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Some thoughts on human nature, past and present

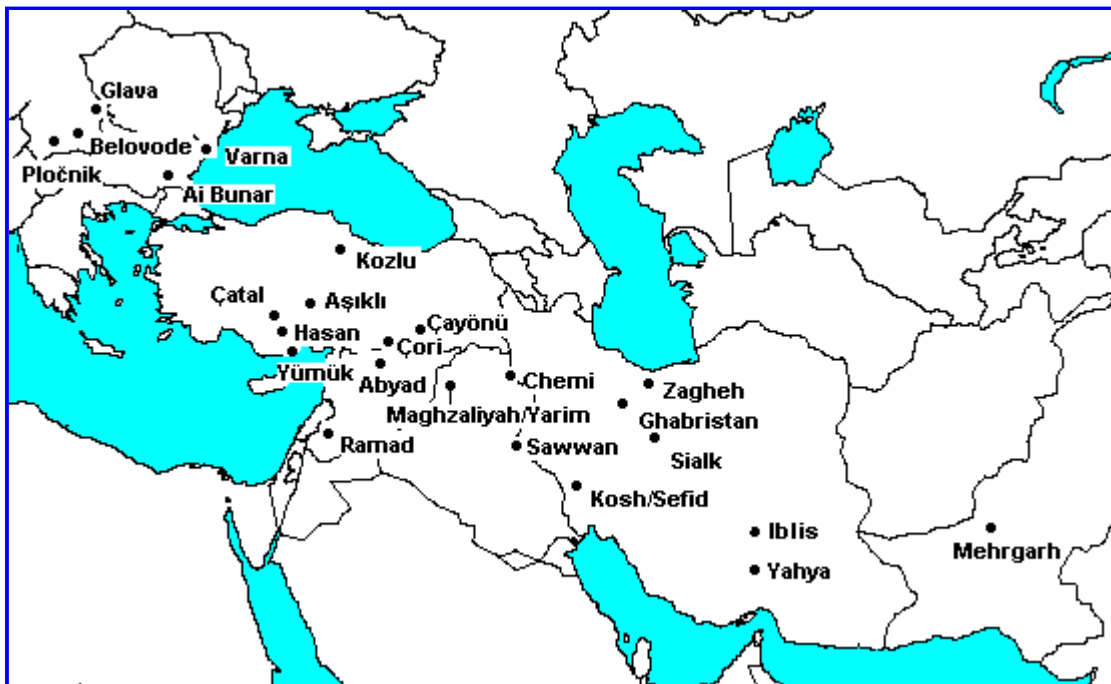
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A primer on old-world metals before the Copper age

by Edward Pegler on 7 July, 2010

A discussion of copper, gold and lead artifacts, their origins and distribution from the Neolithic up to the time of the earliest smelting in the Chalcolithic or Copper age... and where did smelting originate?

(updated March 26th 2011)



map showing places discussed in the text

I'm writing this article simply because there is a fair amount of information out there on the early occurrences of copper. However, it is rarely compiled and the wikipedia entries seem a bit confused. Also I'm trying to get my head around all of this. There will be stuff I've missed. Please let me know if you know better.

(Note also that this article does not discuss the use of copper in the Americas which started, probably independently, about 5000BC and lead to copper smelting around the first millennium BC)

Copper Sources

Copper comes in several natural forms from the ore bodies of the Earth.

Native copper - copper in its metallic form. This occurs at the surface of ore bodies and sometimes deeper in the ore body. Although now scarce it was once more common.

In the weathering zone, between the surface and the major ore body below, ores are oxidised to form various rock minerals, including:

1 – The *copper oxide* cuprite

2 – *Copper carbonates* – produced in the presence of limestone. The best known minerals are malachite, which is green, and the more unstable azurite, which is a deep blue (not to be confused with lapis lazuli). Malachite was often used as an ornament for beads. Both minerals were frequently ground to use as pigments.

3 – *Copper silicates* – such as the blue-green chrysocolla.

4 – Turquoise – a rare, blue *copper aluminium phosphate* mineral prized in itself.

Below this, in the reducing conditions of ore bodies deep in the ground you get *copper sulphide* ores. These are now the major source of copper. Minerals include chalcopyrite, bornite and chalcocite.

Processing into copper

Early working of native copper usually involved hammering the copper into a sheet, then rolling the sheet copper up to make beads, hooks or awls (points). Copper is best heated (annealed) to make it less brittle after it's been hammered.

Carbonate and sulphide ores need roasting in air to drive off volatiles and leave copper oxide. This can then be smelted at high temperatures (at least 700°C, hotter than a normal fire) to produce copper. This requires a lack of oxygen and the presence of carbon (charcoal) to remove the oxide (reduction).

Melting of copper requires temperatures of around 1100°C. At the temperatures available to early societies it was perfectly possible to produce small amounts of copper in pottery ovens from carbonates and oxides such as malachite, azurite and cuprite. However, you had to know what you were doing to achieve this.

Whilst pottery only came into existence in Europe and the Middle East after the seventh millennium, people were able to fire clay objects even before they could make pots. Therefore whilst smelting of copper before this date may be unlikely it's not impossible.

Copper keeps it's shiny red appearance quite effectively and would have been a prized object in the Neolithic. However, it was rarely useful as it was slightly soft, so tended to be for ornaments more than for useful items. Copper artefacts buried in the ground for several thousand years copper can oxidise or reduce slightly, and small artefacts can be difficult to tell from ore minerals.

Gold and lead

Lead occurs naturally in the ground as lead sulphide ores such as galena. Galena, having a metallic look, was polished for use as beads or ground up for cosmetics. Whilst lead melts at just 330°C,

lead ores need temperatures of about 800°C to smelt into pure lead. However, metallic lead is soft, poisonous and oxidises easily to a dull tarnish so its uses to early peoples were limited.

Gold is unreactive. It does not form other minerals so does not need to be smelted. It can be found in streams or in veins in rock. It was probably always prized but only for ornaments as it is quite soft.

Earliest evidence for ore use

Shaped pieces of copper ore date back to before the beginning of agriculture. Beads of malachite, turquoise and, possibly, chrysocolla have been found from Natufian culture settings in Israel. More have been found from early agricultural settings. § As later sites often contain beads of copper ore or ore fragments I won't discuss these further here.

The oldest known piece of worked copper is often quoted as being a copper pendant from the burial site of Zawi Chemi / Shanidar Cave, northern Iraq, dated to the middle of the ninth millennium BC. However, this is not worked copper but ground and polished copper ore, probably from Turkey to the north. It is made up of malachite and chrysocolla but happens to contain a fair amount of native copper*.

Neolithic copper finds

Turkey



Copper bead
from Aşıklı
Höyük

Various sites, such as Aşıklı Höyük, Nevalı Çori and Çayönü Tepesi, have definite items of native copper dating to the period either side of 7000BC *and perhaps as far back as the beginning of the eighth millennium BC*. Çayönü's collection of between 50 and 100 items is by far the most impressive. It weighs several kilos and consists of small artifacts such as beads, hooks and awls (points).

Most of these artifacts were found in two areas of a single courtyard and date to the period of most activity in the site. Çayönü happened to be near sources of native copper, so perhaps the presence of this much copper is not surprising. Native copper has also been found at Çatal Höyük, Turkey, dating to the late seventh millennium.

Iran

A rolled native copper bead, from the *late eighth or early seventh millennium BC*, has been found at Tepe Ali Kosh, *but is probably an imported item from eastern Anatolia*. Other examples of native copper date to the sixth and fifth millennia (e.g. awls from Tepe Zagheh, fragments from

Chogha Sefid, pins, projectile points, awls and spiral coils from Tepe Sialk and two awls from Tepe Yahya).

Iraq

A conservative estimate of the native copper artifacts suggests that there are very few in Iraq. Those confidently identified are an awl from seventh millennium Tell Maghzaliyah, a very small, perforated knife from sixth millennium Tell es-Sawwan, two rings and a copper sheet bead from sixth millennium Yarim Tepe, and a slightly later copper seal from the same location. Yarim Tepe was also the site of a lead bracelet which will be dealt with shortly.

Syria

A native copper nugget, made into a pendant, from Tell Ramad, and other objects of rolled copper sheet from Sabi Abyad are dated to the seventh millennium BC.

Pakistan

Copper beads, dating from the the end of the seventh into the sixth millennium BC, have been found at Mehrgarh.

Europe

The first evidence of native copper here is late, only during the sixth millennium BC, just after the appearance of the first farmers. Sites such as Belovode in Serbia have evidence for some native copper beads.

Possible early evidence of smelting

Turkey

Lead smelting was possibly easier than copper and may have happened first. At Çatal Höyük, Turkey a mid to late seventh millennium bead was thought to be of smelted lead, but is now known to be of shaped galena. However at Yarim Tepe I, Iraq, there is a lead bracelet from the sixth millennium BC which, unless it came from a rare source of native lead, is likely to be smelted.

The earliest evidence for copper smelting, now questioned, is also from Çatal Höyük. A small quantity of copper ore and a melting slag from the mid-seventh millennium are thought by some to be heated and worked native copper and part of the vessel used to melt the copper. At Nevalı Çori, Turkey there is also disputed evidence of smelted copper. Objects which appear to be from the seventh millennium have impure chemical signatures possibly indicative of smelting.

These disputed cases of copper smelting seem largely to have been discounted at present. However, regardless of other interpretations, the evidence above suggests that people at the time could produce temperatures sufficient to smelt copper, even if they didn't actually smelt it.

Better evidence of smelting

Turkey



Copper mace head from Can Hasan (on display in Ankara's Museum of Archaeology)

At Can Hasan a round copper mace-head, several centimetres across, was found and dated to around 5000BC (but see \$ below). Despite its size, it is now thought to be made of hammered native copper. However, Yümük Tepe / Mersin has cast copper axes and chisels from around the early fifth millennium BC. Some of these show compositions which strongly suggest smelting.

Europe

A 2007 discovery at Pločnik/Prokuplje, Serbia revealed a copper chisel casting which is older than the one at Yümük Tepe, dating sometime to a period just after 5500 BC. What is really interesting is that the site also shows some evidence of quite sophisticated copper smelting.^a Solid evidence for smelting has also turned up at Belovode, also in Serbia, at 5000 BC (and perhaps as old as 5400BC). This is currently the oldest definite evidence of smelting in the world.²

*There is little evidence for copper smelting in other parts of Europe until the late fifth millennium BC, the earliest being from Brixlegg, in Austria. Copper smelting seems to be relatively widespread in central Europe by the mid fourth millennium BC.*⁵

Iran

The earliest evidence for copper smelting on the Iranian Plateau *is probably from Tal-i Iblis. The dating of this evidence is poor and can currently only be limited to the range 5200-4400BC. However, there also is good evidence for copper smelting at other places such as Tepe Ghabristan and Tepe Sialk from the mid to late fifth millennium BC.*⁴

Pakistan

Crucibles from Mehrgarh, Pakistan date from the first half of the fourth millennium BC, a little later again.

Early copper mining evidence

Europe

Copper mining seems to be associated with the earliest smelting of copper. Two early copper mines, Ai Bunar, Bulgaria and Rudna Glava, Serbia, are dated to the early fifth millennium (and possibly older?) to early fourth millennium, based on evidence in the mines and matching chemical signatures of copper artifacts. Chemical signatures indicate that perhaps four other mines were operating somewhere in the Balkans during this period.

Turkey

The earliest copper mine, Kozlu Eski Gümüşlük, is dated as no older (and perhaps younger) than 4000 BC, based on radiocarbon dating of wood from the mine.³

Gold

As far as I can tell, there is no Neolithic gold. The earliest evidence of gold artifacts comes from the Varna cemetery in Bulgaria, dated to the middle of the fifth millennium. This again seems to predate any gold artifacts in the Middle East, or anywhere else, by hundreds of years.

Silver

The oldest occurrence of silver is also relatively late, coming from a hoard in Alepotrypa, in southern Greece, dated to the mid 5th to early 4th millennium BC. However, there is also evidence of actual silver smelting from Sardinia by the end of the fifth millennium BC or the beginning of the 4th millennium.⁵

Discussion

Small quantities of native copper

The total amount of Neolithic native copper found in archaeological contexts in the Middle East, i.e. before smelting was invented, amounts to no more than a few kilograms. Even guessing at all the Neolithic copper artifacts that have not yet been found, the total amount is probably never going to amount to much. When it's realised how much native copper was probably available to Neolithic people in Turkey alone, perhaps tens of thousands of kilograms, it indicates how much has been lost.

This could mean perhaps that native copper was not highly prized in the Neolithic so no-one bothered collecting it. It's an interpretation, but it goes against type for a shiny rare thing to be uninteresting to people. The alternative, as outlined [here](#), is that copper did not get lost or reburied very often, perhaps because it was far too highly prized.

Many origins or one origin for copper smelting?

The smelting of copper has long been assumed to have started in one place, either in Turkey, Iran or Iraq. However, recent evidence of early mining, early smelting and the earliest gold, all from the Balkans, has caused a reassessment.

Most archaeologists now argue for multiple origins for copper smelting, *with one origin in the west, in the Balkans, and one in the east, on the Iranian Plateau*. Much of this hinges on small pieces of evidence, such as the evidence for lead smelting in Iraq from the sixth millennium.

On the other hand, Ben Roberts and Chris Thornton have, through considerable research, recently returned to a single origin view. They suggest that the origin lay neither in the west nor in the east but in the heartland of early smelting and melting experiments, in Anatolia.

Now personally I have no particular thing for the Balkans, but *in both views there* is an interesting reluctance to concede that the Balkans may have been the one originator of copper smelting in the old world. For example, Ben Roberts recently said:

“It’s likely we’ll see copper-smelting evidence at least contemporary with Belovode from the Fertile Crescent once research programs are in place at well-excavated sites”

Of course, the history of technology is always only as old as the oldest evidence found so far. The people of the Balkans may have, for all sorts of reasons, buried their copper when people in the Middle East didn’t. However, there seems to be a peak in Balkan cultures during the early fifth millennium which is not matched by the cultures of either Anatolia or Iran. Indeed, some comment on the decline in Anatolian cultures during the fifth millennium.

Whatever, it is important to test if Anatolia really could have been the first to smelt copper. I think I’d like to see an analysis of the copper items of Yüyük Tepe/Mersin for a start.

Personally, I’d make a guess that Ben Roberts going to be wrong. I may eat my hat later (*and I will let you know when I have to*).

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²Archaeology Daily News 2010 [Belovode site in Serbia may have hosted first copper makers](#), Website

^aB92 News 2007, [Archaeologists stumble on sensational find](#). Website

§Bar-Yosef Mayer, D.E & Porat, N. 2008 [Green stone beads at the dawn of agriculture](#). PNAS 105, p8548-8551.

\$ Betancourt, P. 2006 [The Chrysokamino Metallurgy Workshop and its territory](#), Oxbow, pp462. – this book gives peculiarly high dates for both Çayönü Tepesi and Can Hasan. The dates for Çayönü look plain wrong (possibly BC has been written instead of BP). The date for Can Hasan (which is quoted as 6000BC) seems to contradict most others who have read 5000 BC from the primary source (Yalçın, Ü 1998 Der Keulenkopf von Can Hasan (TR) Naturwissenschaftliche Untersuchung und Neue Interpretation, In Rehren Th. Hauptmann A. & Muhly J.D. 1998: p279-289. [Metallurgica Antiqua. In honour of Hans-Gert Bachmann and Robert Maddin](#). Deutsches Bergbau-Museum, Bochum, pp304). This 6000BC date is now rippling through the internet, including Wikipedia.

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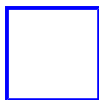
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⁴ Thornton, C.P. 2009 [The Emergence of Complex Metallurgy on the Iranian Plateau: Escaping the Levantine Paradigm](#), Journal of World Prehistory 22, p301-327.

Unknown Provenance, [list of sites in Turkey](#) producing metals from Neolithic to Bronze age.

[Other useful reference page by Chris Thornton](#)

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[Geoff Carter 12 July, 2010 at 5:26 pm](#)

This is an excellent survey. It is not my specialist field, but as you pointed out in relations to the development of agriculture, simple models, and single points of origin, are not helpful. It is sometimes difficult to accept that we lack sufficient evidence, and we may never be able to resolve such issues with any degree of certainty.

What about silver?

[Reply](#)

[Edward Pegler 12 July, 2010 at 9:19 pm](#)

Dear Geoff

This article is a start. Really it resulted from my horror at wikipedia's entry on smelting. It's undoubtedly true that copper smelting has multiple origins, for example in the Americas. Additionally, there is no doubt that plenty of copper smelting evidence has either not yet been found or not yet recognised as found. However, the rise and increasing influence of the Balkans in the middle of the sixth millennium came at a similar point to the failure of certain centres in western Turkey such as Halcilar. I have a feeling that the Balkans advantage may have been short but did exist.

As for silver, it's normally associated with lead ores. I haven't found any evidence of it from before the 5th millennium, like gold. I suspect that once copper was being both purified and alloyed that's possibly when silver came out in the wash. However, that needs more homework and I'll get back to you.

Ned

[Reply](#)

[Ben Roberts 28 September, 2010 at 4:15 pm](#)

Hi Edward

Nice blog and great to have more debate on this – if you send me your email I'll happily send you a more recent article I did with a couple of colleagues

B. W. Roberts, C.P. Thornton, V.C. Pigott, 'Development of metallurgy in Eurasia'. *Antiquity* 83 (2009), 1012–1022.

which gives the big picture for Europe and Asia and puts my European centred paper you cite in a broader context and hopefully makes a better case for my comment!

Cheers

Ben

[Reply](#)

Edward Pegler [28 September, 2010 at 4:56 pm](#)

Dear Ben

Done. And thanks for the positive comment... although I understand your different opinion and may well change mine after reading your paper.

Ned

[Reply](#)

Edward Pegler [15 October, 2010 at 6:17 pm](#)

It seems that the major issue raised by Ben here is the dating of the earliest smelting in Iran, from Tal-i Iblis. This is possibly dated to the early part of the fifth millennium BC, which would be similar in date to the evidence of smelting from the Balkans. If this is correct then it implies simultaneous commencement of copper smelting in two widely separated areas. This could either be due to multiple origins of smelting (as would be argued by Colin Renfrew, say) or because the one origin of smelting happened between the two extremes, for example in Anatolia (as is argued by Ben Roberts). My question is how well established is the accuracy of the dating of Tal-i Iblis? It seems to me that most Iranian sites of smelting seem to occur later, from the second half of the fifth millennium BC. As far as I can tell the dating of Tal-i Iblis allows for some variation. Any thoughts on this would be appreciated.

Ned

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