

Early Tin In The Near East

A Reassessment in the Light of New Evidence from Western Afghanistan

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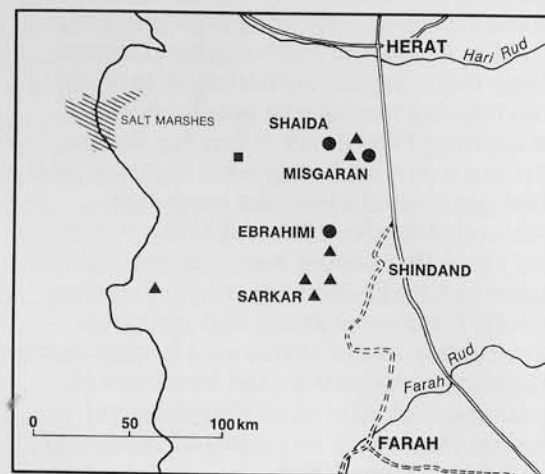
Numerous scholars in different disciplines have devoted considerable thought to the sources of the tin and copper used to make the alloy bronze in antiquity. In Southwest Asia, the absence of geological evidence for exploitable tin has produced only speculation concerning its locations. The identification of copper sources, however, has proved more successful. The general feeling of researchers before World War II, although their sample of ores was too scanty to confirm it, was that Sumerian copper might have come from Oman. This thought was based, in part, on the substantial nickel content in Omani ores as well as in copper artifacts from sites in Sumer. In the postwar era, the question of tin and copper sources was studied by interdisciplinary collaboration, an approach exemplified by the teams led by the late Theodore A. Wertime through Anatolia and the great central deserts of Iran in the '60s and '70s. This research culminated in the symposium "The Search for Ancient Tin," held in Washington, D.C. in 1977. At that time, no consensus on tin sources in Southwest and South-central Asia was reached.

Investigators in all periods have been faced with one major fact. Because southern Mesopotamia is virtually lacking in mineral resources, the materials used to

1 Map of southwest and south Asia.

2 Map of tin and copper occurrences in southwestern Afghanistan.

- Prehistoric Copper Mines
- ▲ Tin Occurrences
- Copper Occurrences
- = Major Roads



make the metal artifacts found there must have come from another locale. Thus, our research led us to the metallogenic zones of Iran, Afghanistan and Oman, where ores of copper, among others, are known to occur in substantial quantities. Though our broad study of the metallurgy of southern Mesopotamia was primarily aimed at disclosing the locations of ancient copper sources, we have also uncovered significant new information on tin deposits which could have been exploited in antiquity.

We worked from 1975 through 1978, visiting mines, sampling ores and artifacts, seeking answers to two basic questions:

Editorial Comment

This article was translated and adapted by Tamara Stech. A more detailed presentation of information on tin in Afghanistan and its cultural position in Southwest Asia during the 3rd millennium is being prepared by T. Stech and V. C. Pigott.

Where did the copper and tin ores originate? When was the alloy of copper and tin first made? Since answering entailed making analytical correlations between ores and artifacts, we had to develop at the outset some basic definitions of tin bronze.

In the minds of many archaeologists, the presence of tin in a copper-base artifact is associated with the idea of alloying in order to obtain a metal with particular properties: bronze. Various scholars have tried to fix a quantitative limit, speaking of bronze only when it contains more than 10% tin, and not taking into consideration artifacts containing lesser amounts. Such a strict definition concentrates on only a single aspect of the work of ancient craftsmen: pragmatic research on certain mechanical properties which they wished to impart to the finished product. If one maintains this definition, it is impossible to speak about the systematic use of tin in the Near East before the end of the 3rd millennium B.C., and lesser tin contents before that date would be in some way accidental. This is not our viewpoint. If we try to establish a minimum amount, it should be one which proves that tin was added to copper, even accidentally, in the course of the diverse transformations between the mineral and the excavated artifact. Before being part of a widely used alloy, tin was added to copper to lower the melting point and to increase fluidity for casting; that is, to facilitate the processing of the metal. Other metals were also used for this purpose by ancient metalworkers, most notably arsenic, antimony and lead. Arsenic, in particular, played an important role in the early metallurgy of the Near East.

The definition of a minimum tin content is strongly dependent on local conditions. Tin may be associated with copper minerals in ore deposits, and then the tin contents of artifacts must be considered in relation to those of the minerals from which they can be shown, by chemical analysis, to derive. The copper ores from western and central Iran, Afghanistan and Oman which we studied are, however, rarely associated with significant quantities of tin. The tin contents of these ores are usually low, typically about 10 ppm (0.001), and in Omani copper ores, specifically, the average is about 1 ppm (0.0001). Higher tin values do, however, occur in the ores of Misgaran, southwest of Herat in Afghanistan, where contents of 600 ppm (0.06) were found. (This area is discussed in more detail below.) We have

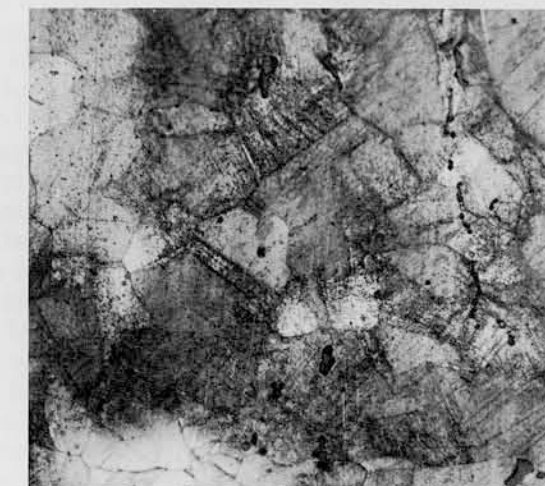
therefore concluded that tin values above 0.5 indicate deliberate combination of copper and tin at some point during the process which transformed ores into metallic bronze, though this is not to imply that the operation was totally controlled and that the results were standard. However, it seems legitimate to suggest that this purposeful addition of tin could easily have led to the understanding that higher levels of tin would produce a significantly harder metal.

Relevant here too is the form in which the tin was added to the copper: as an ore or as a smelted metal. Under laboratory conditions, molten copper can absorb only 1% tin if the tin is added directly in the form of cassiterite (SnO_2). If, however, the



3 Early Dynastic period (ca. 2500 B.C.) spade-shaped tool (University Museum 30-12-272) from a personal grave at the site of Ur in Mesopotamia. This tool from Ur is a tin-bronze as the elemental analysis below demonstrates. Such a bronze may have been produced according to a time-honored recipe mixing one part tin with nine parts copper.

Cu	Sn	As	Pb	Fe	Sb
88.1	9.3	0.69	0.072	0.11	0.067
Ag	Ni	Co	Si	S	
0.048	0.50	≤0.018	0.010	0.081	



PIXE analysis courtesy of the Sumerian Metals Project, University of Pennsylvania.

4 Photomicrograph of microstructure of the Ur tool indicating that the metal had been annealed (i.e., recrystallized by heat), subsequently cold worked and left in that condition. (x 400, etchant $\text{FeCl}_3 + \text{HCl}$, analysis courtesy of the Sumerian Metals Project, University of Pennsylvania).

cassiterite is smelted by placing it in the charcoal above the molten copper, a bronze of greater tin content can result. Since, as far as we know, virtually no artifacts of metallic tin occur in Near Eastern contexts, it is likely that the tin was shipped and used as an ore rather than as a metal. The only possible exception would be artifacts produced from tin-bearing copper ores like those of Misgaran, but these ores are characterized by a precise metallogenic context and can be distinguished on this basis.

The earliest occurrences of tin-bronze date to the 4th millennium. Though the total number of artifacts analyzed from this period is not large, those of tin-bronze are even fewer: three pins from Necropolis A at Susa (with tin contents of 4%, 8% and 2.3% respectively), and an awl from Sialk III (0.95%). In the later 4th and early 3rd millennia, greater tin values occur—5.3% in a pin from Susa B; and 5% in an axe from Mundigak III₆ in Afghanistan; but these are still exceptional in a period characterized by the use of arsenical copper. It is only around 2700 B.C., during Early Dynastic III in Mesopotamia, that both the number of bronze artifacts and their general tin content increase significantly. Eight metal artifacts of forty-eight in the celebrated "vase à la cachette" of Susa D are bronzes; four of them—three vases and one axe—have over 7% tin. The analyses of objects from the Royal Cemetery at Ur present an even clearer picture: of twenty-four artifacts in the Iraq Museum subjected to analysis, eight containing significant quantities of tin and five with over 8% tin can be considered true bronzes in the traditional sense. These computations are conservative because the artifacts from the two sites were probably produced from Omani copper, which has only weak traces of tin, so that a number of other pieces also should be considered as alloys. In addition, a contemporary shaft-hole axe from Kish contains 4% tin, and significant amounts were detected in a few artifacts from Tepe Giyan and Tepe Yahya IV B in Iran, and Hili in Oman.

Thus, we see an increasing pattern of tin usage, yet the source of this material is uncertain. Because tin deposits are virtually non-existent in Southwest Asia, it is tempting to turn to the west and tin mines of Cornwall and the Harz Mountains, or to the east and the tin of India and even Thailand. However, the general archaeological context of tin and later textual references to



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A protohistoric copper mine in the Misgaran area.

it in Mesopotamia suggest a less far-flung trade. Among areas cited as possible tin-producers are Turkey (notably along the course of the Sakarya), Lebanon (Kesserman), the Caucasus, and several parts of Iran (Azerbaijan, Khorasan, the Dasht-i Lut), but geological reconnaissance has failed to confirm the presence of exploitable tin.

We were fortunate in the course of our research in Afghanistan to learn of tin deposits there from Soviet geologists, who had just completed a detailed survey of the entire country. A number of polymetallic deposits including tin were found in central Afghanistan. We explored the area south of Herat, where several deposits of tin were said to exist. At Misgaran, tin appears 500 meters north of a copper mine which was worked in ancient times, although the precise dates of exploitation are not known. The copper ores here contain over 600 ppm (.06) of tin. Tin-bearing sands, which can be easily beneficiated by panning, were worked in the nearby Sarkar Valley. There too the tin was found in association with copper, green traces of which are visible throughout the landscape. The Soviets also reported that tin deposits in Uzbekistan in

Central Asia were exploited from the mid-2nd millennium B.C. Thus, in a general way, it seems reasonable to say that Afghanistan is a good potential source for the tin used in Southwest Asia in the 3rd millennium, certainly the best found thus far.

How does this assumption fit with textual evidence? Documents dating to the 2nd millennium indicate that tin had an eastern origin. Thus, for example, Mari on the Euphrates imported tin from Eshnunna, where it had probably arrived from farther east, from either Susa or Anshan. From Mari, some of the metal was re-exported to Syria and Palestine. It was from Assur that tin was shipped to Anatolia, in quantities which the texts indicate approached a ton per year, a relatively small amount.

We know that the tin came from the east, but from where? Mentions in ancient texts are rare, and only one of them, dating to the time of Gudea of Lagash (2150-2111 B.C.), speaks of the tin of *Meluhha*. *Meluhha* is one of the lands east of Mesopotamia, along with *Dilmun* (Bahrain) and *Makkan* (the peninsula of Oman). Its location is still controversial, but most scholars tend to place it in Afghanistan or Pakistan. The lists of goods imported to Mesopotamia from *Meluhha* point to the Indus Valley and the Harappan civilization, but it is not always easy to make a distinction between those which originated in *Meluhha* and those which passed through *Meluhha*.

Also deserving of mention here is the much later comment by the geographer Strabo (XV.2.10) who, in referring to the inhabitants of Drangiana (modern Sistan), says they have "only scanty supplies of wine, but they have tin in their country." This passage has stimulated fruitless explorations in Iran, but it does accord well with the discoveries in the area of Herat. Thus, in a general way, although the texts are few and vague, there is little contradiction between them and the geological evidence.

A long-distance trade in tin is of course hypothetical. But, on the other hand, the idea of an eastern origin for tin is also supported by research of the past fifteen years in Iran and the Arab coast of the Persian Gulf.

There are two possible routes from Afghanistan to Mesopotamia. One crosses the northern part of the Iranian plateau, along the Elburz Mountains, then through passes in the Zagros descends to Babylonia and Assyria. In the 1st millennium it



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Cesbron and Berthoud collecting sands in a cassiterite bearing zone downstream from the granitic motherlode of tin ore in the Sarkar valley.

was one of the principal supply routes of eastern goods to Assyria. In the 2nd millennium the tin that Assur exported to Anatolia might have followed this route. Along it are found such sites as Tepe Sialk (where the use of tin is attested in the 4th millennium), Tepe Giyan and Tepe Hissar, where other finds (such as lapis lazuli at Hissar) implicate them in long-distance commerce in the 3rd millennium.

The second route is by sea, along the Arabian coast of the Gulf, perhaps also going by land through southern Iran. It was at the time of Gudea of Lagash and earlier in the Early Dynastic III period, the great supply route of eastern commodities to southern Mesopotamia. It is by this route that the copper of *Makkan* came, copper which analysis has shown to have originated in the peninsula of Oman. It also brought the products of *Meluhha*, including lapis lazuli, carnelian, copper, ivory and various woods. Nothing, however, suggests the passage of tin through this area. For example, there is little tin in the artifacts recovered at Qala'at al Bahrain, dating between 2300 and 1800 B.C. Furthermore, we know from the work of Limet, who studied texts concerned with metalworking



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Mineralogist Fabian Cesbron (University of Paris VI) panning cassiterite sands in a qanat pool in the Sarkar Valley.

in Sumer, that Mesopotamian metalworkers did their own alloying. We suspect, therefore, that the tin moved through this area in an unalloyed state.

Recently Oman has yielded the first signs of the use of tin in the region. The analysis of a sword from Hili, dated to the mid-3rd millennium, shows a tin content of 6.5%, and a mold of a tap hole(?) associated with the remains of a furnace held metal with a tin content of 5%. The furnace is dated, after the tree-ring calibration of a radiocarbon analysis (MC2261) to circa 2225 B.C. If we consider that the tin contents in the ores of Oman are between 0.18-1.2 ppm (0.00018 and 0.00012), with a single exception of 6.1 ppm (0.00061), it is clear that the tin was added to the copper and it is also clear that it did not come from Oman itself. At Umm an-Nar artifacts with tin contents on the order of 2% were recovered; the tin must have been mixed with the local copper. This appears without doubt to represent local use, and at the least confirms that tin was imported into the "land of Makkan."

If we now turn to the "land of Meluhha," or at least to the vast area of which parts have been identified with Meluhha, the use of tin is attested already in the late 4th or early 3rd millennium at Mundigak III in southern Afghanistan. Tin appears only in

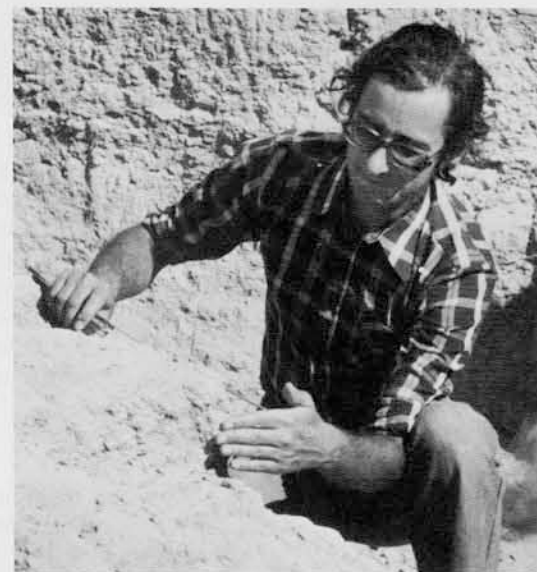
small quantities in artifacts from Shahr-i Sokhta in eastern Iran and at Tepe Yahya in southern Iran (among the sites from which artifacts were studied). In the Indus Valley, the copper-tin alloy is known at Mohenjo-Daro.

The archaeology of the lands around the Straits of Hormuz is unevenly known, although considerable progress has been made in recent years. Oman's trade with southeastern Iran and Baluchistan is well attested, even if a precise interpretation is lacking. There are certain characteristics, notably of ceramics, which in some cases allow the identification of imports. Among the products attributed to Meluhha, lapis lazuli and carnelian are found in sites and tombs of the 3rd millennium. We can suggest with reasonable certainty that the tin used in Oman was in transit through Meluhha and that the most likely source was western Afghanistan.

The discoveries of tin in artifacts at Hili, though singular, are important because the site lies in an area clearly involved in long-distance trade. However, there is no clear evidence that the site was a way-station on the route which brought tin from Afghanistan to Mesopotamia. Therefore the presence of tin at Hili indicates only that it was transported in the Gulf area, where it was also used to fill local needs.

The collective indications are that western Afghanistan was the zone able to provide the tin used in Southwest Asia in the 4th and 3rd millennia. The occurrence of tin with copper ores and the signs of early exploitation make it obligatory for us to consider the problem of tin in direct connection with the metallurgy of copper in this region. Since our original research design was to define copper sources, the information on tin deposits was looked upon only as a complement. In order to elucidate the questions raised by our findings, a project aimed specifically at tin—its sources and metallurgy—should be organized.

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