TRANSITION TO EXTRACTIVE METALLURGY AND SOCIAL TRANSFORMATION IN ARMENIA AT THE END OF THE STONE AGE

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1. Introduction

Recent archaeological work in the South Caucasian region in general and in Armenia in particular, accompanied by a great quantity of new C14 data, have fundamentally changed our reconstructions of the development of the Neolithic and Chalcolithic in the region. In particular, we now know that the southern Caucasus was part of a greater Near Eastern network linked by common technological practices and structural transformations. One of the most important of these transformations was the first use of metal, the appearance of which at the end of the Stone Age had a great impact on various spheres of human society and resulted in an increase in productivity, the accumulation and redistribution of wealth, the growth of social stratification, status, and power, the functional differentiation of society, and the development of long distance trade. It is widely accepted that the earliest evidence of copper smelting, frequently defined as the “first technological revolution” (around 5,000 BC), is limited to regions of the Near East, southeastern Europe, the Iranian Plateau, and the southern Caucasus. The early appearance of metallurgy in the southern Caucasus and the abundance of copper and polymetallic ores make this region particularly important for archaeometallurgical studies. In spite of this, our knowledge about the earliest metallurgy in the region remains limited, and any new discovery such as metal artifacts and metalworking attributes provide an opportunity to study not only the earliest stages of metal production but to understand technology and artifact provenance. During last decade, important evidence of early metalworking has been recovered in Armenia at number of Chalcolithic sites such as Areni-1 cave and the settlements of Nerkin Godedzor and Mushakan-4. This paper provides an introduction to recent
archaeological and archaeometallurgical investigations and attempts to summarise the earliest evidence of copper based metal production in Armenia.

2. Armenia at the End of the Stone Age

According to new data based on recent stratigraphic observations and C14 chronology, we can reconstruct the following sequence of archaeological traditions in Armenia at the end of the Stone Age:

The Early Holocene (Mesolithic/Proto-Neolithic, ca. 10,000–7,500 Cal BC) is represented by sites of Apnagyugh/Kmlo tradition like Apnagyugh-8/Kmlo-2 cave, Kuchak-1 rock-shelter, and the open-air site of Ggeharot-1, among others. This period is characterized by a society at the gateway of a food-producing life style, yet continues to live much like the hunters and gatherers of the preceding Pleistocene. Early Neolithic sites (ca. 7,500–6,000 Cal BC) that evidence the beginnings of a food-producing economy have not yet been recorded in Armenia nor in the southern Caucasus as a whole.

The Late Neolithic (ca. 6,000–5,200 Cal BC) is represented by sites of the “Aratashen-Shulaveri-Shomutepe” tradition like Aratashen (Horizons I-II), Aknashen/Khatunarkh (Horizons II-V), and Masis Blur. The Armenian sites had links to the Syro-Mesopotamian world (e.g. Samarra and Halaf). Society is characterized by a sedentary economy, the full establishment of a food-producing life style, a more-or-less uniform cultural complex, the beginning of pottery production, and first use of native copper.

The Early/Middle Chalcolithic (ca. 5,200–4,300 Cal BC) is known by the “Adablur” and “Sioni” traditions, with sites such as Aratashen (Horizon 0), Aknashen (Horizon I), Artashat, Adablur, and Mushakan-4. Armenian late Middle Chalcolithic settlements have close connections with sites like Sioni, which developed in the Kura Basin after the disappearance of the “Aratashen-Shulaveri-Shomutepe” tradition. The present data suggest a change in the economy towards more mobility with the shifts towards early extractive copper metallurgy. Society is characterized by its relationship to the Syro-Mesopotamian world (Early Ubaid).

The Late Chalcolithic (ca. 4,300–3,500 Cal BC) is represented by the “Areni” and “Godedzor” traditions, with such sites as Areni-1 cave and the settlements of Teghut and Nerkin Godedzor. Society is characterized by a diversity of cultural complexes, growing complexity, relations to the Syro-Mesopotamian (Late Ubaid, Uruk) and North Caucasian (Early Maikop) worlds, as well as extractive copper metallurgy.

1. Cf. Badalyan et al. 2004; 2007; 2010; Avetisyan et al. 2006; Chataigner et al. 2007; Arimura et al. 2010; Areshian et
3. Early South-Caucasian Metallurgy and the Armenian Evidence

The first metal objects, made from native copper, appear during the Neolithic of Anatolia and Iran in the 8th–6th millennia BC. The 5th millennium is characterized by significant changes in a number of regions of the Old World that ultimately led to copper smelting (Pernicka 1990; Meliksetian et al. 2011; Pigott et al. 1999). The earliest reliable evidence for copper smelting is dated to the 5th millennium BC and is found at sites related to the late Ubaid period in Mesopotamia (Zwicker 1977; Hauptmann 1982; Seeliger et al. 1985) and Late Neolithic and Chalcolithic sites in Iran (Piggot 1999). Contemporary copper based metallurgy is also evident in the Balkan region in southeastern Europe (Radivojević et al. 2010; 2013).

In the southern Caucasus, early use of metals dates to the 6th millennium BC and is characterized by the extraction of native metal and cold-working-cum-annealing (Khramis Didi-Gora, Arukhlo and Gargalar Tepesi, represented mainly by beads). Copper smelting appears at late 5th millennium BC (Mentesh Tepe, with a mould find). The evidence of metallurgical activities in the region increases in the early 4th millennium BC and is represented by previously known finds from Kültepe I in Nakhijevan, Alikemektepesi (knife, bead like ornaments, made of pure copper, some with low arsenic) and new finds, particularly in the Middle Kura region, such as pit furnaces, slags (Leylatepe), casting molds (Böyük Kesik, Qarakepektepe), heavy tools like axes or knife/daggers (Ovçular Tepesi, Soyugh Bulagh) with use of arsenical copper (Berikldeebi, Böyük Kesik, Leylatepe), and gold and electrum beads (Soyugh Bulagh)\(^2\).

What, then, is the situation in Armenia? Recent excavations in the Ararat valley and southern Armenia revealed new data on early metallurgy from Late Neolithic horizons as well as early (First Stage) and late (Second Stage) Chalcolithic horizons.

**First Stage.** Copper beads and their fragments as well as some pieces of copper ore minerals from Ararat valley sites represent the earliest known appearance of copper in the southern Caucasus. The finds of azurite and malachite from Aratashen Horizon IId (5,905–5,711 Cal BC)

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1. For historiography of the question and the southern Caucasian context, cf. Munchayev 1975; 1982; Kiguradze 1976; Chataigner 1995; Areshian and Ghafadaryan 1996; Kushnareva 1997. For correlation of cultural and metallurgical developments, cf. Gevorkyan 1980; Meliksetian et al. 2011; Courcier 2014 (with further literature). In all these publications we can trace a wide range of diverse terminologies concerning Neolithic-Chalcolithic “cultures/groups/assemblages/complexes-communities/sites” of the region. We use here the neutral term “tradition” to bridge the former culture-historical approaches to modern ones.
and Horizon I (probably mid 6th millennium BC), as well as from the nearby site of Aknashen/Khatunarkh (first half of the 6th millennium BC)\(^3\) have parallels in the 8th–6th millennia sites of Anatolia and Iran (Hallan Çemi, Çayönü, Aşıklı, Hassuna, Yarim Tepe I and II).

In Aratashen IIb (5,878–5,775 Cal BC) a bracelet about 6 cm in diameter made of 57 partly oxidized copper beads and their fragments made of a foil rolled up around a stem was unearthed *in situ*. They were made of native copper (Meliksetian *et al.* 2011), but the technique and shapes are known from the 8th–6th millennia BC at sites in North Mesopotamia (Yarim Tepe I and II, Chagar Bazar) and others of “Aratashen-Shulaveri-Shomutepe” tradition (Gargalar Tepesi, Chalaghantepe).

A ring, a bracelet fragment with secondary use, a hook, a holed disk (bead?), an awl/retoucher, and a small piece of copper derive from the Chalcolithic settlement Mushakan-4, which probably dates to the third quarter of the 5th millennium BC (Figure 1). Although all of the metal finds from Mushakan-4 are from the disturbed components of Horizon I and only the holed disk (bead?) was found *in situ* from the Chacloithic context (Figure 1: 1), there is no doubt about their belonging to the same layer since the site has an exceptionally well-preserved Chalcolithic occupation (excavations of B. Gasparyan).

Especially important for reconstructions of metallurgical procedures are a basalt pestle-hammer/grinding stone with traces of crashed oxide copper ore and two ceramic crucibles (Figure 6: 7-8) from the Chalcolithic Horizon of Aknashen/Khatunarkh (more probably dating by mid 5th millennium BC).

**Second Stage.** The transition to extractive metallurgy between the 5th and 4th millennia BC is also evident in the territory of Armenia. The metal objects from the Chalcolithic settlement of Teghut (4,000–3,700 BC), analyzed in the 1970s, turned out to be made of arsenical copper (3–4.6 % As), among which the knife is particularly noteworthy (Figure 7: 2, after new restoration). A similar knife, though with only 0.69% As, was recently found by an Armenian-German joint expedition during excavations at the settlement of Sotk 2 (Horizon IIa, 3,700–3,400 Cal BC) (Figure 7: 3). Four small awls and a ring (Figure 8: 5-9) originate from the Late Chalcolithic settlement of Nerkin Godedzor (3,700–3,400 Cal BC) excavated by an Armenian-French joint expedition (co-directors P. Avetisyan and C. Chataigner): the composition of the pins is similar to the objects from Teghut, showing an arsenical copper with an arsenic content ranging from 4 to 5%\(^4\).

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4. New Data from Areni-1

Excavations of the Areni-1 cave in the Arpa River valley (southern Armenia) open a new stage in our understanding of Chalcolithic societies of the southern Caucasus. Owing to cave’s dry conditions, the perishable organic materials have been wonderfully preserved. As a result, stratigraphic observations and a set of secure radiocarbon dates allow the reconstruction of the Late Chalcolithic sequence of Armenia (and the entire Caucasus and Near East) between 4,300–3,400 Cal BC with unparalleled precision. It appears that from the end of the 5th millennium BC onwards, people used the cave for different purposes – as a habitation, for keeping animals and storing plant foods, for the production of wine, as well as for ritual purposes. The data from the cave demonstrated evidence for early social complexity, and connections to contemporary Near Eastern and North Caucasian societies.

The excavations of Areni-1 also revealed a very significant group of finds that reflect metallurgical processes, most of which derive from the Chalcolithic Horizons I and II and the garbage layer in front of the cave, the latter of which is contemporary with the Horizons II and III.

Horizon I is represented by reinforced and repeatedly rebuilt paved and plastered floors with household pits and jar burials that date to the final phase of the Late Chalcolithic (3,700–3,400 Cal BC). It is spread only within the limits of Trench 3 outside the entrance to the first gallery and the slope at the entrance of the cave complex. Metallurgical data from the context of Trench 3 include crucibles of basalt and clay with traces of fire (Figure 4: 1, Figure 5: 1) and a casting mould (Figure 6: 10).

Horizon II occupies a more extensive area. It begins in Trench 3 (here it underlies Horizon I but is separated from it by a layer of zoogenic humus or dung) and extends into the cave, to the rear part of the first gallery across to the limits of Trenches 1 and 2. The Horizon II of the Trench 3 is also characterized by reinforced and repeatedly finished floors and includes wooden constructions or buildings and large, unfired bins. Trench 1 contains artifacts and features that are clearly related to metallurgical processes.
to funerary rituals including human remains and a wine producing complex. Trench 2 is adjacent to Trench 1 and has produced pots containing cremations, as well as isolated human remains recovered from loci between the pots. A set of carbon dates from Horizon II produces a time range of 4,000–3,800 Cal BC, which places it in the middle phase of the Late Chalcolithic. It is this horizon that reveals a majority of data on complex metallurgical processes, which is attested in five contexts: the partially excavated workshop at the south-eastern side of Trench 3, the stratified plastered floor (also in Trench 3), in the context of the wine producing complex, inside and nearby the ritual features in Trench 1, and, finally, the garbage layer on the slope at the entrance of the cave complex (Trench 4).

Copper ores (Figure 2: 1-2), basalt pestle-hammer and grinding stones with metal working/crushing traces (Figure 3: 1), ceramic crucibles with traces of fire (Figures 4: 2 and 5: 2), a spouted vessel (Figure 6: 6), a pourer with metal traces (Figure 6: 1), and casting molds (Figure 6: 9-10), the last of which were very probably used for the smelting of such objects as ingots (Figure 8: 4), have been found within the limits of the workshop.

Additional stratified metal finds appeared on the paved and plastered floors around the workshop in Trench 3, including copper ores (Figure 1: 3), a small ceramic crucible (Figure 6: 5), a knife and corresponding fragment (Figure 7: 4 and 6), and an awl (Figure 8: 2).

One of the most interesting finds, a copper ingot originating from the Chalcolithic garbage layer partly opened in Trench 4 on the steep northern slope in front of the cave complex (Figure 7: 1), most probably belongs to Horizon II.

The other archaeometallurgical finds from Horizon I appear in connection with the wine producing complex and the accompanying funerary pots and features (clay constructions) in Trenches 1 and 2. These finds include a pourer (Figure 6: 2), a ventilation pipe with traces of fire (Figure 6: 11), a small knife (Figure 7: 5), an ingot (Figure 8: 3), an adze (Figure 7: 7), a bowl fragment (Figure 7: 8), a bracelet fragment (Figure 8: 10), and a massive pike head (Figure 8: 1).

The majority of the present finds from Horizon II of Areni-1, almost all of which are in situ with some light Middle Age disturbances, reconstruct a chaîne opératoire with most stages of the metallurgical process (ore working, smelting, and recycling). The workshop, wine producing complex, and the funerary features or “burials” represent a common ritual and production oriented complex, where a syncretic landscape of human behavior is attested connected mainly with creating and sacrificing procedures. In such a context metal activity is not only a practical but also a sacred/cult/ritualistic action. In this respect some of the metal finds such as the knives and especially the pike head, as their context suggests, can be considered as weapons used during the ritual.
Preliminary investigation of the metal objects from Areni-1 demonstrates that we are dealing with an open mould and additional hammering techniques. Archaeometallurgical analyses of the metal objects from Areni-1 are in process (cf. Table 1)\(^7\).

The materials concerning metallurgical activities from Areni-1 find parallels at Early and Late Chalcolithic sites of the Armenian Highlands as well as in the North Caucasus and Iran. First of all, connections are discernable at previously Armenian sites (cf. azurite of Aratashen and Aknashen/Khatunarkh, basalt pestle-hammer from Aknashen/Khatunarkh, awls from Godedzor, knives of Teghut and Sotk). The awl and the knife from Kültepe I can also be mentioned in this context. Similarities in finds and context are also visible in the settlements of the Middle Kura and Karabakh such as Mentesh Tepe (crushed azurite, crucibles, moulds, awls, rings – Courcier et al. 2012, pp. 211-214, fig. 6: 9; Lyonnet et al. 2012, pp. 112-114, fig. 155-156); for awls in contemporary Sioni horizon sites of Georgia – Alazani III, Tisiteli Gorebi, Kviriatskhali (cf. Courcier 2014, p. 210), Leylatepe (ingots, a fired clay fragments plashed with pieces of oxidized metal, awls, an adze, knife fragments – Narimanov et al. 2007, pp. 62-64; Museyibli 2007a, pp. 142-143; Akhundov and Makhmudova 2008, p. 65), Böyük Kesik (knifes, awls, molds – Museibli 2007, pp. 138-140, 174, Tab. 16: 6-8, XL; Akhundov and Makhmudova 2008, p. 160, Photo 14), and Hantepe near Fizuli (a clay crucible – Museyibli 2007a, p. 142). Worth mentioning also are metal finds from the kurgans of Soyugh Bulagh and Telmankend (flat axe-adzes, awls, knives – Akhundov and Makhmudova 2008, pp. 62-63, 145, 170, Tab. 28: 5, Tab. 30: 3-6, Photo 32).

The knives/daggers, pourers, and ingot molds find parallels at the Maikop sites as well (Chernykh 1992, pp. 75, 82-83, fig. 24: 14, fig. 27: 5-6, fig. 28: 8; Korenevskiy 2004, p. 42, knife subtypes 1-2). Especially noteworthy is a metal vessel fragment from Areni-1; such vessels are also known in the Maikop sites (Chernykh 1992, p. 76, fig. 25; Hansen 2013, p. 154, fig. 25) and the contacts to which can be postulated through finds of Maikop ceramics at Areni-1 (Zardaryan and Gasparyan 2012, p. 48; Areshian et al. 2012, p. 128).

Finds similar to the Areni-1 ores, chisels, awls, and crucibles are reported at Arslantepe VII (3,800–3,400 BC) (Di Nocera 2010, pp. 255-256, fig. XIII. 3: 15).

Similar crucibles, ingot moulds, and knives/daggers are visible also in Chalcolithic Iran, particularly in such sites as Tal i-Iblis, Cheshmeh Ali, Tepe Ghabristan, Qaleh Gusheh, and Arisman (Azarnoush and Helwing 2005, p. 209, fig. 30; Thornton 2009, pp. 310-313, fig. 2-5; Ivanova 2012, p. 11, Abb. 7: 6-8). A chisel/adze like that at Areni-1 is reported from Mersin in the period after ca. 5,000 BC (Hansen 2013, p. 139, fig. 1).

\(^7\) Analyses are made in Curt-Engelhorn-Zentrum Archäometrie, GmbH, Mannheim.
Resemblances are also discernable in metal compositions: like at Areni-1, Teghut, Nerkin Godedzor (see above), Mentesh Tepe (Courcier 2014, p. 221, Tab. 3), Leylatepe, Külepe I, Poylu II (Museyibli 2007a, p. 142; Akhundov and Makhmudova 2008, p. 66) and Arslantepe VII (Di Nocera 2010, p. 255), the main objects are copper based, some of which contain ca. 1 to 4% and, rarely, up to 5%, arsenic.

5. Chemical compositions of Chalcolithic metal finds in the territory of Armenia

As mentioned above, the first evidence of smelted copper in Armenia appear as several Chalcolithic metal objects from the settlement of Teghut (Torosyan 1976), the OES analysis of which revealed the use of arsenical copper (3-4.6% of As) (Gevorkyan 1980). Obviously, these objects were smelted from ores, pointing to a transition from the use of rare native copper to extractive metallurgy. Some of previously mentioned copper based artifacts from Areni-1 cave and Nerkin Godedzor were recently analyzed for chemical composition (XRF) and Pb isotopes (ICP-MS) by Curt-Engelhorn-Zentrum Archäometrie GmbH, Mannheim, Germany. Detailed study of these artifacts is still in progress and here we present some discussion based on preliminary results.

By means of chemical composition, four of the objects from Nerkin Godedzor, two fragments and two pins (MA-082106, MA-070019, MA-071550, MA-071551 respectively) turned out to consist of copper-arsenic alloys with about 5% of As (Table 1). Enrichment of copper with arsenic is a feature typical for Chalcolithic and Early Bronze Age metal production in the region (Gevorkyan 1980; Meliksetian et al. 2003; Meliksetian and Pernicka 2010). The chemical composition of the fifth object, another pin (MA-082105), turned out to be quite surprising: it consists of copper (84%) with an admixture of nickel 3.6%, arsenic (6%), and silver (6%). It seems reasonable to assume that such a composition is not an intentional alloying, but is a characteristic of the polymetallic ores that were utilized.

Another interesting geochemical feature of all the objects from Nerkin Godedzor is the extremely low concentration of lead. XRF analysis shows that lead content is below the detection limit of the method (<100 ppm), but attempts to measure lead concentration with more sensitive method such as ICP-MS shows that the lead content is extremely low, around 10 ppb (0.01 ppm). The concentration of lead in these objects is so low, in fact, that it was not possible to perform lead isotope analysis for these artifacts. While this makes provenancing these objects quite complicated, the very low content of lead could also be an important geochemical feature of the ore deposit.
Table 1
Chemical composition of metal objects from Areni-1 cave and Nerkin Godedzor settlement. Concentrations of copper are given in weight percents, all other values are in ppm.

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Original sample #</th>
<th>Site Description</th>
<th>Dating</th>
<th>Cu %</th>
<th>Fe</th>
<th>Co</th>
<th>Ni</th>
<th>Zn</th>
<th>Pb</th>
<th>Bi</th>
<th>Sn</th>
<th>As</th>
<th>Sb</th>
<th>Se</th>
<th>Te</th>
<th>Au</th>
<th>Ag</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. MA-082105</td>
<td>Gd-07-34</td>
<td>Pin (Figure 8/5)</td>
<td>Late Chalcolithic</td>
<td>84.0</td>
<td>&lt;200</td>
<td>&lt;100</td>
<td>36000</td>
<td>&lt;2000</td>
<td>&lt;100</td>
<td>&lt;50</td>
<td>61000</td>
<td>250</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>540</td>
<td>60000</td>
<td></td>
</tr>
<tr>
<td>2. MA-082106</td>
<td>Gd-07-28</td>
<td>Ring-fragment (?), (Figure 8/9)</td>
<td>Late Chalcolithic</td>
<td>95.0</td>
<td>&lt;200</td>
<td>&lt;100</td>
<td>140</td>
<td>&lt;2000</td>
<td>&lt;100</td>
<td>&lt;100</td>
<td>90</td>
<td>52000</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;100</td>
<td>230</td>
</tr>
<tr>
<td>3. MA-070019</td>
<td>GD-05-2</td>
<td>Nerkin Godedzor settlement</td>
<td>Late Chalcolithic</td>
<td>94.7</td>
<td>200</td>
<td>100</td>
<td>&lt;100</td>
<td>2000</td>
<td>&lt;100</td>
<td>&lt;100</td>
<td>58</td>
<td>51516</td>
<td>15</td>
<td>50</td>
<td>92</td>
<td>100</td>
<td>76</td>
</tr>
<tr>
<td>4. MA-071550</td>
<td>GD-05-03</td>
<td>Pin (Figure 8/6)</td>
<td>Late Chalcolithic</td>
<td>95.1</td>
<td>1248</td>
<td>100</td>
<td>&lt;100</td>
<td>2000</td>
<td>&lt;100</td>
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<td>86</td>
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<td>383</td>
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<td>50</td>
<td>200</td>
<td>347</td>
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<td>5. MA-071551</td>
<td>GD-05-04</td>
<td>Pin (Figure 8/7)</td>
<td>Late Chalcolithic</td>
<td>94.8</td>
<td>200</td>
<td>100</td>
<td>111</td>
<td>2000</td>
<td>&lt;100</td>
<td>&lt;100</td>
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<td>6. MA-082097</td>
<td>Areni-1</td>
<td>Pike head (Figure 8/1)</td>
<td>Late Chalcolithic</td>
<td>99.0</td>
<td>&lt;200</td>
<td>&lt;100</td>
<td>&lt;100</td>
<td>&lt;2000</td>
<td>&lt;100</td>
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<tr>
<td>7. MA-082098</td>
<td>Areni-2</td>
<td>knife (Figure 7/5)</td>
<td>Late Chalcolithic</td>
<td>97.0</td>
<td>470</td>
<td>&lt;100</td>
<td>230</td>
<td>&lt;2000</td>
<td>&lt;100</td>
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<td>8. MA-082100</td>
<td>Areni-4</td>
<td>knife (Figure 7/4)</td>
<td>Late Chalcolithic</td>
<td>97.0</td>
<td>850</td>
<td>&lt;100</td>
<td>870</td>
<td>&lt;2000</td>
<td>&lt;100</td>
<td>&lt;100</td>
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<td>30000</td>
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<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;100</td>
<td>160</td>
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<tr>
<td>9. MA-124777</td>
<td>T3-SP7</td>
<td>Copper ingots (Figure 8/3-4)</td>
<td>Late Chalcolithic</td>
<td>96.0</td>
<td>&lt;200</td>
<td>&lt;100</td>
<td>950</td>
<td>&lt;1000</td>
<td>144</td>
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<td>397</td>
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<tr>
<td>10. MA-124778</td>
<td>T2A-SP20</td>
<td>Late Chalcolithic</td>
<td>Late Chalcolithic</td>
<td>97.0</td>
<td>&lt;200</td>
<td>&lt;100</td>
<td>2610</td>
<td>&lt;1000</td>
<td>2205</td>
<td>&lt;100</td>
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<td>&lt;50</td>
<td>&lt;100</td>
<td>366</td>
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</table>
and thus may be used for locating the origin of these objects. It should be noted that all studied Armenian copper ores and all studied Bronze Age artifacts contain a noticeable amount of lead (Meliksetian and Pernicka 2010). According to Dr. Nima Nezafati, some ores with very low lead content are known in the Tarom-Hashtjin region (western Alborz, North-West Iran) but more work and comparison to chemical composition of ores in North-West Iran is necessary. Therefore, our current state of knowledge does not allow the determination of a matching ore source for these objects, but presumably it is outside the southern Caucasus region, perhaps in northwest Iran.

The compositions of the Areni-1 objects are less surprising (Table 1), being made of copper with an admixture of arsenic ranging from 1.3 to 4.2%; comparable arsenic content is typical for tools and weapons of Early Bronze Age Armenia, while for decorative objects the content is usually much higher (Meliksetian and Pernicka 2010; Meliksetian et al. 2011). Also noteworthy is the elevated content of Ni in three of Areni-1 samples (870-2600 ppm) and an admixture of lead (about 0.2% in one of the ingots; MA-124778). Figure 9 shows a comparison of Ni and Ag content in the analyzed Chalcolithic artifacts compared with available data from Early Bronze Age artifacts (Meliksetian and Pernicka 2010). With the exception of Cu + (Ni-Ag-As) alloy (MA-082105), most of the artifacts from Areni-1 and Nerkin Godedzor are within the range of Armenian ores and Early Bronze Age artifacts.

For two samples, MA-124777 and MA-124778, lead isotope values are also available (Table 2). Figure 10 shows a comparison of $^{207}\text{Pb}/^{206}\text{Pb}$ vs. $^{208}\text{Pb}/^{206}\text{Pb}$ of analyzed Chalcolithic artifacts with the lead isotope compositions of Armenian and regional ores. Interestingly, the artifacts from Areni-1, at least according to their lead isotope signature, lie at the intersection of the Armenian “old” lead compositional field with those of Anatolia and the ores of Oman. So, it is unclear whether their source ores are within the region or from distant sources. More detailed lead isotope

<table>
<thead>
<tr>
<th>Sample #</th>
<th>MA-124777</th>
<th>MA-124778</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original sample #</td>
<td>T3-Sp7</td>
<td>T2A-Sp20</td>
</tr>
<tr>
<td>Site, Description</td>
<td>Areni-1 cave</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>Copper ingots</td>
<td></td>
</tr>
<tr>
<td>$^{208}\text{Pb}/^{206}\text{Pb}$</td>
<td>2.0848</td>
<td>2.0860</td>
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<tr>
<td>$^{207}\text{Pb}/^{206}\text{Pb}$</td>
<td>0.84746</td>
<td>0.84816</td>
</tr>
<tr>
<td>$^{206}\text{Pb}/^{204}\text{Pb}$</td>
<td>38.546</td>
<td>38.528</td>
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<td>$^{207}\text{Pb}/^{204}\text{Pb}$</td>
<td>15.669</td>
<td>15.666</td>
</tr>
<tr>
<td>$^{206}\text{Pb}/^{204}\text{Pb}$</td>
<td>18.489</td>
<td>18.470</td>
</tr>
</tbody>
</table>

We gratefully acknowledge Dr. Nima Nezafati (Islamic Azad University of Tehran, Iran) for information about copper sources in Iran with low lead content.

8. We gratefully acknowledge Dr. Nima Nezafati (Islamic Azad University of Tehran, Iran) for information about copper sources in Iran with low lead content.
investigations of ore sources around Areni-1, which is in progress, may provide further information about their provenance.

6. Discussion

Metallurgical developments in Armenia and the southern Caucasus region were directly connected with important social transformations. As we noted above, during the Late Neolithic (6,000–5,200 Cal BC) Armenia was involved in the “Shulaveri-Shomutepe” tradition, which by the Early/Middle Chalcolithic (5,200–4,300 Cal BC) was followed by the “Adablur” and, eventually, the “Sioni” traditions. These were, on the whole, uniform societies that relied on native copper and some relations to the South (Samarra, Halaf-Ubaid). Beginning with Late Chalcolithic (4,300–3,500 Cal BC) we see unprecedented complexity, intensive inter-regional contacts, and use of extractive metallurgy.

The Late Chalcolithic traditions in Armenia (Areni-1, Teghut, Nerkin Godedzor), Azerbaijan (Ovçular Tepesi, Mentesh Tepe, Leylatepe) and Georgia (Berikldeebi) share common characteristics and regional contacts to Maikop\textsuperscript{9} and Ubaid-Uruk\textsuperscript{10}. These societies are on the way towards growing complexity, a process reflected in the appearance of developed copper based metallurgy (molds, slags, ingots, kilns, pure and arsenic copper), new metal weapons/tools (knife/daggers, spearheads, flat axes), ceramics (potter’s wheel, pottery signs), exotic and prestigious objects of gold, silver, and lapis-lazuli, stamp seals and status symbols (scepters), kurgans and jar burials, and rudiments of monumental architecture (cf. the “temple” of Berikldeebi). This is all accompanied by the blossoming of long distance trade, essential transfer of knowledge, and the development of centralized hierarchies\textsuperscript{11}.

Recent investigations demonstrate that although these developments were typical for the Near Eastern region\textsuperscript{12}, the highland zone between the Caucasus and Taurus, that is, territories

\begin{itemize}
  \item In the literature Caucasian specialists speak mainly about the Ubeid-Uruk (Akhundov and Makhmudova 2008), Ubeid (Museibli 2007a) or Uruk (Munchayev 2007, pp. 8-9; Areshian \textit{et al.} 2012, pp. 128-129) influences.
  \item So the Ubeid chaff-tempered ware alongside the Ubeid-related painted black-on-buff ware spreads not only in the southern Caucasus but also in the regions from Mediterranean coast to North Zagros (Helwing 2012, pp. 204-210; cf. Ivanova 2012, pp. 19-23).
\end{itemize}
from the Upper Euphrates to the regions around lakes Van, Urmia, and Sevan, also shared common trends of development\textsuperscript{13}. This is a landscape of mountainous communities which were clearly distinguished by their mode of life from the Maikop people in the North (inhabitants of river valleys in the environment of steppe landscapes) and that of the Syro-Mesopotamian peoples in the South (inhabitants of the lowland).

These transformations have been often related to the establishment of Ubaid or Uruk related communities. Various ideas based on migration or early imperialism theories have been suggested as possible interpretations of those developments. However, recent approaches suggest new models that acknowledge more locally rooted paths towards complexity in the highlands (cf. Marro 2007; Thornton 2009; Helwing 2012). The material similarities are thereby understood to indicate shared practices/knowledge of production and consumption.

Metal seems to be a very essential factor in these regional connections, and it can also explain the interests of Mesopotamians in the southern Caucasus, being a kind of “moteur des relations” (Lyonnet 2007, p. 15; cf. Munchayev 2007, p. 9; Courcier 2014, p. 643)\textsuperscript{14}. Other factors such as obsidian (cf. Chataigner \textit{et al.} 2010, pp. 401-402) and wine\textsuperscript{15} may also have played an essential role in those contacts, realized either by trade (cf. Palumbi 2007, p. 75) or through nomadic pastoralists (cf. Marro 2005, p. 32; 2007, p. 93; Chataigner \textit{et al.} 2010, pp. 401-405).

Two routes from the Near East to the South Caucasus have been identified as contact zones, one passing through the Urmia basin (cf. Museyibli 2007a, p. 89; Ivanova 2012, p. 23) and the other through the Upper Euphrates region (cf. Marro \textit{et al.} 2011), both of which have the nearest analogies to southern Caucasian materials and practices (cf. also Munchayev 1975, pp. 122-123, 130). In the same time, the southern Caucasian route over Dagestan to the North-West Caucasus could be essential for the transmission of Near Eastern influences to the North and vice

\textsuperscript{13}Cf. Torosyan 1976; Areshian and Ghafadaryan 1996; Lyonnet 2000; Marro 2005; 2007; 2008. For B. Helwing the Late Chalcolithic landscape of modern eastern Turkey, North-West Iran, and the southern Caucasus “falls into a series of parallel, largely comparable yet individual clusters of sites that develop in lockstep and share a general lifestyle, visible from a closely related material record” (Helwing 2012, pp. 201-203, 214).

\textsuperscript{14}In this regards noteworthy is the statistical point of L. Avilova, according to which, the Mesopotamian Ubaid period sites lack metal in sharp contrast to Iran, which implies that the technological skills elaborated in Mesopotamia during the Ubaid period apparently originated in Iran (Avilova 2009, pp. 52, 56). Perhaps the relations of the southern Caucasus to Mesopotamia were really conditioned by the growing interest of Syrian-Mesopotamian societies in metal.

\textsuperscript{15}The mentioned grape pressing context with preserved remains (seeds, stems, skins) of crushed or pressed grapes from Areni-1 (Horizon II, 4,223–3,790 Cal BC) is thus far the oldest known wine production complex (Barnard \textit{et al.} 2011; cf. Areshian \textit{et al.} 2012, pp. 128-129), which attests that the wine could be South Caucasian “brand” in the ancient Near East.
versa\textsuperscript{16}. Chemical and isotope characteristics of Chalcolithic metal artifacts from Nerkin Godedzor also suggest that a North-West Iranian ore source may have been utilized to produce copper. This datum underlines the importance of the North-West Iranian route and is in accordance with other assemblages from this site, again hinting at a North-West Iranian direction of contacts, among which especially painted pottery (from South to North) and obsidian (from North to South) should be mentioned (Chataigner \textit{et al.} 2010, pp. 399-401).

The transformational processes in the southern Caucasus described above did not develop further in the second half of the 6th millennium BC. Similar to highly developed Chalcolithic Carpato-Balkan metallurgical centers, which collapsed at the beginning of the Bronze Age in the wake of invasions from steppe nomads (Chernykh 1992, p. 55), the southern Caucasus’s “Near Eastern way” stalled with the emergence of the Kura-Araxes complex. Although Late Chalcolithic diversity was changed by Early Bronze Age uniformity\textsuperscript{17}, in contrast to the Carpato-Balkan Early Bronze Age invaders, the Kura-Araxes people, who were indigenous to the region, possessed highly developed metallurgy and ceramic making traditions.

One of the most difficult questions is the relationship between the Late Chalcolithic and Kura-Araxes traditions. Various sites in modern Armenia, Georgia, Azerbaijan, and eastern Turkey show clear coexistence of the ceramic and metal (first use of arsenic, molds and heavy tools) traditions of these two stages going back to the end of the 5th and first half of the 4th millennia BC\textsuperscript{18}. Essential differences between those traditions are reflected in other practices such as their

\textsuperscript{16} Some influences such as introduction of potters’ wheel and Ubaid-Uruk similar ceramics appear also in Dagestan (Ginchi, Velikent) demonstrating some affinities to South Caucasian Chalcolithic centers (Magomedov 2007, p. 53; Munchayev 1982, p. 124; 2007, p. 8) as well as in Maikop (Ivanova 2007, p. 17). More Iranian-Central Asian than Mesopotamian direction of contacts for Maikop have been recently postulated on the ground of metal and precious stone finds (Ivanova 2012).

\textsuperscript{17} Kura-Araxes communities clearly secluded the Highlands from the Mesopotamian world (cf. Marro 2007, p. 92). Such a transformation was especially crucial for the sites which were deeply involved in Syrian-Mesopotamian developments, among which Arslantepe VIA, the large public building of which gave way to the settlement of wattle-and-daub architecture and Late Chalcolithic pottery diversity was narrowed to red-black burnished Kura-Araxes pottery (cf. Kiguradze and Sagona 2003, p. 92).

\textsuperscript{18} For Armenia, cf. Torosyan 1976; Avetisyan \textit{et al.} 2006; Zardaryan 2011; Wilkinson \textit{et al.} 2012; Zardaryan and Gasparyan 2012; for Georgia, cf. Kiguradze 1976; 2000; Kiguradze and Sagona 2003; for eastern Turkey, cf. Marro 2005; 2008, for Nakhijevan, cf. MARRO 2011; for Karabakh, cf. Museyibli 2007a, pp. 60, 73, 87, 92, 142-143 (also as regards metallurgy, especially molds, cf. also Courcier 2014, p. 213) contra Narimanov \textit{et al.} 2007, p. 74; Akhundov and Makhmudova 2008, p. 77. Based on materials from eastern Turkey C. Marro develops a possible point of view that in Late Chalcolithic (4,000–3,500 Cal BC) at least four pottery trends developed in the Highland zone where later Kura-Araxes culture came to existence: Late Sioni, Proto-Kura-Araxes, Tilki-Tepe and chaff-faced wares. If the chaff-faced ware was connected to Mesopotamia and Syria, than Late Sioni and Proto-Kura-Araxes were local. Tilki Tepe had both local and influenced traits. These four assemblages could develop more or less at the same time (Marro 2008).
use of painted pottery, potters’ wheel, seals, gold and silver, lapis lazuli, flint, rather than obsidian, tools, and jar burials and kurgans, traits that are strange to the Kura-Araxes and typical more for the Upper Mesopotamian and Maikop traditions. Regardless, it is clear that the social context that accompanied Bronze Age developments in the region goes back to the Chalcolithic period (cf. Avetisyan 2012, p. 9). There is, moreover, one systematic feature common to both – the landscape: the Kura-Araxes tradition evolved in the same environment as the Late Chalcolithic communities, i.e. in the area from the Upper Euphrates to Mt. Ararat and around lakes Van, Urmia, and Sevan. This condition creates an essential background to consider both phenomena in the same developmental contexts.

7. Conclusion
According to new data, metallurgy in the southern Caucasus and Armenia in particular, appears with the extraction of native copper and cold-working-cum-annealing at the beginning of the 6th millennium BC. Copper smelting is practiced by the late 5th millennium BC. Metallurgical activities essentially increased in the early 4th millennium BC with evidence of chaine opératoire, attested most spectacularly at Areni-1, which makes this site one of the most important in the whole Near Eastern landscape, and not only as regards the perfectly preserved organic materials. These all allow us to challenge the earlier understanding of the Caucasian Copper Age as a “fairly modest cultural focus” (Chernykh 1992, p. 54; cf. also Munchayev 1982, p. 136).

Due to its rich ores and important geographic location, the southern Caucasus turns out to be a kind of bridge between two metallurgical centers – Anatolia and Near East, where metallurgy commenced at the 8th–6th millennia BC, and South-East Europe, where during the 5th–4th millennia BC we have highly developed metallurgical centers. The southern Caucasus had definite Near Eastern (North Syrian-Mesopotamian and North Iranian) direction of contacts, which is reflected both in material assemblage and in metal industry.

However the Near Eastern relations of the southern Caucasus, which undoubtedly accelerated the process of the appearance of early complex societies in the region, should not be interpreted in terms of significant migrations, expansions, or colonizations from core to periphery being linked to forms of territorial control, as used to be the case, but more as a reflection of shared knowledge and widening of mental horizons born as the result of active interactions in which the “highland zone” turned out to be not only an imitator of Near Eastern values but possessed its own independent identities and even privileges: and this is especially visible in developments of metallurgy.
References


Figure 1
Mushakan-4. Metal artifacts from the Chalcolithic Horizon I (third quarter of the 5th millennium BC).
Figure 2
Areni-1 cave. Copper ores from the Chalcolithic Horizon II (4,000–3,700 Cal BC).
Figure 3
Areni-1 cave. Basalt pestle-hammer and grinding stone from the Chalcolithic Horizon II (4,000–3,700 Cal BC).
Figure 4
Areni-1cave. Basalt (1) and clay (2) crucibles from the Chalcolithic Horizons I (1) and II (2) (4,000–3,400 Cal BC).
Figure 5
Areni-1 cave. Clay crucibles from the Chalcolithic Horizons I (1) and II (2) (4,000–3,400 Cal BC).
Figure 6
7-8: Aknashen/Khatunarkh. Clay crucibles from Chalcolithic Horizon (mid 5th millennium BC).
Figure 7
Figure 8
Figure 9
Ag vs. Ni diagram from comparison of Armenian ores, Early Bronze Age artifacts and analyzed Chalcolithic artifacts from Areni-1 cave and Nerkin Godedzor settlement.
Figure 10
Diagram of the 207Pb/206Pb vs. 208Pb/206Pb in analysed artifacts from Areni-1 cave and previously analysed Early Bronze Age Armenian artifacts. Isotope compositional fields of Armenian ores are shown.