THE METALLURGY OF THE LATE BRONZE AGE SAPALLI CULTURE (SOUTHERN UZBEKISTAN) AND ITS IMPLICATIONS FOR THE TIN QUESTION

BY

Kai KANIUTH

Extrait d'Iranica Antiqua, vol. XLII, 2007

GENT

Iranica Antiqua, vol. XLII, 2007
doi: 10.2143/IA.42.0.2017869

THE METALLURGY OF THE LATE BRONZE AGE SAPALLI CULTURE (SOUTHERN UZBEKISTAN) AND ITS IMPLICATIONS FOR THE 'TIN QUESTION'

BY

Kai KANIUTH
(Universität München)

Abstract: This article summarizes current knowledge about the metallurgy of the Late Bronze Age Sapalli Culture (Northern Bactria) and discusses its implications for the 'tin question'. It is suggested that tin was used in southern Central Asia predominantly to influence the visual appearance of copper objects. The Zerafshan ores, recently highlighted through current research, are not considered a likely source for the tin imported into Mesopotamia during the third and early second millennium BC.

Keywords: Central Asia, Bronze Age, Sapalli Culture, Metallurgy, Tin trade.

The tin question — general issues

Few research problems in Near Eastern archaeology have, over the years, generated so much discussion as the 'tin question'. This has been ably summarised by a number of scholars (Muhly 1973; Muhly 1995; Pigott 1999; contributions in Giumlia-Mair/Lo Schiavo 2003; Weeks 2004). In essence, the debate centres on two main questions: First, what were the sources for the tin used as a routine ingredient in Mesopotamian metallurgy during the later third and second millennium BC and second, by which routes was the tin traded to Mesopotamia from its source region(s)?

The focus for all discussions relating to the tin trade has traditionally been the early second millennium BC, because it is in this period that evidence from a wide range of disciplines can be brought to bear (Larsen 1987; Muhly 1995). In addition to archaeological and scientific (i.e. geological, chemical) evidence there are the numerous cuneiform texts from the archives at Kültepe/Kaniš level 2 and Mari, dated to the 20th and 18th centuries BC. While it must always be kept in mind that these archives cover only a fraction of the ancient trade — both chronologically and geographically — they give a consistent, if somewhat blurred picture of the Mesopotamian metals trade.

This article will focus on the narrow time span of the 20th-18th century BC, where evidence of metallurgical practices has recently been accumulated from the northeastern periphery of the ancient Near East. Two projects in particular have generated new insights. A joint mission of the German Mining Museum, Bochum, the Eurasian Department of the German Archaeological Institute, Berlin and Freiberg Technical University has investigated the Central Asian tin ore belt along the Zerafshan River with the aim of examining a potential source region of Bronze Age tin (Alimov et al. 1998; Parzinger/Boroffka 2003). At the same time, the Eurasian Department and the Institute of Archaeology of the Uzbek Academy of Sciences conducted excavations at the site of Dzarkutan, which have produced a sizeable amount of data on early second millennium BC metallurgical practices (Huff 2000; Huff et al. 2001; Kaniuth in print).

Source regions

Overviews of potential sources of tin were given by Penhallurick (1986) and, in condensed form, by Weeks (2004: 166-173). If we exclude archaeologically and geographically improbable options such as Cornwall (England) or the Erzgebirge (Germany and Czech Republic), or geologically unsuitable deposits as those in Egypt or the Arabian Peninsula, we are essentially left with the following choices in the greater Near East: Anatolia (Yener/Vandiver 1993; Yener 2000), Afghanistan (Cleuziou/Berthoud 1982; United Nations 1995; see also Weisgerber 2004) and Central Asia (Besenval et al. 1988; Parzinger/Boroffka 2003). All these regions have the necessary deposits and at least some evidence for the local use of tin. The exploitation of the Taurus deposits is, however, hotly debated (Yener/Vandiver 1993; Muhly 1995; Muhly 1999; Yener 2000) and textual evidence seems to suggest, that the region could not have been a major supplier of tin in the first half of the second millennium BC because early second-millennium texts make it clear that tin was exclusively traded in an east-west direction, through Eshnunna, Mari and Assur, and into Northern Syria and Central Anatolia (Leemans 1960; Larsen 1976; Joannès 1991; Michel 1993; Deercksen 2005). The assertion that tin most likely derived from Afghanistan or Central Asia has therefore been accepted in more recent publications (Moorey 1994: 299-301; Pigott 1999b: 81; Weeks 2004: 188-189, 200). Actual mining operations had, however, not yet been demonstrated in either case.

Trade routes

Depending on the source regions, three routes may be proposed (Fig. 1):

1) A northern land route leading west along the Elburz range before descending into the Mesopotamian alluvial plain (Laessøe 1959; Larsen 1967). This option has lost some of its appeal because information on north-western Iranian tin sources has not been substantiated (Eidem/ Laessøe 2001: 59). Still, it would be the obvious route for any materials transported from southern Central Asia into northern Mesopotamia.
2) A southern land route passing to the south of the Iranian deserts and into Elam. This variant is currently favored because a few texts actually refer to *some* tin being traded through Susa (Dossin 1970; Joannès 1991).
3) A sea-based route, presumably from Indus Civilization territory, leading through the Persian Gulf (Potts 1994). The existence of a major trade route through the Gulf is beyond doubt for the late third millennium BC, but the question is whether tin moved along it in bulk (Heimpel 1987: 54; Weeks 2004). Also, there are some indications that in Old Babylonian times, tin was traded from Eshnunna southwards, instead of northwards from the coast (Leemans 1968).

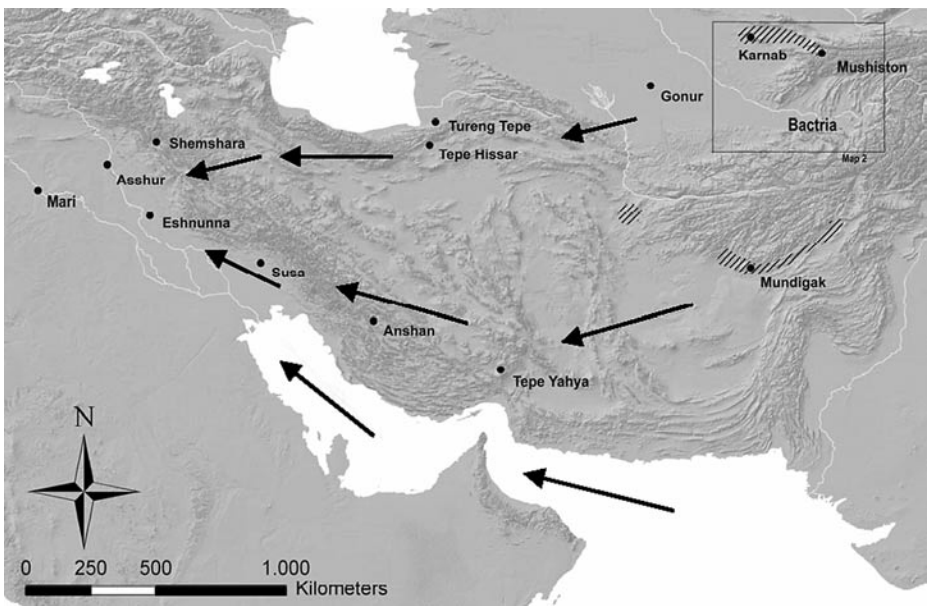

Fig. 1. Main sites discussed in the text. Source regions of tin are hatched, possible trade routes are indicated by arrows.

Central Asia in the early second millennium BC

In the early second millennium Central Asia was a contact zone between two large cultural provinces. In the south, populations with a Near Eastern lifestyle and material culture predominate, which can be subsumed under the term 'Namazga-related cultures'. They are characterized by a village- and town-based settlement system clinging to the oases, elaborate ceramic forms and well-documented links to the Iranian and Indus spheres. Our knowledge about the early second millennium — the Late Bronze Age (LBA) according to local terminology — mainly derives from three regions. In Margiana (Southern Turkmenistan) the settlement system has been extensively mapped and a large number of sites have been excavated (Sarianidi 1990, 1998; Gubaev et al. 1998), the most prominent being Gonur-Depe. Still, the chronology of the region suffers from the small number of contextualized finds published. Southern Bactria (Northern Afghanistan) is best known for its intensively plundered graveyards, which have produced tremendously rich finds, comprising many objects made of precious metals (Sarianidi 1986; Ligabue/Salvatori 1990). There is general agreement that the date of unprovenanced finds stretches back further than that of the 20th-18th-century BC graves scientifically excavated at Dashly-1 and 3 (Sarianidi 1976), and that they start in the last centuries of the third millennium BC. Lastly, Northern Bactria (Southern Uzbekistan) has produced some monumental buildings, but nothing to rival the spectacular architectural or sepulchral finds of Margiana and Southern Bactria. Instead, the painstaking work of Uzbek researchers has provided us with a large number of graves which can form the basis for a solid chronological framework.

The northern part of Central Asia was inhabited by populations belonging to the Eurasian Andronovo complex. They are known almost exclusively from burials, which contained coarse, hand-made pottery and elaborate bronze weapons, predominantly made of tin bronze (Avanesova 1991: 73-83; Chernykh 1992: 213). Living in a steppe environment, these groups are generally considered 'semi-nomadic' or 'nomadic'. The relations between the Namazga and Andronovo groups in Southern Turkmenistan seem to gain importance only during a later stage of the LBA (Shchetenko/Kutimov 1999; Hiebert 2002: 241-245), but the precise sequence of events is somewhat obscured by the shaky chronological frameworks used for both cultural entities. In Margiana, scatters of 'steppe' ceramics are found close to 'Namazga'

sites, but their contemporaneity remains yet to be proved (see Ceraseti 1998: 67-74). Only along the Zerafshan river are finds appearing which suggest a more substantial relationship in the 20th-18th centuries (Avanesova 1996; Avanesova et al. 2001; Avanesova 2002; Bobomullaev 1997).

Recent research in Uzbekistan and Tadjikistan

Explicitly investigating early tin sources, an interdisciplinary team of archaeologists, geologists and archaeometallurgists has recently looked for traces of prehistoric exploitation in the 'tin belt' along the middle course of the Zerafshan river in Uzbekistan and Tajikistan, following the lead given by the Soviet archaeologist B. Litvinskij (1950). Chemical analyses of metal objects and ores were carried out and nearby sites excavated. This research programme has yielded some remarkable results, in that mining can now be shown to have taken place in the Mushiston mines since the early second millennium BC. Culturally, this exploitation was exclusively linked to groups of the Andronovo complex (Alimov et al. 1998; Boroffka et al. 2000; Boroffka et al. 2002; Parzinger/Boroffka 2003).

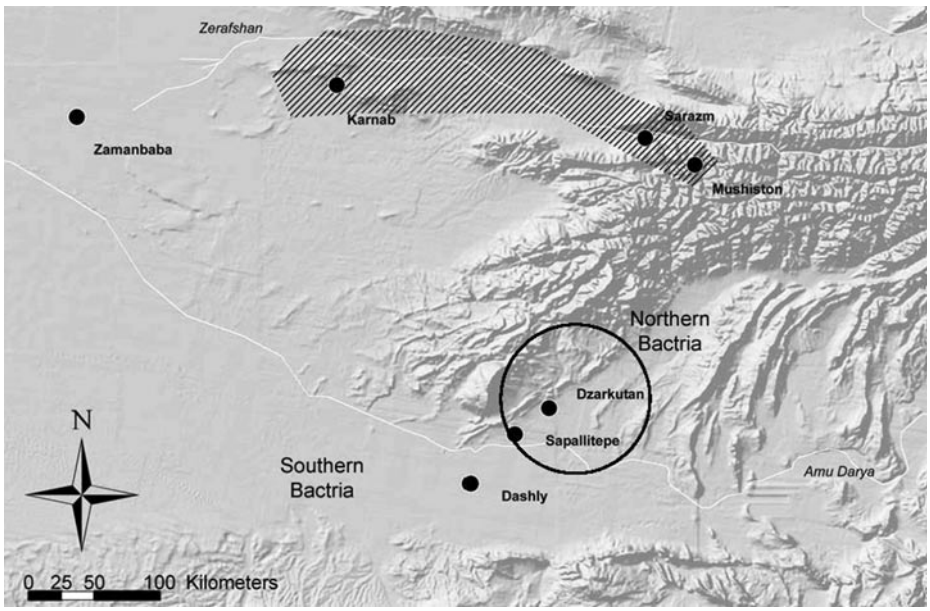

Fig. 2. Bactria with major late-third and early-second-millennium sites mentioned in the text. Encircled is the area covered by the LBA Sapalli Culture.

At the same time, from 1994 to 2003, excavations were conducted at the Late Bronze Age settlement of Dzarkutan in Southern Uzbekistan by a joint team from the German Archaeological Institute and the Institute of Archaeology of the Uzbek Academy of Sciences. This research and the restudy of burial data from the sites of Sapallitepe and Dzarkutan led to a revision of the region's chronology (see the chronological chart Fig. 3): in the early second millennium, the local Sapalli Culture has two distinct stages, Late Bronze I and II, which can be differentiated by their pottery, burial customs and, above all, by their metal inventories.

Years BC	Margiana	Southern Bactria	Northern Bactria	Eastern Bactria	Steppe tribes
	Yaz I	Tillya I	Kuchuk I		
1400				**Vakhsh**	
1500			**LB IIb**	Tulkhar Southern	Tazabagyab
1600	**Late Bronze B**	Dashly 17	**LB IIa**	Tulkhar Northern	
	(Takhirbaj 3)	Dashly 19			**Andronovo**
1700				Shortughai IV	
1800		Dashly 1	**LB Ib**	Shortughai III	
	Late Bronze A				Zardza Khalifa
1900	(Gonur South,	Dashly 3	**LB Ia**		Dzham
	Togolok 1, 21)				
2000					**Petrov** (Tugaj)
	MB/LB trans.			?	
2100	(Gonur, Takhtab.)				
		Plundered			
2200	**Middle Bronze**	Bactrian Graves			
	Gonur Necroplis			Shortughai II	**Zamanbaba**

Fig. 3. Chronological chart of Southern Central Asia in the Middle and Late Bronze Age. Periods in bold.

In LB I, dating roughly between 2000 and 1700 BC according to calibrated radiocarbon dates (Görsdorf/Huff 2001; Kaniuth/Teufer 2001; Teufer 2005; Kaniuth in print), typological associations of the metal artefacts point to a very close relationship with the other Bronze Age centres of southern

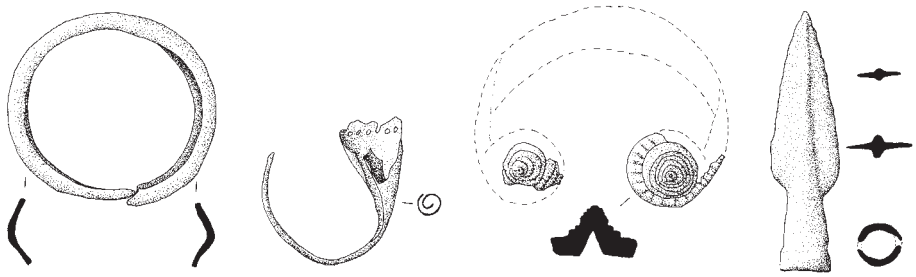

Fig. 4. LB II Andronovo-type metal forms from Dzarkutan (not to scale).

Central Asia (Margiana and Southern Bactria) and eastern Iran (Fig. 5). Later, in LB II — about 1700-1500 BC — they developed clear links with the cultures of the 'Northern Steppes', in particular with the Tazabagyab Culture, a local subgroup of the Andronovo complex (Fig. 4). As LB II postdates the floruit of the Mesopotamian tin trade, we shall concentrate in the following on the LB I evidence.

The metallurgy of the Sapalli Culture

In publications on Central Asian metalwork the Sapalli Culture is usually highlighted for its surprisingly large share of tin bronzes, with up to 45 % of all metal objects assigned to this category (Askarov/Ruzanov 1977: 56-59; Chernykh 1992: 179). This is much less than in the Andronovo complex, where more than 80 % of all metal objects are tin bronzes, depending on the usage of the term in the literature, but a quite remarkable figure when compared to the culturally more closely-related regions: contemporary Iranian metalworkers almost exclusively made use of copper with an admixture of arsenic, and even in adjacent regions such as Margiana and Southern Bactria tin bronzes never made up more than 10 % of the assemblages (Sarianidi et al. 1977: 38-39; Terekhova 1990: 177-202; Chernykh 1992: 179-182).

The larger number of analyses now available (150 for LB I alone — see Table 1) taken from contexts other than the rich graves of Sapallitepe has reduced the overall proportion of tin bronzes (defined as copper objects with a tin content of at least 3 %) to about 25 % of all objects sampled. Still, there is a major discrepancy between the proportion of Sapalli Culture tin bronzes and those in Margiana or Southern Bactria (where a 1 %

Table 1. Numbers of LB I metal objects from Sapallitepe and Dzarkutan according to compositional groups.

Material	Tin bronze (Sn >3 %)	Arsenical bronze (As >3 %)	Lead bronze (Pb >3 %)	Copper with low tin content (Sn 1-2,99 %)	Copper with low arsenic content (As 1-2,99 %)	Copper (Sn, As, Pb <1 %)	Total
Sapallitepe	31	29	16	4	13	2	95
Dzarkutan	6	12	3	1	27	6	55
Total	37 (25 %)	41 (27 %)	19 (13 %)	5 (3 %)	40 (27 %)	8 (5 %)	150 (100 %)

tin content is often considered sufficient to qualify an object as a tin bronze — see Ruzanov 1999a; Terekhova 1990: 201). Traditionally, this difference has been explained by Northern Bactria's proximity to the tin sources along the Zerafshan river.

If we take a closer look at LB I artefacts (Table 1; Fig. 5), the percentages of tin contained in the metal objects show, that tin was an intentionally added ingredient. There are only five low-tin objects, but a large number of tin bronzes (37). Out of these 42 pieces with a tin content of more than 1 %, 34 (80 %) actually lie within a 5-12 % bracket, proof for an intentional and relatively well-controlled alloying practice. By comparison, arsenic was found in a wide range of concentrations, with an almost random distribution. The third major alloy, lead, can also be assumed to have been purposefully introduced, because objects with a lower concentration of lead (1-3 %) are completely absent.

So why were objects produced of tin and lead alloys in the first place? Usually, explanations involve the material characteristics of the final product. This may either be hardness or an attractive colour (Northover 1989; Pernicka 1995; Pigott 1996; Stech 1999; Weeks 2004). If we consider the types produced from various alloys (Table 2), we notice that tin-alloys are disproportionately well-represented in prestigious goods such as mirrors, vessels and personal ornaments, even though sheet metal vessels, for example, would have been much easier to manufacture from more pliable unalloyed copper. Weapons and tools, which would benefit most from the superior hardness of tin bronze, were produced more often than not from unalloyed copper. If there was a reason for using the 'inferior' metal, it

Table 2. Composition of LB I artefacts arranged by types.

Material	Tin bronze (Sn >3 %)	Arsenical bronze (As >3 %)	Lead bronze (Pb >3 %)	Copper with low tin content (Sn 1-2,99 %)	Copper with low arsenic content (As 1-2,99 %)	Copper (Sn, As, Pb <1 %)	Total
Mirrors	4	3			3		10
Mirror handles			2				2
Seals			4				4
Vessels	7	2	1	1	1	1	13
Flacons			9				9
Weapons / Tools	7	4	2		14	2	29
Pins	6	7	1	1	11	1	27
Wands	3	5	1	1	9	1	20
Bracelets	6	10	3		3		22
Earrings	4	1		1	2	2	10
Beads	2						2
Diadems		1				1	2
Total	39	33	23	4	43	8	150

may have been to ease repeated resharpening. Two artefact types, which were made of tin bronze, namely axes (Fig. 5) and mace-heads, must probably be considered symbols of authority rather than ordinary weapons.

Cosmetic containers and compartmented seals were mostly produced from lead bronze, an alloying pattern typical for eastern Iran and southern Central Asia from the Early Bronze Age onwards (Baghestani 1997: 13). Presumably, the casting process of closed vessel forms and intricate seal designs required a higher fluidity of the metal. That lead was the material of choice for difficult production processes is also indicated by two lead bronze mirror handles cast onto arsenical-bronze mirrors (Tab. 2; Fig. 5, left). In sum, the overall picture strongly suggests that Sapalli Culture metal smiths used alloys for two reasons: to add some ‘splendour’ to a selected range of (already prestigious?) metal objects through the addition

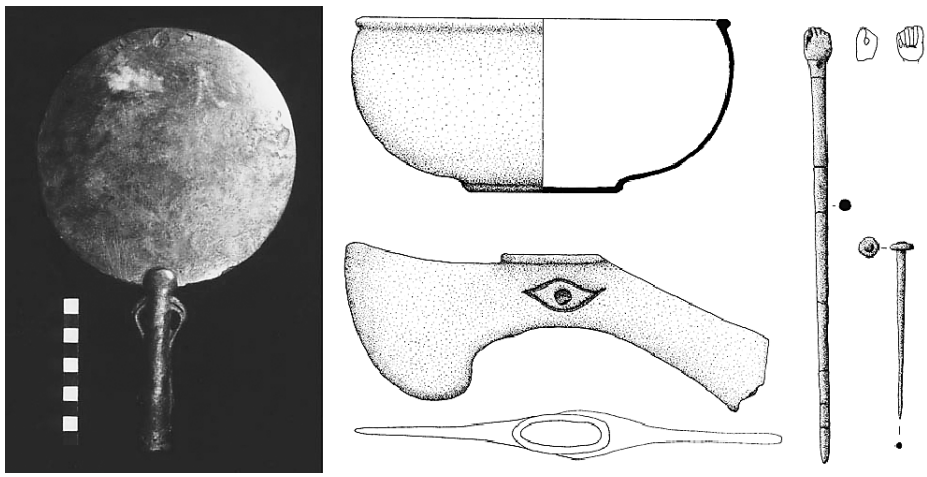

Fig. 5. Sapalli Culture LB I metal objects. Mirror of arsenical bronze with cast-on lead-rich handle. All other objects of tin bronze (not to scale).

of tin and to facilitate the production of difficult castings by using a lead alloy. There is no evidence that any LB I types were imported, so the above picture seems to give us a good impression of the possibilities and limitations of Northern Bactrian metal technology.

The question still remains, why was tin more frequently used in Northern Bactria than elsewhere? One possible explanation would be to assume easier access to tin sources. Demonstrating the proximity of exploited ore sources could substantiate this argument. The examination of the Zerafshan ores — as the closest attested mining area — is therefore of utmost importance. The two deposits along the course of the Zerafshan river, Karnab and Mushiston, were sampled between 1996 and 1999 and good evidence for Late Bronze Age mining activities was found. Although the final report on the analyses has not yet been published, the tin used in the LB I stage does not seem to have come from either source (Parzinger et al. 2003: 301).

We therefore have to reconsider the use of tin at Sapalli and Dzarkutan. If tin was not more easily available than in other regions, why was it present in amounts far exceeding those found in the richer centres to the south and southwest? Probably, the answer does not even lie with the presence of tin in the Sapalli Culture, but with its absence elsewhere. The clue seems to be in the rarity of precious metals: Gold and silver have seldom

turned up in LB I contexts in Northern Bactria (two silver earrings from Sapallitepe are published in drawings), while they were widely used in both Margiana and Southern Bactria, as objects from the Gonur excavations and illicit finds from Afghanistan show (Sarianidi 1986; Sarianidi 1998; Sarianidi 2001; Rossi Osmida 2002; Ligabue/Salvatori 1990). The types manufactured from gold in these regions compare well with the range of tin-bronze objects from Northern Bactria, being mostly vessels and personal ornaments. Seen from this perspective, the higher frequency of tin bronzes within the metal inventory of the LB I stage of the Sapalli Culture need not be explained by privileged access to a highly desirable raw material. Instead, tin bronze appears as a substitute for the true luxury metals on the market, silver and — most importantly — gold.

Sources, again

Where, then, was the source of tin for the Sapalli Culture, and what are the implications of recent research in Central Asia for the Mesopotamian 'tin question'? As has been shown, the Zerafshan mining operations were exclusively linked to the Andronovo communities from the Eurasian steppes, whose metallurgy is dominated by tin bronze (Chernykh 1992: 213; Avanesova 1991: 73-83; Parzinger et al. 2003). Before the 17th century BC, contacts between these northern groups and the Namazga-related communities of southern Central Asia are scarce (Vinogradova/Kuzmina 1986; Gubaev at al. 1998; Hiebert 2002; but see Kohl 2002), a fact supported by the Sapalli Culture metal inventory (Kaniuth in print). Attempts to explain the incipient use of tin in early-second millennium eastern Iran through recourse to Central Asian influence — either of the Andronovo complex (Thornton/Lamberg-Karlovsky 2004: 268-269) or the Namazga cultural groups (Lamberg-Karlovsky 2003: 16) — must therefore be viewed with extreme caution. The north-east Iranian sites of Tepe Hissar and Tureng Tepe, while rich in metal forms, are devoid of tin bronze (Pigott 1989: 32) and there is no evidence suggesting that tin was traded across the Amu Darya and onto the Iranian Plateau as part of the massive metals trade one would expect to complement the Mesopotamian evidence. This is confirmed by evidence from cuneiform texts. Earlier assumptions concerning a northern Iranian 'tin route' in the early second millennium BC, based on the mention of tin in a text found in the Shemshara archive, which forms the easternmost extension of the Old Assyrian text corpus,

have proved unfounded, as it refers only to a local exchange system (Eidem 1992; Eidem/Laessøe 2001). For the third millennium the record looks even less promising as there is no evidence for mining activities from Karnab and Mushiston at this time. Neither the third-millennium sites of Sarazm and Zamanbaba, situated within the tin belt (Kuzmina 1966; Besenval 1988; Besenval/Isakov 1989; Ruzanov 1999a), nor the third-millennium sites in South-western Turkmenistan (Khlopin 2002) yielded the least scrap of tin bronze. In sum, the Zerafshan deposits may be ruled out as possible sources for the Near Eastern tin.

The only other substantial tin belt in the region stretches from the Helmand basin through Kandahar and up towards the Kabul Valley (United Nations 1995; Pigott 1999b; see also Weisgerber 2004). No research on ancient mining has yet been conducted in that area, but the third-millennium site of Mundigak produced a number of metal objects with a high tin content (Casal 1961: 244-245; Stech/Pigott 1986: 47-48; Pigott 1999b: 87). By default, these deposits are now our best candidate for a source area supplying both Mesopotamia and Central Asia. A good case for third-millennium tin trade through the Persian Gulf was recently made by Weeks (2004). Alternatively, and probably supplanting this route, tin may also have been transported through the area of the late third-/early second-millennium Kaftari Culture in south-western Iran, which made frequent use of tin (Pigott et al. 2003: 161-164) and further through Susa, where tin-bronze usage dominates in early second-millennium (Susa VB) contexts (Malfoy/Menu 1987: 371), into Mesopotamia (Deercksen 2005: 19). It becomes increasingly clear, that in the south of Iran tin metallurgy was well-known by the late third millennium BC, whereas cultures around the Caspian continued to employ only copper high in arsenic content.

Conclusions

In the Near East, the use of tin differed from that in Central Asia. In early second-millennium Mesopotamia, it appears as a common but expensive ingredient, an essential part of bronze metallurgy, valued mostly for its superior functional characteristics. In Central Asia, use of tin was not the technological breakthrough that it has previously been thought to indicate. Here, tin-bronze was simply employed as a cheaper alternative to gold.

According to archaeological, metallurgical and textual evidence, the Central Asian (Zerafshan) ores are not a likely source for the Mesopotamian

(or southern Iranian) tin. They do not even seem to have supplied the tin used in the LB I Sapalli Culture and we can only guess that the answer to the 'tin question' must be sought in the — as yet unexplored — mining districts of southern and western Afghanistan.

References

ALIMOV, K., BOROFFKA, N., BUBNOVA, M., BURJAKOV, J., CIERNY, J., JAKUBOV, J., LUTZ, J., PARZINGER, H., PERNICKA, E., RADILILOVSKIJ, V., RUZANOV, V., ŠIRINOV, T., STARŠININ, D. and WEISGERBER, G., 1998. Prähistorischer Zinnbergbau in Mittelasien, *Eurasia Antiqua* 4: 137-199.

ASKAROV, A.A. and RUZANOV, V.D., 1977. Nekotorye dannye o metallicheskikh splavakh s poselenija Sapallitepa, *Obshchestvennye Nauki Uzbekistana* 6: 56-59.

AVANESOVA, N., 1991. *Kultura pastusheskich plemen epokhi bronzy aziatskoj chasti SSSR*. Tashkent: FAN.

—, 1996. Pasteurs et agriculteurs de la vallée du Zerafshan (Ouzbekistan) au début de l'Age du Bronze: Relations et influences mutuelles, in: Lyonnet B., *Sarazm: Céramiques. Chalcolithique et Bronze Ancien*. Mémoires de la Mission Française en Asie Centrale 7. Paris: 117-131.

—, 2002. Novye materialy epokhi bronzy Zarafshanskoj doliny, in: Shirinov T. (ed.), *Arkheologicheskie issledovanija v Uzbekistane 2001 god*. Tashkent: 19-26.

AVANESOVA, N., ŠAJDULLAEV, Š. and ERKULOV, A., 2001. Džam — ein neuer bronzezeitlicher Fundort in der Sogdiana, *Archäologische Mitteilungen aus Iran und Turan* 33: 63-73.

BAGHESTANI, S., 1997. *Metallene Compartimentsiegel aus Ost-Iran, Zentralasien und Nord-China*. Archäologie in Iran und Turan 1. Rahden.

BERTHOUD, T., CLEUZIOU, S. and HURTEL L.P., 1982. Cuivres et alliages en Iran, Afghanistan, Oman au cours des IVe et IIIe millénaires, *Paléorient* 8/2: 39-54.

BESENVAL, R., 1988. L'étain dans l'Asie Centrale protohistorique: une source possible pour les métallurgies moyen-orientales, in: Gardin, J. (ed.), *L'Asie Centrale et ses rapports avec les civilisations orientales, des origines à l'âge du fer. Actes du colloque franco-soviétique, Paris, 19-26 nov. 1985*. Paris: 229-235.

BESENVAL, R. and ISAKOV, A., 1989. Sarazm et les débuts du peuplement agricole dans la région de Samarkand, *Arts Asiatiques* 44: 5-20.

BOBOMULLAEV, S., 1997. Ein bronzezeitliches Grab aus Zardza Khalifa bei Pendzikent (Zerafshan-Tal), *Archäologische Mitteilungen aus Iran und Turan* 29: 121-134.

BOROFFKA, N., CIERNY, J., and LUTZ, J., 1999. Bronze Age tin from Central Asia, in: Levine, M. (ed.), *Late Prehistoric Exploitation of the Eurasian Steppe*. Cambridge: 14-29.

BOROFFKA, N., CIERNY, J., and LUTZ, J., 2002. Bronze Age tin from Central Asia: Preliminary notes, in: Boyle, K., Renfrew, C. and Levine, M. (eds.), *Ancient interactions: East and West in Eurasia*. Cambridge: 136-160.

CASAL, J. M., 1961. *Fouilles de Mundigak*. Mémoires de la Délégation Archéologique Française en Afghanistan 17. Paris.

CERASETI, B., 1998. Preliminary report on ornamental elements of Incised Coarse Ware, in: Gubaev, A., Koshelenko, G. and Tosi, M. (eds.), *The archaeological map of the Murghab Delta. Preliminary reports 1990-95*. Reports and Memoirs, Series Minor 3. Rome: 67-74.

CHERNYKH, E., 1992. *Ancient metallurgy in the USSR. The early metal age*. Cambridge.

CLEUZIOU, S. and BERTHOUD, T., 1982. Early tin in the Near East, *Expedition* 3: 14-19.

DEERCKSEN, J.G., 2005. Metals according to documents from Kültepe-Kanish dating to the Old Assyrian colony period, in: Yalcin, Ü. (ed.), *Anatolian Metal III*. Der Anschnitt, Beiheft 18. Bochum: 17-34.

DOSSIN, G., 1970. La route de l'étain en Mésopotamie au temps de Zimri-Lim, *Révue d'Assyriologie et d'Archéologie Orientale* 64: 97-106.

DYSON, R.H. and HOWARD, S. M. (eds.), 1989. *Tappeh Hissar — Reports of the restudy project, 1976*. Monografie di Mesopotamia 2. Florence.

EIDEM, J., 1992. *The Shemshara archives 2. The administrative texts*. Historisk-Filosofiske Skrifter 15. Copenhagen.

EIDEM, J. and LAESSØE, J., 2001. *The Shemshara archives 1. The letters*. Historisk-Filosofiske Skrifter 23. Copenhagen.

GIUMLIA-MAIR, A. and LO SCHIAVO, F. (eds.), 2003. *The problem of early tin / Le problème de l'étain à l'origine de la métallurgie*. BAR IS 1199. Oxford.

GÖRSDORF, J. and HUFF, D., 2001. 14C-Datierungen von Materialien aus der Grabung Dzarkutan, Uzbekistan, *Archäologische Mitteilungen aus Iran und Turan 33*: 75-87.

GUBAEV, A., KOSHELENKO, G. and TOSI, M. (eds.), 1998. *The archaeological map of the Murghab Delta. Preliminary reports 1990-95*. Reports and Memoirs, Series Minor 3. Rome.

HEIMPEL, W., 1987. Das Untere Meer, *Zeitschrift für Assyriologie und Vorderasiatische Archäologie* 77: 22-91.

HIEBERT, F.T., 1999. The archaeological evidence for interaction between Eurasian steppe and Central Asian cultures, in: Levine, M. (ed.), *Late Prehistoric Exploitation of the Eurasian Steppe*. Cambridge: 123-127.

—, 2002. Bronze Age interaction between the Eurasian steppe and Central Asia, in: Boyle, K., Renfrew, C. and Levine, M. (eds.), *Ancient interactions: east and west in Eurasia*. Cambridge: 237-248.

HUFF, D., 2000. Tempel oder Palast? Dscharkutan — Monumentalbauten und Siedlung im bronzezeitlichen Baktrien, in: Kyrieleis, H. (ed.), *Archäologische Entdeckungen. Die Forschungen des Deutschen Archäologischen Instituts im 20. Jahrhundert*. Mainz: 115-118.

HUFF, D., PIDAEV, C. and CHAYDOULLAEV, C., 2001. Uzbek-German archaeological researches in the Surkhan Darya region, in: Leriche, P., Pidaev, S. and Gelin, M. (eds.), *La Bactriane au carrefour des routes et des civilisations de l'Asie Centrale. Termez et les villes de Bactriane-Tokharestan*. Paris: 219-233.

JOANNÈS, F., 1991. L'étain, de l'Elam à Mari, in: Meyer, L. and Gasche, H. (eds.), *Mésopotamie et Elam. Actes de la XXXVIème Rencontre Assyriologique Internationale, Gand, 10-14 juillet 1989*. Mesopotamian History and Environment. Occasional Publication 1. Ghent: 67-76.

—, 1997. Metalle und Metallurgie. A.I. In Mesopotamien, in: Edzard, D.O. (ed.), *Reallexikon der Assyriologie und Vorderasiatischen Archäologie* 8 (1993-97). Munich: 96-112.

KANIUTH, K., in print. *Metallobjekte der Bronzezeit aus Nordbaktrien*. Archäologie in Iran und Turan 6.

KANIUTH, K. and TEUFER, M., 2001. Zur Sequenz des Gräberfeldes von Rannij Tulchar und seiner Bedeutung für die Chronologie des spätbronzezeitlichen Baktrien, *Archäologische Mitteilungen aus Iran und Turan* 33: 89-113.

KHLOPIN, I., 2002. *Epokha bronzy jugo-zapadnogo Turkmenistana*. Trudy JuTAKE 21. St. Petersburg.

KOHL, P.L., 2002. Archaeological transformations: Crossing the pastoral/agricultural bridge, *Iranica Antiqua* 37: 151-190.

KUZMINA, E.E., 1966. *Metallicheskie izdelija eneolita i bronzovo veka v Srednej Azii*. Arkheologija SSSR. Svod arkheologicheskikh istochnikov B,4-9. Moscow.

LAMBERG-KARLOVSKY, C.C., 2003. Civilization, state, or tribes? Bactria and Margiana in the Bronze Age, *The Review of Archaeology* 24: 11-19.

LARSEN, M.T., 1967. *Old Assyrian caravan procedures*. Publications de l'Institut Historique et Archéologique Néerlandais de Stamboul 22. Leiden.

—, 1976. *The Old-Assyrian city-state and its colonies*. Mesopotamia 4. Copenhagen.

—, 1987. Commercial networks in the Ancient Near East, in: Rowlands, M., Larsen, M. and Kristiansen, K. (eds.), *Centre and periphery in the Ancient World*. Cambridge: 47-56.

LAESSØE, J., 1959. *The Shemshara tablets. A preliminary report*. Arkaeologisk-kunsthistoriske meddelelser 4,3. Copenhagen.

LEEMANS, W.F., 1960. *Foreign trade in the Old Babylonian period*. Leiden.

—, 1968. Old Babylonian letters and economic history, *Journal of the Economic and Social History of the Orient* 11: 171-226.

LIGABUE, G. and SALVATORI, S. (eds.), 1990. *Bactria. An ancient oasis civilization from the sands of Afghanistan*. Venice.

LITVINSKIJ, B.A., 1950. K istorii dobychi olova v Uzbekistane, *Trudy Samarkandskogo Gosudarstvennogo Universiteta* 11: 51-67.

MALFOY, J.-M. and MENU, M., 1987. La métallurgie du cuivre à Suse aux IV^{e} et III^{e} millénaires, in: Tallon, F., *Métallurgie Susienne I. De la fondation de Suse au XVIII^{e} siècle avant J.-C*. Paris: 354-372.

MICHEL, C., 1996. Le commerce dans les textes de Mari, in: Durand, J.-M. (ed.), *Amurru 1. Mari, Ébla et les Hourrites. Dix ans de travaux*. Première Partie. Actes du Colloque International. Paris: 385-426.

MOOREY, P.R.S., 1994. *Ancient Mesopotamian materials and industries. The archaeological evidence*. Oxford.

MUHLY, J.D., 1973. Copper and Tin. The distribution of mineral ressources and the nature of the metals trade in the Bronze Age, *Transactions of the Connecticut Academy of Arts and Sciences* 43: 155-535.

—, 1995. Mining and metalwork in Ancient Western Asia, in: Sasson, J. (ed.), *Civilizations of the Ancient Near East*. New York: 1501-1521.

—, 1999. Copper and bronze in Cyprus and the Eastern Mediterranean, in: Pigott, V.C. (ed.), *The archaeometallurgy of the Asian Old World*. Philadelphia: 15-25.

NICKERSON, J.L., 1983. *Intrasite variability during the Kaftari Period at Tal-e Malyan (Anshan), Iran*. Ann Arbor.

NORTHOVER, J.P., 1989. Properties and use of arsenic-copper alloys, in: Hauptmann, A., Pernicka, E. and Wagner, G.A. (eds.), *Archäometallurgie der Alten Welt*. Bochum: 111-118.

PARZINGER, H. and BOROFFKA, N. (eds.), 2003. *Das Zinn in der Bronzezeit in Mittelasien I. Die siedlungsarchäologischen Forschungen im Umfeld der Zinnlagerstätten*. Archäologie in Iran und Turan 5. Mainz.

PARZINGER, H., PERNICKA, E. and WEISGERBER, G., 2003. Zusammenfassung, in: Parzinger, H. and Boroffka, N. (eds.), *Das Zinn in der Bronzezeit in Mittelasien I. Die siedlungsarchäologischen Forschungen im Umfeld der Zinnlagerstätten*. Archäologie in Iran und Turan 5. Mainz: 287-301.

PENHALLURICK, R.D., 1986. *Tin in antiquity: its mining and trade throughout the ancient world with particular reference to Cornwall*. London.

PERNICKA, E., 1990. Gewinnung und Verarbeitung der Metalle in prähistorischer Zeit, *Jahrbuch des Römisch-Germanischen Zentral-Museums* 37: 21-129.

PIGOTT, V.C., 1989. Archaeo-metallurgical investigations at Bronze Age Tappeh Hesar, in: Dyson, R.H. and. Howard, S.M (eds.), *Tappeh Hissar — Reports of the restudy project, 1976*. Monografie di Mesopotamia 2. Florence: 25-33.

—, 1996. Near Eastern archaeometallurgy: Modern research and future directions, in: Cooper, J.S. and Schwartz, G.M. (eds.), *The study of the Ancient Near East in the twenty-first century. The William Foxwell Albright Centennial Conference*. Winona Lake: 139-176.

—, 1999a. The archaeometallurgy of the Asian Old World. Introductory comments, in: Pigott, V.C. (ed.), *The archaeometallurgy of the Asian Old World*. Philadelphia: 1-13.

—, 1999b. The development of metal production on the Iranian Plateau: An archaeological perspective, in: Pigott, V.C. (ed.), *The archaeometallurgy of the Asian Old World*. Philadelphia: 73-106.

PIGOTT, V.C., ROGERS, H.C. and NASH, S.K., 2003. Archaeometallurgical investigations at Malyan: The evidence for tin-bronze in the Kaftari phase, in: Miller, N.F. and Abdi, K. (eds.), *Yeki bud, yeki nabud. Essays on the archaeology of Iran in honor of W. M. Summer*. Los Angeles: 160-176.

POTTS, T.F., 1994. *Mesopotamia and the East. An archaeological and historical study of foreign relations ca. 3400-2000 BC*. Cambridge.

REITER, K., 1997. *Die Metalle im Alten Orient. Unter besonderer Berücksichtigung altbabylonischer Quellen*. Alter Orient und Altes Testament 249. Münster.

ROSSI-OSMIDA, G. (ed.), 2002. *Margiana. Gonur-depe necropolis. 10 years of excavations by Ligabue Study and Research Centre*. Padova.

RUZANOV, V.D., 1999a. K voprosy o istokakh olovjanistykh bronz v metallobrabatyvajushchykh proizvodstvakh plemen juga Srednej Azii v epokhu bronzy. *O'zbekiston Moddiy Madaniyati Tarikhi* 30: 37-40.

—, 1999b. Zum frühen Auftreten der Zinnbronze in Mittelasien, in: Hauptmann, A., Pernicka, E. and Rehren, T. (eds.), *The beginnings of metallurgy*. Proceedings of the international conference. Der Anschnitt, Beiheft 9. Bochum: 103-106.

SARIANIDI, V.I., 1976. Issledovanie pamjatnikov Dashlinskogo oazisa, in: Kruglikova, I. T. (ed.), *Drevnjaja Baktrija 2,1. Materialy sovetsko-afganskoj ekspeditsii 1969-1973gg*. Moscow: 21-86.

—, 1986. *Die Kunst des alten Afghanistan*. Leipzig.

—, 1990. *Drevnosti strany Margush*. Ashkhabad.

—, 1998. *Margiana and protozoroastrism*. Athens.

—, 2001. *Nekropol gonura i iranskoe jazychestvo*. Moscow.

SHCHETENKO, A.JA. and KUTIMOV, JU.G., 1999. Keramika stepnogo oblika epokhi pozdnej bronzy Tekkem-Depe (Juzhnij Turkmenistan), *Arkheologicheskie Vesti* 6: 114-123.

STECH, T. and PIGOTT, V.C., 1986. The metals trade in Southwest Asia in the third millennium BC, *Iraq* 48: 39-64.

STECH, T., 1999. Aspects of early metallurgy in Mesopotamia and Anatolia, in: Pigott, V.C. (ed.), *The archaeometallurgy of the Asian Old World*. Philadelphia: 59-71.

TEREKHOVA, N.N., 1990. Obrabotka metallov v drevnej Margiane, in: Sarianidi V.I., *Drevnosti strany Margush*. Ashkhabad: 177-202.

TEUFER, M., 2005. The Late Bronze Age chronology of Southern Uzbekistan. A reanalysis of the funerary evidence, in: Franke-Vogt, U. and Weisshaar, H.-G. (eds.), *South Asian Archaeology 2003. Proceedings of the Seventeenth International Conference of the European Association of South Asian Archaeologists*. Forschungen zur Archäologie außereuropäischer Kulturen 1. Aachen: 199-209.

THORNTON, C.P. and LAMBERG-KARLOVSKY, C.C., 2004. Tappeh Yahya and the prehistoric metallurgy of early South-eastern Iran, in: Stöllner, T. (ed.), Persiens antike Pracht: Bergbau — Handwerk — Archäologie. Bochum: 264-273.

UNITED NATIONS, 1995. *Geology and mineral resources of Afghanistan*. Atlas of mineral resources of the ESCAP region vol. 11. New York.

VINOGRADOVA, N.M. and KUZMINA, E.E., 1986. Kontakty stepnykh i zemledelcheskikh plemen Srednej Azii v epokhu bronzy, in: Litvinskij, B.A. (ed.), *Vostochnyj Turkestan i Srednjaja Azija v sisteme kul'tur drevnego i srednevekovogo vostoka*. Moscow: 126-152.

WEEKS, L.R., 1997. Prehistoric metallurgy at Tell Abraq, U.A.E., *Arabian Archaeology and Epigraphy 8*: 11-85.

—, 1999. Lead isotope analysis from Tell Abraq, United Arab Emirates: new data regarding the 'tin problem' in Western Asia, *Antiquity* 73: 49-64.

—, 2004. *Early metallurgy of the Persian Gulf. Technology, trade, and the Bronze Age world*. Boston.

WEISGERBER, G., 2004. Prähistorischer und historischer Bergbau in Afghanistan, Teil 2, *Der Anschnitt* 56: 190-211.

YENER, K.A., 2000. *The domestication of metals. The rise of complex metal industries in Anatolia*. Culture and History of the Ancient Near East 4. Leiden.

YENER, K.A. and VANDIVER, P.B., 1993. Tin processing at Goltepe, an Early Bronze Age site in Anatolia, *American Journal of Archaeology* 97: 207-238.