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Chalcolithic Metallurgy in the Southern Levant: Recent Research in Ore Selection and Alloying

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**Introduction**

In this paper I will discuss recent investigations into early copper production in the Southern Levant. I will review the general archaeological background of the area and discuss Chalcolithic metallurgy in the Southern Levant. I will then introduce the recent excavations of the archaeological site of Abu Matar and discuss selected technical studies done on the metallurgical finds. Results of these studies have led to the conclusion that deliberate co-smelting of copper and arsenic-rich ores was done on site. Long distance trade will also be discussed in an attempt to suggest possible sources of copper producing ore for the Ghassulian Beersheva metallurgical activities.

**Archaeological Background**

In the 1950s, John Perrot began excavation of a Chalcolithic site in the Beersheva Valley called Tell Abu Matar (Perrot 1955). Abu Matar is a large, well-developed Chalcolithic settlement located in the Southern Levant, Northern Negev, and is presently encompassed by the modern city of Beersheva. It is situated along the northern bank of Nahal Beersheva, approximately 1.5 km south east of the old city of Beersheva. Abu Matar is widely recognised as the most important ancient Near Eastern Chalcolithic site that contains remains of the earliest copper smelting industry (Tylecote 1974; Craddock 1995; Rothenberg and Merkel 1995; Rothenberg and Merkel 1998). Following the discovery of sites1 with similar
unique cultural material remains, the term "Ghassul-Beersheva" was coined to distinguish the Late Chalcolithic culture of the Southern Levant after the term "Ghassulian" named for the type site of Teleilat Ghassul (Mallon, Koeppel et al., 1934). The Ghassulian culture is considered to be characteristic of the Chalcolithic period, but it has not yet been identified further to the south, or in Feinan.

The Ghassul-Beersheva culture appears around 4200 BCE (Joffee and Dessel 1995) and represents the first major exploitation of the region (Mazar 1992; Levy 1995). The region seems entirely uninhabited during the Neolithic period. The newly established settlements were located mainly along the shores of the Nahals (Wadis) Besor, Beersheva, Grar and Patish, among others. These sites include Bir es-Safadi, Abu Matar (Perrot 1955; Perrot 1984), Horvat Beter (Dothan 1959), Shiqmim (Levy 1987), Tell Farah (Macdonald 1932), Gilat (Alon 1977), Grar (Gilead 1989), and at the outer fringe of the area around the Dead Sea, the Nahal Mishmar caves (Bar-Adon 1980), and the shrine at En-Gedi (Ussishkin 1980). The sites mentioned here are the larger sites, but only a fraction of the total. In a small section on Nahal Grar surveyed by Alon (1961), over 30 sites were discovered. More recent surveys have shown there to be over 70 sites (54 settlements and 21 find spots) along Nahal Beersheva and lower Nahal Besor (Alon and Levy 1980). The larger settlements are characterised by planned villages with a unique feature in architecture consisting of underground structures, which have provoked debate as to their occupational chronology and their purpose.

In explaining this new settlement pattern it has been suggested that an intrusive culture infiltrated the Southern Levant. Infiltration from the north by the Halafian culture has been suggested as the main intrusive element. Proponents of this position point to evidence for changes in pottery design and stone tool industry and the sudden advent of advanced metallurgy. An alternative view is offered by Gilead (1988),
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who has provided evidence for continuity of the Neolithic population with expansion and resettlement into more favourable areas. From a metallurgical perspective, an intrusive element appears to be a necessity for such an enigmatic advance in technological abilities to have occurred, whether this influence was in the form of a cultural influx or solely in the transmission of new concepts and ideas. The advent of such an advanced state of metallurgical production with no prior evidence for any metallurgy in the immediate vicinity justifies this conclusion.

Chalcolithic Metallurgy

Earlier analyses done on only a few ore samples discovered in the Beersheva valley (Tylecote, Rothenberg et al. 1974; Hauptmann 1989), using mineral content, textural analysis, host rock, lead isotope analysis (Gale, Bachmann et al. 1990), and chemical compositional analysis to compare with present day ore samples from both Timna and Feinan, led to the conclusion that the ores smelted in the region derived from Feinan, approximately 125 km away.

Based on these analyses and additional analysis of metallurgical remains found at Abu Matar and other contemporary sites in the region, several theoretical process models have been suggested for copper production in the Southern Levant, and the model of crucible smelting is still widely held today. In general, these process models propose that high grade carbonate copper ores were mined at Feinan and likely were minimally beneficiated on site. The concentrated ore was transported to the Beersheva region for further concentration after which the ores were hand selected to ensure the highest possible copper yield. The highest grade copper ore was smelted in crucibles placed in a hearth type ground furnace. Once smelted, the copper was then re-melted for casting into utilitarian objects, that would have been worked and polished on site. Similar models based on crucible smelting have been proposed for the metallurgical activities at Shiqmim (Levy 1995). At the newly
discovered Chalcolithic settlement at Fidan 4. Adams states that all smelting and casting was done in the same crucibles and there is no evidence for smelting furnaces or hearths for metallurgical purposes (Adams and Genz 1995:14). This conclusion was reached based on the lack of evidence for a proper smelting furnace at these sites. Slag lined furnaces have been found at Abu Matar (Rothenberg 1991:6) suggesting a more advanced method of production in which smelting was done in a furnace and casting was done separately in crucibles.

**Enigma of the Nahal Mishmar Hoard**

The most spectacular metallurgical find dated to the Chalcolithic of the Southern Levant has to be the Nahal Mishmar hoard. This hoard, discovered in the Judean Desert in 1961 by Bar-Adon, can be considered the single most important find for the study of Chalcolithic Metallurgy in the Levant (Bar-Adon 1980; Tadmor, Kedem et al. 1995). The hoard contained over 400 metal objects, consisting of elaborate crowns, standards, and maceheads, and some basic axes and adzes. Initial chemical analysis revealed two metallurgically distinct categories of artefacts, which have been classed as prestigious items consisting of the elaborately decorated maceheads, crowns and standards, and utilitarian items consisting of basic tools. Tadmor, Kedem et al. (1995) established that a combination of antimony and arsenic, in high concentrations, identifies the prestigious materials as a type of alloy very rare in the Near East. Based on stylistic comparisons (Moorey, 1988) and chemical compositional analysis (Levy and Shalev 1989), it was concluded that the artefacts discovered in the Nahal Mishmar hoard were produced locally in the Southern Levant and that the ores used contained arsenic and antimony and were imported from an unknown source (Moorey 1988; Tadmor, Kedem et al. 1995).

Until now, however, there has been no proof that arsenical copper was made in the region. There also has been no site with enough metallurgical debris to suggest that the volume of metal required for the hoard was produced locally. Even Abu Matar has,
as excavated thus far, not revealed sufficient manufacturing capacity for the amounts of metal discovered at Nahal Mishmar.

**Recent Excavations of Abu Matar**

Let us turn now to the new excavations at Abu Matar. In 1990, the land containing the archaeological site of Abu Matar was re-zoned for development thus forcing salvage excavations which were carried out in 1991 by Prof. Itzak Gilead for the Israel Antiquities Authority (Gilead, Rosen et al. 1991; Gilead, Rosen et al. 1992). During the excavation, layers of ash where found and upon further investigation, a copper workshop was revealed. The workshop, or what remained of it, consisted of several elements. In the centre was an oven [furnace], about 0.5 m in diameter, with baked walls indicative of high temperatures while in use. Above the oven's floor, there were lenses loaded with charcoal flecks and baked lumps of silt. Charcoal flecks, chunks of baked silt and dark ashes were also spread in the immediate vicinity of the oven, in a circle of about 2 meters in diameter (Gilead, Rosen et al. 1991:175). There were numerous pieces of slag, crucible fragments, furnace fragments, a possible tuyere, groundstones and pieces of ore in the surrounding area. About 3 meters west of the furnace, there was a concentration of artefacts, possibly utensils used for copper processing. Also present were large cobbles split in the centre that could well have been used as anvils. Charcoal and flint artefacts were strewn around the area.

My research is based on the technical studies of these metallurgical materials. This new assemblage of (prehistoric) metallurgical material, is far better preserved and more extensive than previously excavated by Perrot. Furthermore, the vast amount of metallurgical material found at Abu Matar far exceeds the amounts of material found at any other contemporary site in the Levant. It therefore provides the greatest potential for answering questions about the metallurgical abilities, and even about some of the socio-cultural practices, of the Chalcolithic peoples.
In an investigation I carried out this winter, electron probe micro-analysis (EPMA) of copper prills entrapped in the furnace and crucible slag have shown that some prills contain arsenic, in the range of 0.5% to 2.5% with total wt. % of 95%-99% for all elements. Corroded prills show slightly higher concentrations of arsenic. This is the first evidence of arsenic alloying in the Chalcolithic period in the Southern Levant and suggests the advent of co-smelting to produce a copper arsenic alloy.\(^6\) With the ores from both Timna and Feinan showing no significant arsenical content, one must ask where the source of arsenic was for these early metallurgists. Ores discovered on site were analysed to investigate this question.

**Evidence for Intentional Arsenic Alloying**

The first arsenical coppers where likely unintentionally or accidentally produced from arsenic-rich copper ores or fluxes. Experimental smelting of carbonate copper ores with complex copper arsenic ores such as enargite (\(\text{Cu}_6\text{As}_3\text{S}_8\)) or tennantite (\(\text{Cu}_2\text{As}_4\text{S}_{13}\)) has produced arsenic bronzes (Rostoker and Dvorak 1991). However, arsenic can also be introduced by the flux. For the high silicate ore from Feinan, iron based ores are an ideal flux. Arsenopyrite (\(\text{FeAsS}\)) or leucopyrite (\(\text{Fe}_3\text{As}_4\)) are ores which may have been added as a flux and could have produced a viable copper arsenic alloy (Merkel, Shimada et al. 1994:203). While Pollard, Thomas et al. (1990; 1991) have shown in experimentation that arsenic can enter copper at temperatures as low as 900°C by solid state diffusion, the process requires extended heat treatment and, as yet, there has been no archaeological confirmation that such processes could have been performed in antiquity. Evidence from archaeological remains and experimental smelting at Batan Grande, Peru, has shown that co-smelting of malachite with arsenic-rich ores followed by visual hand sorting of the resulting copper prills achieved a copper alloy ingot with arsenic concentrations over 2% (Merkel, Shimada et al. 1994:221). Arsenic-rich prills are distinctive for their shiny silvery colour, which makes them easy to identify and select.
Three process models can be described for the production of copper arsenic alloys:

1. Accidental production of arsenical copper in which complex arsenic-rich copper ores are smelted much the same as carbonate copper ore is smelted, or fluxes containing arsenic are introduced into the smelt. The resulting copper would be unintentionally arsenic-rich.

2. Purposeful co-smelting at the smelting stage of arsenic-rich ores with copper ores, complex arsenic-rich copper ores alone, or the addition of arsenic-rich flux.

3. Purposeful alloying in which carbonate copper ore is smelted to produce pure copper which is then re-melted with arsenic-rich ore added at the refining stage to increase the arsenic content.

The only clear way to differentiate between accidental and intentional alloying in the first two examples is to determine if any of the locally available ore is arsenic-rich. If it is, then accidental alloying could be occurring. If there is no readily available arsenic-rich ore source nearby, it must have been imported for intentional use.

The ores which have been discovered in the Chalcolithic settlements of the Southern Levant have been clearly associated with the copper ore formations at Feinan, which contain no substantial amounts of arsenic (Shalev and Northover 1987; Hauptmann, Begemann et al. 1992). There are also no known sources of arsenic in the immediate area. Where could the arsenic have come from? There have been some recent finds of arsenical ores in Makhtesh Ramon about 50 km to the south, but the finds are very limited and derive from metamorphic rock, which this is not identifiable in the slag from Abu Matar (I. Segal 1997: personal communication). A complex copper arsenic ore has been discovered in the Sinai, but the resource is limited and it likely was not exploited during the Chalcolithic period (Beno Rothenberg, personal communication). Geographically, the closest large source of copper/arsenical ores is in Anatolia (Palmieri, Sertok et al. 1993). In Anatolia, there are a few large copper ore deposits where arsenic-rich minerals do occur and these seem the most plausible source for the Southern Levant (de Jesus 1980).
Attempts to Provenance the Copper Ore

Preliminary investigation of the Abu Matar ores, funded by the Institute of Mining and Metallurgy, showed that some of the ores resembled ores from past analyses attributed to Feinan. Other ores analysed revealed distinct differences from the Feinan group (Shugar 1998). Microscopic and petrographic investigation, in conjunction with XRD analysis, was used to determine the general complexity of the Abu Matar ores and to confirm their mineralogy. Individual mineral phases and host rock were analysed for chemical composition under a scanning electron microscope. The results show that the ores from Abu Matar are extremely complex comprising many mineral phases, mostly copper sulphides, such as chalcocite, chalcopyrite, and covellite, but also carbonate ores, such as malachite, chrysocolla, and cuprite. No significant concentration of arsenic has yet been found in the selected ore samples, but work is continuing. Although some of the ores have definite and direct links to the Massive Brown Sandstone (MBS) formations at Feinan, most of the ores have textural differences from the MBS formations, and have chemical composition suggesting that these ores derive from an alternative source. ICP analysis used to determine bulk chemical composition has also shown differences in many of the Abu Matar ores from those at Feinan. The trace element comparisons of the ratios of As/Sb and Co/Ni established by Hauptmann (1989) also support this variation in provenance.

In recent years, lead isotope analysis has become an established method for geographical provenancing of metallurgical artefacts. Isotopic analysis is the process of determining the ratio of isotopes of a particular element and comparing them to other known samples. Lead is the most typical element that is used for metal as its properties do not alter when an ore is smelted, casted, corroded, etc. While the relevance of the LIA of metals has been questioned by some (with the possibility of mixing metals from different sources), the analysis of ore samples does not fall under the same criticism.' Lead isotope analysis is controlled
by the geological age and formation of an ore deposit. With this in mind, it can be seen how LIA can be considered of great help in the provenancing of ore samples. Analysis of selected Abu Matar ores is now underway at the Oxford University Isotrace Laboratory by Prof. Gale and Dr. Stos-Gale. Early indications are that the ores came from both Feinan and another source. Although further analyses remain to be completed, the early indications are that the second source of complex ore is in Anatolia.

The current analytical results will raise questions as to why no arsenic has been discovered in all the previous analyses of copper prills from Ghassulian sites. I see four possible explanations. First, the metallurgical materials previously excavated from Abu Matar were discovered in the underground structure. Arsenic is poisonous and smelting any amount in closed quarters would be extremely dangerous. So it is unlikely that any smelting of arsenic-rich ores would have been done underground. The recently discovered furnace was located above ground in open air and appears to be in a workshop setting rather than a domestic dwelling. Smelting in this location with ample fresh air would not have been as dangerous.

Second, when the earlier metallurgical material was collected by Perrot (1955), there were quite likely strong sampling biases. The belief that only carbonate copper ore could have been smelted at this stage of metallurgical development in the Southern Levant was strong. Consequently, non-carbonate ore types may have been totally overlooked as not being reflective of smelting. The majority of recognised ore samples from the early excavations of Abu Matar were carbonate copper ore. However there were other types of ore collected that did not fit into the expected prescribed technology. Rothenberg (1991) identified this problem with the sampling of ores from Abu Matar. "There remained however, the problem of the ore fragments found at Abu Matar, and the suggestion that these ores "must have had some other use perhaps, for example, as a cosmetic or for ritual purposes"
was never considered really satisfactory” (Rothenberg 1991:6). Sampling bias is made more likely by the fact that most carbonate copper ores are distinctively green or red, while arsenic ores are mostly dark colours and easily mistaken for ambient rock.

Third, the volume of analysis previously done on the metallurgical material is limited to only a few ore and prill samples. This study has analysed over 100 copper prills entrapped in the slag of over 10 furnace fragments alone. It is notable that Levy (1989) has suggested that since there was no arsenic discovered at Shiqmim, there was likely another craft specialised site that produced copper arsenic alloys in the Beersheva valley.

Fourth, in Renfrew's model of obsidian trading, he introduces the concept of "parallel decline" in which the abundance of artefacts is inversely proportional to the distance from the source (Dixon, Cann et al. 1968). It is likely that whatever arsenic ores traded into the area where completely consumed as they would have been highly valued. One should note that the Renfrew model assumes that the resource is being used along the entire trade route and as yet there is no evidence for Chalcolithic copper arsenic alloying in Lebanon or the north of Israel. Any site found in these regions will strengthen this theory.

**Establishing a Possible Trade Route**

Levy has argued that the Chalcolithic settlements in the Beersheva valley represent "a ... ranked society which emerged as a result of population growth and concomitant new developments in agro-technology, craft specialisation, and social organisation" (Levy 1993:64; Levy 1995). He has used the example of the role of copper metallurgy in describing the emergence of a new hierarchically organised society in the Beersheva region. Levy's model establishes the possibility of regional groups being subdivided based on their individual site specialisation of production, such as ivory production at Bir Safadi, and metallurgy at Abu Matar.
The specialisation of the Ghassulian culture may have been predicated upon existing ties, or links between groups of people engaged in specialised production which promoted the exchange of products; "variation in degrees of specialisation can best be understood through an examination of exchange networks themselves" (Bates and Lees, 1977:826). What trade networks in particular would have promoted acquisition of arsenic-rich ores for metal production?

In the Near East, some of the oldest trade routes were established for access to salt, incense and bitumen (Anati 1962:30). There is also evidence for some limited trading of ivories, shells and flint tools between Egypt and Southern Palestine during the Chalcolithic period (BenTor 1997). Ore samples contextually dated to the late Chalcolithic-Early Bronze Age that were discovered at Maadi, in Egypt, have been analysed and found to be similar to the Dolomite Limestone Shale layers at Feinan (Hauptmann 1989:129). It is generally agreed that permanent and substantial trade relationships between these two regions were not firmly established until the Early Bronze Age.

Renfrew (1969:152) suggests that traffic in a commodity must be "through peaceful human agency." "Peaceful human agency" implies protection of a commodity during its travel. It is clear that trade through peaceful and friendly territory is preferred. There are no known Ghassulian settlements south of the Beersheva region to link it to Egypt. However, there is extensive Chalcolithic settlement along the coastal plains (over 50 sites) concentrating mainly in the south (Gophna and Portugali 1988), while in the central highland of present day Israel, another concentration of Chalcolithic sites has been recorded (Finkelstein and Gophna 1993: over 25 sites). Trading between these similar socio-economic regions which were likely politically linked should be expected and was probably practised. Furthermore, long distance trade routes travelling throughout the Southern Levant can be clearly seen as early as the Neolithic.

Through trace element analysis Renfrew established that during the Neolithic
period, obsidian mined in Anatolia was traded into Southern Levant (Dixon, Cann et al. 1968; Renfrew, Dixon et al. 1968). In his research he notes that obsidian was being traded in distances up to 900 km. Similar long distance trade up to (900 km) has been witnessed ethnographically in ceramic production in Africa (Nicklin 1971). Bushmen hunters living in south-west Africa have been witnessed transferring 50-60 tons of copper ore to the metal producing Owambo tribe 220 km away (Gilead 1992:39). In Chalcolithic settlements in the Southern Levant there is almost no obsidian found, suggesting that the trade network that flourished during the Neolithic period diminished, or that trade in obsidian was no longer required.

As Kohl states in discussing the archaeology of trade, "Trade cannot be divorced from its role in the socio-economic structures of each society participating in a trading network. It cannot be considered separately from an economic "subsystem" which has a firm technological base" (Kohl 1975). The progression from the Neolithic to the Chalcolithic in the Southern Levant witnesses a distinct change in socio-economic structures. While the technological base of the Neolithic in the Southern Levant was stone tool production, the Chalcolithic saw both an alteration in its stone tool industry and the advent of advanced metal production. Obsidian almost completely vanished from use in Chalcolithic settlements in the Southern Levant, and only a few samples have been found. Trace element comparison of one obsidian sample from the Ghassulian site of Gilat shows that it fits into the prescribed context established by Renfrew (Yellin, Levy et al. 1996) indicating that at least some trade continued with Anatolia. With the developing technology of copper production in the Southern Levant, the trade goods required would have changed and expanded. Adams (1992) "has stated from an anthropological perspective on trade that once one valued object is traded other valuable objects will inevitably enter the existing route of trade. It is therefore possible that valuable arsenic-rich ores would have entered the trade
network, once advanced copper production was established in the Southern Levant.

While arsenic-rich ore was likely a highly valued commodity in the Southern Levant, based on its rarity, it is still only a raw material. A finished product of metal would have been much more valuable and would have been given the higher ranking in commodity value (Gosden 1989:371). Of course, metal is not the only item that would have proceeded along a trade route, but for present purposes we shall focus on it.

Trade is only one form of exchange (Kohl 1975). For example, exchange can consist of gifts, tribal payments and marriage dowries. Gosden (1989) has shown that when exchange comes in the form of a gift, a debt may be incurred. To maintain political and social power that debt must be re-paid. But if the debt is paid with a commodity that has a higher value to the cultures concerned, the power balance can shift and provide an advantage to the supplier. It is likely that in attempting to maintain a political, social, or economic advantage, items of equal or of higher value would be returned to the original trade source.

What is known about the distribution of Ghassulian metallurgical production northward towards Anatolia? Until recently there have been limited finds of metal artefacts in the entire region and the main concentrations of finds have been surrounding the Beersheva valley. No artefacts have been found south of the Beersheva valley. To the east, of course, we have the Nahal Mishmar hoard and some additional finds at Teleilat Ghassul and Nahal Makuh. To the north and northwest, there are a few sites along the coast that yield such artefacts, but nothing further north than present day Ashkelon (Shalev 1994). In recent excavations east of Tel Aviv, near Lod, a hoard of over 20 copper objects similar to those of the Nahal Mishmar hoard was found (I. Finkelstein 1997, personal communication). Further north in the Galilee, excavation of Peqi’in, a Chalcolithic cave, uncovered another small hoard described as being similar to the Nahal Mishmar hoard as well (Gal and Smithline 1996). There is still
much to be surveyed and excavated further north in Lebanon, and work is not nearly complete in Israel itself. More of these small hoards may yet be found. It can be suggested that there was a movement of finished copper objects northward, most likely as trade items, but further evidence is required to firmly establish this. However, on the whole, I think it is acceptable to assume that trade was active in many items, including arsenic-rich ores, between the peoples of the Ghassulian culture and the peoples in Anatolia during the Chalcolithic.

**Suggested Alternative Process Model for the Copper Production of the Southern Levant**

At present, based on the evidence provided, I can offer an alternative process model for the production of copper and copper arsenic alloys in the Southern Levant during the Chalcolithic period. With the evidence of arsenic copper alloying found in the recent investigation of the Abu Matar metallurgical materials, combined with the lack of any substantial complex arsenic-rich copper ore in the vicinity, one has to assume that the valued commodity, arsenic-rich ores, was acquired through trade. If this is the case, accidental or unintentional alloying seems unlikely. Carbonate copper ores were mined at Feinan during this period and brought to the region for production. The ores obtained from Feinan were perfectly suitable for copper production on their own. So why then were these metalsmiths importing arsenic-rich ores? It would appear that they had a better understanding than previously supposed of the advantageous qualities resulting from adding arsenic to copper. These include lowering melting temperature, improved casting, and altering colour. What appears to have occurred was a purposeful co-smelting of arsenic-rich ores with high grade carbonate ores from Feinan. The resulting slag, in this model, would have been crushed to separate the arsenic copper prills which where collected and re-melted in a crucible for casting. Objects resulting from this process would contain approximately 2% arsenic. Experiments by Merkel *et al.* (1994) suggest that even small quantities of arsenic-rich ores, added to a smelting charge, would
be sufficient to produce the desired copper arsenic prills.

**Conclusion**

In this paper I have reviewed the archaeological details of the Ghassulian-Beersheva culture with specific reference to their metallurgical capabilities. The recent excavations at Abu Matar revealed extensive metallurgical activities with remains from all aspects of production. Detailed chemical compositional analysis by EPMA indicated that arsenic was being alloyed with copper on site. Reasons are provided for assuming that this was a product of intentional co-smelting of arsenic-rich ores with carbonate copper ores. The resulting copper prills entrapped in the slag would be removed and re-melted and cast into objects. Some of these objects might have been returned along the trade routes towards Anatolia. Subsequent investigation of the recovered ores revealed that some of the ores derived from Feinan in Trans-Jordan as previously established. Other ores showed distinct differences from the Feinan source with stronger links to Anatolia as revealed through chemical compositional analysis and lead isotope analysis.

Although arsenic-rich ores have not yet been identified from Abu Matar, sources have been identified in Anatolia. Based on lead isotope analysis of ores from Abu Matar it can be considered quite possible that ores from Anatolia were the source of the arsenic identified in the prills. Although it has not yet been collected from the site because of selection bias, or because its high value ensured that it was fully used.

Long distance trade of obsidian during the Neolithic was discussed with the intent of establishing the likelihood of similar trading networks during the Chalcolithic period in the Southern Levant. Strong trading links are assumed based on the strong social, political, and economic environment that existed for the Ghassulian culture.

This thesis provides a most exciting possibility for confirming that the production of the elaborate prestigious items discovered in the Nahal Mishmar hoard were produced
locally, in the Beersheva valley. The discovery of locally produced metal artefacts with substantial levels of antimony and nickel would strengthen this position. Work is continuing with lead isotope analysis in an attempt to proveance more of the ores found on site.

Notes

1. For details of some of these sites see Dothan 1959 for Horvat Beter; Perrot 1984 for Abu Matar and Bir Safadi; Levy 1987 for Shiqmim; and Gilead 1989 for Grar.


4. Fidan 4 is a Chalcolithic site but no remains of the Ghassulian culture have been identified

5. See Key 1980 for initial results and see Levy and Shalev 1989 for classifications.

6. See Charles 1967; Craddock 1985; Budd and Ottaway 1991; Rostoker and Dvorak 1991 for discussion on the amount of arsenic required in a copper arsenic alloy to be considered intentional.

7. For arguments see Gale 1989; Sayre, Yener et al. 1992; Pernicka 1993; Budd, Haggerty et al. 1996.

8. For more details on the properties of arsenical copper see Northover 1989 and Budd and Ottaway 1991

Bibliography


