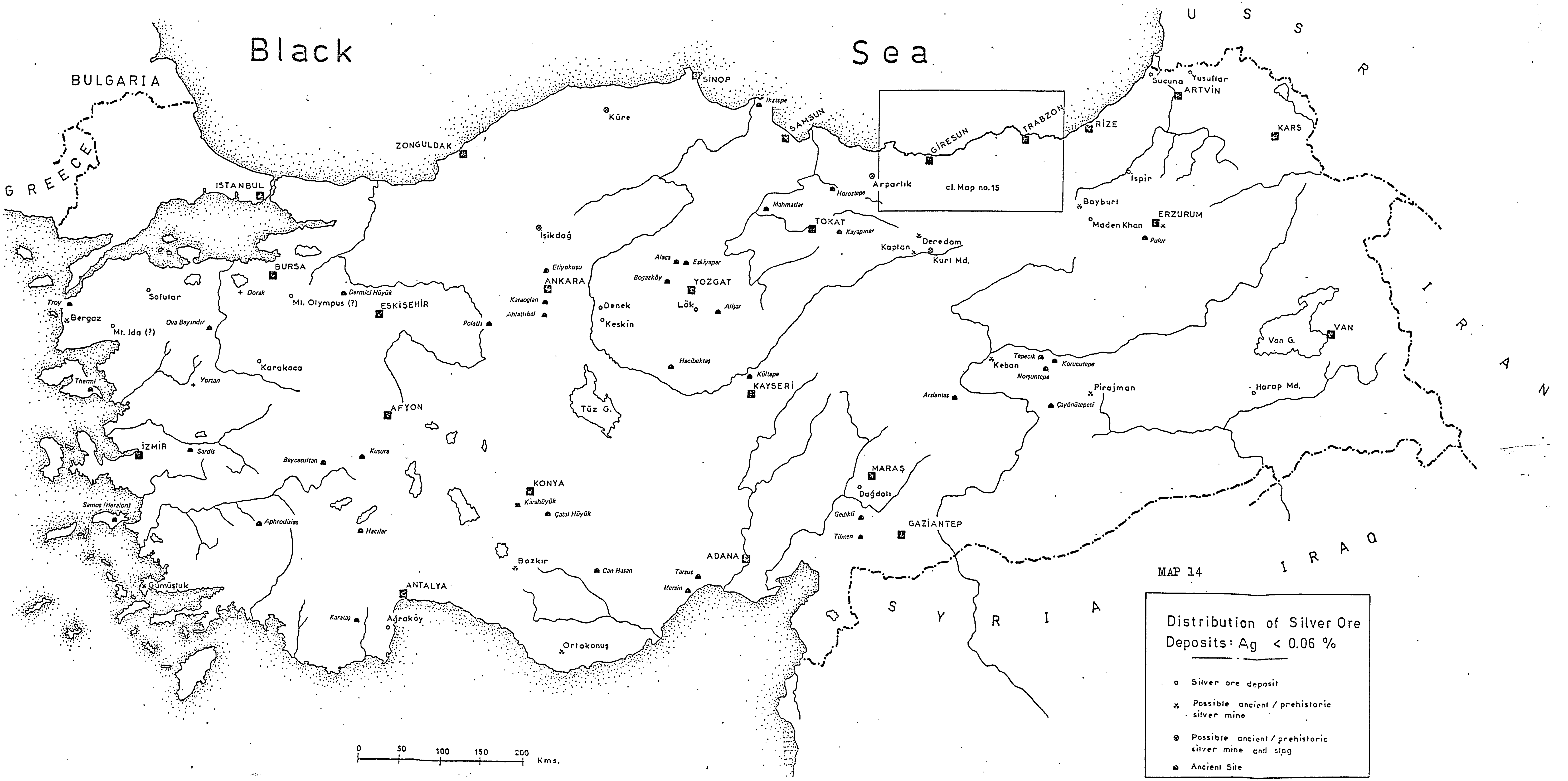
MAP 11
Metal Deposits in Turkey


Black Sea
Sinop
Zonguldak
Samsun
Artvin
Istanbul
Giresun
Gumuşane
Erzurum
Tokat
Bursa
Yozgat
Ankara
Eskişehir
Tunceli
Elazığ
Kayseri
Usak
Afyon
Izmir
Diyarbakır
Maraş
Adana
Mersin
Antalya
Lead Deposits in Turkey
• Lead
o Lead-Zinc
+ Lead-Silver
x Copper-Silver
Group Boundaries (cf. text)
I
II
III
V
VI
0 40 60 80 160 km.

MAP 12

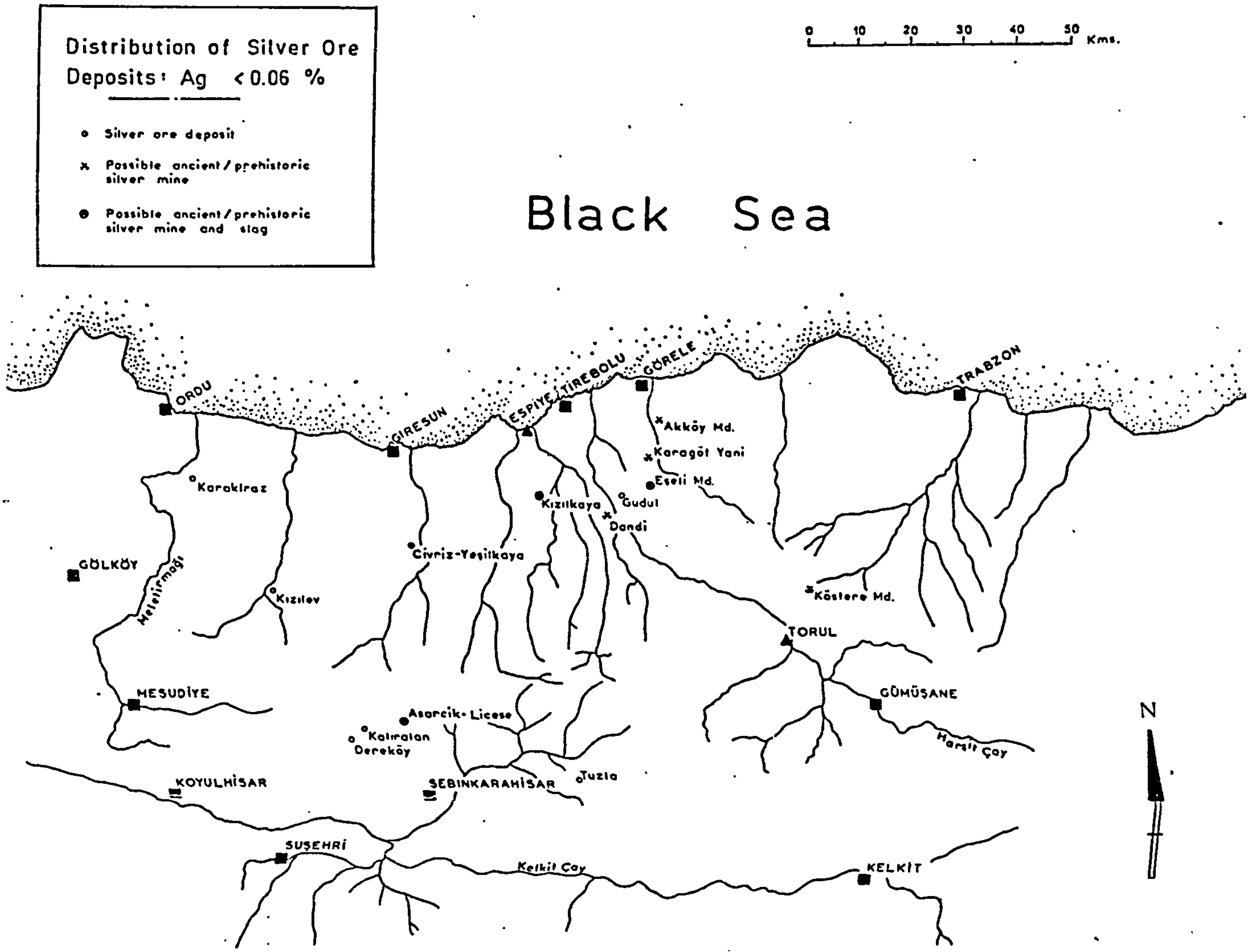


Black Sea
BULGARIA
GREECE
USSR
IRAN
IRAQ
SYRIA
MAP 13
Distribution of Possible Prehistoric / Ancient Lead Silver and Zinc Workings
Mine
Slag
Mine and Slag
Deposit only
Ancient Site
0 50 100 150 200 Kms.
ISTANBUL
ZONGULDAK
SİNOP
SAMSUN
GİRESUN
TRABZON
RİZE
ARTVİN
KARS
ERZURUM
TOKAT
SİVAS
YOZGAT
ANKARA
BURSA
ESKİŞEHİR
AFYON
İZMİR
KONYA
KAYSERİ
ADANA
GAZİANTEP
ANTALYA
VAN
Van G.
Tuz G.
Kasbası Cu-Ag
Akçukur Pb-Zn Cu
Kestane Pb-Zn
Kurudere Pb-Zn
Kirazlıyayla Pb-Zn
Kocayayla Pb-Zn-Cu
Korudsre Cu-Ag
Bergaz Pb-Zn-Cu-Ag
Karaaydın Pb-Cu
Balya Md. Pb-Ag-Zn-Au
Gümüsköy Pb
Alibey Pb
Gümüldere Pb-Zn
Gümüs Pb-Ag
Gümüslük Pb-Ag
Işıkdağ Pb-Zn-Ag
Gümüs Pb-Fe-As-Ag
Kiraztepe Pb
Kumarlı Pb-Cu
Sarıyakıp Pb-Zn
Arpalık Pb-Cu
Kıllık Zn-Cu
Dandi Cu-Pb-Ag
Karabulduk Pb-Zn
Asarcık Pb-Ag
Sisordu Pb
Sucak Pb-Zn
Hazine Ma. Pb-Ag
Artabil Zn
Deredam Pb-Ag
Kaplan Cu-Pb-Ag
Kurt Md. Pb-Cu-Zn-Fe-As
Ogne Derebaşı Pb-Ag
Bayburt Ag
Peronit Zn
Latum Md.
Yukaro Kutunit Zn
Cu-Zn-Pb-Ag
Nukavur Pb-Zn
Akdağmadeni Pb-Ag-Zn
Akçakışla Pb-Ag-Zn
Akcaparmak Pb
Kayış Md. Pb-Cu
Aladağ Pb-Ag-Au
Bulgar Dag Md. Pb-Ag
Bozkır Pb-Ag
Yuları Pb
Ortakonuş Pb-Ag-Zn
Keban Pb-Ag
Deri Pb-Zn
Pirajman Pb-Ag-Zn
Troy
Dorak
Thermi
Yortan
Sardis
Samos (Heraion)
Aphrodisias
Beycesultan
Kusura
Hacılar
Karataş
Demirci Hüyük
Polatlı
Etiyokuşu
Ahlatlıbel
Karaoglan
Alaca
Eskiyapar
Bogazköy
Alişar
Hacibektaş
Kültepe
Mahmatlar
Horoztepe
Ikiztepe
Karahüyük
Çatal Hüyük
Can Hasan
Tarsus
Mersin
Gedikli
Tilmen
Arslantaş
Tepecik
Korucutepe
Norşuntepe
Çayönütepesi
Karaz
Pulur

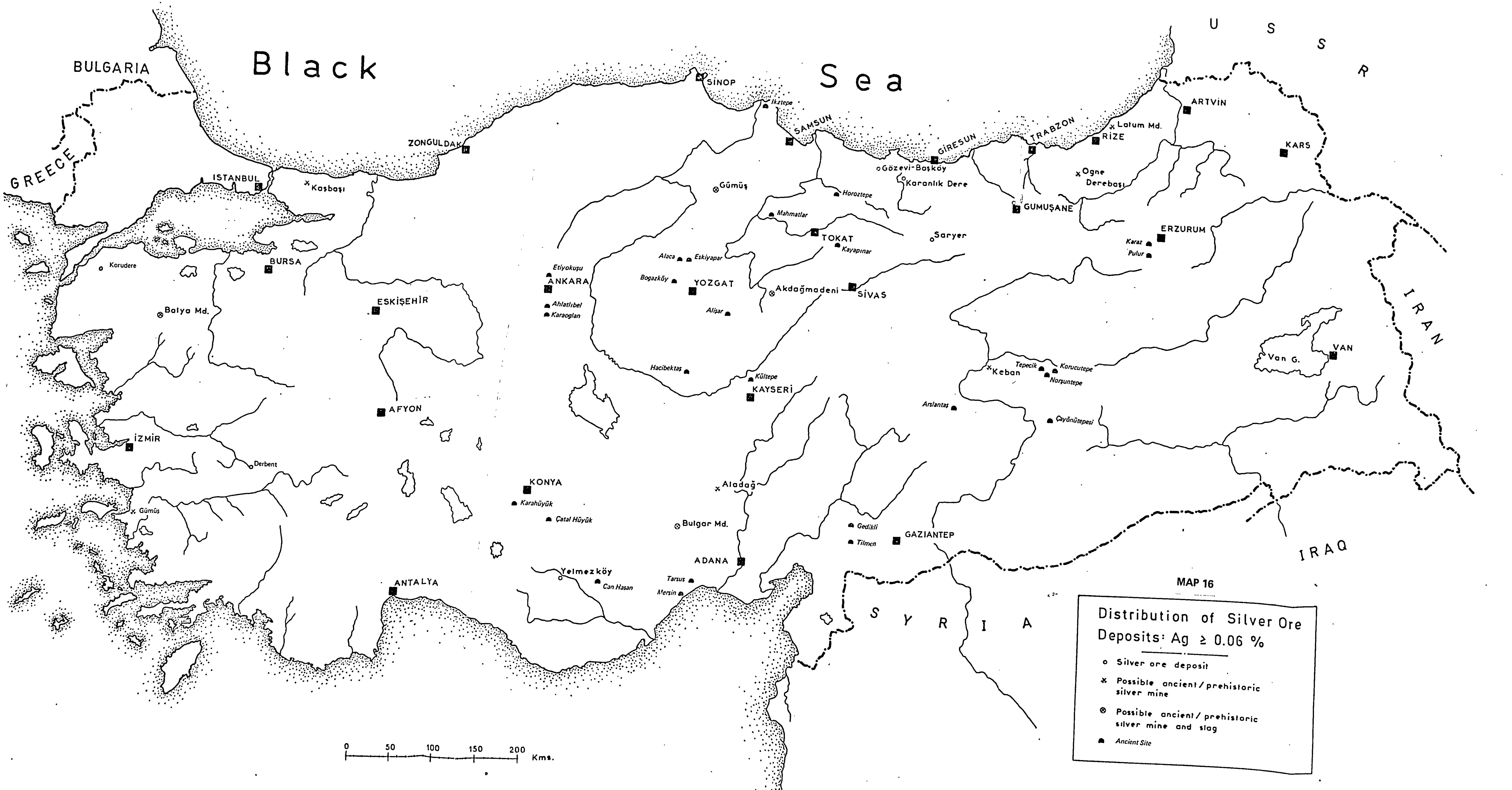

Black Sea
BULGARIA
GREECE
USSR
IRAN
IRAQ
SYRIA
ISTANBUL
ZONGULDAK
SINOP
Ikztepe
Küre
SAMSUN
GIRESUN
TRABZON
cf. Map no. 15
RIZE
Sucuna
Yusuflar
ARTVIN
KARS
İspir
Bayburt
Maden Khan
ERZURUM
Pulur
Arparlık
Horoztepe
Mahmatlar
TOKAT
Kayapınar
Deredam
Kaplan
Kurt Md.
Işıkdağ
Etiyokuşu
ANKARA
Karaoglan
Ahlatlıbel
Polatlı
Alaca
Eskiyapar
Bogazköy
YOZGAT
Lök
Alişar
Denek
Keskin
Hacibektaş
Kültepe
KAYSERİ
Tüz G.
BURSA
Dorak
Sofular
Mt. Olympus (?)
Dermici Hüyük
ESKİŞEHİR
Troy
Bergaz
Mt. Ida (?)
Ova Bayındır
Karakoca
Thermi
Yortan
AFYON
İZMİR
Sardis
Kusura
Beycesultan
KONYA
Karahüyük
Çatal Hüyük
Samos (Heraion)
Aphrodisias
Hacılar
Bozkır
Can Hasan
Gümüşluk
ANTALYA
Karataş
Ağraköy
Ortakonuş
ADANA
Tarsus
Mersin
MARAŞ
Dağdalı
Gedikli
Tilmen
GAZİANTEP
Arslantaş
Tepecik
Keban
Korucutepe
Norşuntepe
Pirajman
Çayönütepesi
Van G.
VAN
Harap Md.
0 50 100 150 200 Kms.
Distribution of Silver Ore Deposits: Ag < 0.06 %
Silver ore deposit
Possible ancient / prehistoric silver mine
Possible ancient / prehistoric silver mine and slag
Ancient Site

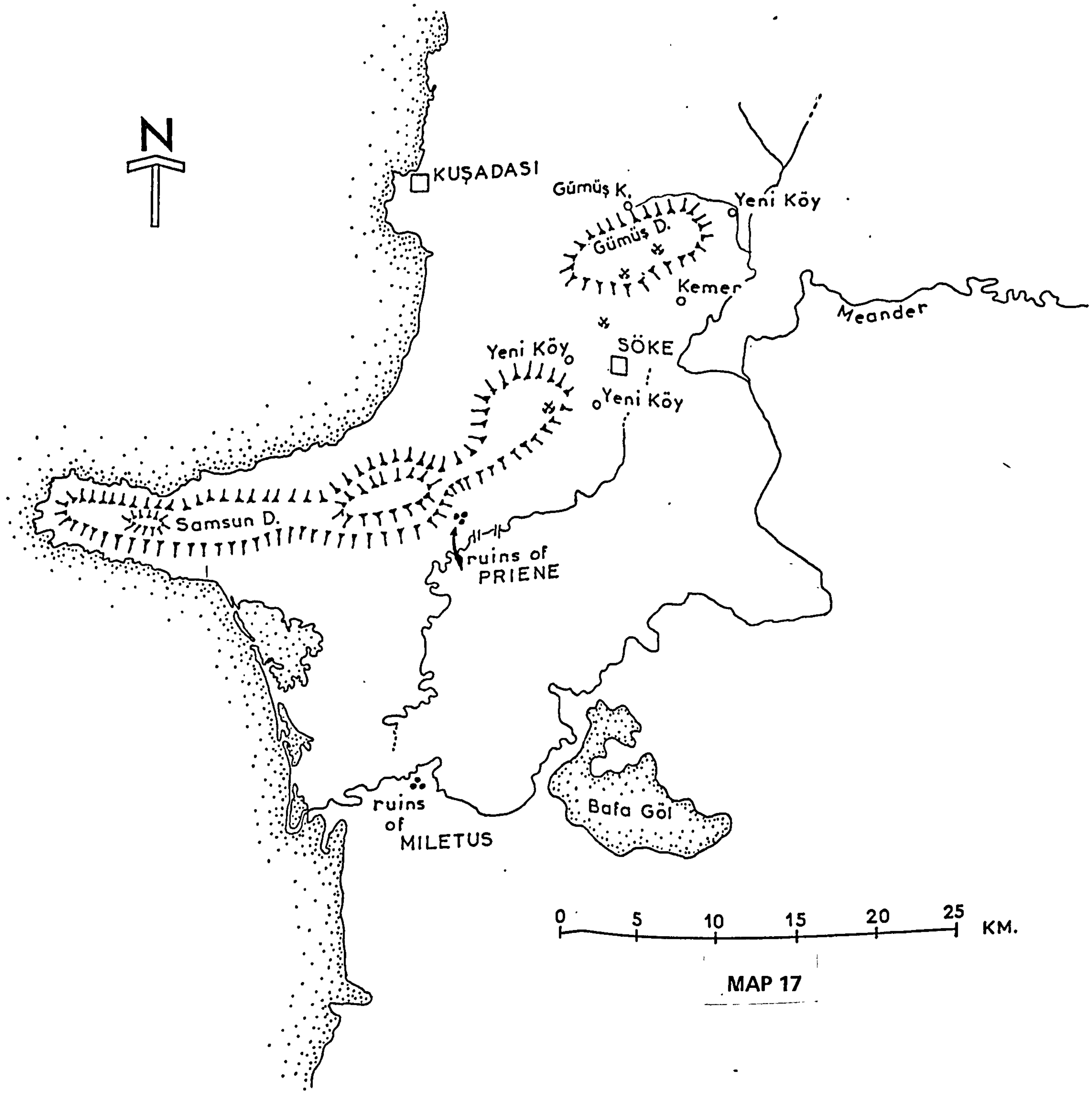
MAP 14

MAP 15



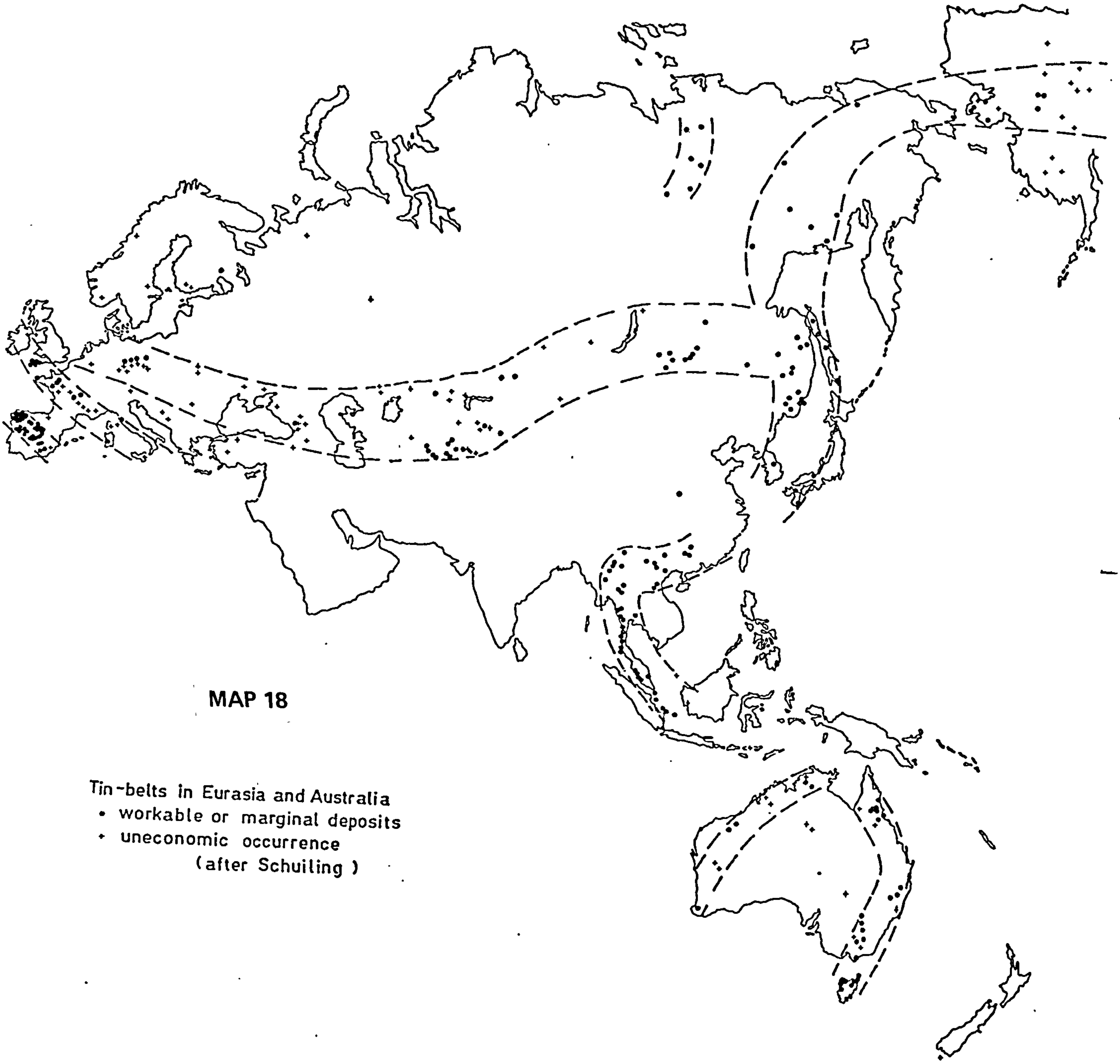
Distribution of Silver Ore Deposits: Ag <0.06 %
Silver ore deposit
Possible ancient / prehistoric silver mine
Possible ancient / prehistoric silver mine and slag
0 10 20 30 40 50 Kms.
Black Sea
ORDU
GIRESUN
ESPIYE
TIREBOLU
GÖRELE
TRABZON
Akköy Md.
Karagöl Yani
Eseli Md.
Karakiraz
Kızılkaya
Gudul
Dandi
Civriz-Yeşilkaya
GÖLKÖY
Kızılev
Köstere Md.
TORUL
GÜMÜŞANE
Harşit Çay
MESUDİYE
Asarcik-Licese
Katıralan
Dereköy
Tuzla
KOYULHİSAR
ŞEBINKARAHİSAR
SUŞEHRİ
Kelkit Çay
KELKİT
N


MAP 16
Distribution of Silver Ore Deposits: Ag ≥ 0.06 %
Silver ore deposit
Possible ancient/prehistoric silver mine
Possible ancient/prehistoric silver mine and slag
Ancient Site
Black Sea
BULGARIA
GREECE
U S S R
IRAN
IRAQ
S Y R I A
ISTANBUL
Kaşbaşı
ZONGULDAK
SINOP
Ikztepe
SAMSUN
GİRESUN
TRABZON
RİZE
Latum Md.
ARTVİN
KARS
Gözevi-Başköy
Karanlık Dere
Gümüş
Horoztepe
Mahmatlar
TOKAT
Kayapınar
Saryer
GUMUŞANE
Ogne Derebaşı
ERZURUM
Karaz
Pulur
BURSA
Korudere
Balya Md.
ESKİŞEHİR
Etiyokuşu
ANKARA
Ahlatlıbel
Karaoglan
Alaca
Eskiyapar
Bogazköy
YOZGAT
Alişar
Akdağmadeni
SİVAS
Hacibektaş
Kültepe
KAYSERİ
Keban
Tepecik
Korucutepe
Norşuntepe
Van G.
VAN
Arslantaş
Çayönütepesi
AFYON
İZMİR
Derbent
Gümüş
KONYA
Karahüyük
Çatal Hüyük
Aladağ
Bulgar Md.
Gedikli
Tilmen
GAZIANTEP
ADANA
Yelmezköy
Can Hasan
Tarsus
Mersin
ANTALYA
0 50 100 150 200 Kms.



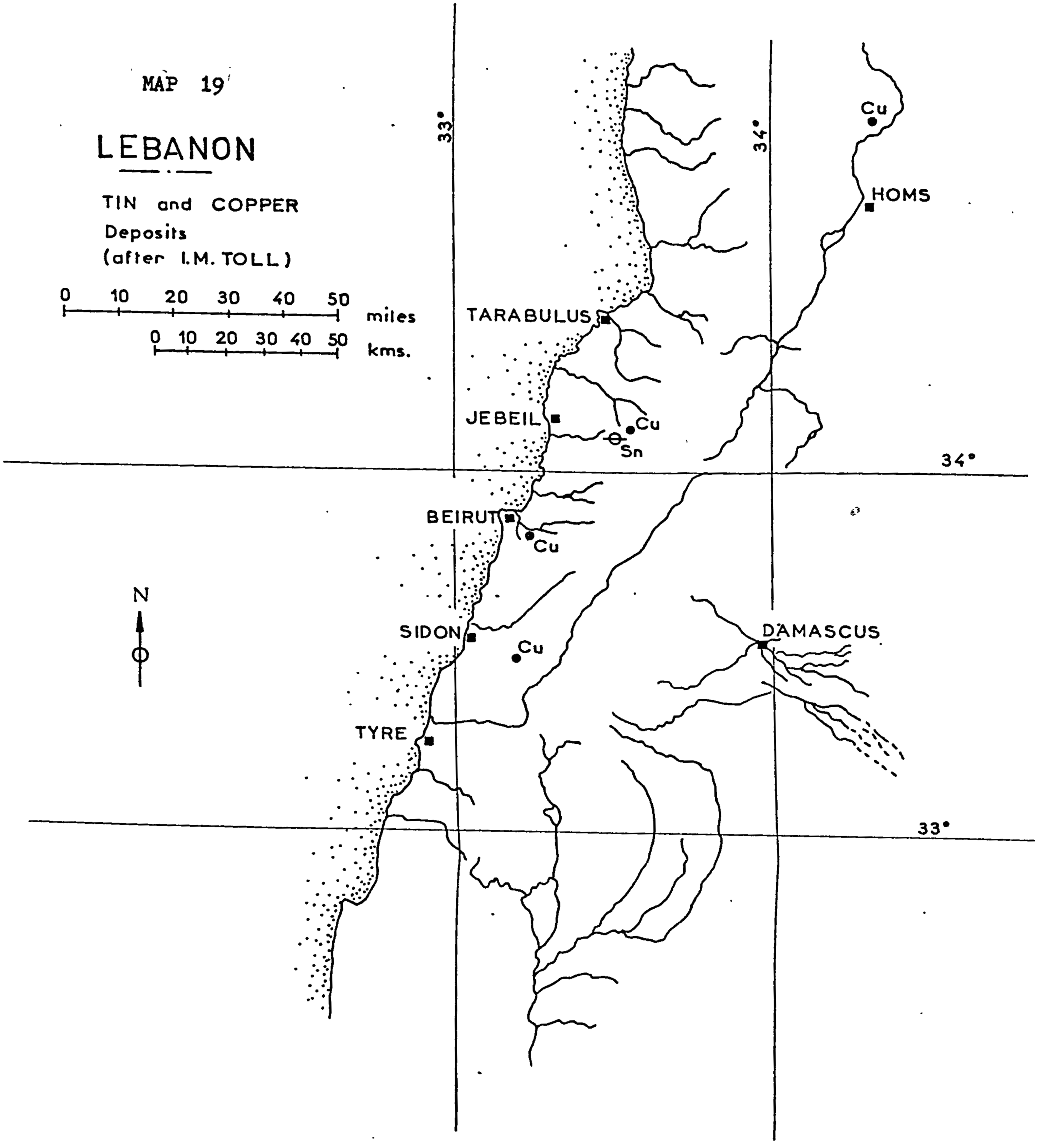
N
KUŞADASI
Gümüş K.
Yeni Köy
Gümüş D.
Kemer
Meander
SÖKE
Yeni Köy
Yeni Köy
Samsun D.
ruins of
PRIENE
ruins
of
MILETUS
Bafa Göl
0
5
10
15
20
25
KM.

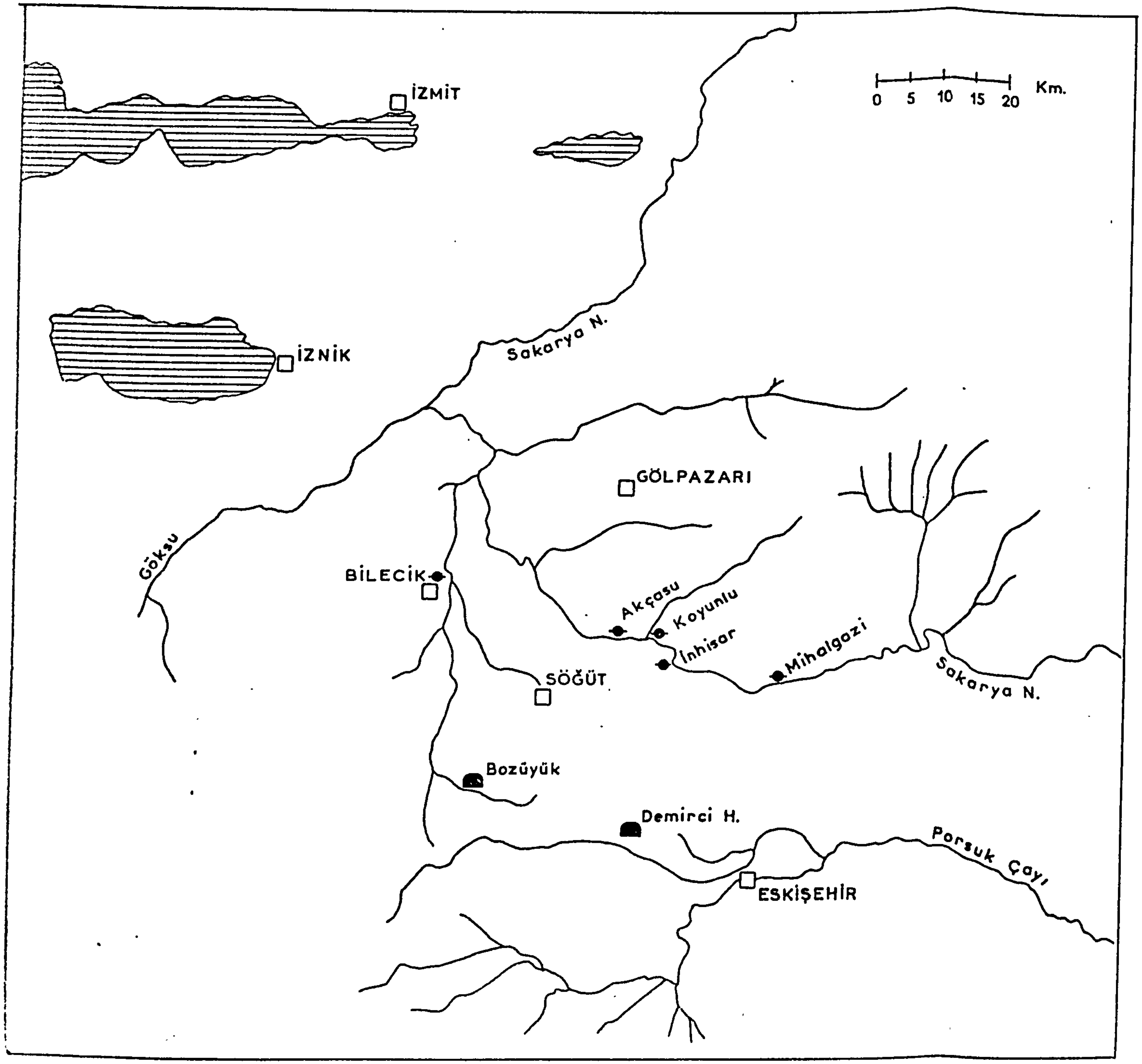
MAP 17



MAP 18

Tin-belts in Eurasia and Australia
• workable or marginal deposits
+ uneconomic occurrence
(after Schuiling)

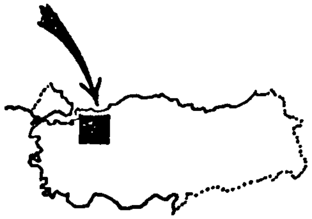

MAP 19
LEBANON
TIN and COPPER
Deposits
(after I.M. TOLL)
0 10 20 30 40 50 miles
0 10 20 30 40 50 kms.
N
33°
34°
Cu
HOMS
TARABULUS
JEBEIL
Cu
Sn
34°
BEIRUT
Cu
SIDON
Cu
DAMASCUS
TYRE
33°
MAP 19

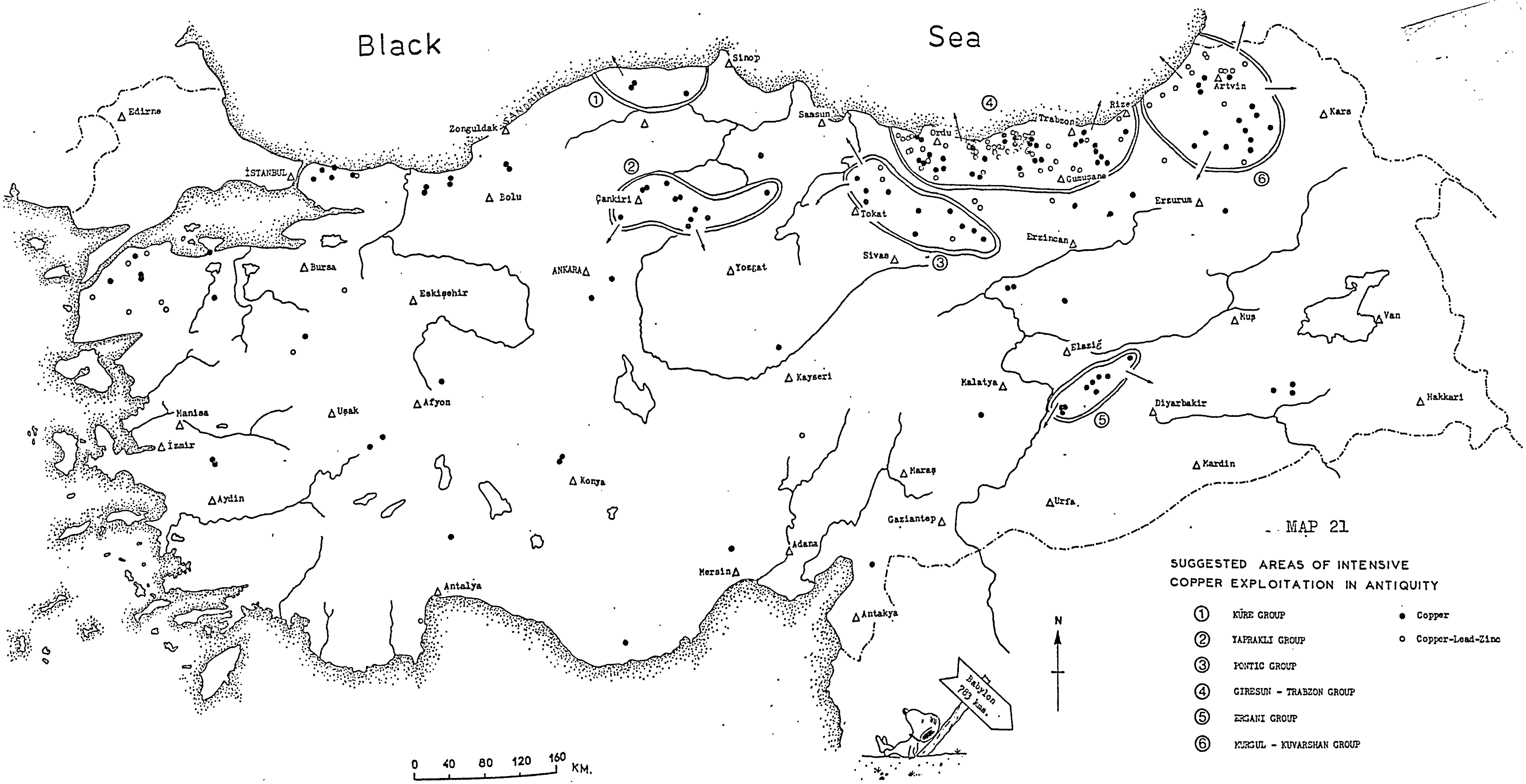


MAP 20

SAKARYA BASIN

- TIN DEPOSIT REPORTED
- EBA SETTLEMENT





MAP 21

SUGGESTED AREAS OF INTENSIVE COPPER EXPLOITATION IN ANTIQUITY

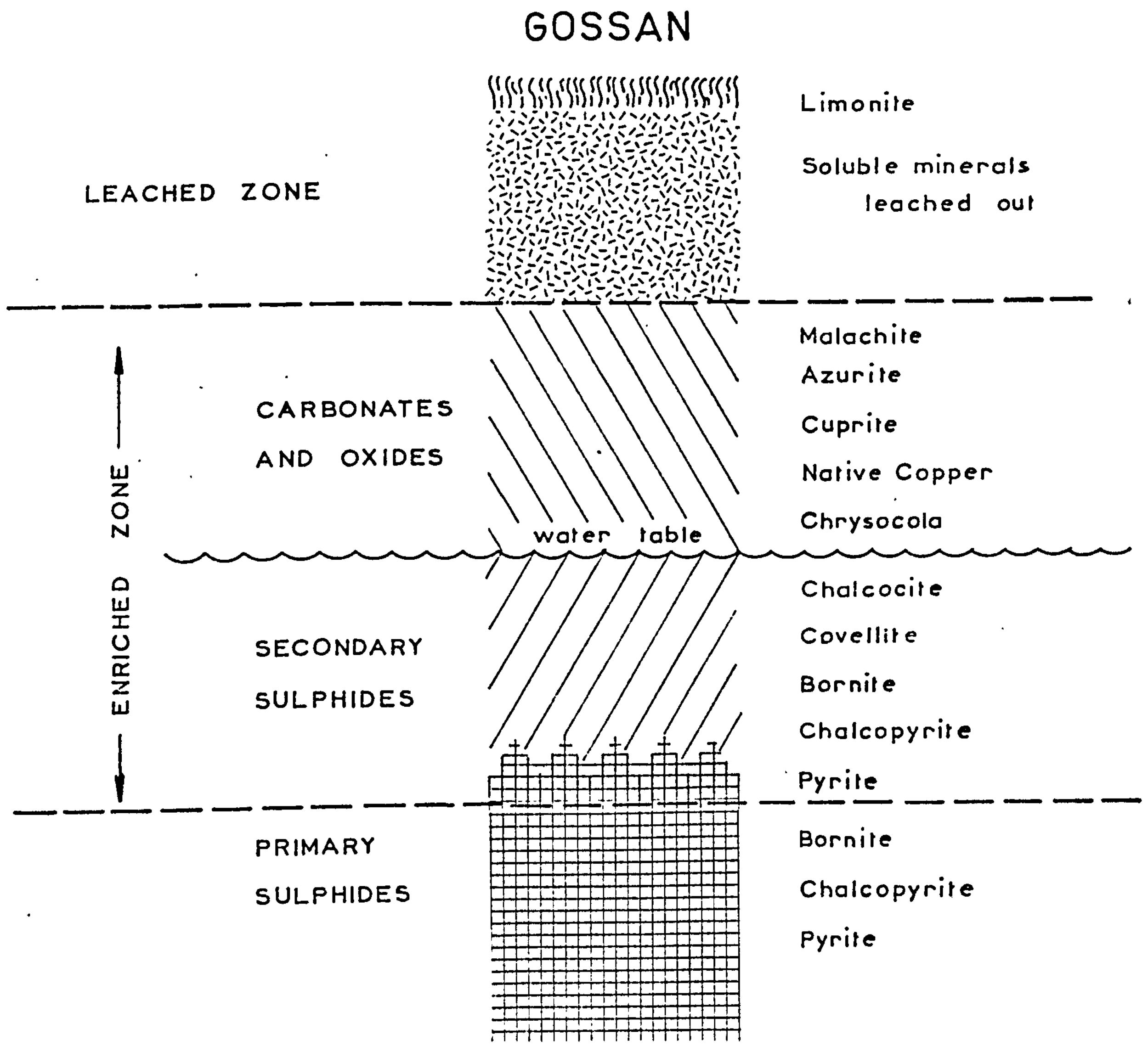

GOSSAN
LEACHED ZONE
Limonite
Soluble minerals leached out
ENRICHED ZONE
CARBONATES AND OXIDES
Malachite
Azurite
Cuprite
Native Copper
Chrysocola
water table
SECONDARY SULPHIDES
Chalcocite
Covellite
Bornite
Chalcopyrite
Pyrite
PRIMARY SULPHIDES
Bornite
Chalcopyrite
Pyrite

FIGURE 1

Plan & Section of Mine Shaft near the Village of Hrištene, Bulgaria (after Černih & Radučeva, 1972)

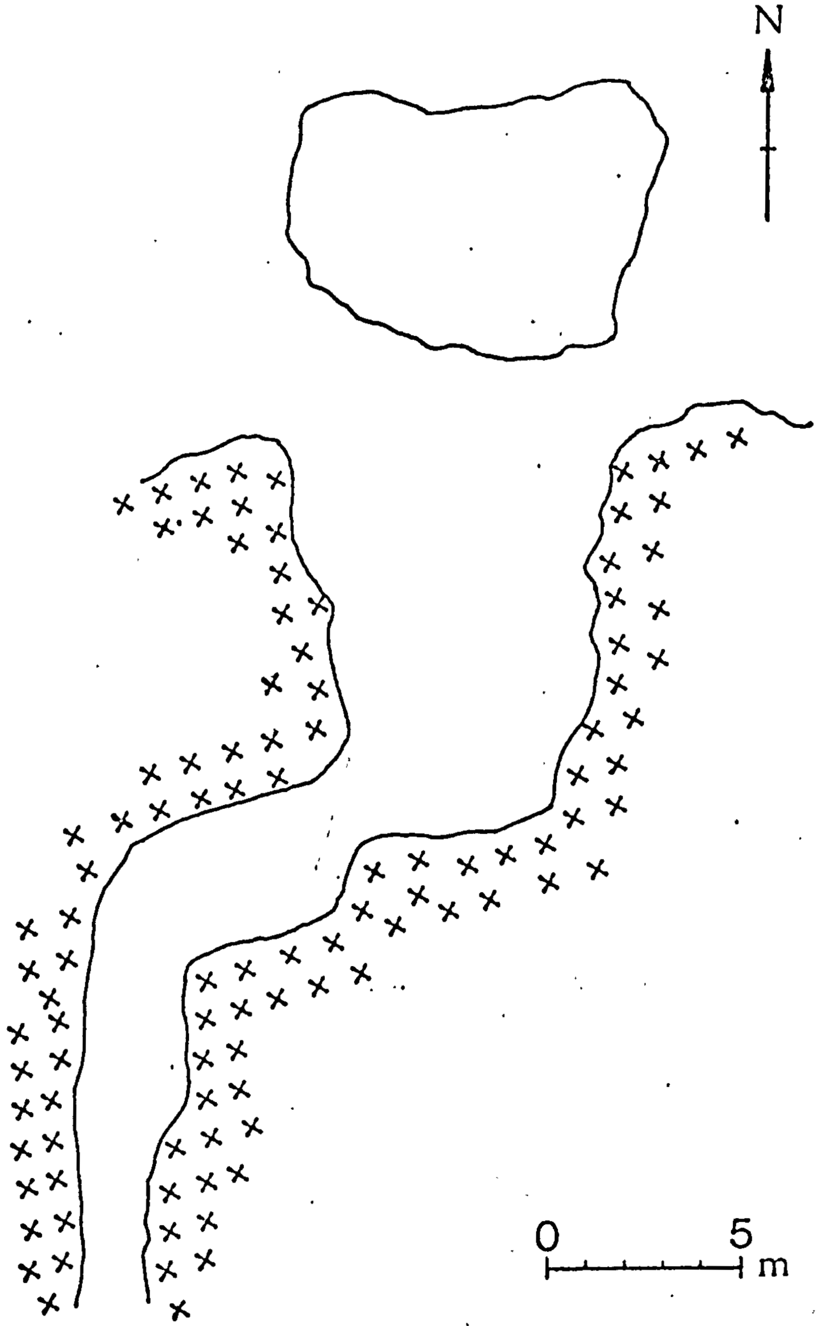


FIGURE 2

Image removed due to third party copyright

FIGURE 3

Image removed due to third party copyright

FIGURE 4

FIGURE 5

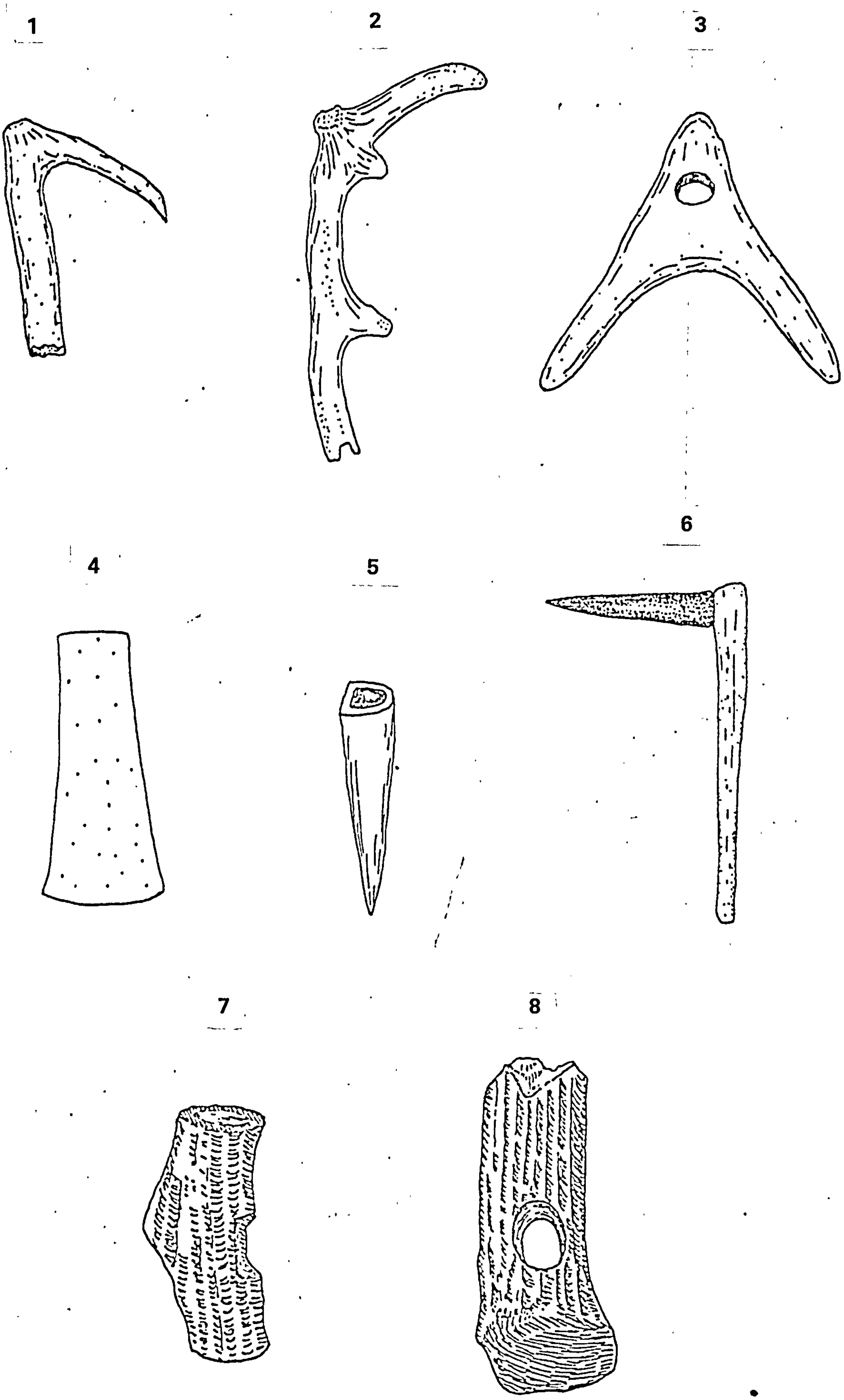
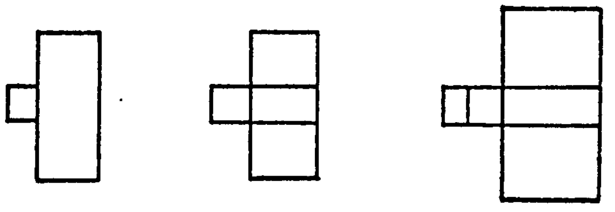


Image removed due to third party copyright

FIGURE 6

FIGURE 7

1



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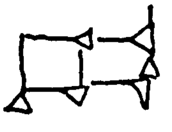

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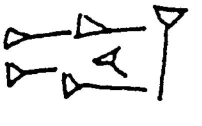
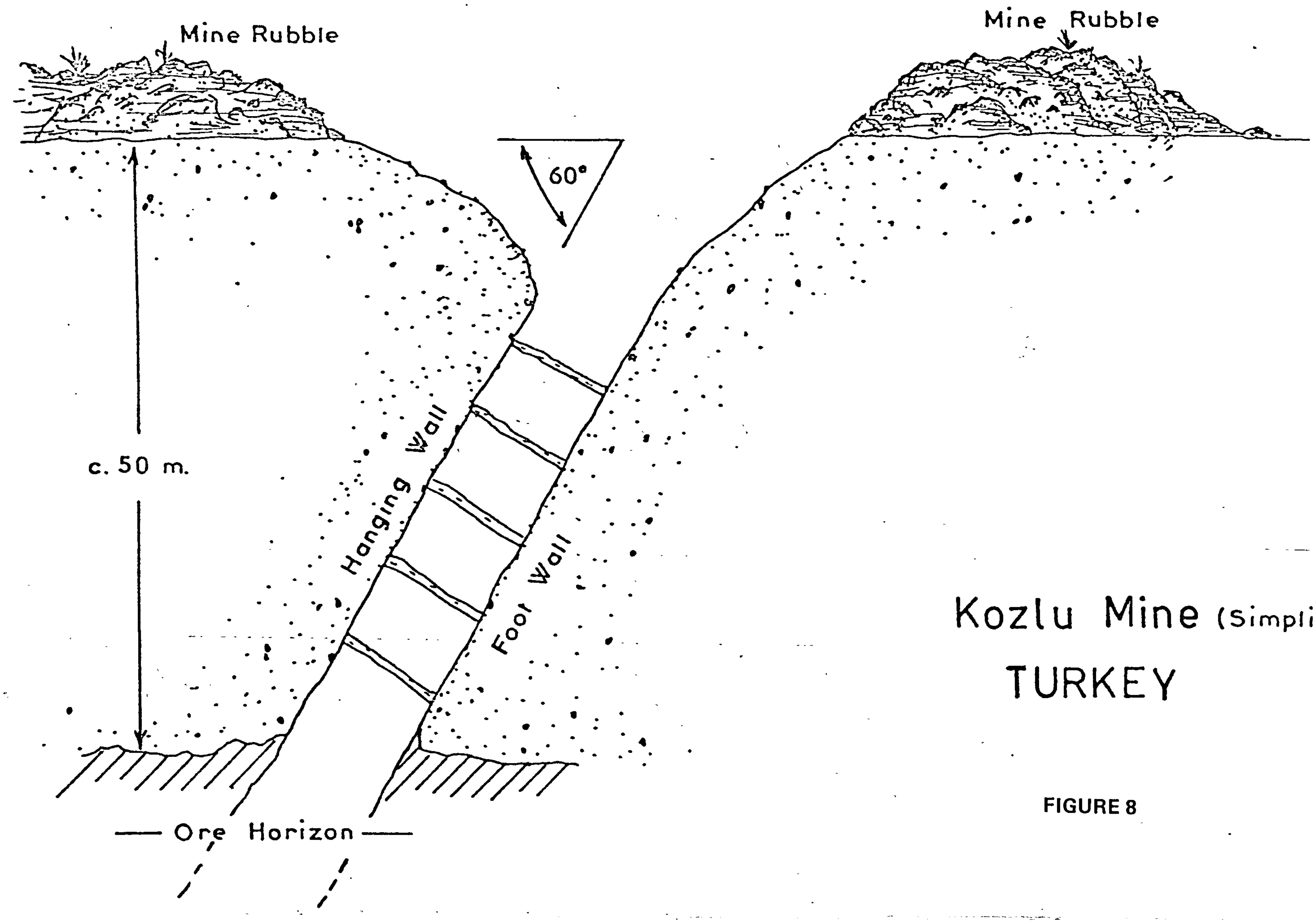




Kozlu Mine (Simplified)
TURKEY

FIGURE 8

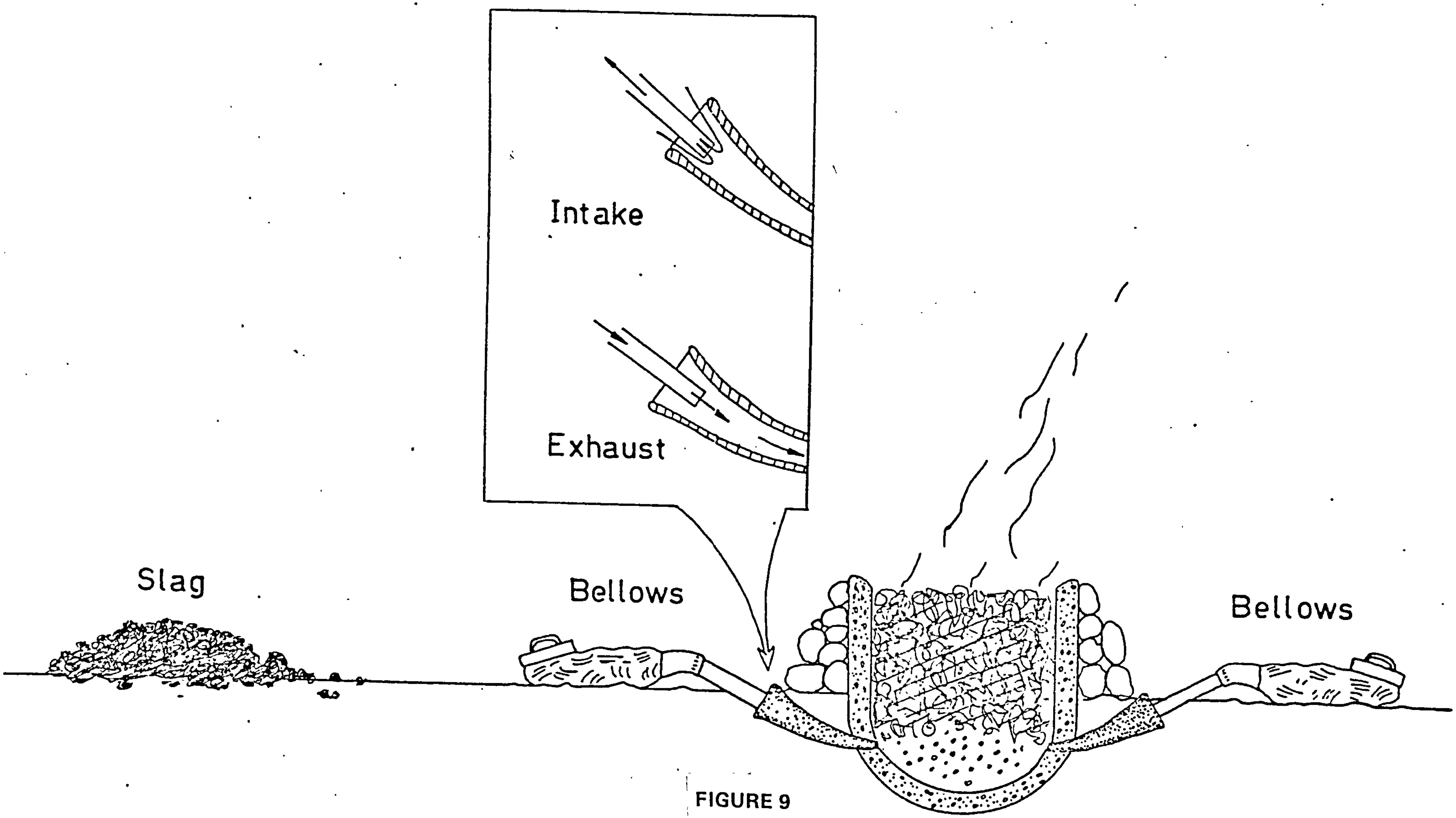


FIGURE 9

Image removed due to third party copyright

Silver Smelting

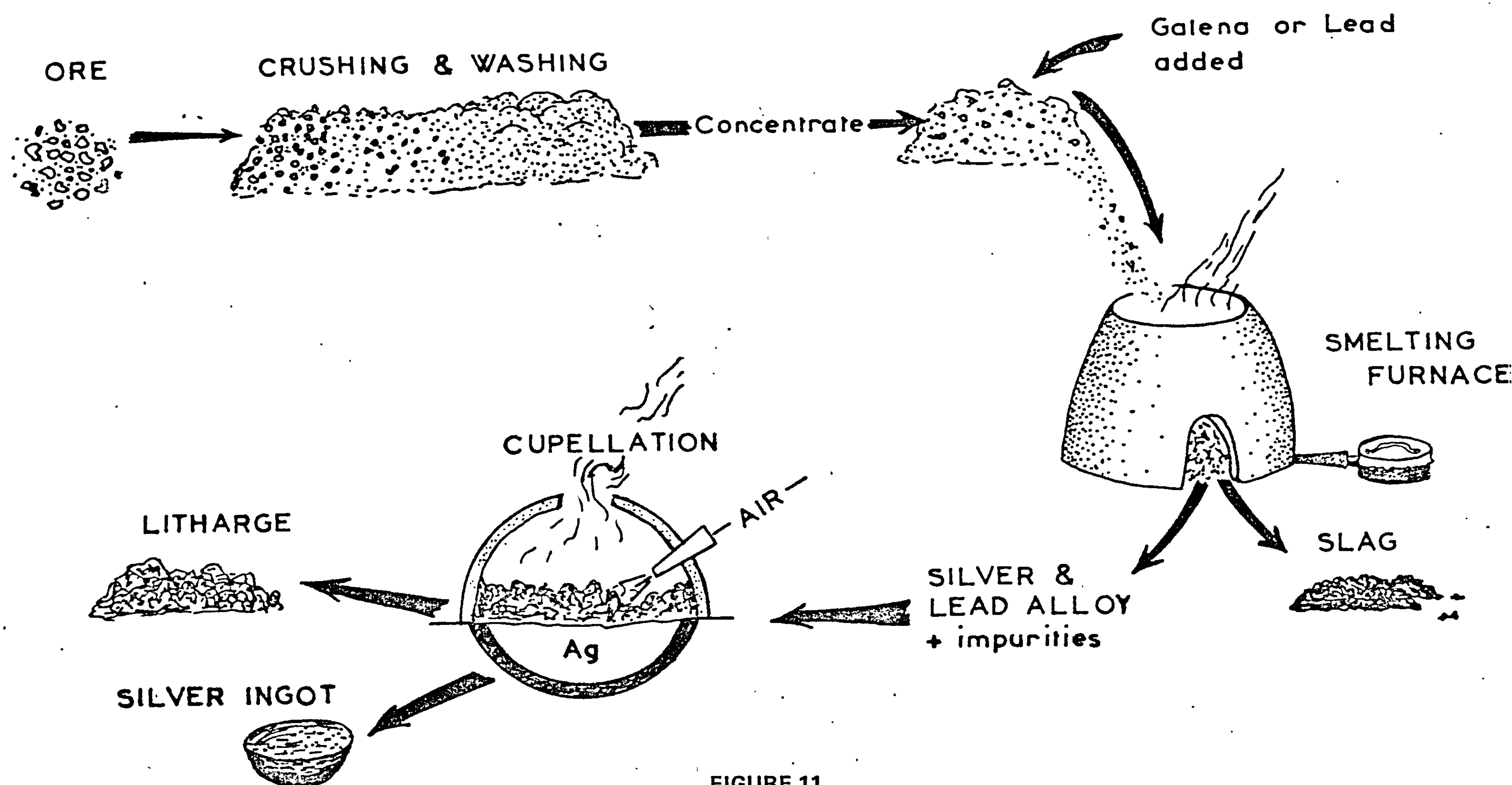
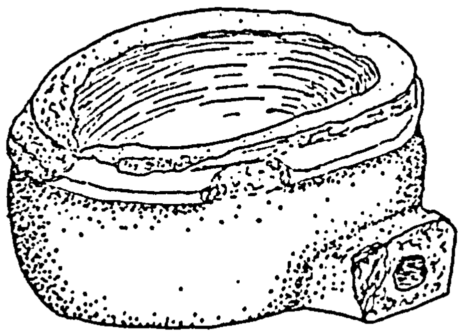


FIGURE 11

FIGURE 12

1



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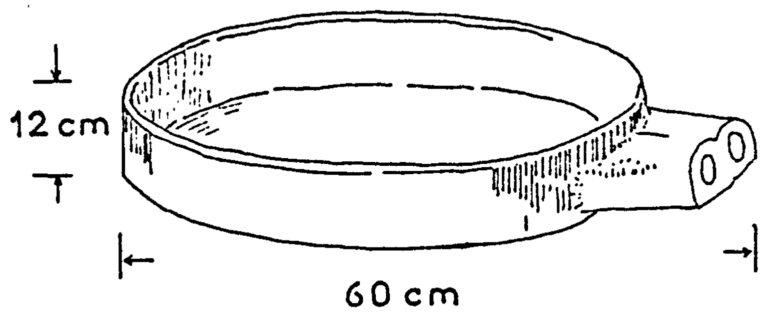

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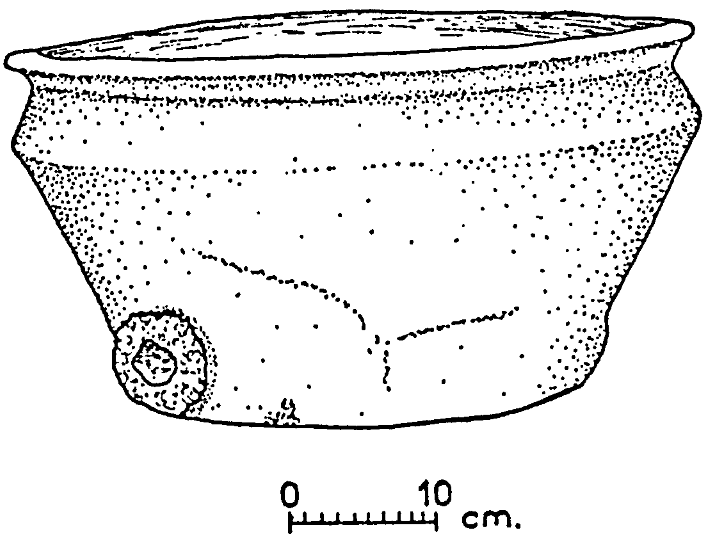
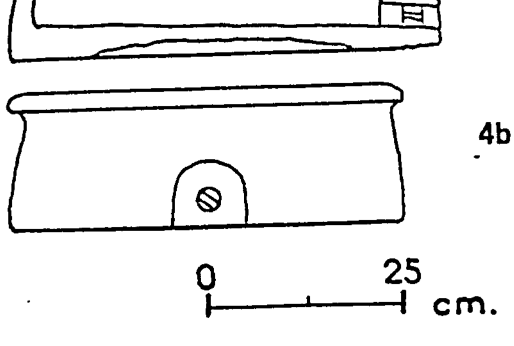
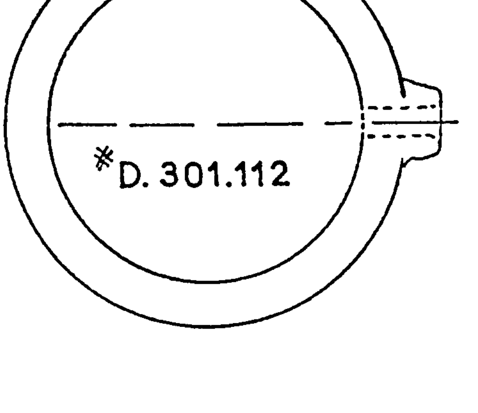




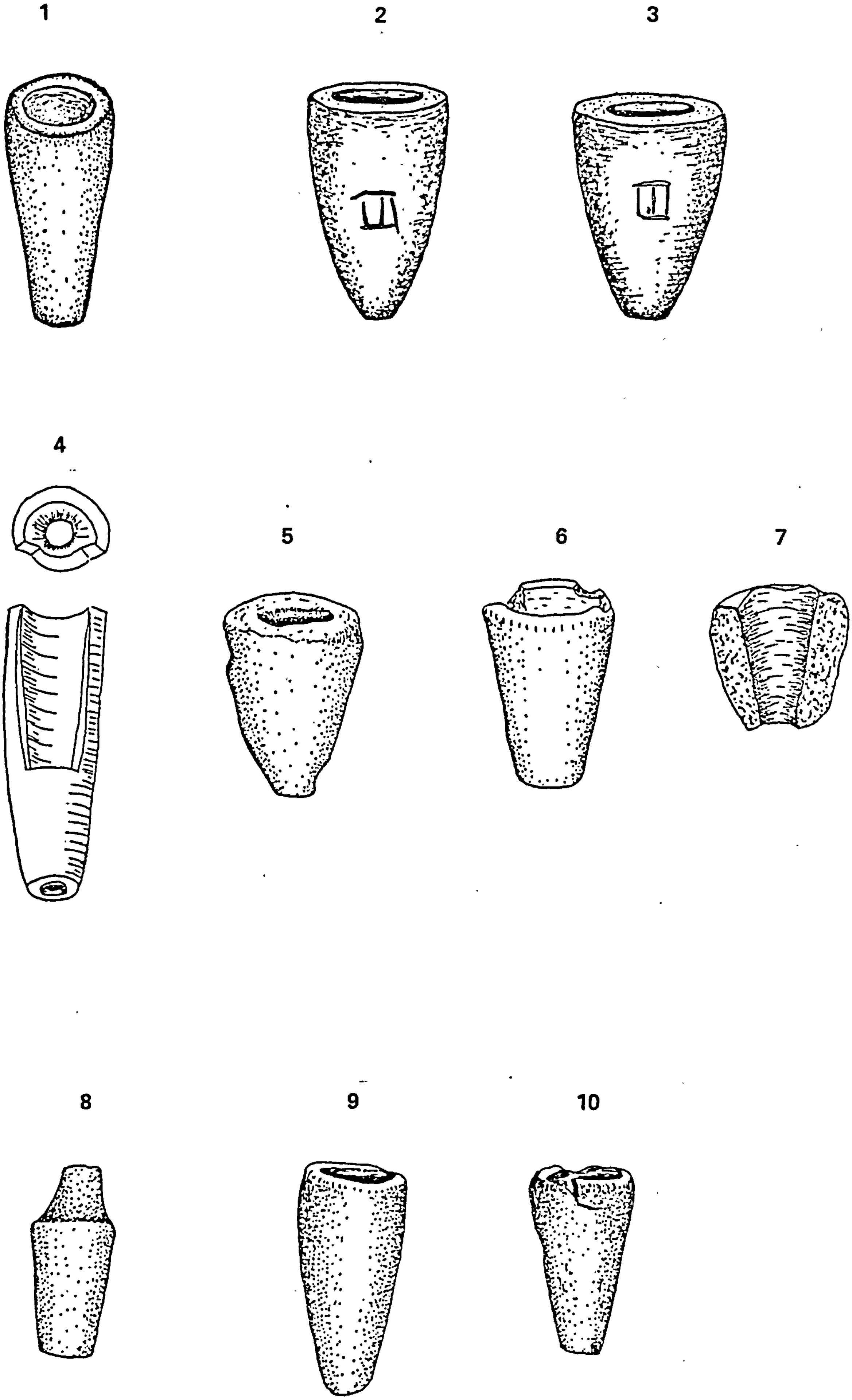
4a

4b



4c

FIGURE 13



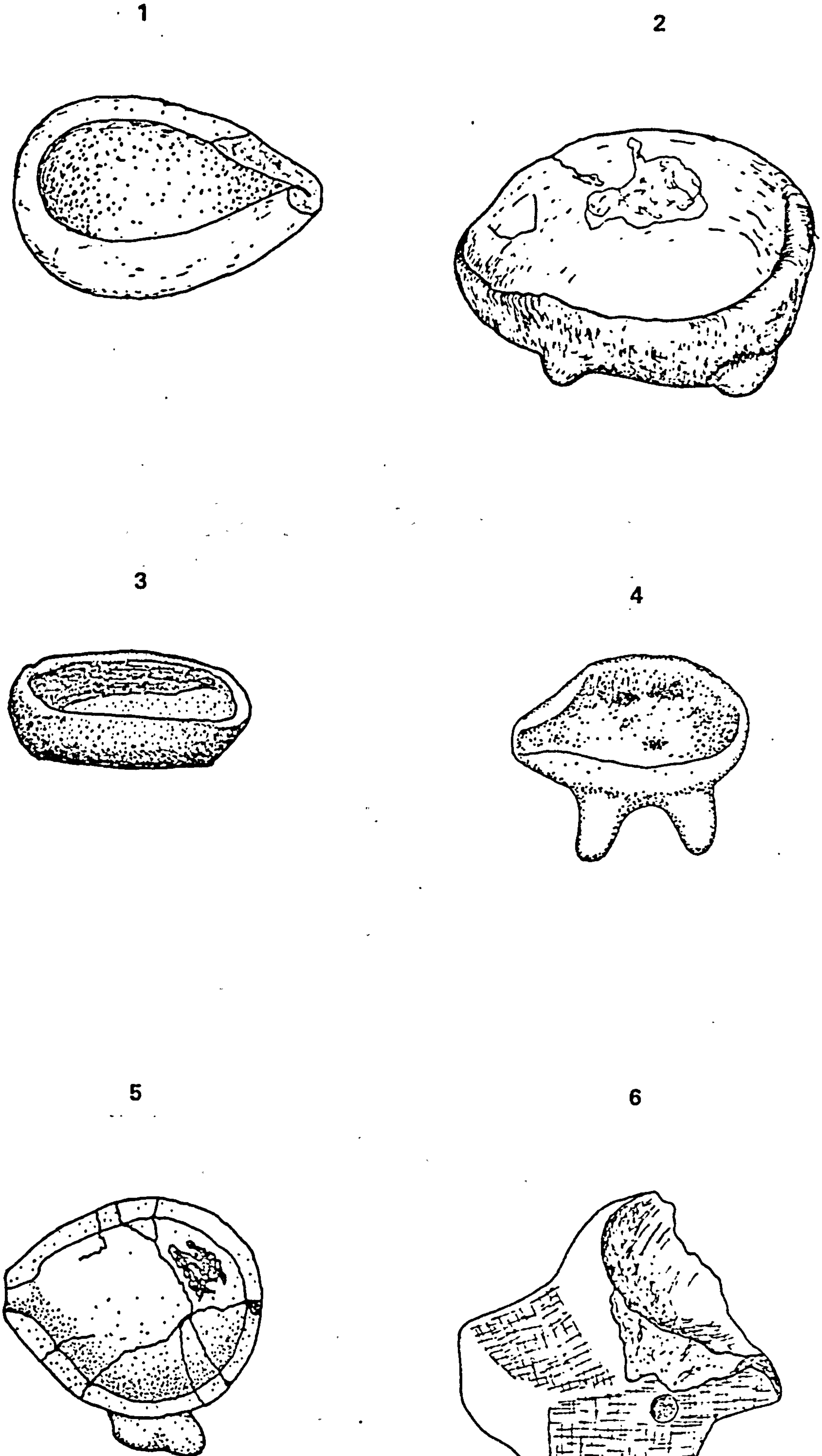
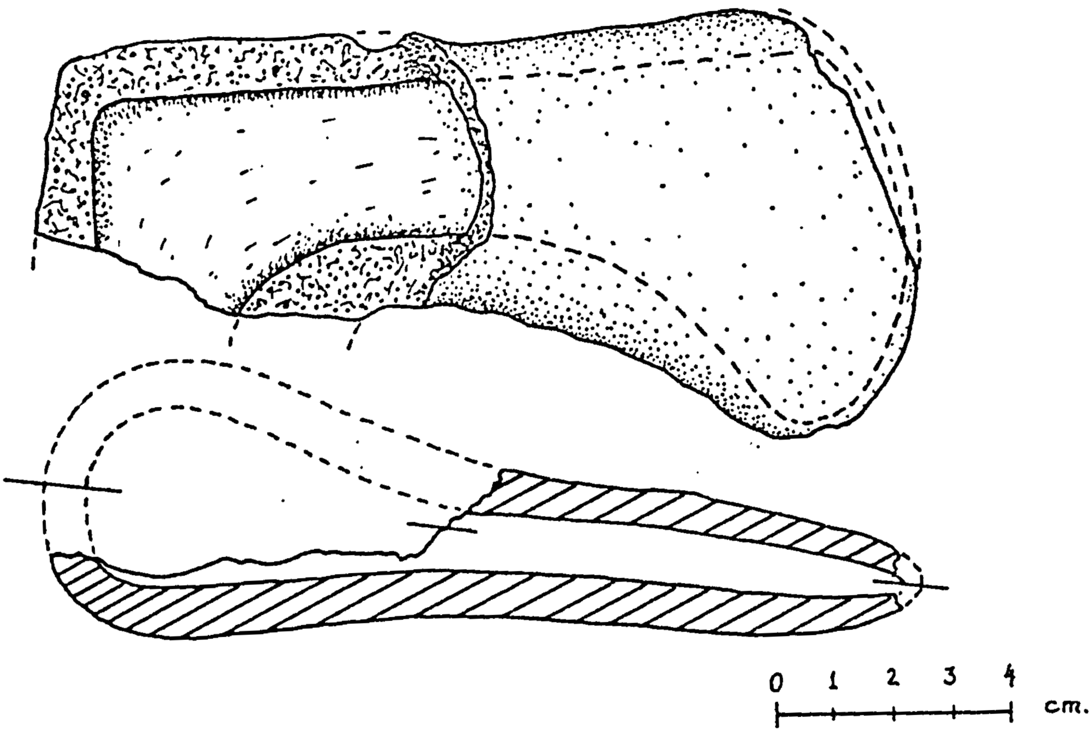

1
2
3
4
5
6

FIGURE 15

1



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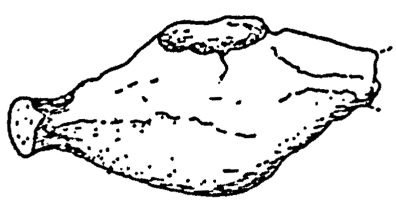

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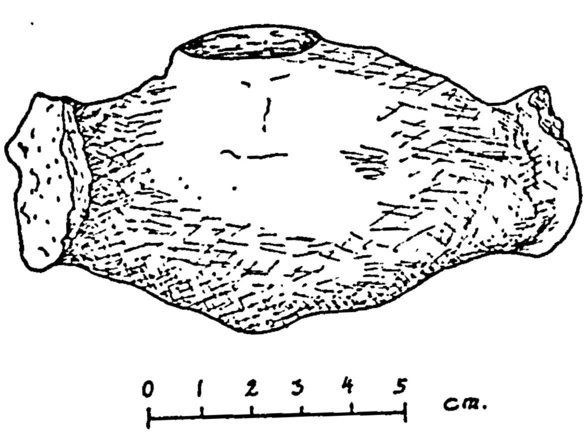


FIGURE 16

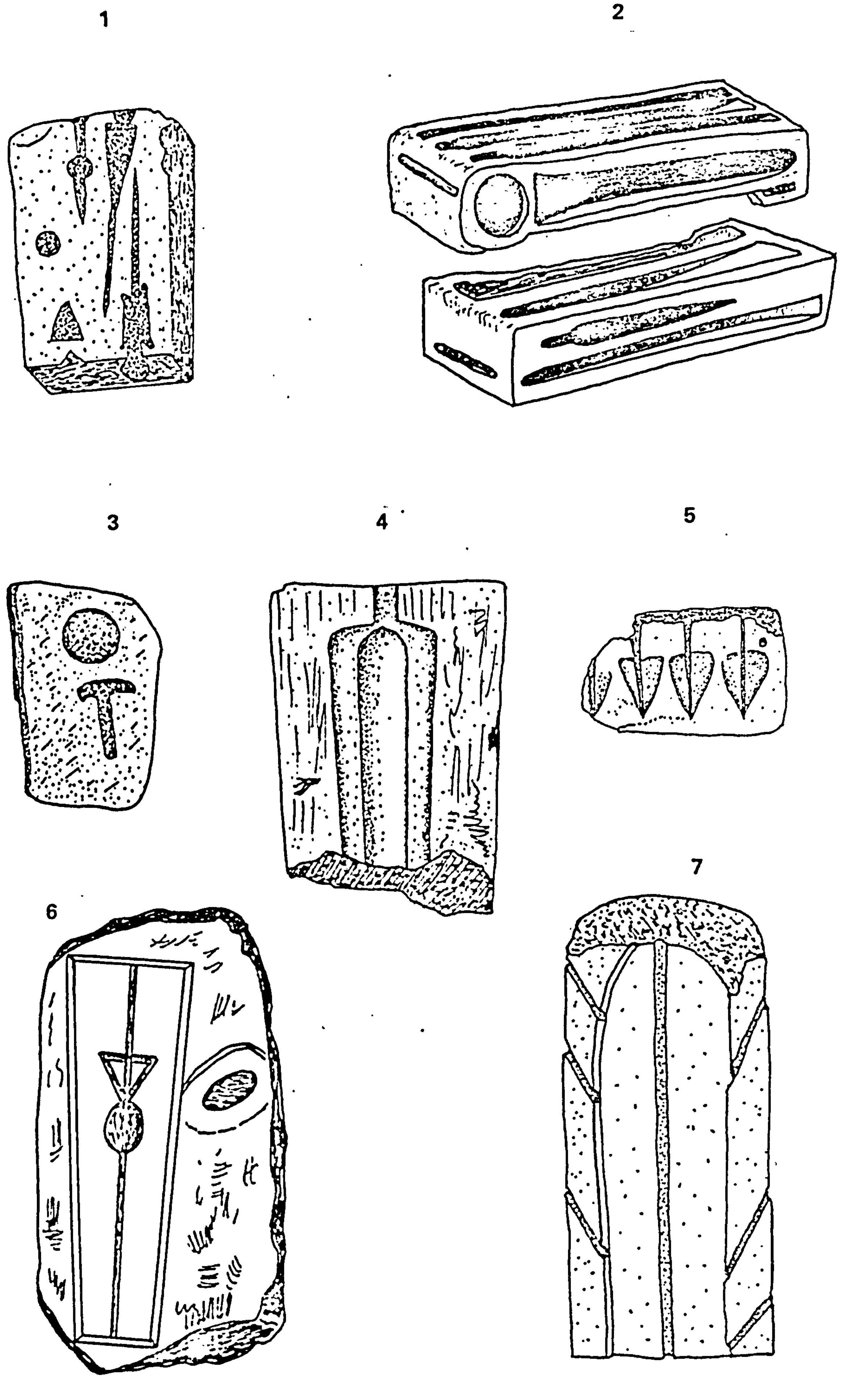
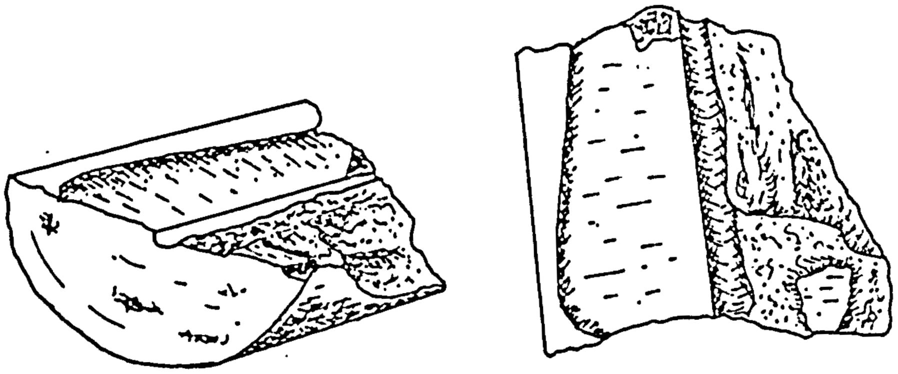


FIGURE 17

1



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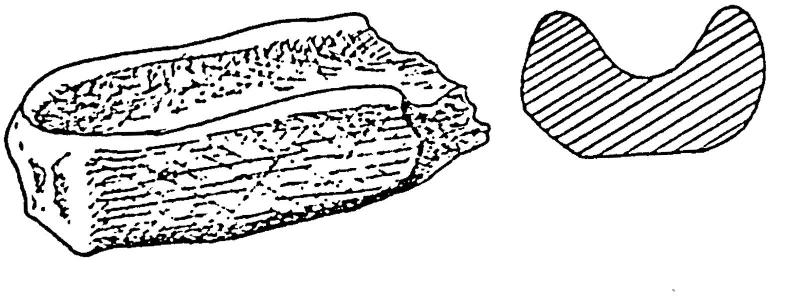

FIGURE 18

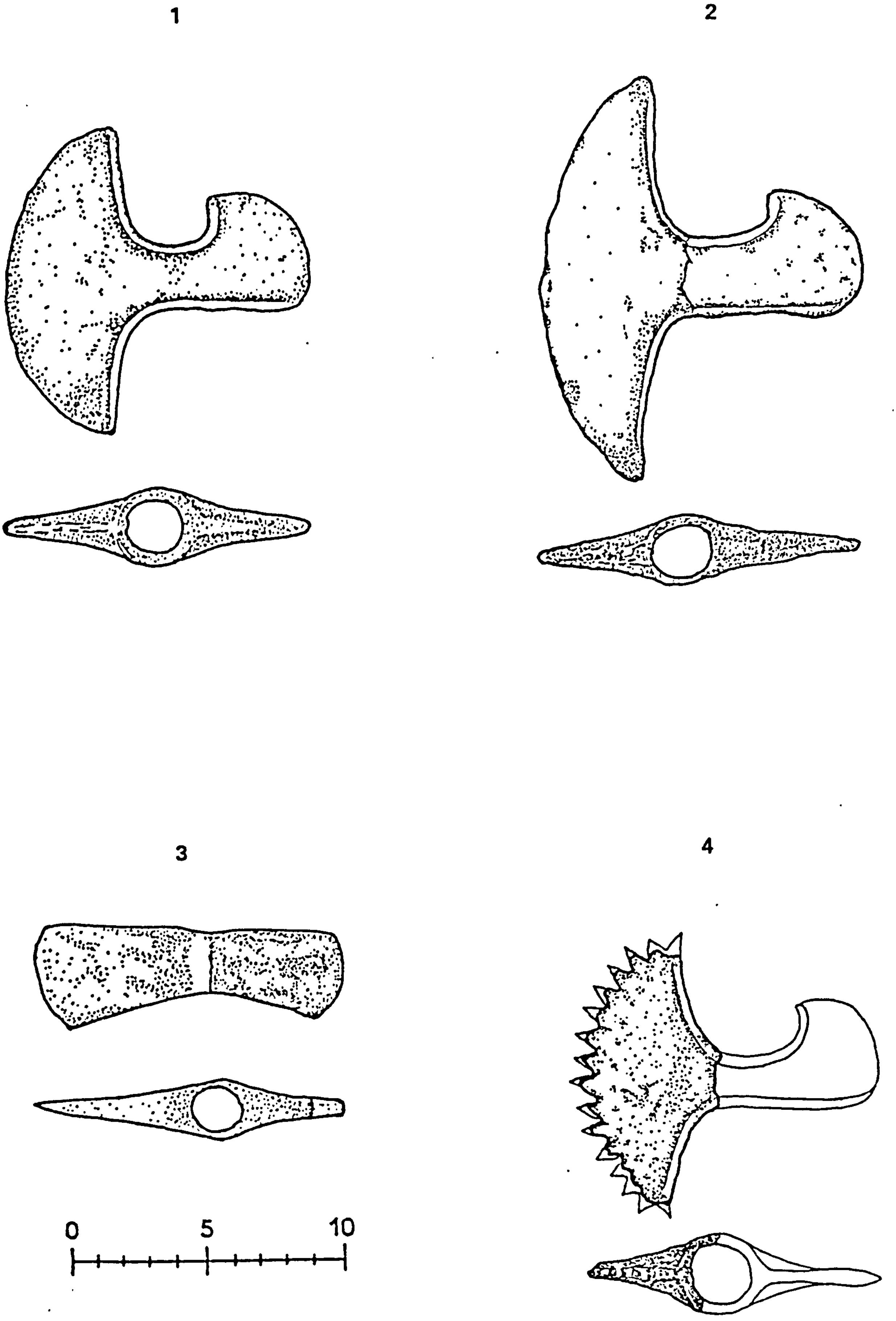

FIGURE 19

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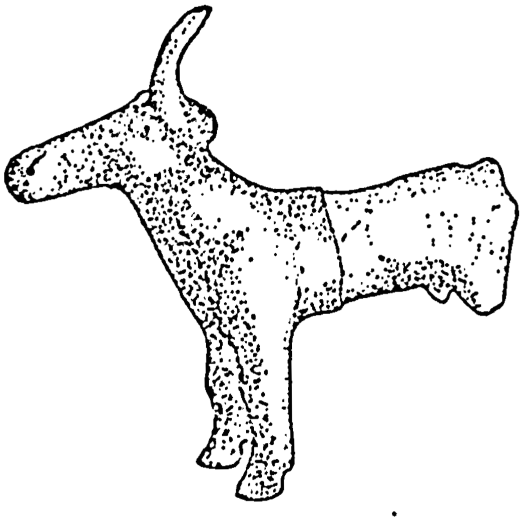

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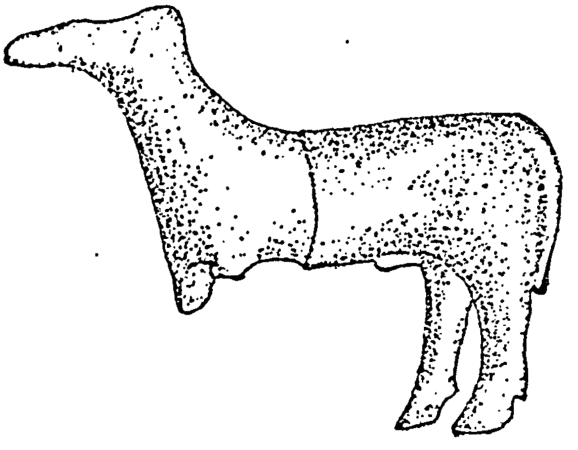

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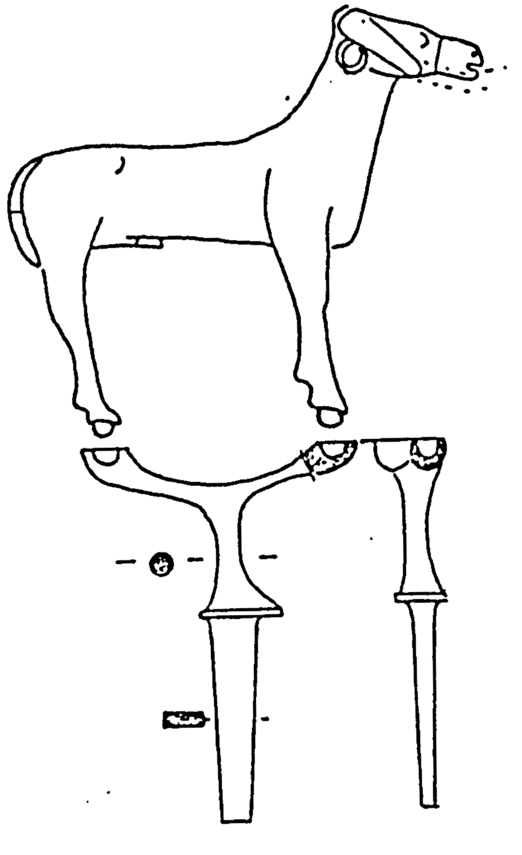

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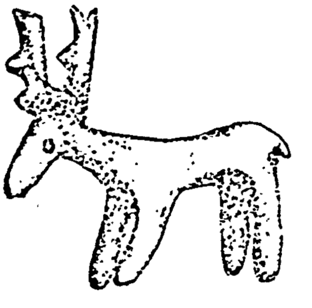
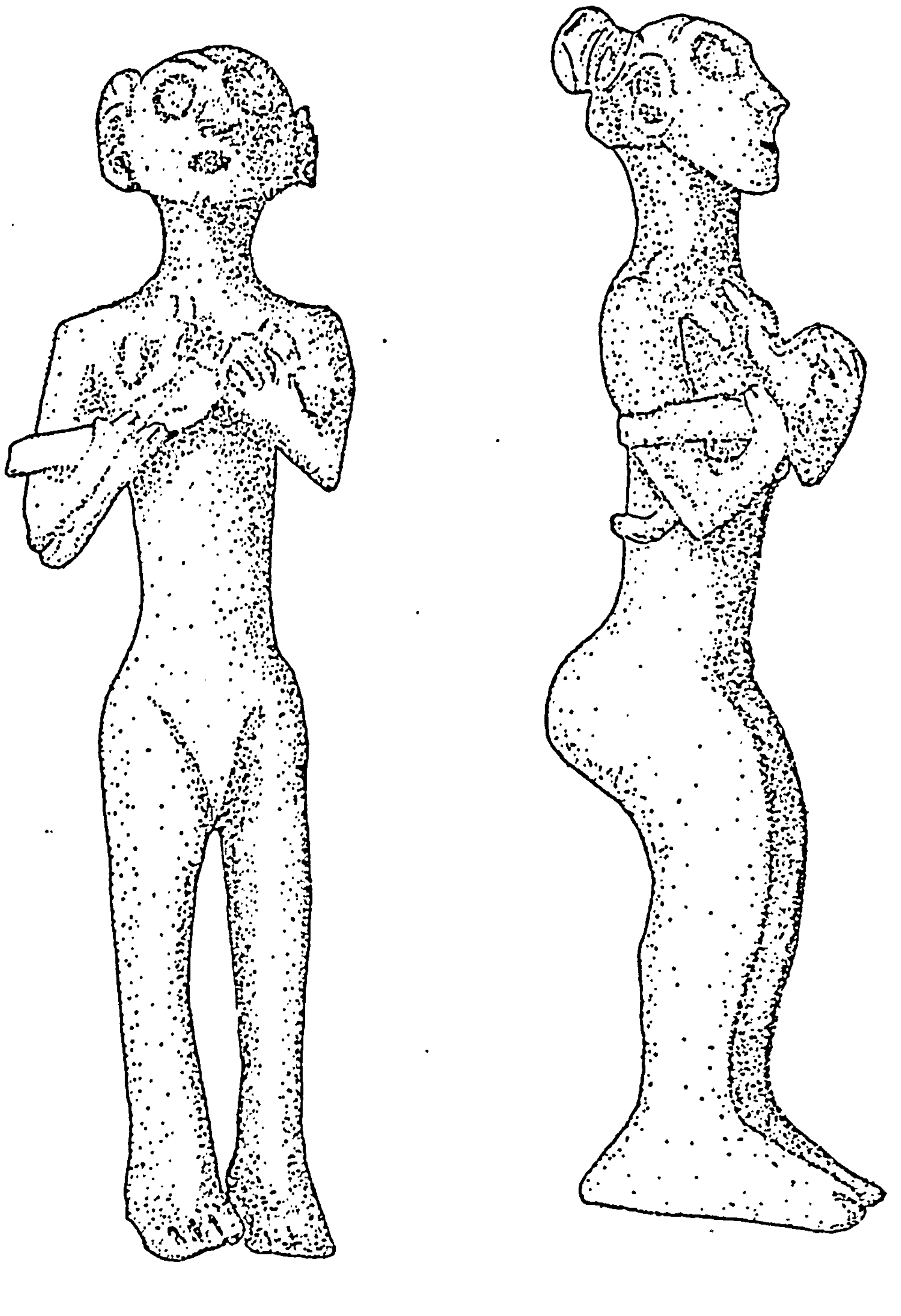


FIGURE 20



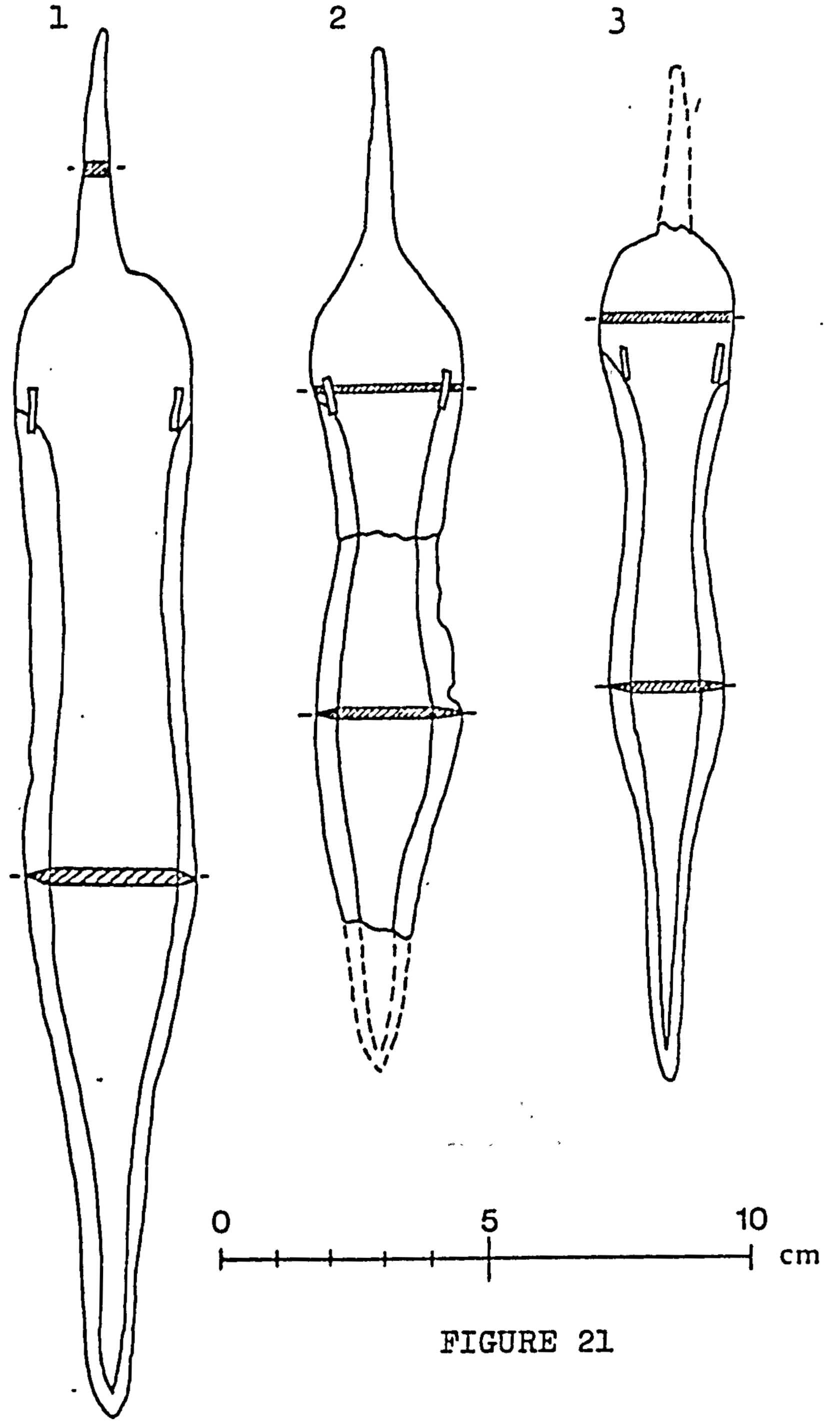
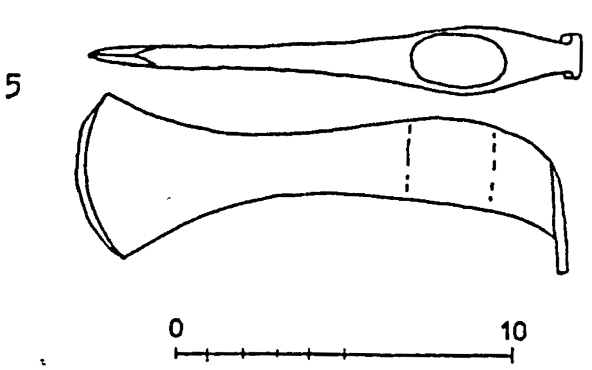
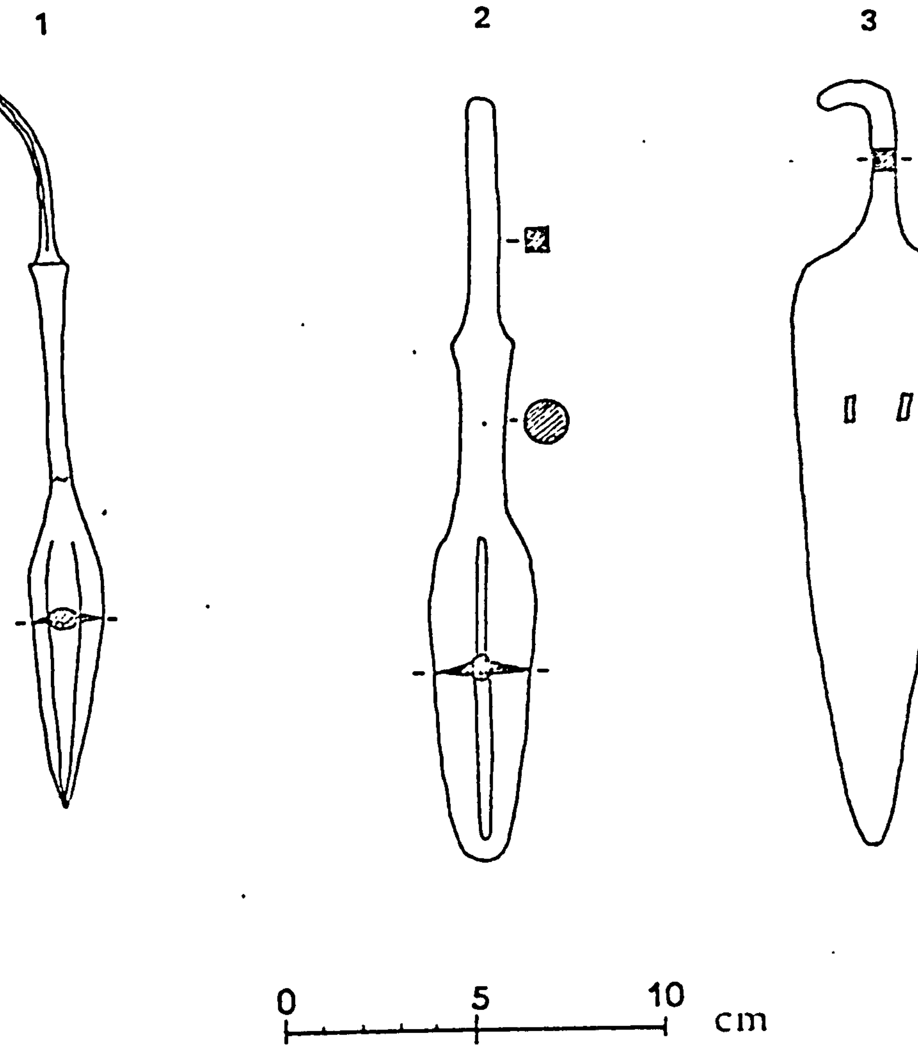


FIGURE 21




1
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cm

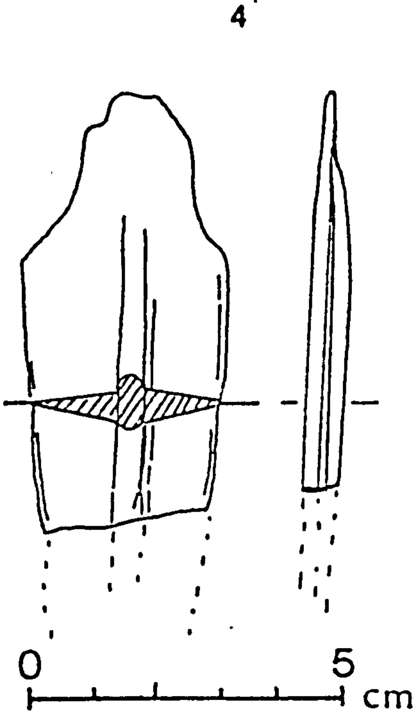
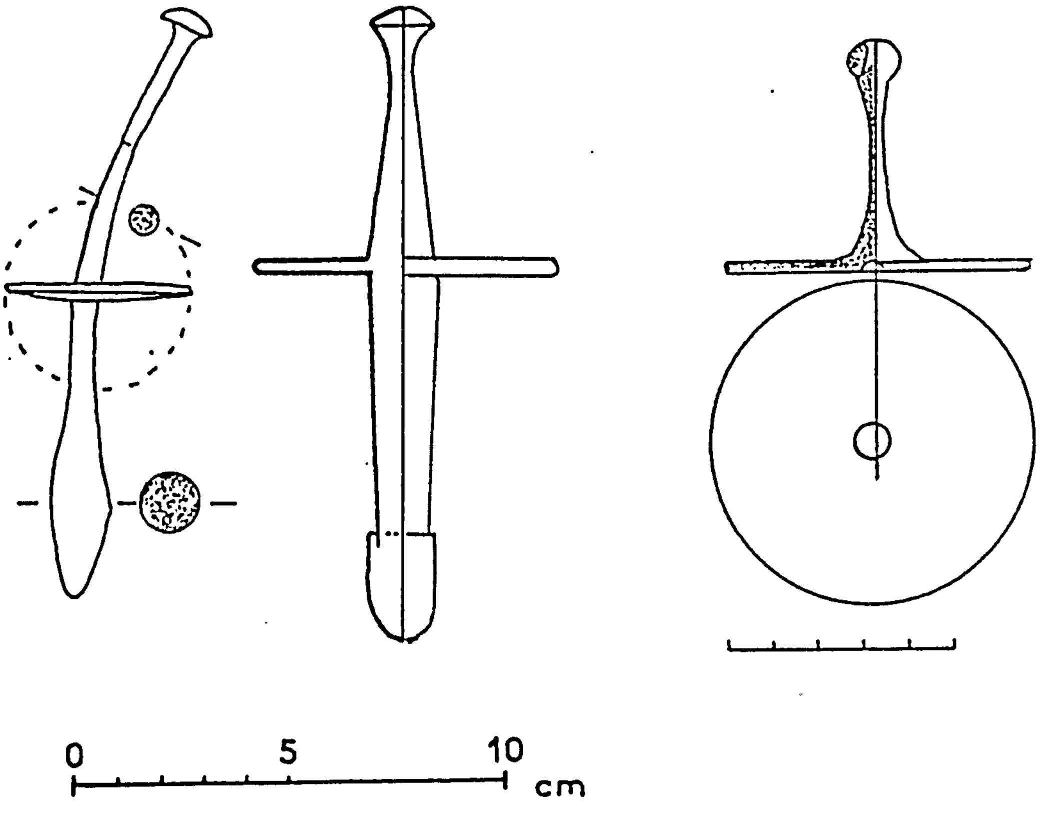

4
0
5
cm

FIGURE 23

1 2 3



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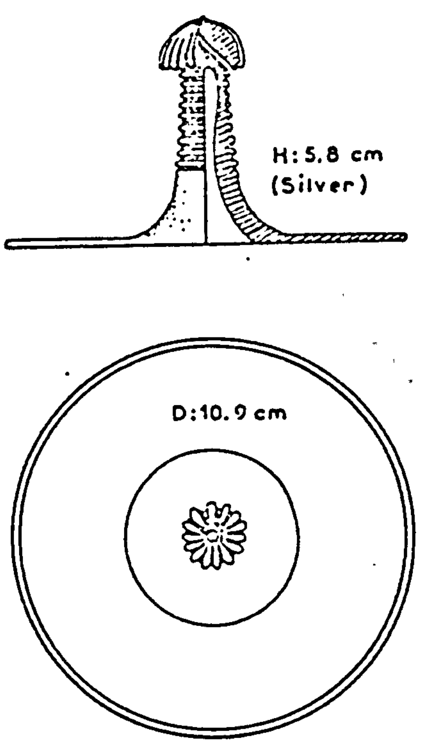


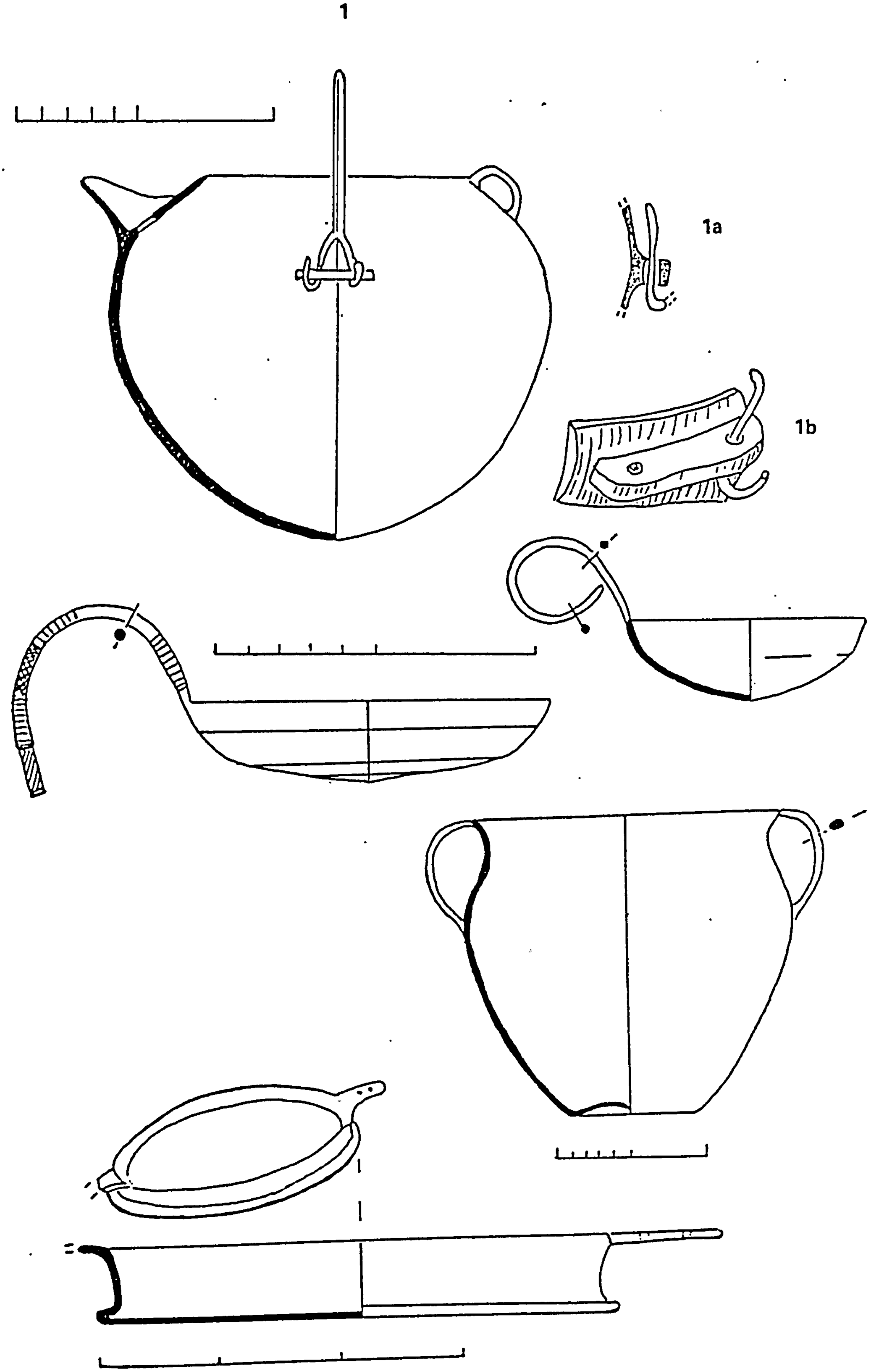

1
1a
1b

FIGURE 25

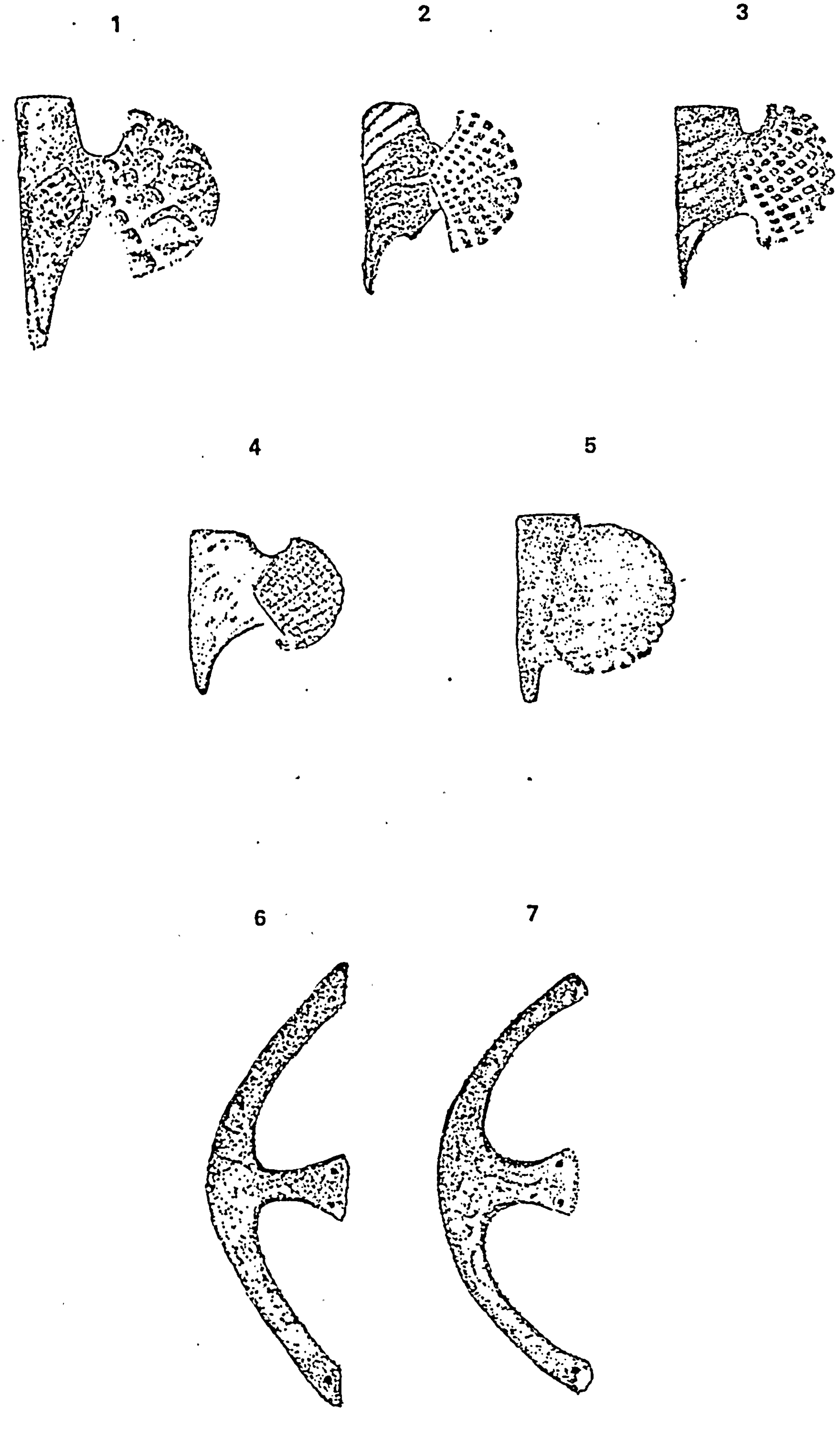
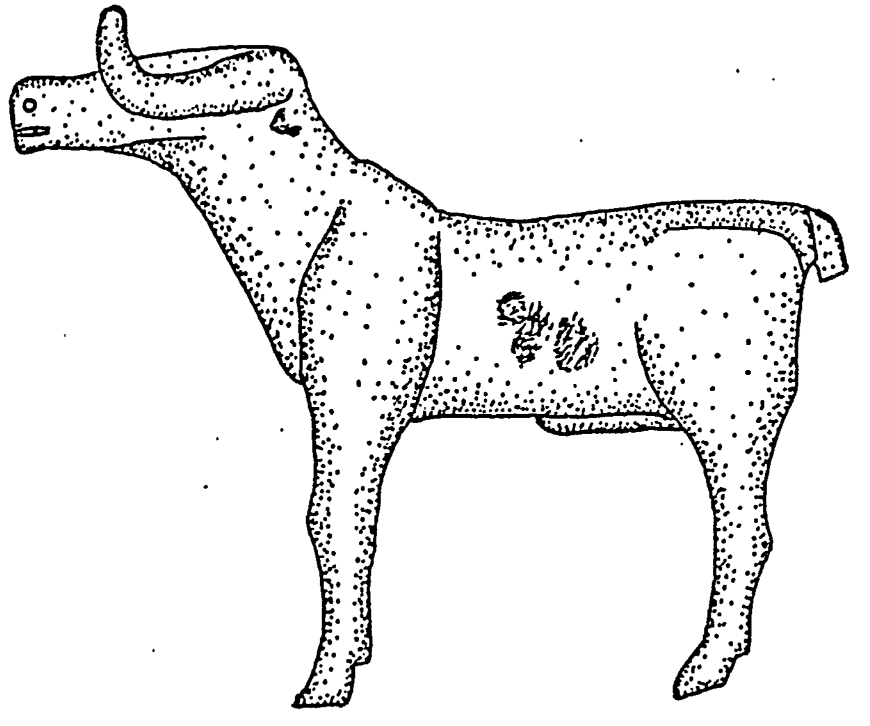


FIGURE 26

1



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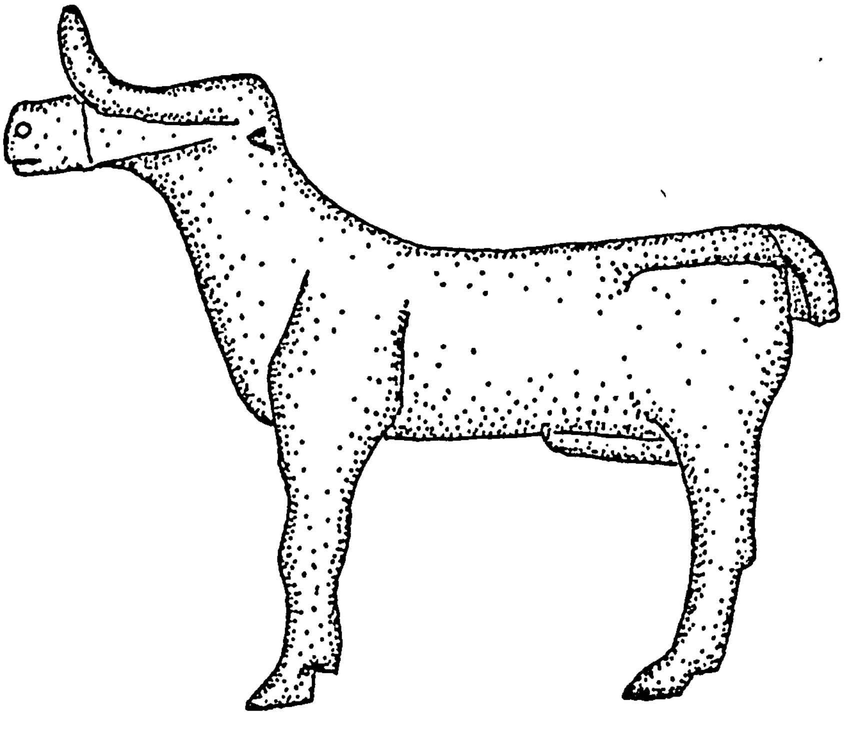

FIGURE 27

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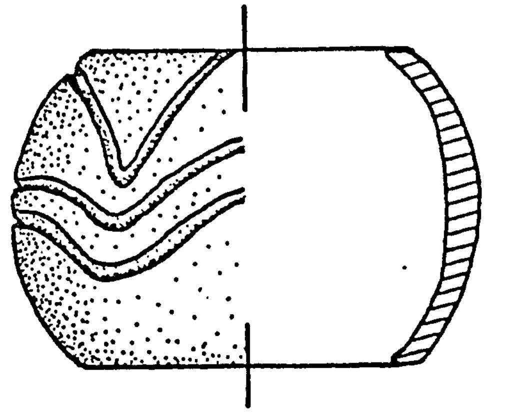

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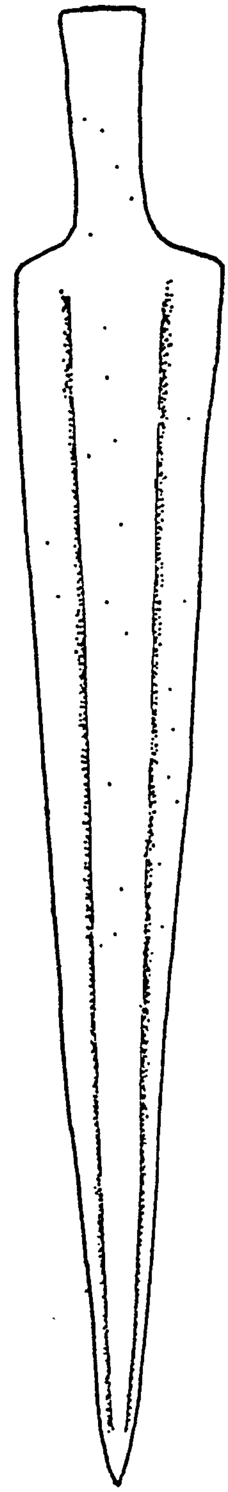

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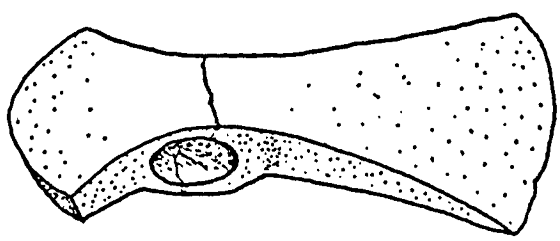

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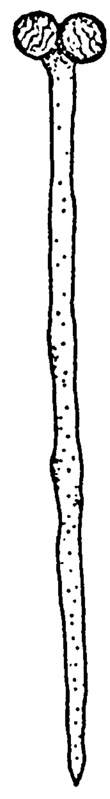


FIGURE 28

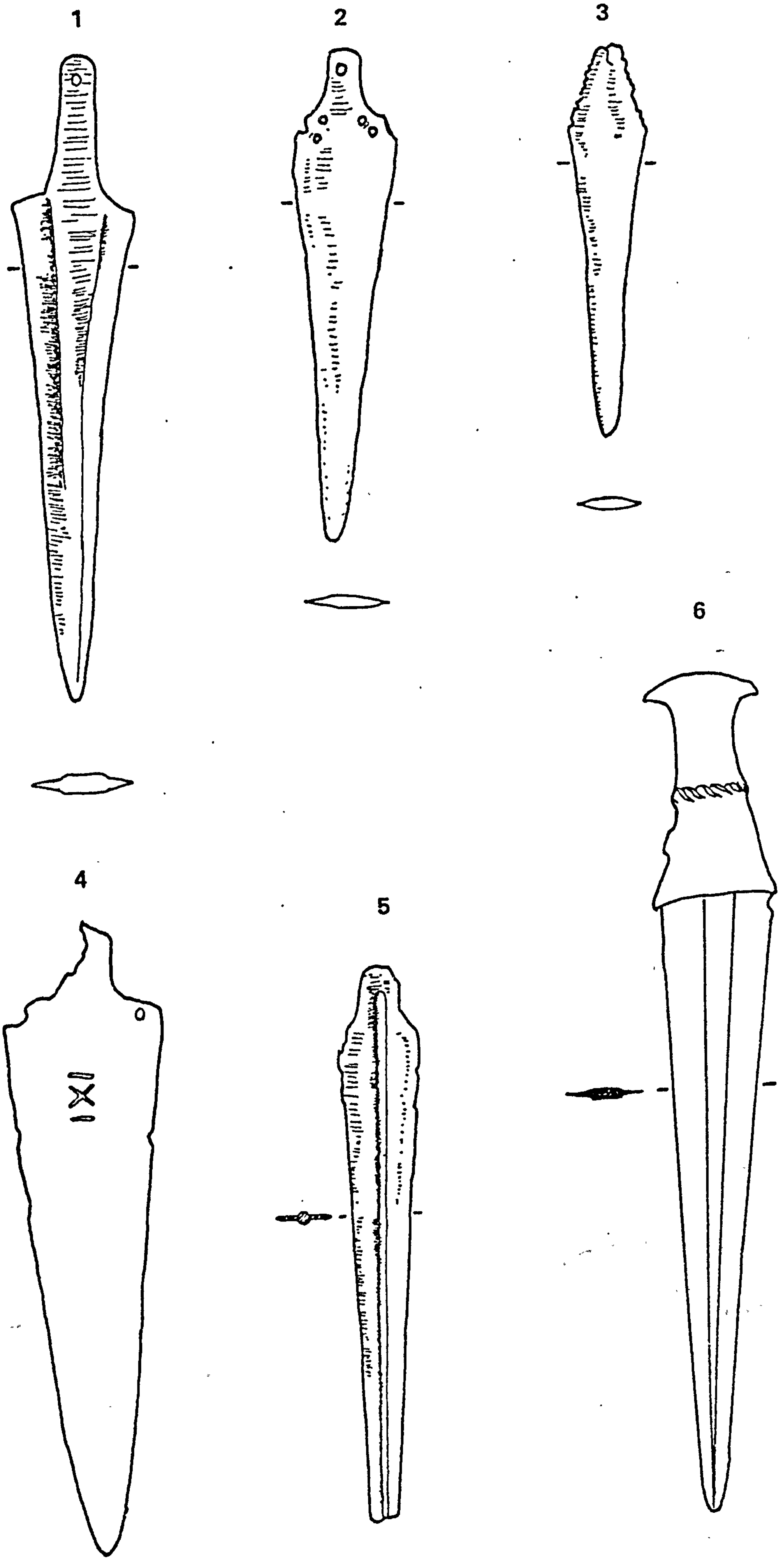


FIGURE 29

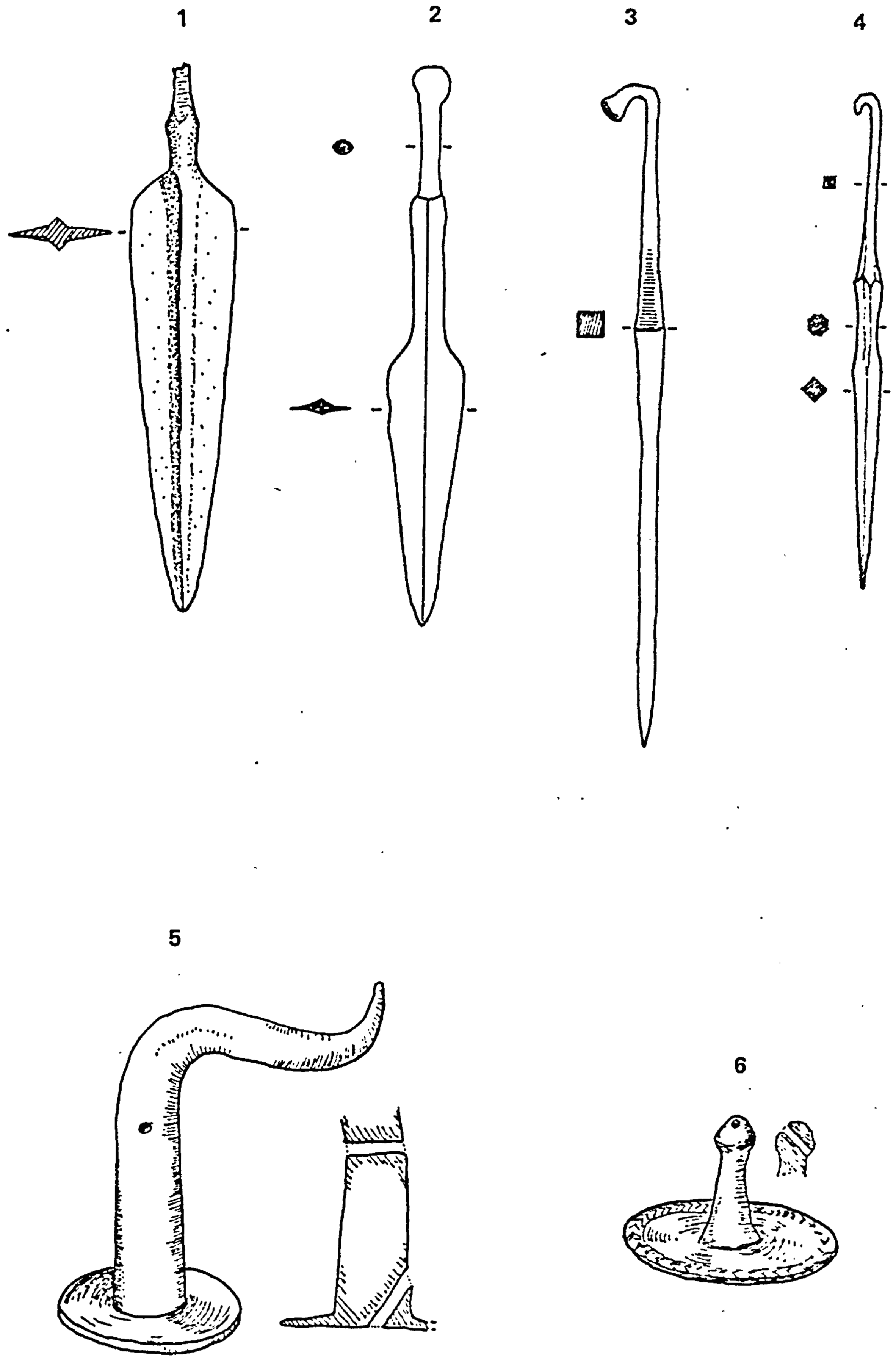


FIGURE 30

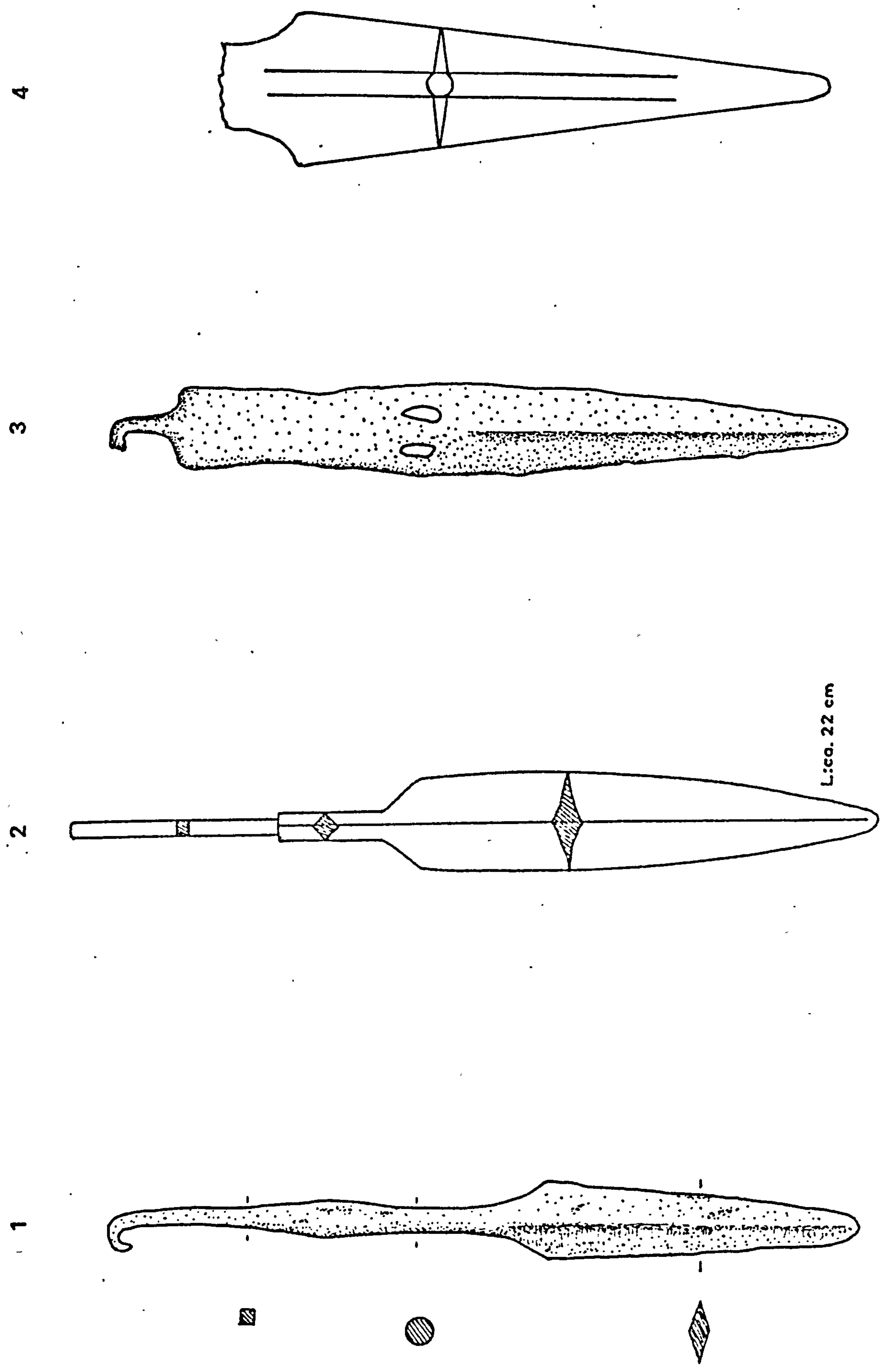
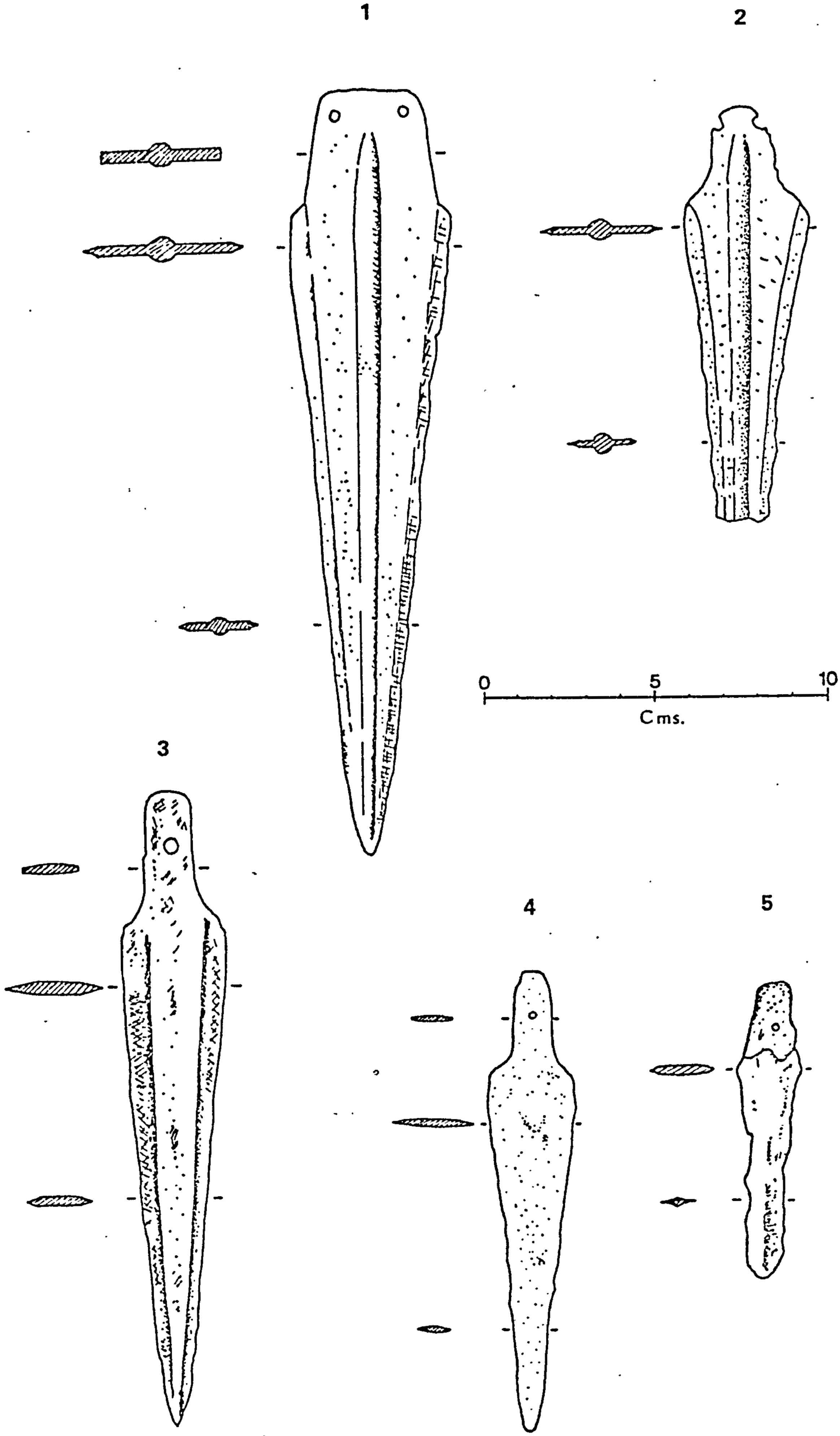


FIGURE 31



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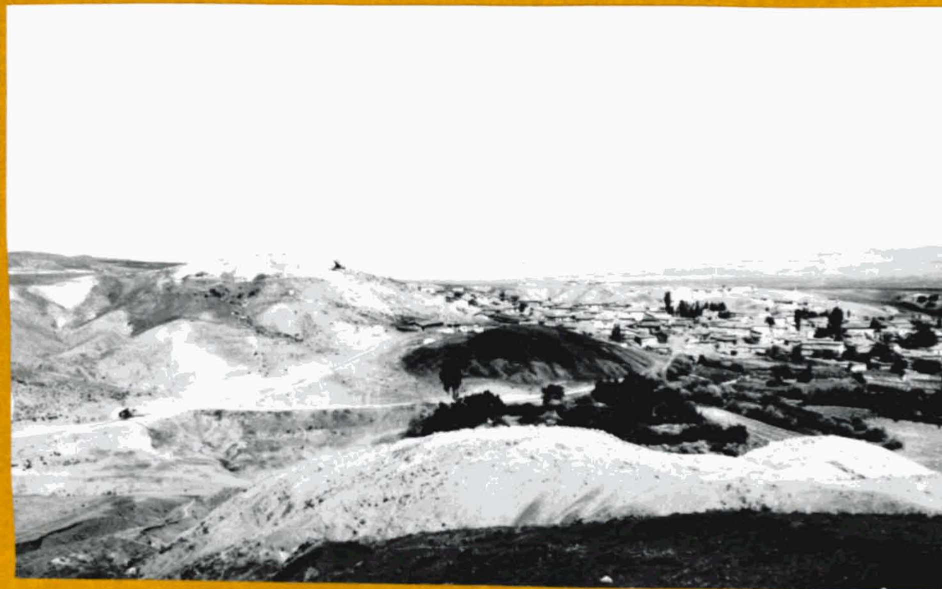

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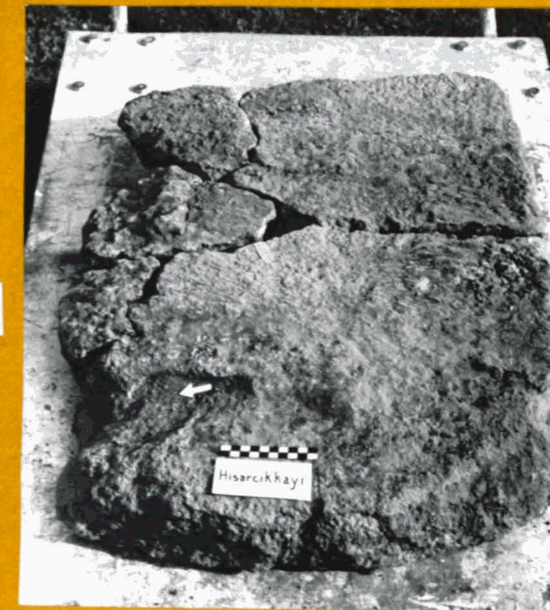

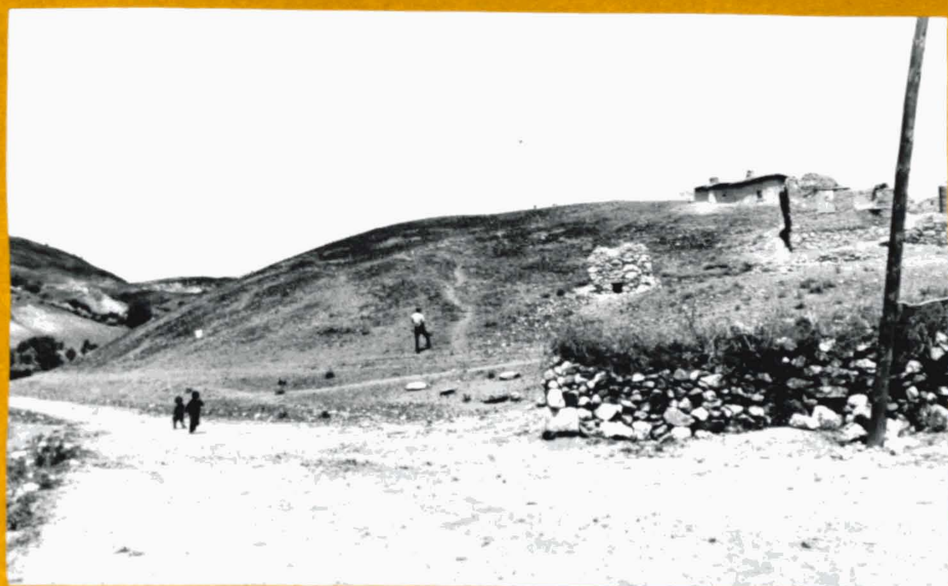

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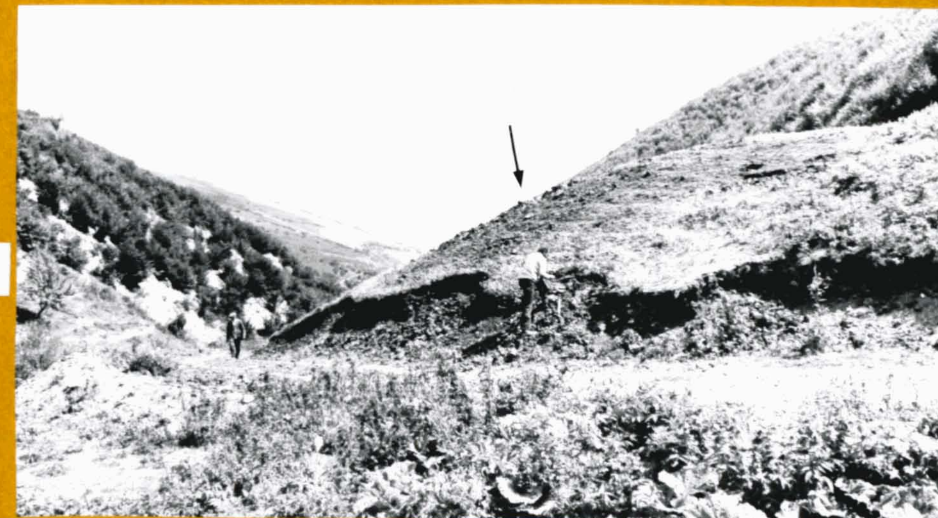
PLATE I

1

2



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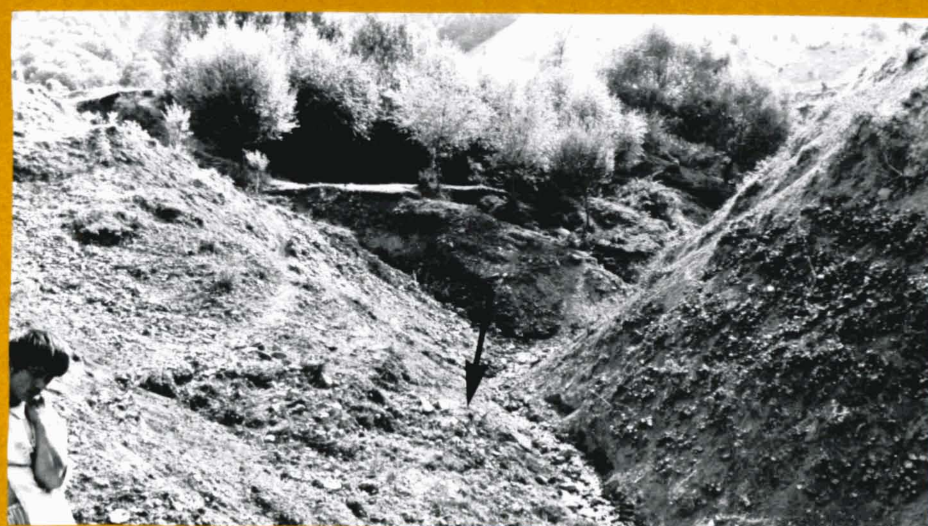

PLATE II

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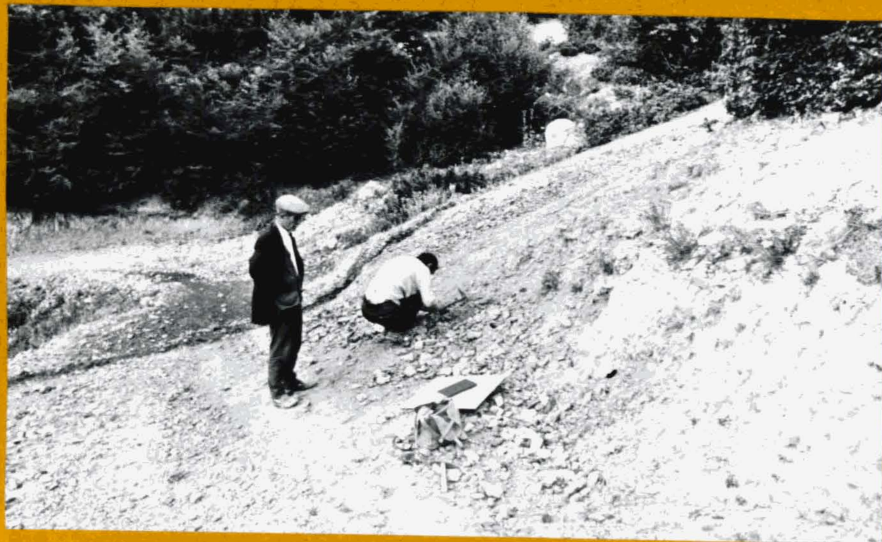

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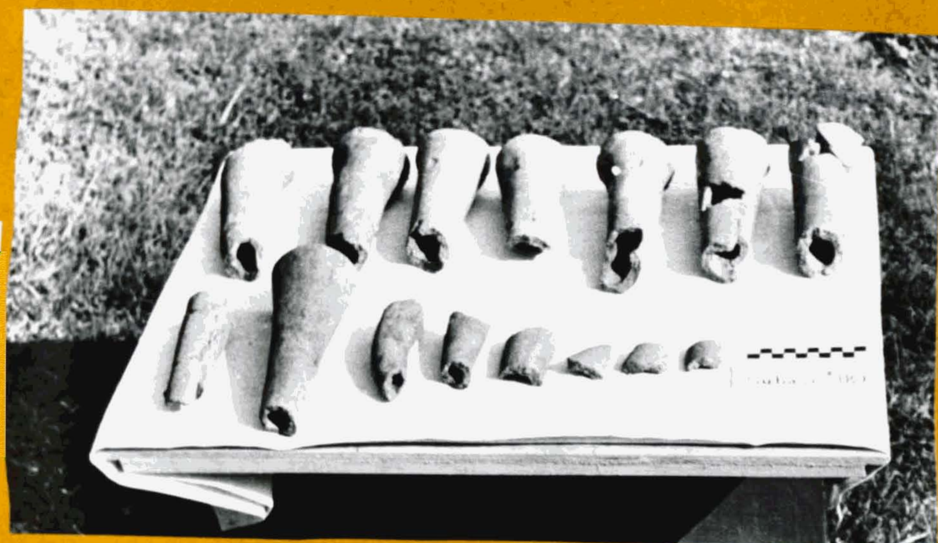

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PLATE III

1

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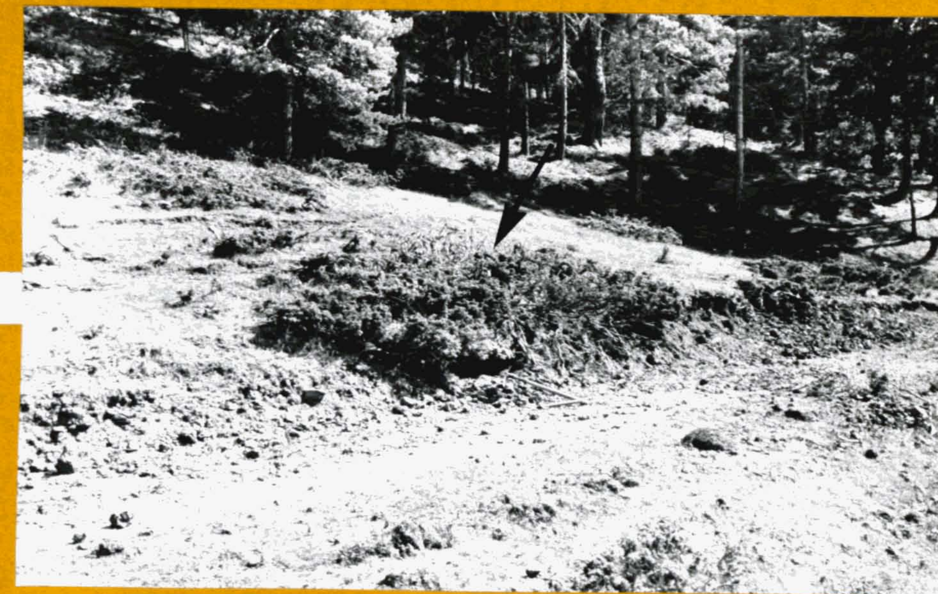

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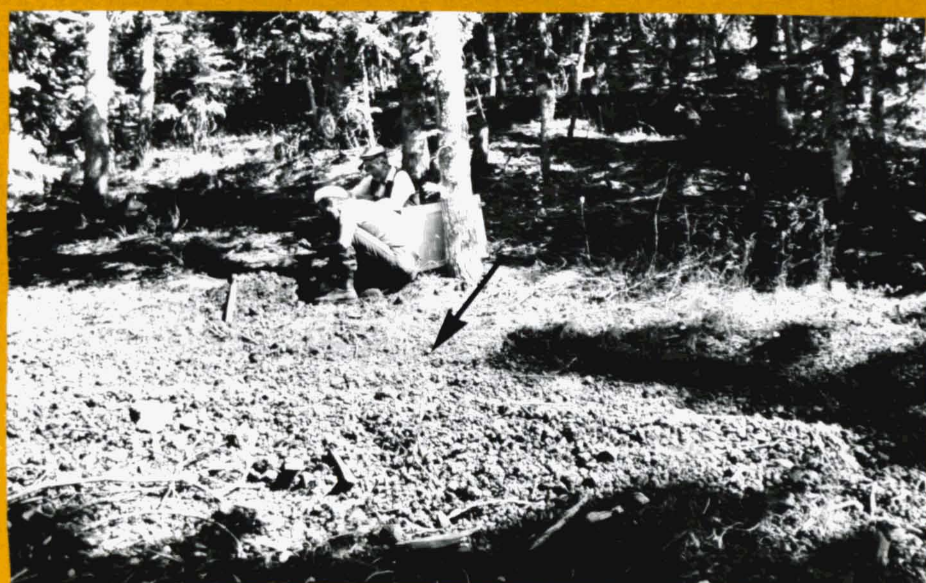

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PLATE IV

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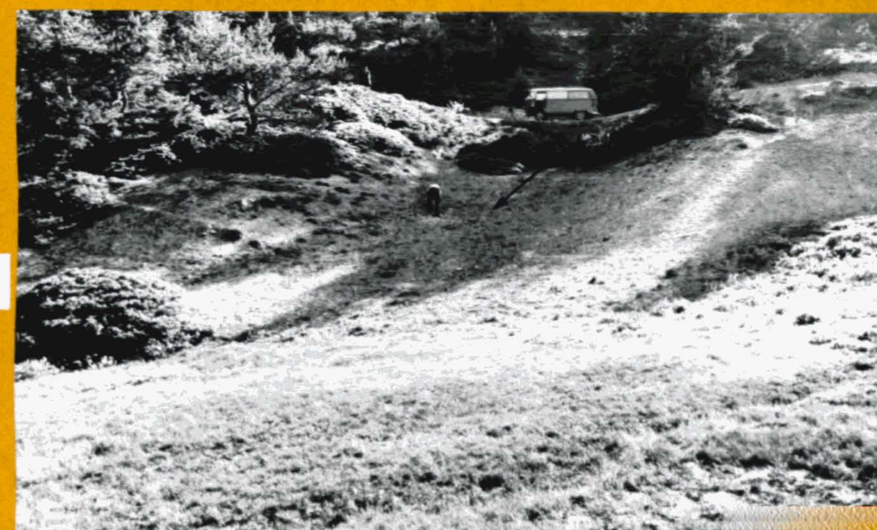

PLATE V

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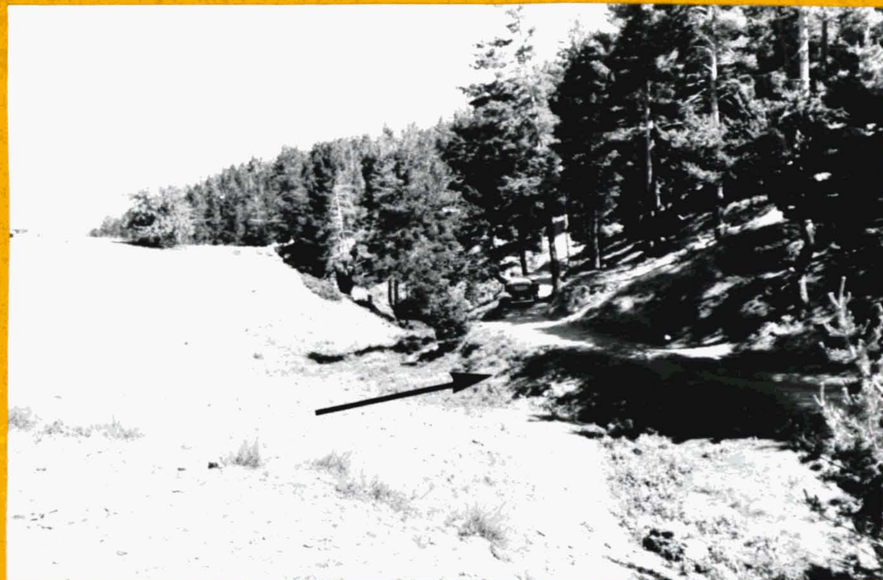

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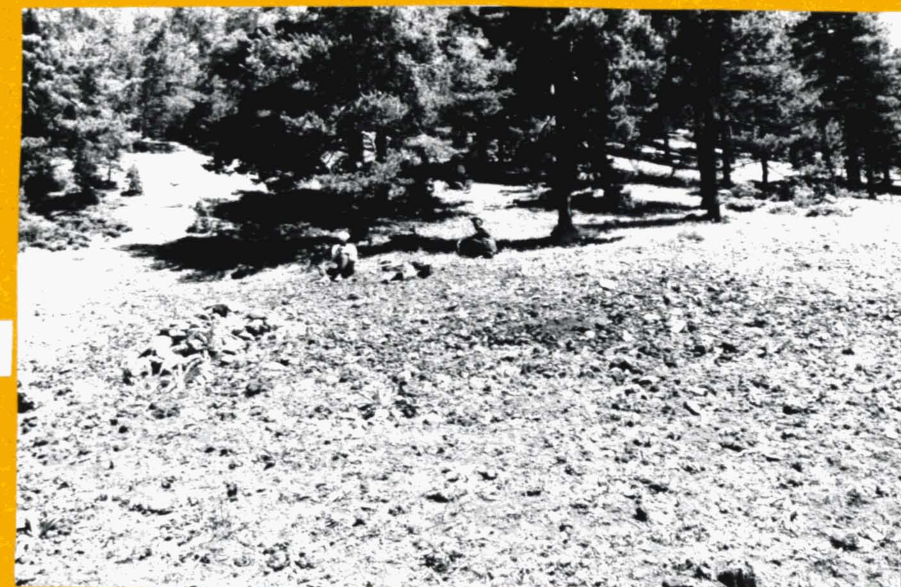

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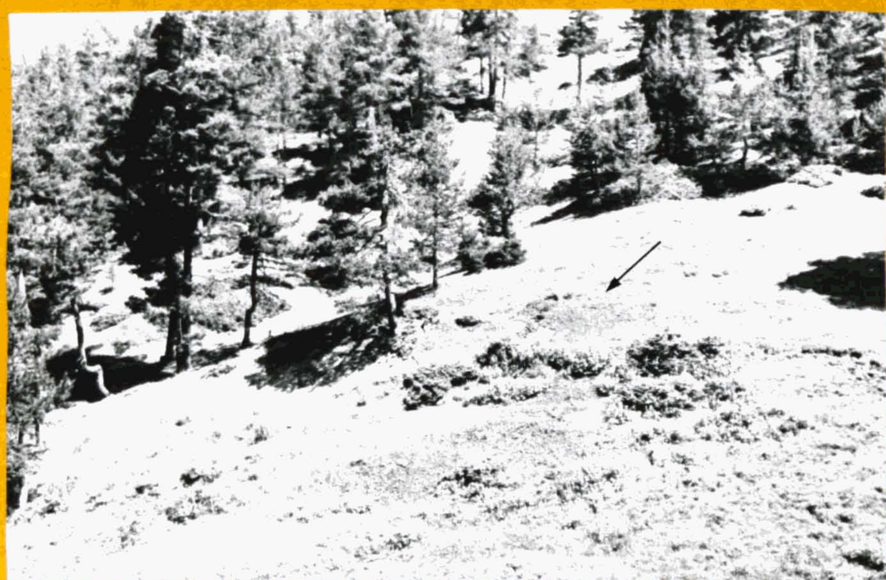
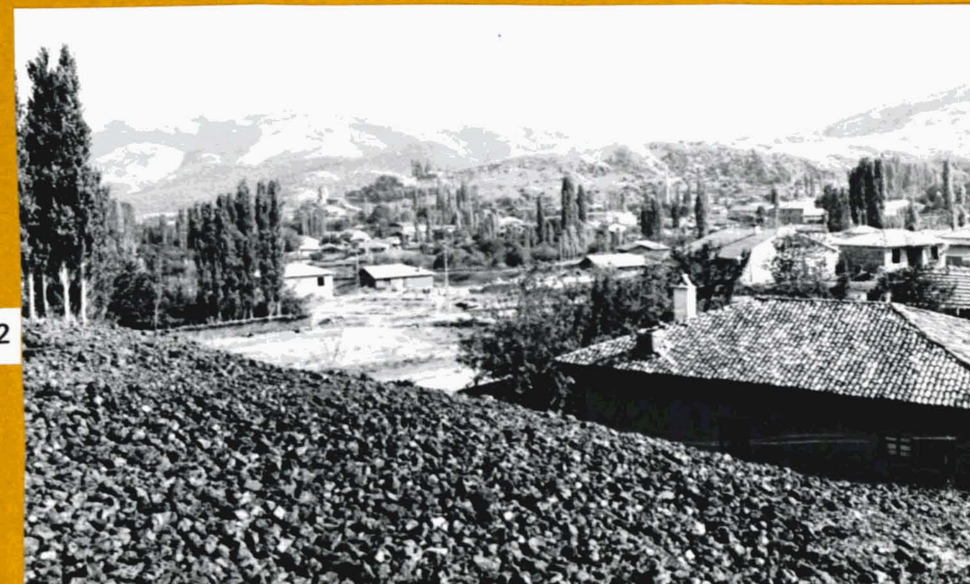


PLATE VI

1

2



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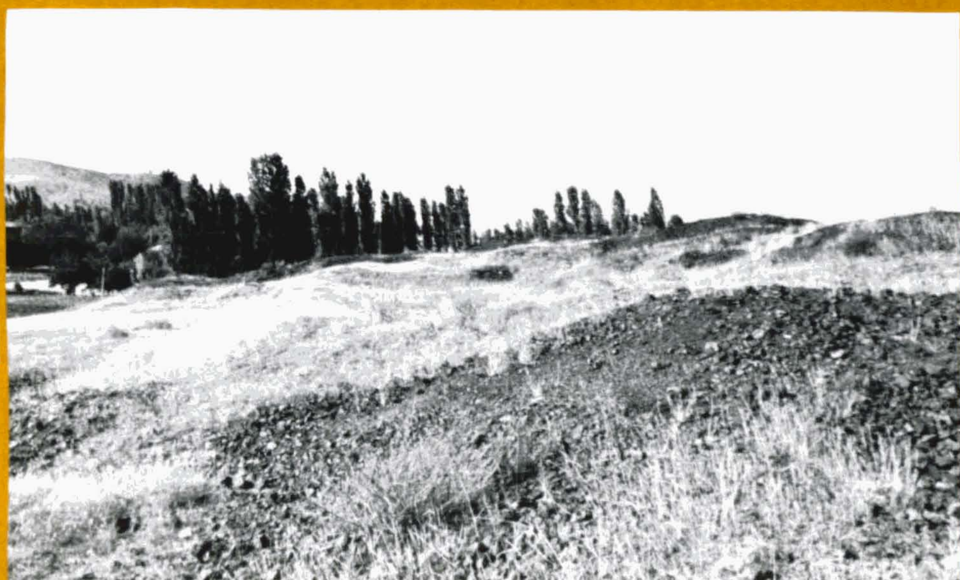

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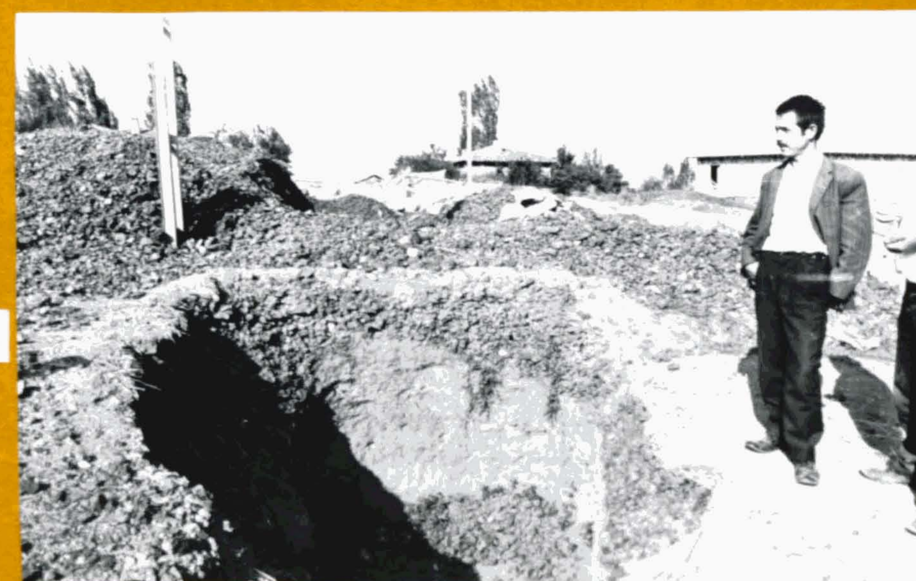

PLATE VII

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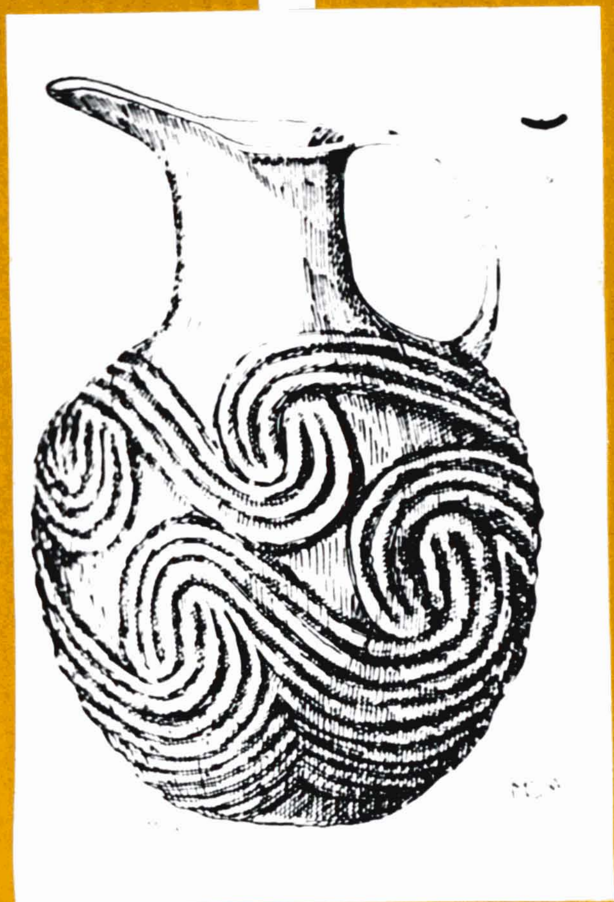

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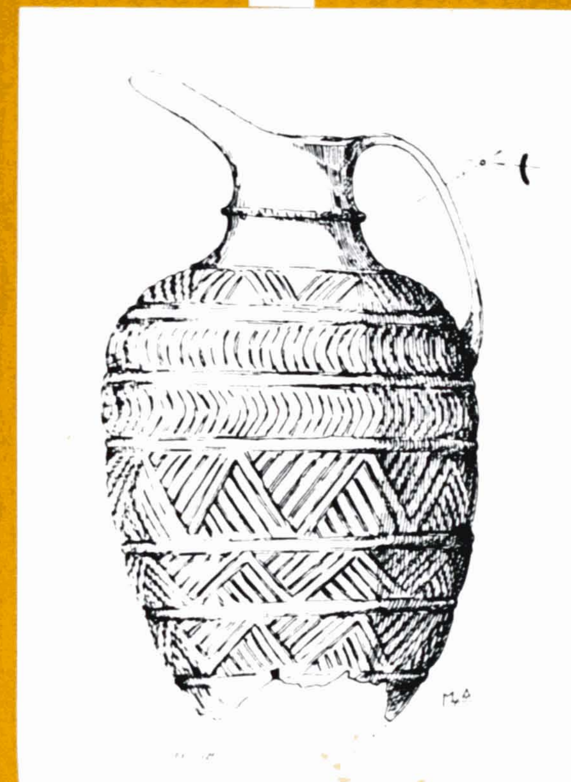

PLATE VIII

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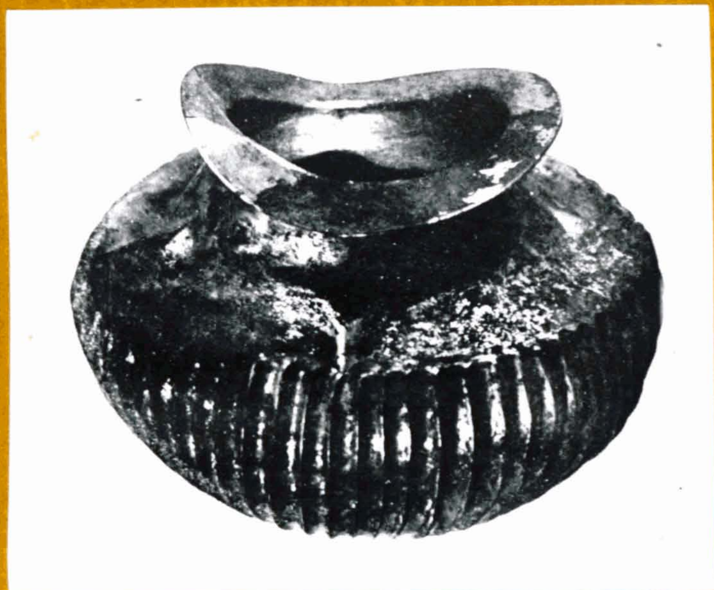

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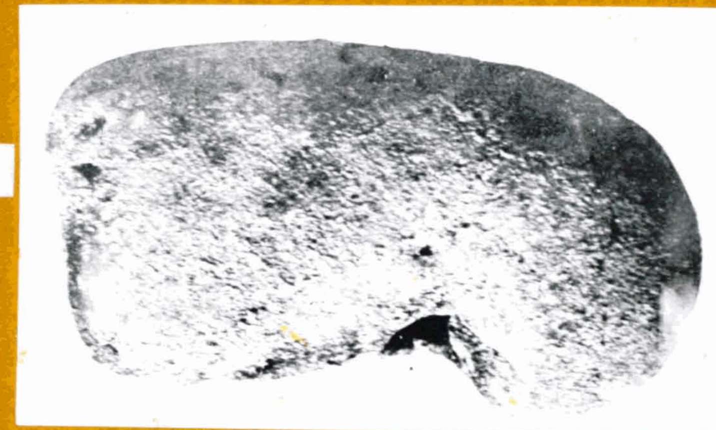

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4

5

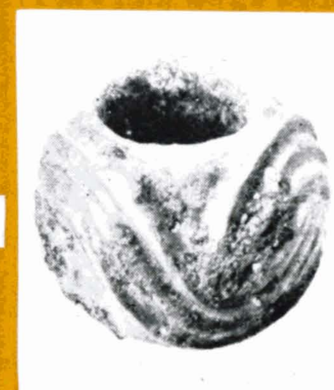

PLATE IX

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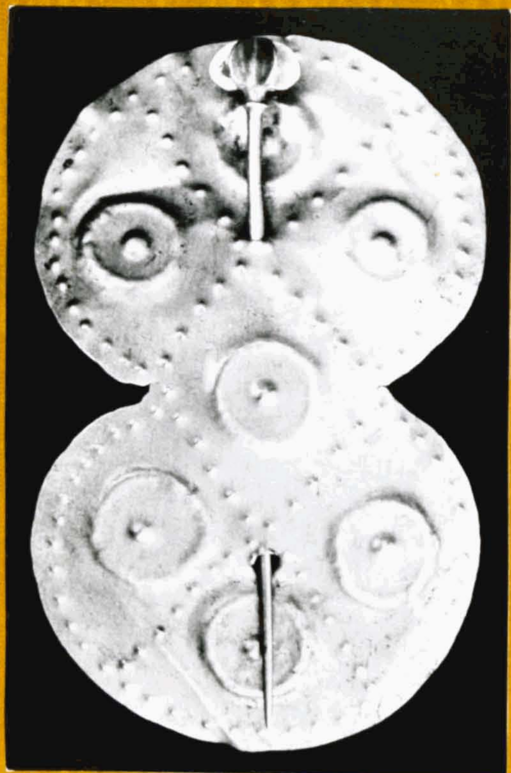

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PLATE X

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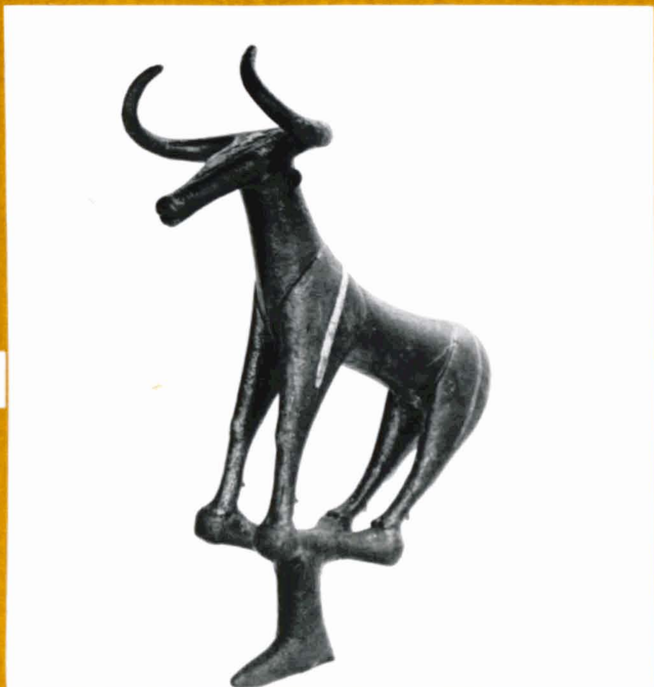

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PLATE XI

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PLATE XII

1

2

3a

3b

PLATE XIII

1

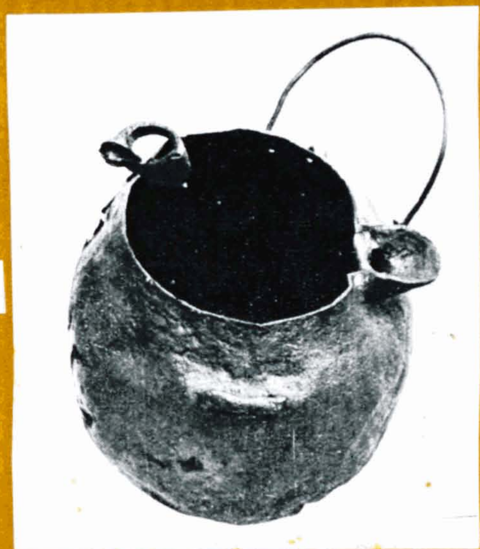

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PLATE XIV

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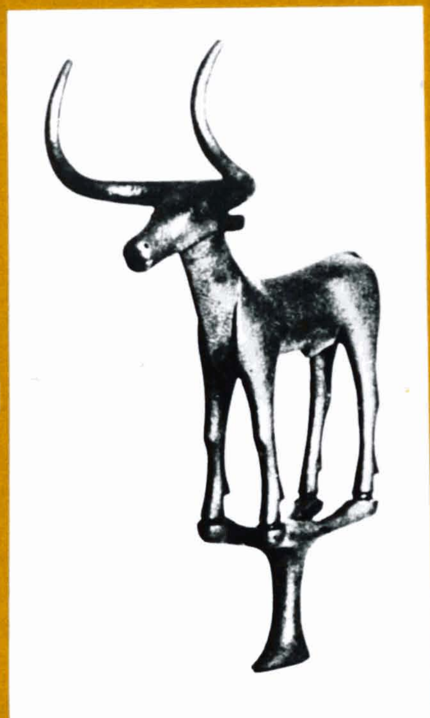

2a

2b

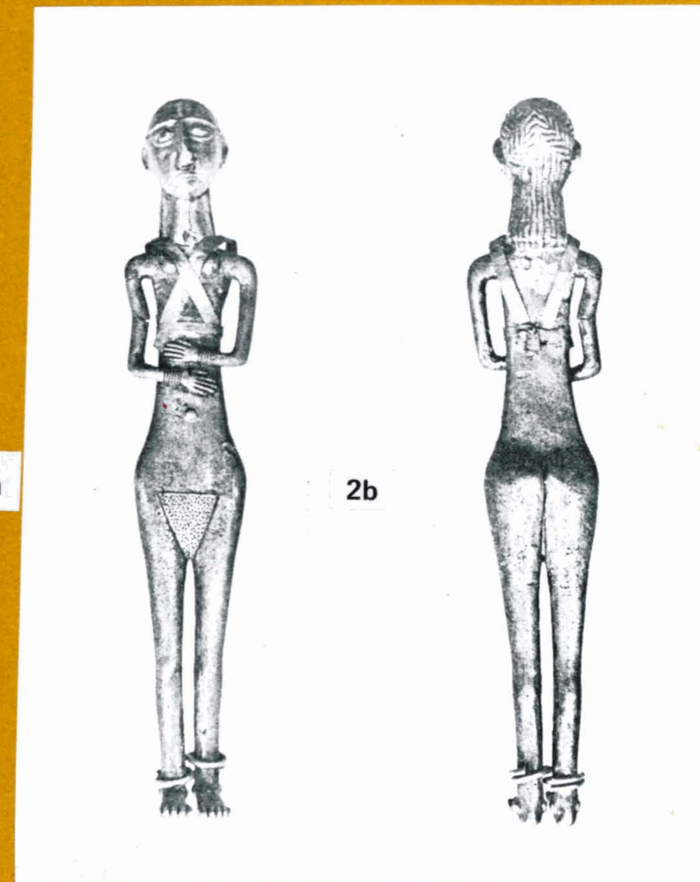

PLATE XV

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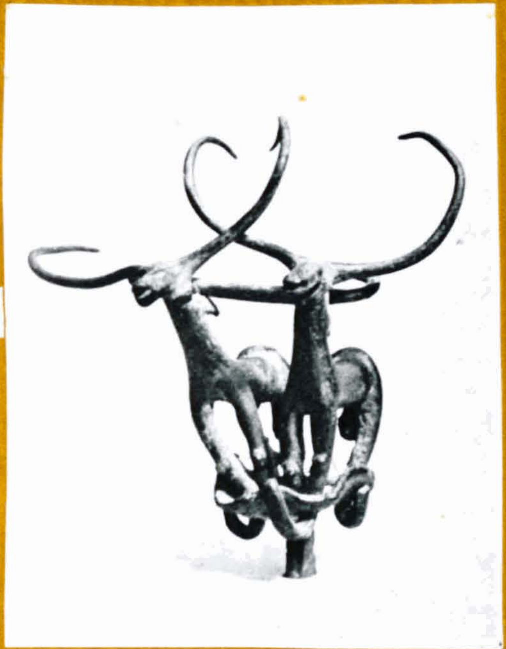
PLATE XVI

1



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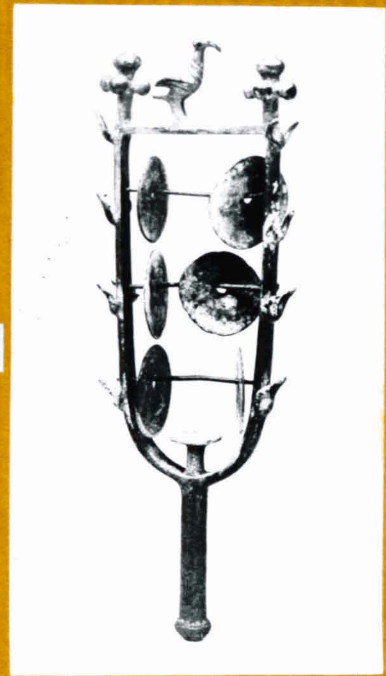

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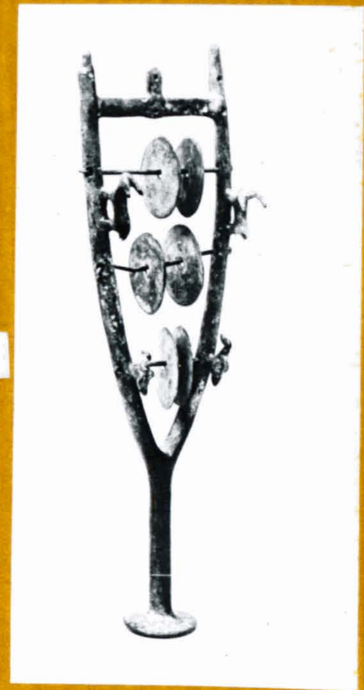
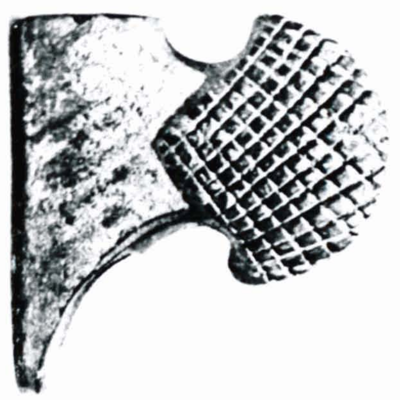


PLATE XVII

PLATE XVIII



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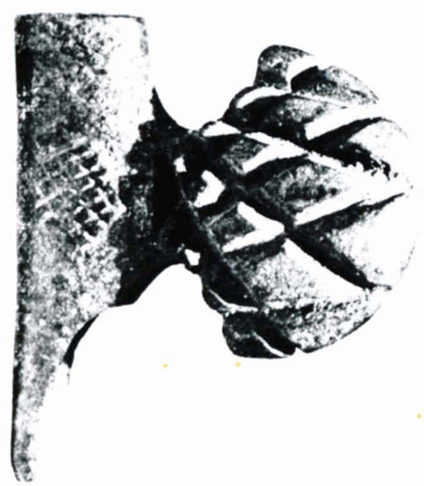

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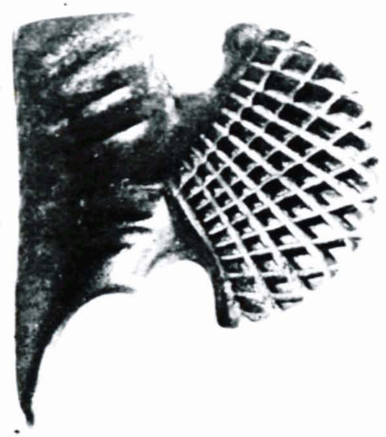

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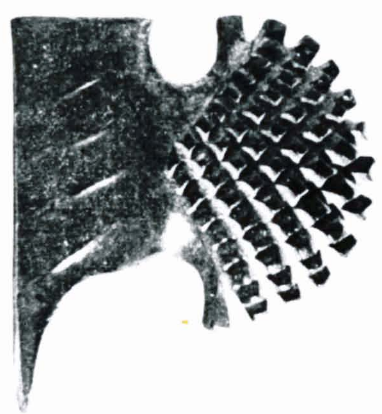

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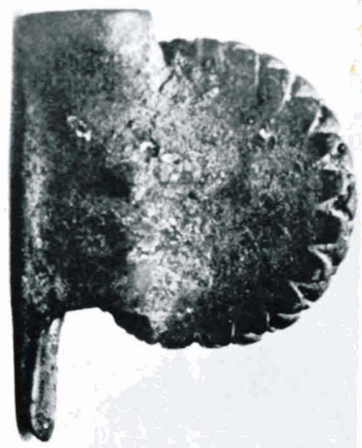

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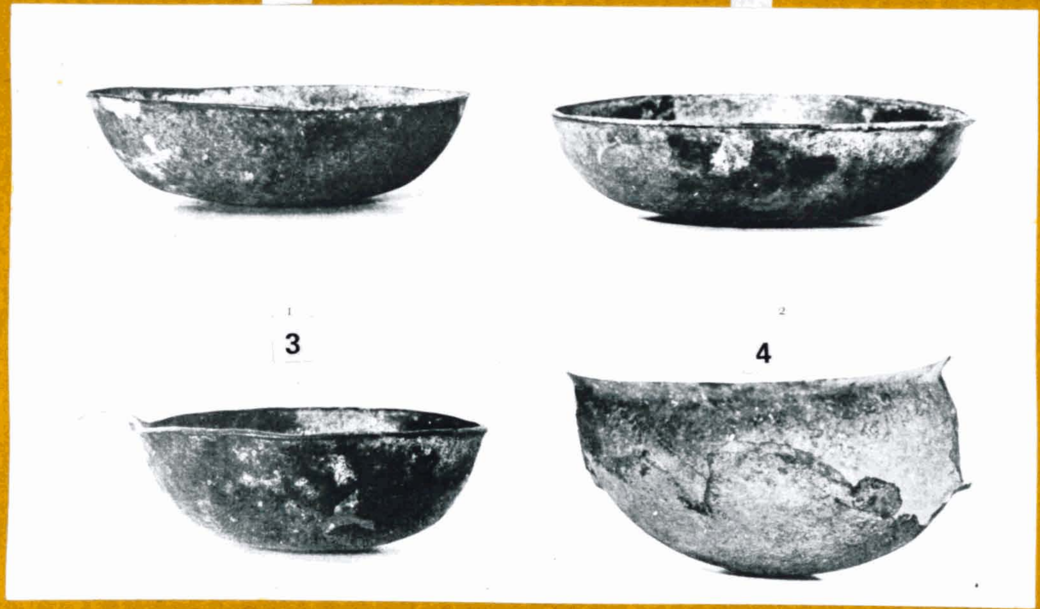

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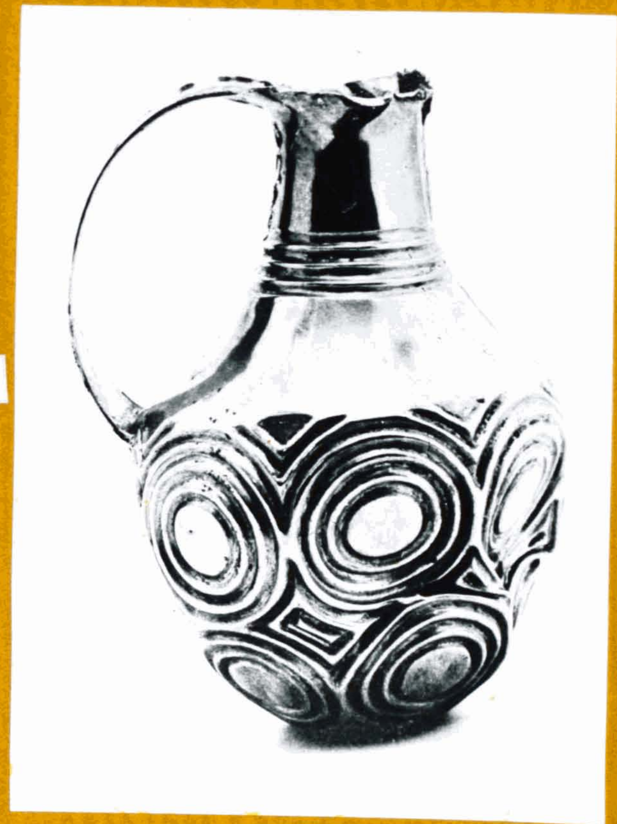

PLATE XIX

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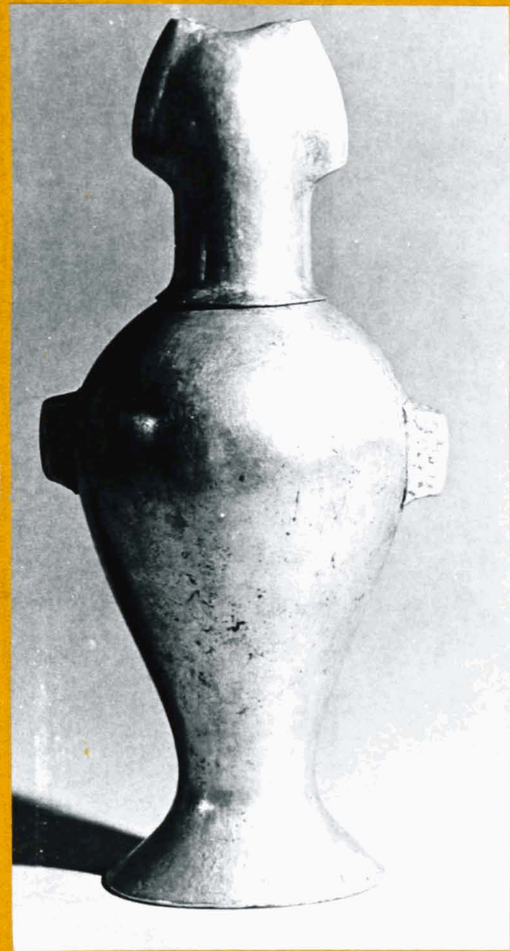

PLATE XX

1

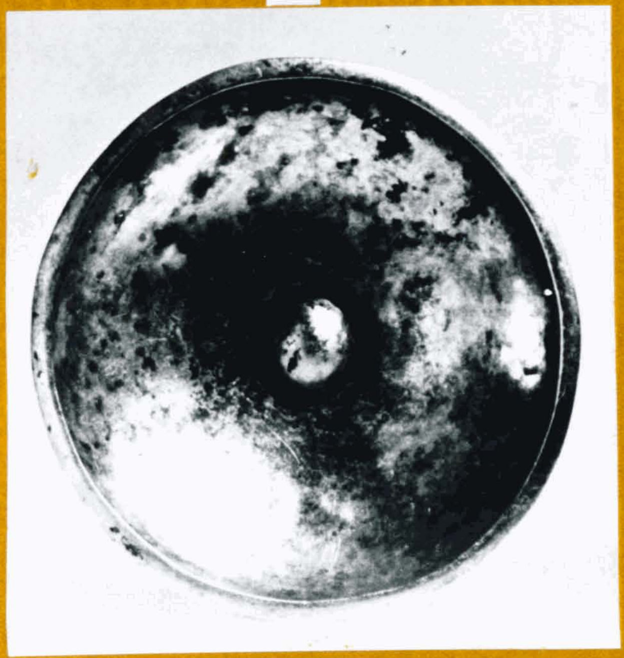

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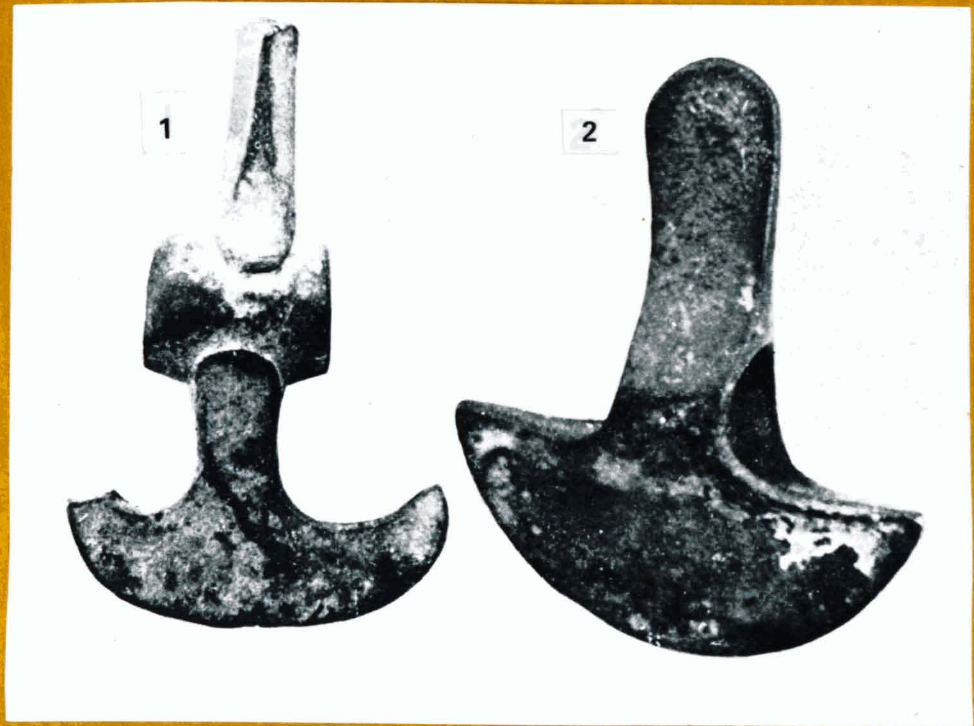
PLATE XXI



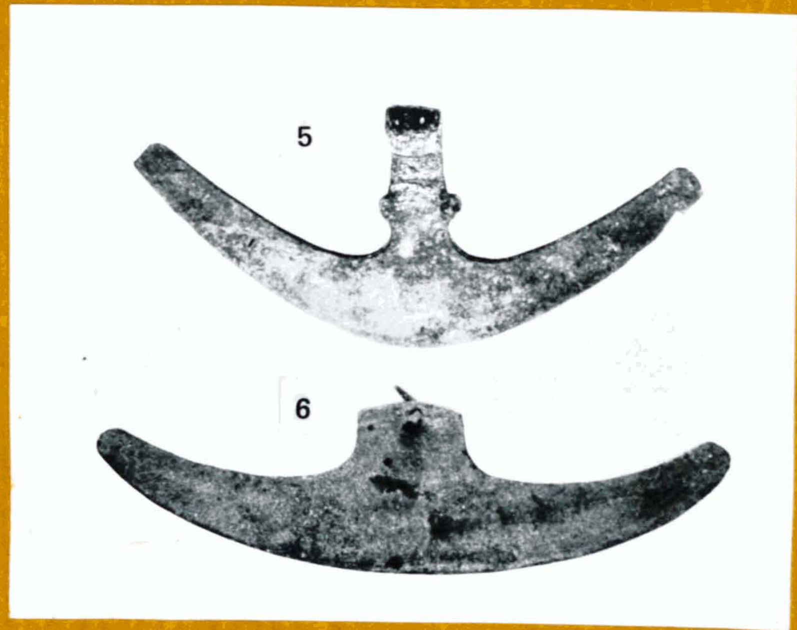


PLATE XXII

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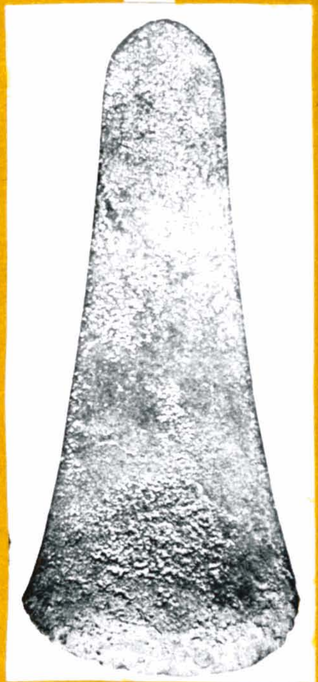

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PLATE XXIII

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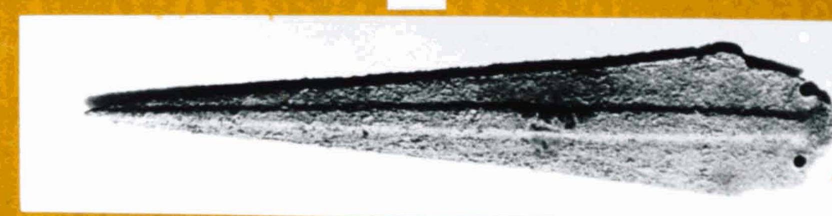

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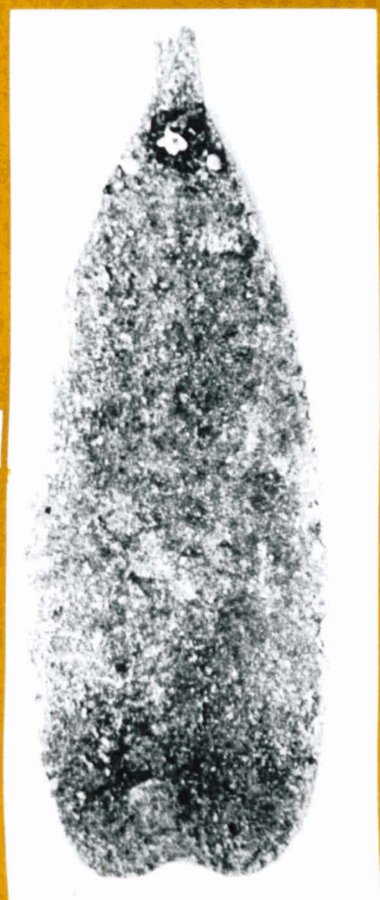

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PLATE XXIV

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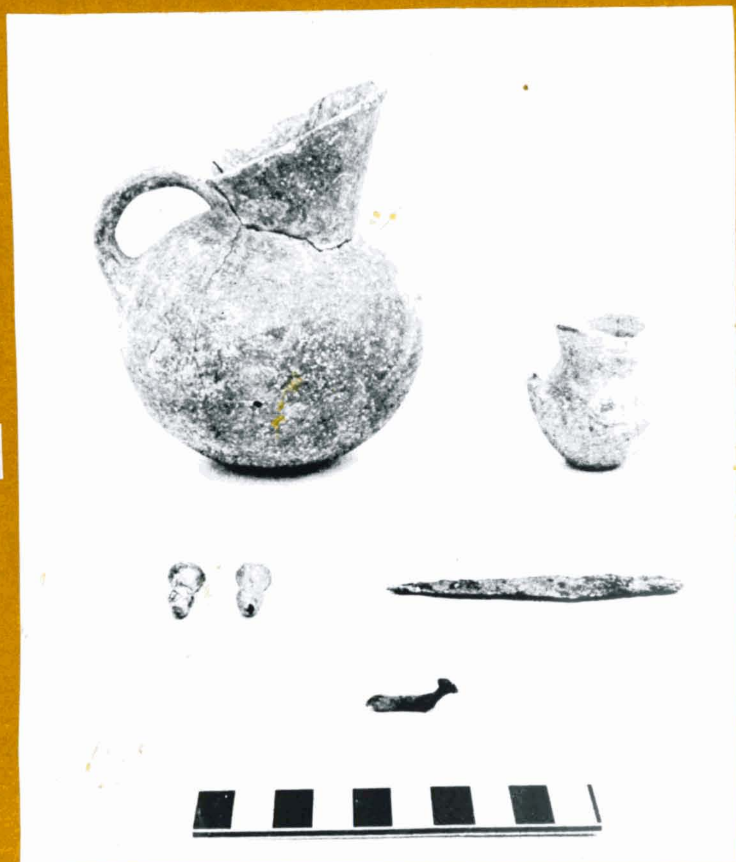

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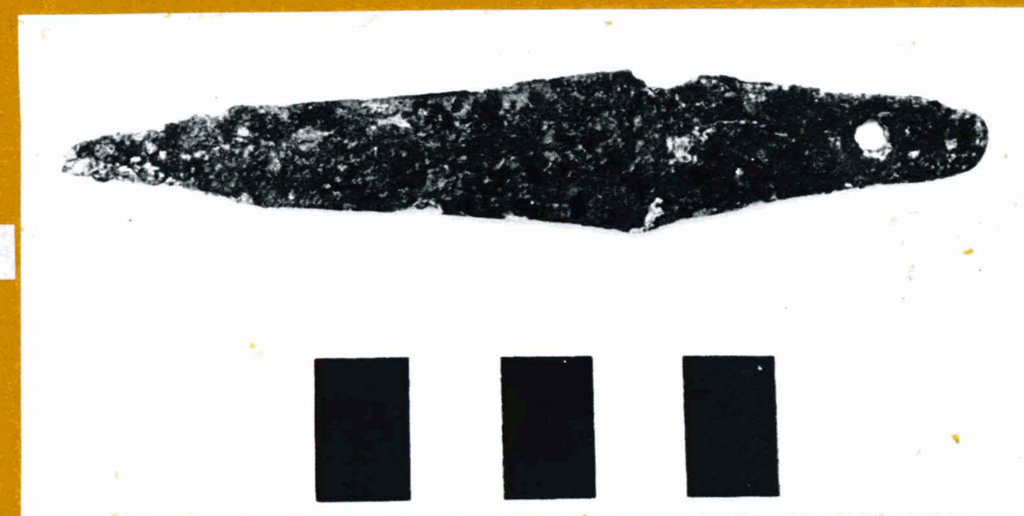

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PLATE XXV

1 2 3 4 5 6

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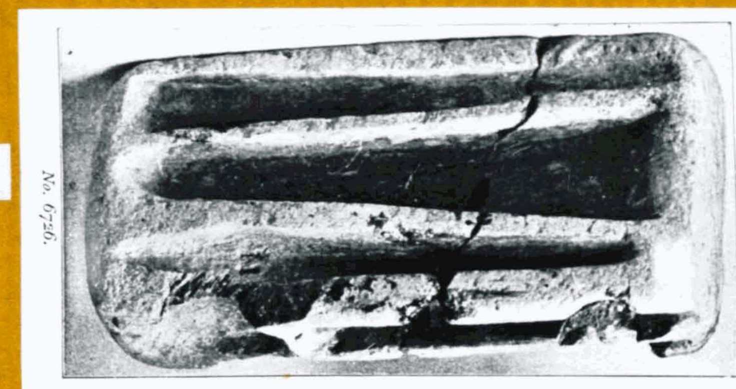

No. 6726.

8

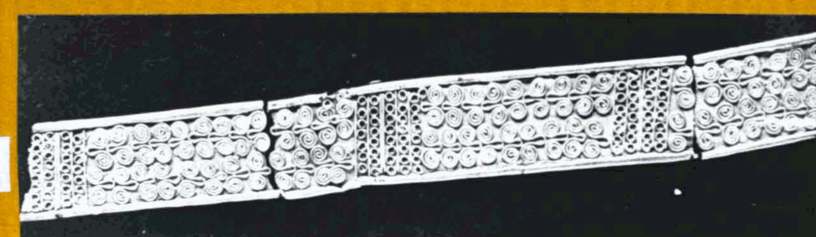

PLATE XXVI

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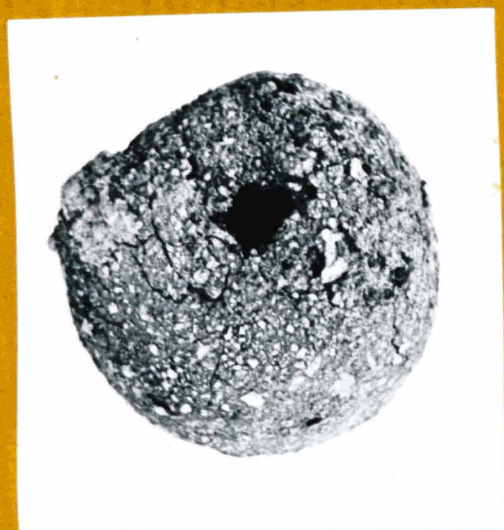

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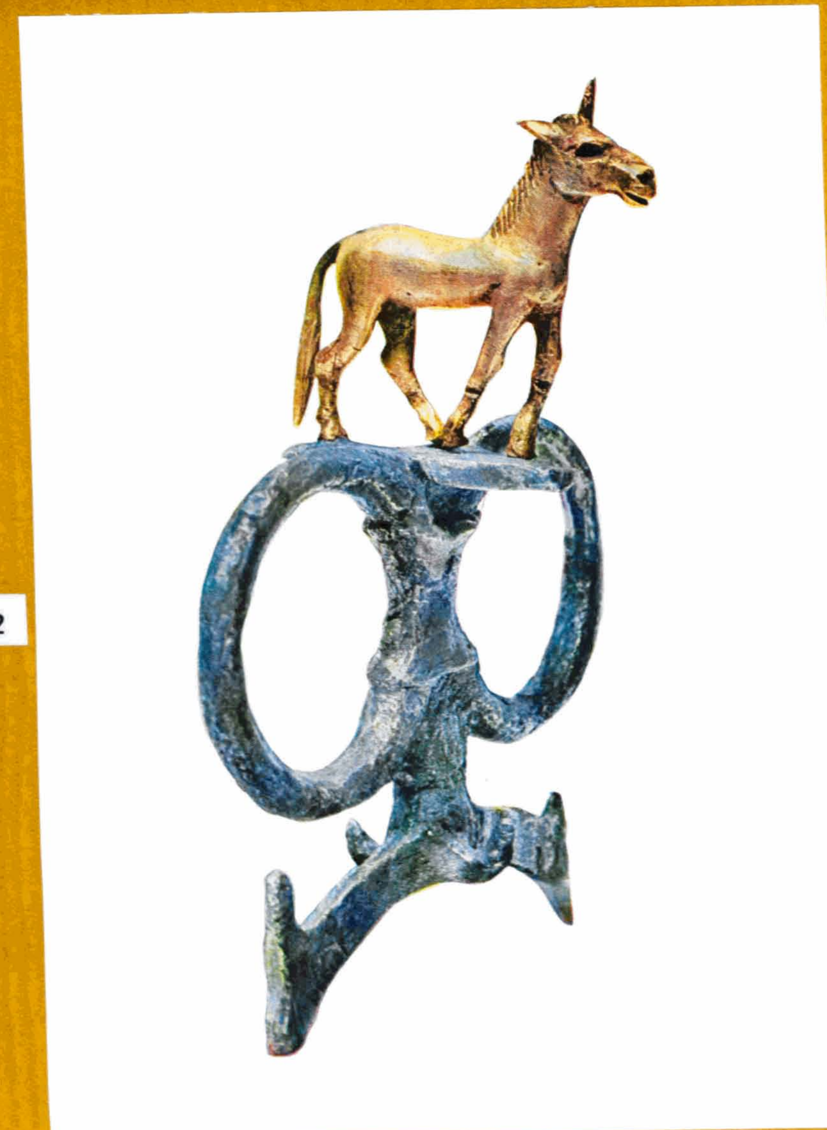

PLATE XXVII

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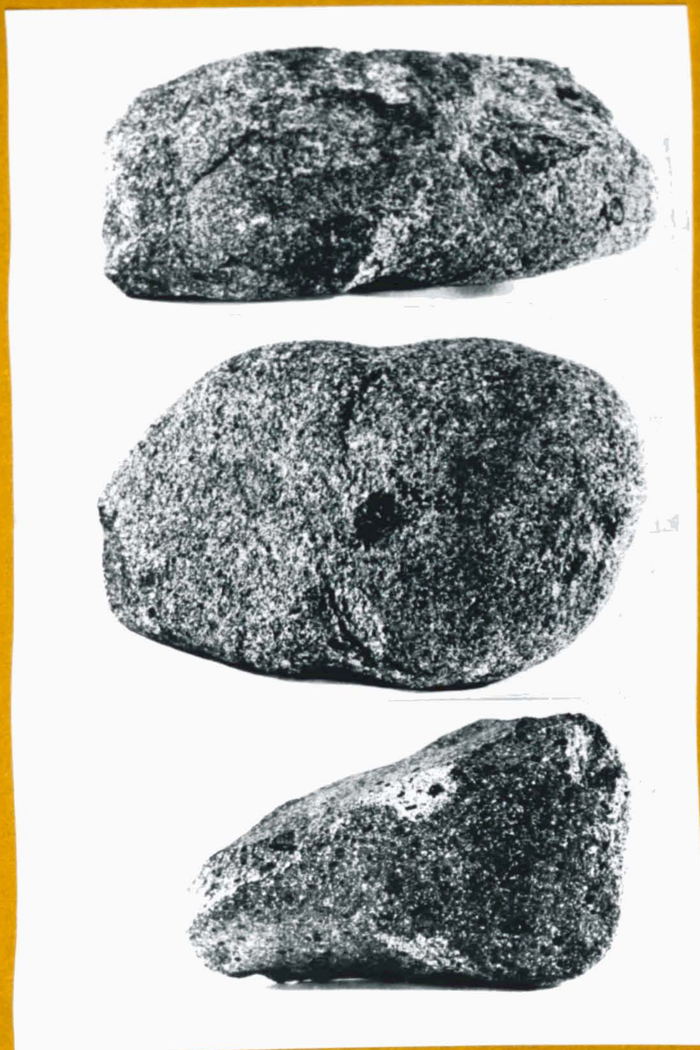

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PLATE XXVIII