SHARING ORE SOURCES: LEAD ISOTOPE ANALYSES OF THIRD AND SECOND MILLENNIUM BC METALS FROM TELL ATCHANA (ALALAKH) AND TELL LEILAN (SHUBAT ENLIL)

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Abstract

The present work addresses the topic of long-distance metal exchange during the late 3rd and 2nd millennium BC between the sites of Tell Leilan (ancient Şubat Enlil) and Tell Atchana (ancient Alalakh). With new lead isotope data, we can demonstrate that during the EBA and MBA both sites were acquiring metals from a similar source. While it is not currently possible to definitively identify this deposit, the most likely candidates are the Amanus mountains or the Trabzon ore fields in the Black Sea region, with reasonable archaeological and historical explanations justifying either choice. In the subsequent LBA, this source no longer appears to be active to any significant degree, with Taurus 1A and 2B deposits providing the vast majority of material to Alalakh. Finally, from a technological perspective we can further note that the Leilan material shows patterning suggestive of a greater degree of recycling than that seen at Atchana, potentially reflecting more limited access to metal resources.

Introduction

It is both an honor and pleasure to have been invited to contribute an article to a festschrift for Jak Yakar: a pleasure because it is gratifying to have the opportunity to pay tribute to a scholar who played such an important role in the understanding of early metal use in Anatolia; and an honor because his intellectual inquiry into ethnoarchaeological studies greatly enriched anthropological science in a rarely studied area. In the course of a distinguished career, Professor Yakar touched on many aspects of nomads, their crafts and the iconography of symbols, and inspired Yener's interest in metal trade. This contribution addresses the lead isotope ratio (LIA) results of third and second millennium BC metal artifact samples from two urban sites in Turkey and Syria (Fig. 1), Tell Atchana (Alalakh) and Tell Leilan

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(Shubat Enlil) respectively. Here we report on the LIA analyses of eleven Early Bronze Age (EB; ca. 3000-1900 BC) and Middle Bronze Age (MB; ca. 1900-1750 BC) artifacts from Tell Leilan and fifteen Middle Bronze Age and Late Bronze Age (LB; 1500-1100 BC) samples from Alalakh (Table 1).

The site of Tell Atchana, Alalakh is located 50km inland in the most southern state of Turkey. Bounded by the north-south alignment of the Amanus Mountains on the west, only a few passes provided access to inland areas from the Mediterranean Sea where Alalakh is located. Alalakh was the capital of a small Bronze Age principality called Mukish, situated on a crucial interregional communication route on the border between Anatolia, the Levant, and inner Syria. Access to the sea via the Orontes added Cyprus and the Aegean to Alalakh's horizons. From its founding in the transition to the Middle Bronze Age, Alalakh was part of the Amorite cultural and linguistic horizon that extended from the foothills of Anatolia in the north to the area of the southern Levant and east into much of Syro-Mesopotamia. Furthermore, within this region was a complex matrix of Amorite, Hurrian and Luwian cultural and linguistic elements, the latter of which become predominant in later occupation phases.

Tell Atchana was surveyed by Robert Braidwood as part of his Syro-Hittite

Table 1: Lead isotope ratios and sample data for Tell Leilan and Tell Atchana artifacts.

Excavation #	LIA Analysis #	Object	Material	Major Period	$^{204/206}Pb$	$^{208/206}Pb$	$^{207/206}Pb$
L79-58(=45T115)	SAN819	Pin	Pb	MBA	0.053694	2.082489	0.841466
L80-61(=op236)	SAN820	Pin	Cu-based	EBA	0.057713	2.148558	0.899665
L80-60(=op236)	SAN821	Pin	Cu-based	EBA	0.053917	2.087097	0.844537
L87-76G20 83	SAN828	Amorph	Pb	EBA	0.052331	2.068629	0.823867
L85-45 511 111	SAN829	Wire	Cu-based	MBA	0.053683	2.085940	0.843869
L87-44w1z 26	SAN830	Amorph	Cu-based	EBA	0.052961	2.068775	0.830855
L80-30 (=op161)	SAN831	Amorph	Cu-based	EBA	0.052906	2.053156	0.829678
L87-1700(=44w1235)	SAN832	Amorph	Cu-based	EBA	0.053261	2.077559	0.836608
L82-53	SAN835	Nail	Cu-based	MBA	0.054724	2.091219	0.854679
L80-6	SAN837	Pin	Cu-based	EBA	0.052744	2.068412	0.827929
L80-6	SAN838	Pin	Cu-based	EBA	0.054110	2.085330	0.847680
AT22915	AAUI1	Amorph	Cu-based	LB2	0.053558	2.079779	0.840570
AT22669	AAUI2	Shaft	Cu-based	LB2	0.053186	2.063164	0.833193
AT16124	AAUI3	Ingot	Pb	LB2	0.052705	2.055364	0.826964
AT2467	AAUI4	Amorph	Cu-based	LB2	0.052810	2.059492	0.828929
AT21644	AAUI6	Amorph	Cu-based	LB2	0.052792	2.058694	0.828880
AT2444	AAUI7	Shaft	Cu-based	LB2	0.052865	2.058919	0.829606
AT15908	AAUI8	Shaft	Cu-based	LB2	0.052809	2.059054	0.828859
AT15275	AAUI9	Strip	Pb	LB2	0.052679	2.054262	0.826409
AT569	AAUI10	Amorph	Cu-based	LB2	0.052874	2.057393	0.829156
AT1564	AAUI11	Ring	Pb	LB1	0.053767	2.083052	0.843832
AT11799	AAUI12	Pin	Cu-based	MB	0.054133	2.088365	0.847191
AT22404	AAUI13	Amorph	Cu-based	LB2	0.052757	2.054207	0.826963
AT11716	AAUI14	Pin	Cu-based	MB	0.053713	2.083370	0.842187
AT12336	AAUI15	Ring	Pb	LB1	0.055859	2.119798	0.872732
AT4950	AAUI16	Sheet	Cu-based	LB1	0.053365	2.068700	0.834605

expedition, the Amuq Valley survey project in the 1930‘s (Braidwood 1937). Sir Leonard Woolley excavated the site in 1936-1939 and 1946-1949 and identified it as Alalakh (Woolley 1955 and references). The Amuq Valley Regional Project (AVRP) returned to the mound in 2000 (Yener 2005, 2010, 2019) and excavations have been underway since 2003 revealing the Middle Bronze II through the Late Bronze II periods (Figs. 2 and 3). Metal objects excavated from the site were found to contain tin-bronze, copper, arsenical copper, and lead objects that, while deeply corroded, retained substantial metal. Atomic absorption spectrography analyses of the assemblage by Hadi Özbal (2006) at Boğaziçi University revealed substantial evidence of ternary bronzes, suggesting alternate sources of tin (Yener 2010; Yener et al. 2015) or recycling.

Tell Leilan, centrally located on the left bank of the Wadi Jarrah on the high yield dry-farming Habur Plains of northeast Syria, is a 90-hectare walled site that dominates the plain 20 meters below. Occupation as a sixth millennium BC 15 hectare town suddenly expanded to a ca. 90 hectare walled city at ca 2700 BC (Leilan IIId/IIa periods), when the city was known as Shekhna, part of the still unexplained abrupt wave of urbanization across west Asia. At 2300 BC, the southern Mesopotamian Akkadians imperialized northern Mesopotamia, destroyed the Leilan Acropolis palace, and the early Akkadian schoolroom across the street, rebuilt a new palace in the shell of the old, and began a program of region-wide imperialization (Weiss, ed. 2017). This imperial program was expanding imperial storeroom constructions when the abrupt onset of the 4.2 ka BP megadrought forced settlement abandonments across dry-farming west Asia and habitat-tracking to riparian and paludal refugia, such as the Amuq Plain and the Euphrates River (Weiss 2015).

Three hundred years later, at the return of pre-medgadrought precipitation ca. 1900 BC, the dry-farming plains were resettled by formerly pastoralist Amorite populations, with previously abandoned Tell Leilan now selected as the Habur Plains regional capital and renamed Shubat Enlil by the Amorite paramount chief Shamshi-Adad (Ristvet and Weiss 2013) who lived 1839-1776 BC (Manning et al 2016) and controlled an imperial territory that extended from the western Zagros Mountains to Tuttul on the Euphrates River . Other Khabur Plains sites, such as Tell Brak and Tell Mozan, remained reduced population towns (Weiss 2012) within a landscape now heavily repopulated (Ristvet 2008). The retrieval of the Acropolis Northeast temple (Figures 4 and 5) floors uncovered the scores of inscribed royal servant seal impressions that identified the site as Shubat Enlil (Weiss 1985). The terminal occupation floor revealed a fragment of gold leaf and remains of burnt wood furniture with fragmentary embellishments of both tin bronze and arsenical copper sheathing (Peter Northover in deRyck et al. 2005).

Almost 1700 early second millennium Leilan cuneiform tablets derive from a sample of the Lower Town Palace East built and occupied by Shamshi-Adad and successors until the destruction of Shubat Enlil by Samsuiluna of Babylon in 1728 BC. Within the Lower Town Palace East archives is the documentation for five Old Assyrian *kārum*s (merchant colonies) that exchanged Iranian or Afghani source tin ores for Anatolian copper and gold: two *kārum*s for distant merchants, from Assur ("The House of the Servant of Assur") and Sippar, and three *kārum*s for local Habur Plains region merchants from Kahat, Sunā, and Amursakkum. Also retrieved, a treaty with the city of Assur provided a legal frame for resident Assur merchants and for "up and down" merchants travelling between Assur and Leilan (Eidem 2008; Eidem 2011; Veenhof 2013). The five Old Assyrian *kārum*s at Tell Leilan comprised a major lowland Mesopotamia copper and tin trade hub for the highland Anatolia hub at Kultepe Kanesh controlling widespread additional *kārum*s. The Lower Town Palace North (Figure 4), the embassy of the king of Andarig, about 100 kilometers to the south, was yet another vector for regional influences at Leilan (van de Mieroop 1994; Pulhan 2000). The multiple sources of merchants and trade resources are reflected at Tell Leilan in the multiple styles of legitimizing iconography within assemblages of scores of royal official cylinder seals (Parayre 1985). Noteworthy is the contemporary and complementary tin distribution and copper ore acquisition systems that passed from Iran to along the Euphrates and linked Elam, Mari, Aleppo, and Ugarit, and thence Hazor and Laish in Palestine (Dossin 1970; Muhly 1985; Joannès 1991).

Methods

The Leilan samples were part of a LIA project directed by Yener, which was initiated in the 1980's (Yener et al. 1991; Sayre, Yener and Joel 1992, 1993, 1995; Sayre, et al. 1992). The early studies of compositional analysis of Syro-Anatolian metals at Boğaziçi University and the necessity of more precise characterization afforded by lead isotope research spurred a separate arm of the archaeometallurgy initiative directed toward obtaining ore and slag samples from various mining districts in Turkey. Since the selection and processing of ores would be directly reflected in the lead isotope ratios, this consideration formed the basis for the first target region, the central Taurus Mountain range and the possibility that it and various other Turkish resources had been exploited in the formative years of metallurgy and Bronze Age trade both within Anatolia and with Syro-Mesopotamia. The isotopic measurements of the Leilan artifact samples and many Anatolian ore sources were carried out at the National Institute of Science and Technology (NIST, formerly the National Bureau of Standards) by Emile Joel of the Conservation Analytical Laboratory of the Smithsonian Institution working with I. L. Barnes of the Center for Analytical Chemistry at NIST. Edward V. Sayre of the Conservation Analytical Laboratory of the Smithsonian Institution collaborated with K. Aslıhan Yener on the statistical analyses of these data. The analytical method in lead isotope analysis used chemical separation techniques of acid dissolution, ion-exchange chromatography, and electrodeposition procedures designed for the separation of micro and sub-microgram quantities of lead. The lead isotope ratios are determined using a NIST thermal ionization mass spectrometer designed for high precision measurements (see Yener et al. 1991: 572 and references).

The analysis of 15 MBA and LBA Cu-based and Pb-based samples from Tell Atchana was conducted by Johnson on a Nu Plasma MC-ICP-MS at the University of Illinois Urbana-Champaign Geosciences Department. The procedure for sample preparation generally followed the "HCl Method" outlined by Kamber and Gladu (2009). Sample dissolution was carried out in 3ml capped Teflon beakers using 2ml concentrated HNO_3, which was then evaporated to dryness at 90°C. Prior to use, separation columns were cleaned in a bath of 4M HNO_3 and loaded with sufficient anion exchange resin (BioRad AG 1-X8) to fill the neck of each column. Columns were flushed using a full reservoir rinse of 10M HCl, followed by a full reservoir rinse of Milli-Q H_2O. Columns were equilibrated using 8 drops of 0.5M HBr. Dried samples were brought up using 500µl 0.5M HBr and charged into equilibrated separation columns. Each sample was rinsed dropwise using 75µl 0.5M HBr followed by two bulk rinses of 1000µl each using 0.5M HBr. Two rinses using 300µl 10.5M HCl were used to elute lead from the separation columns, which was then collected in 3ml Teflon beakers and dried overnight on a hot plate at 90°C. Samples were then brought up with 1500µl 2% HNO3 and treated with a 10µl $^{205/203}Tl$ spike for mass bias correction. During analysis, system stability was evaluated via analysis of a 50ppb solution of Pb standard SRM-981 per four samples.

Results and Discussion

The lead isotope ratios of artifacts from Tell Atchana and Tell Leilan, plotted alongside those of regional ore sources at the Taurus, Cypriot, Amanus, Black Sea, Iranian, Omani, and Levantine deposits suggests both important points of overlap in metal sourcing for the two sites and a historical narrative describing in part the use of different sources. The results of the current analyses were compared with a total of 338 analyses from the regions mentioned above. Given the variety of methods currently used to LIA data visualization, we initially evaluated our results using all of the typical plot configurations currently deployed in archaeometallurgical practice. In all cases, the suggested attributions discussed below remained valid, with only a handful of instances in which different plot configurations suggested a potential alternative. In the interest of clarity and legibility, we have opted to present only the plots for $^{208/206}$Pb vs. $^{207/206}$Pb and $^{204/206}$Pb vs. $^{207/206}$Pb and included only those ore groups that appeared as the most probable sources. Because the sample sets from both sites included both copper-based and lead objects, the ores used for comparison included both copper and lead minerals. In a number of instances, such as for the Taurid sources, the vast majority of our samples stem from Pb-rich polymetallic ores with a relatively low copper content (cf. Yener et al. 1991; Sayre et al. 2001). We acknowledge that using lead ores for the evaluation of copper sources – and vice versa – present a variety of geochemical pitfalls. Conclusions drawn from such comparisons are necessarily tentative until availability of a more robust collection of copper ore analyses for the Taurus range. However, given the polymetallic nature of many of these ores, we consider their comparison a worthwhile exercise.

In the case of the Tell Atchana objects, it is possible to identify three object clusters plotting to Taurid deposits, with a smaller number potentially associated with the Black Sea and other deposits, and only a small number of unattributable objects (Figs. 7 and 8). Two sets of artifacts cluster exceptionally well in close proximity to the Taurus 1A (Bolkardağ) and 2B (Aladağ) ore groups (1A: AAUI3, AAUI9, and AAUI13; 2B: AAUI4, AAUI7, AAUI6, AAUI8, and AAUI10). Even if we are obliged to hedge on the precise origin of the ores for these objects, the clustering in each case is generally indicative of similar sources. The remaining samples from Tell Atchana fall into several different groups with varying degrees of archaeological plausibility. Potential Taurus 2A (Aladağ) specimens include AAUI14 and AAUI1, while a further set of two samples (AAUI12 and AAUI11) may be tentatively assigned to the Trabzon ore group. The remaining three Tell Atchana objects AAUI2, AAUI15, and AAUI16 fall into substantially different categories. AAUI2 is generally unattributable. It is probable that they should be assigned to Taurid deposits or classed as recycled material. AAUI15 (not shown on the plot) is consistent with Levantine LIA signatures, with a strong suggestion of Timna as a source. AAUI16 appears likely to be a result of recycling between Taurus 2B and 1B sources, although there is also reasonable concordance with a group of ores originating from northwestern Anatolia. Given the limited indication of interaction between northwestern Anatolia and northern Syria during the Late Bronze I period (1500-1400 BC), a Taurid identification seems possible.

The Tell Leilan objects display substantially more diffuse patterning, suggesting the exploitation of a greater range of source areas, though the position of several objects at the interstices of ore groups could also be taken to indicate limited recycling (Nørgaard, Pernicka, and Vandkilde 2019, 14). The most clearly attributable set of Leilan objects consists of SAN821, 829, and 838. These objects all plot comfortably into the field for the Trabzon ore group, providing a potentially interesting overlap with Atchana samples AAUI12 and AAUI11. SAN819 then plots into the Taurus 2A group. The remaining Tell Leilan samples do not fall securely within any particular ore fields, leading us to suspect that these objects may be a result of recycling, mixing of metal from different sources, and/or alloying processes such as the addition of lead, pending complementary compositional analysis. SAN832, falls between Taurus 1B and 2A, while SAN835 falls between Trabzon and Levantine sources. The rather unusual position of the latter will require further explanation moving forward. Samples SAN828, 830, and 837, extending directly leftward from the general trend on the $^{208/206}$Pb vs. $^{207/206}$Pb plot (Fig. 7), represent unusual outliers for which we are currently unable to provide an explanation. SAN831 could potentially be a result of recycling involving Keban or Amanus ores. Finally, SAN820 (not shown) represents an extreme outlier for which there is also no current explanation.

Particularly striking is the extent to which Tell Leilan material falls along the entire distribution of ore analyses, as opposed to the comparatively ore-specific associations of the Tell Atchana material. This broad distribution could be taken as indicative of Tell Leilan's extensive regional interconnections. The observation that much of the associated material falls within the interstices of the Taurid sources supplying Tell Atchana seems better explained by the use of metals from similar sources, but with the former exhibiting a greater degree of recycling. From a technological perspective, we can suggest that reliance on long-distance, likely intermittent, supplies of metal would lead local smiths to adopt a maximizing strategy that encouraged recycling. Conversely, at a site like Atchana, located in relatively close proximity to the Taurid sources, and with potentially easy access to Amanus ores, recycling seems to have generally been a less common phenomenon, or when recycling did take place, it did not frequently involve the mixing of metals from different sources. Evidently, Tell Leilan at a substantial distance from primary ore sources was a major regional and inter-regional Old Assyrian tin trade hub with significant access to overland trade, reliance on long-distance trade, and/or metals recycling.

One of the more intriguing points seen in these plots, however, is clustering of both Atchana and Leilan objects in the field of the Trabzon ore group, for which we may suggest two potential explanations. The first is that the Trabzon deposits were in fact a minor supplier of copper to the north Syrian milieu during the EBA and MBA. The second explanation, based on our single Amanus point, which plots in close proximity to the objects concerned, is that sources local to Atchana supplied both sites with a limited amount of copper during the same period.

Regarding the first option, despite the significant distances involved in transporting material from the Black Sea to northern Syria, if we consider the significant involvement of Black Sea sources in the intra-Anatolian copper trade of the Early and Middle Bronze Age, this suggestion gains substantial merit. In particular, Barjamovic's (2011, 242–66) discussion of the location of Durmitta – a major copper emporium of the Middle Bronze Age – is significant. Within this discussion, we see first that Durmitta is located within the Black Sea region, somewhere between the modern cities of Sinop and Trabzon. Second, while the city itself is not necessarily involved in the primary production of copper, it does represent a local collection point and market for metal resources, with traders moving quantities of copper in excess of several tons (Barjamovic 2011, 262). Finally, we know from the Kültepe archives that Durmitta represented a portion of the textually attested Assyrian Trade Network that maintained direct links to the hub at Kanesh, but was also frequently accessed by smuggling routes east of Kaneş known as the "Narrow Track" (Barjamovic 2011, 176). From either location, copper was sent back to Assur or circulated through central Anatolia as part of the broader trade network, with both possibilities providing access to sites in northern Syria (Lehner et al. 2014, 195).

Having established the historical link between Black Sea metallurgical resources and the broader Central Anatolian trade network, there remains the question of how this material would have made it to Tell Atchana. In this respect, past and recent excavations at the site have revealed a host of connections with Kültepe/Kaneş. Several lines of evidence suggest that exchange relationships between Alalakh and the Middle Bronze Age central Anatolian kingdoms, such as Kanesh, were established prior to the arrival of Hattushili I who destroyed the MB II Level VII Palace. The production of fine artifacts such as sophisticated metallurgy (bronze, gold, silver and other metals), glass, faience, bone and ivory carving were under palace patronage (Yener 2007). As such, seals and sealings from Alalakh more or less contemporary to Kültepe show intriguing administrative connections between the two sites. For example, the sealing of Ilbani written in Old Assyrian script from the mud brick debris from the wall of Level X (Collon 1982, no. 14) and a whole series of seals and sealings depicting skeletal figures at Alalakh (Collon 1982, no. 11) found all over central Anatolia and northern Syria presumably belonged to minor administrative officials.

However, this evidence applies exclusively to the Middle Bronze age, leaving for explanation the presence of potential Black Sea materials at Tell Leilan during the Early Bronze Age. Over roughly the past two decades, an increasing body of scholarship has articulated the outlines of a local Anatolian Early Bronze Age predecessor to the trade networks given voice in the Kültepe tablets (Yener et al.

2015; Massa and Palmisano 2018; Mehofer 2016; Şahoğlu 2005). Among the key features of this trade is its capacity to connect western and central Anatolia with the northern Levant and Mesopotamia, in essence suggesting that the basic infrastructure of the Middle Bronze Age network was already in place and functioning prior to the activities discussed in the Kültepe texts (Yener 2015). As such, there would seem to be multiple archaeological and historical explanations for Trabzon area metals as far south as Tell Leilan.

As for the possibility of Amanus ores being the source of some of the metals found at Leilan and Atchana, our single data point only hints at this as an option. We are currently awaiting LIA results for a series of copper ores from the Amanus range to improve our characterization of these deposits, but for the time being this suggestion remains highly tentative. Nevertheless, from an archaeological perspective, the Amanus present a more satisfying option as a source area in terms of closer proximity to both sites, while also helping to account for the presence of primary production debris at Atchana. In addition, this suggestion also frees us from reliance on a narrative relying on an expansive EB trade network, which is at present only loosely defined.

In light of the preceding discussion, it is worth considering our results from a chronological perspective. When plotted according to broad periodizations, the LIA values for the objects from Tell Atchana and Tell Leilan show a striking division in their potential provenance. As seen in (Fig. 9a) we may note that this potential Trabzon grouping is almost entirely composed of materials dating to the MBA and EBA. When we then examine these according to their general composition and in relation to the major ore groups (Fig. 9b), we find that the copper-based objects plot in proximity to the Trabzon copper ores. Once again, however, our point from the Amanus range, originating from Söğüt, is also a copper ore that could be related to materials for these earlier artifacts. In the latter case, however, we must then provide an explanation for why we would see exploitation of a closer ore source in earlier periods, only to see it abandoned in favor of more distant Taurid sources in the LBA.

Our current evidence, therefore, provides for a few general suggestions. First and foremost is the observation that ore deposits in the Taurus seem to have formed the primary suppliers for metallurgical activity at Tell Atchana and Tell Leilan. In the case of lead artifacts, this pattern is clearest, with the most likely sources being the Taurus 2A and 1A groups. In the case of copper-based artifacts, there is a clear distinction between MBA-EBA materials on the one hand and LBA materials on the other. For earlier periods, we may posit the inclusion of both sites in a wide-ranging Anatolian trade network with roots in the EBA, reaching its apex during the

MBA. Nevertheless, we cannot exclude the possibility that these earlier materials were produced from ores located near the modern village of Söğüt, approximately 75km north of Tell Atchana. Pending LIA results of artifacts from Alalakh and ores from the Amanus, we reserve judgement on this fascinating question. Finally, while the data clearly demonstrate the use of similar metallurgical resources at both sites, there appear to be clear differences in how those resources are used, with a potentially greater degree of multi-sourcing and/or recycling at Tell Leilan.

Conclusions

The examination of 26 copper-based fragments has illuminated an urban tier of a highland production model for Syro-Anatolia (Yener 2000). This model is one that involves the two-tiered production of metal artifacts. The first tier entails the mining and smelting operations in the metalliferously rich ore deposits and forests, usually located in the mountains. The second tier are the lowland urban centers where the processed ores, either in the form of ingots or semi-processed materials are then refined, resmelted, alloyed and cast into the various idiosyncratic metal corpus of each site. Recent research in ancient metallurgy and its sources have led to a better understanding about cultural relations especially during the formative periods of metal technology and state formation in Anatolia. Once metal became locked into a cultural system as an indicator of wealth, disparities in access to labor and resources influenced how individuals operated within and between communities of producers and consumers. These relations often linked distant groups together into cooperative agreements, such as Alalakh and Leilan. Therefore, metal technologies are strategically placed in complex networks and institutions of production, exchange, and consumption that effectively unite disparate highland resource areas and agricultural lowlands; in effect, a multi-tiered production model (Yener et al. 2015; Lehner and Yener 2014).The analytic results of these copper-based metal fragments have important ramifications in illuminating the practices of bronze production in the early second millennium BC.

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Figures

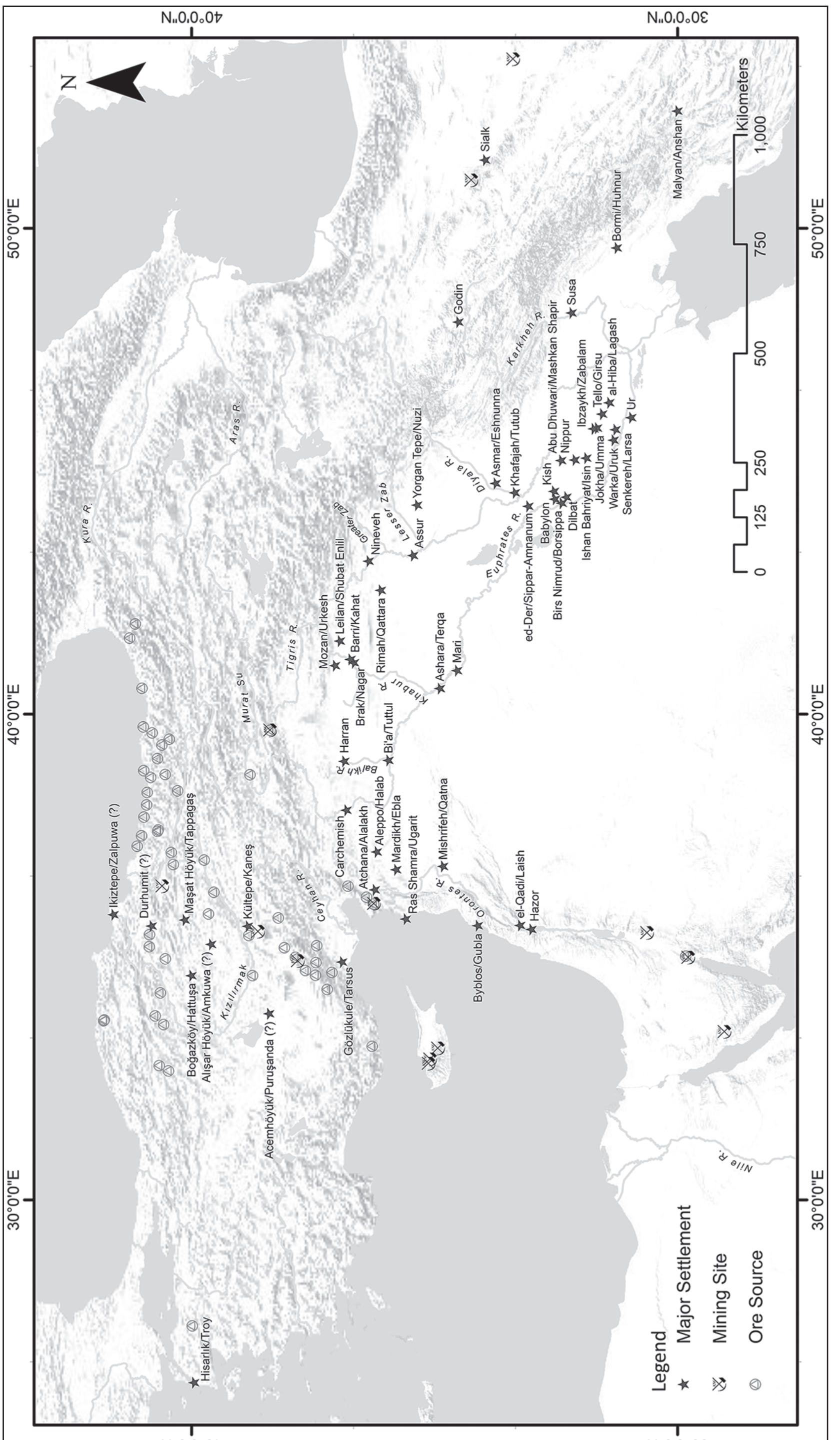

Figure 1: Major near eastern settlements and mining sites of the late 3rd – early 2nd millennium BC and sample locations for pertinent ore specimens with LIA values.

Figure 2: Tell Atchana trench 33.32, showing primary context for MB samples. Photo: Murat Akar, 2009.

Figure 3: Tell Atchana trench 42.10, showing one primary context for LB samples. Photo: Murat Akar, 2015.

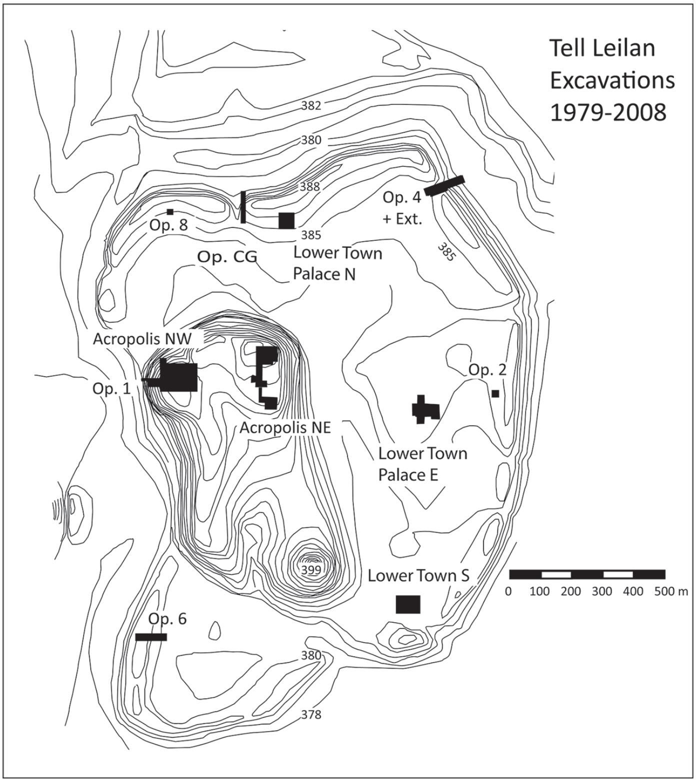

Figure 4: Tell Leilan topographic map, indicating areas excavated.

Figure 5: Tell Leilan Acropolis Northeast, Period I, Building Level II temple, ca. 1850 – 1750 BC, north façade. Photo: H. Weiss, 1982.

Date BC	Aegean	Egypt	Syria-Palestine	South Mesopotamia	Tell Leilan	Tell Atchana (Yener)	Kültepe Mound and Lower Town	Kültepe N. Trench
1200						Period 0		
1300	Late Helladic III	New Kingdom	Late Bronze IIb Late Bronze IIa			Period 1 Period 2		
1400			Late Bronze I			Period 3		
1500	Late Helladic II	Second		Kassite		Period 4 Period 5		
1600	Late Helladic I	Intermediate				Period 6	Mound 6 Lower Town Ia	
1700		Period	Middle Bronze II		———	Period 7		
1800	Middle Helladic II	Middle Kingdom		Old Babylonian	Leilan I	Period 8/9 (Tenative)	Mound 7 Lower Town Ib	
1900	Middle Helladic I		Middle Bronze I				Mound 8 Lower Town II Mound 9/10 Lower Town III/IV	
2000		First	Early Bronze IVc (?)	Isin-Larsa	“17 Kings who lived in tents” Leilan IId		Mound 11a	
2100	Early Helladic III	Intermediate		Ur III			Mound 11b	I
2200		Period	Early Bronze IVb					II
2300				Akkadian	Leilan IIc		Mound 12	III
2400	Early Helladic II		Early Bronze IVa		Leilan IIb		Mound 13	IV
2500		Old Kingdom		Early Dynastic III	Leilan IIa		Mound 14	V VI VII
2600			Early Bronze III	Early Dynastic II/III	Leilan IIId			VIII

Figure 6: Regional chronology for the late 3rd – early 2nd millennium BC. (Leilan dates after; Weiss 2017).

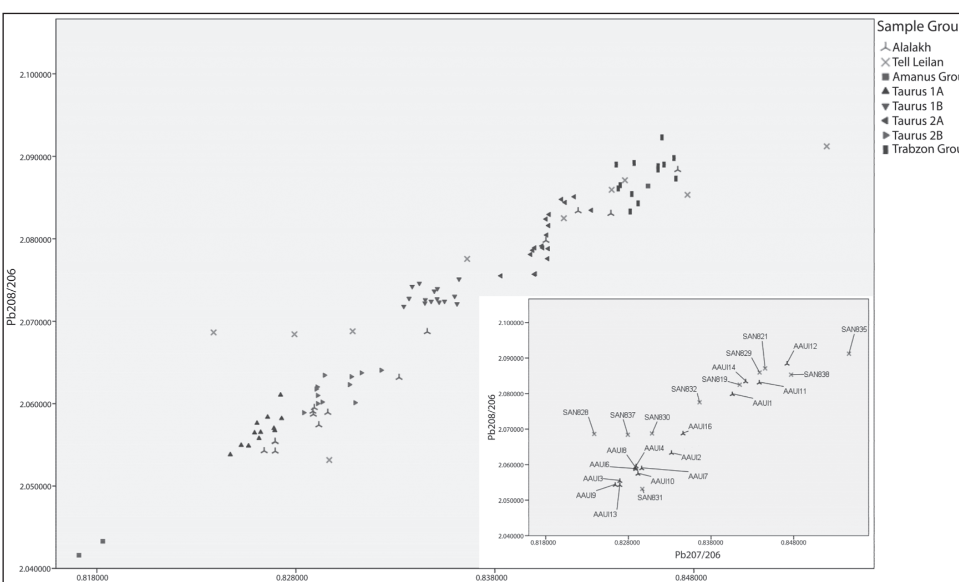

Figure 7: $^{208/206}$Pb vs. $^{207/206}$Pb lead isotope ratios plotted with relevant ore analyses.

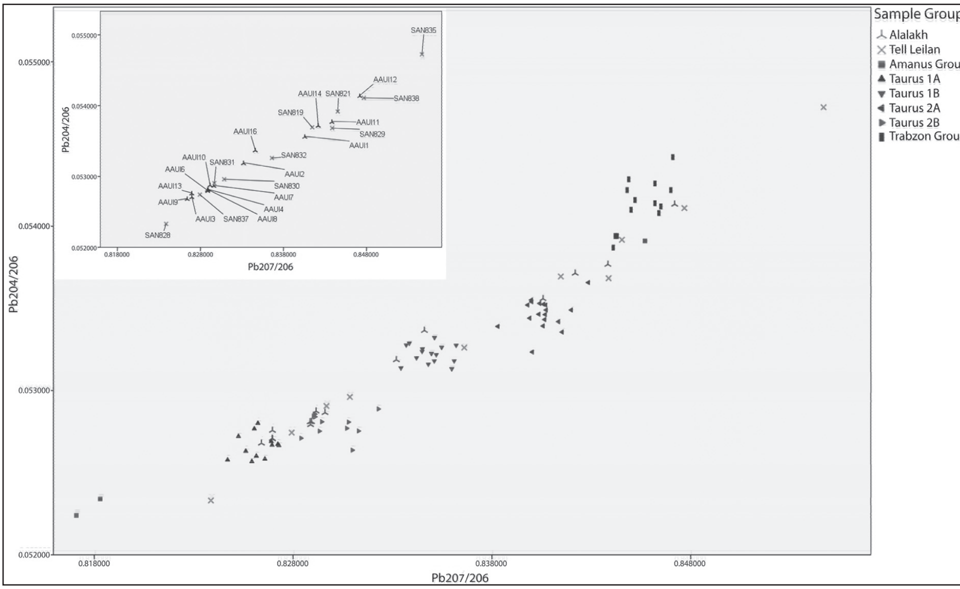

Figure 8: $^{204/206}$Pb vs. $^{207/206}$Pb lead isotope ratios plotted with relevant ore analyses.

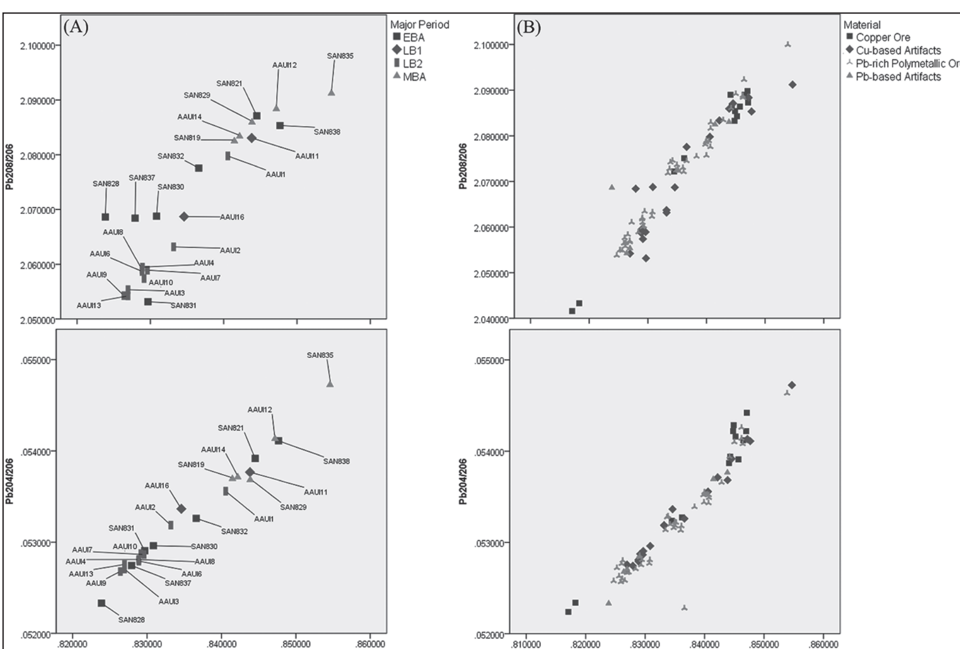

Figure 9: (a) Combined plot showing artifacts by broad periodization. (b) Combined plot showing artifacts and ores by general composition.