10.1.2 Native Copper

Is There a *Native Copper* "Age"?

The first metal used by humans appears not to have been gold but *copper*. Or maybe *lead*? I have dealt with the gold puzzle in the preceding sub-chapter, now let's look into the copper issue. Or is it the lead issue? Am I confusing? Well - I'm just staying with the gist of the ongoing discussion in "insider" scientist circles and between all kinds of interested "outsiders" (like me).
Let's start by asking another deceptively simple question:

Who used the first metal (Copper or Lead), _when_ and _where_?

If you think that this is a simple question, think again. There is a simple first answer, however: *Nobody knows for sure!*
First of all, it is not impossible that some ancient culture we have not yet discovered had used metals long before any of those we know at present. Maybe this culture has perished without leaving a trace, or maybe we just haven't found it yet. There is plenty of speculation about the lost continent of Atlantis, for example, and while that is mostly (or better: completely) baloney, you can never be sure that there isn't something spectacular out there waiting to be discovered. In fact, during the last 50 years or so, totally unexpected finds have been made; suffice it to mention "Varna" and "Göbekli Tepe".
However, it is rather *unlikely* that we find totally unknown cultures that were more advanced then the ones we know about. The reason is simple: It is just not likely that much advanced stuff has happened before the end of the last ice age about 10 000 years ago that triggered what is called the "neolithic revolution", and we do have a general idea of what happened then.

So let's rephrase that question: "Who, *as far as we know from digging around*, used the first metal; when and where?" This question can be answered and it has been answered. Many times, actually. There is not just one answer but many - the particular answer you get depends on whose book or paper you consult and on how old it is. If you want the one-and-only definite answer, you will have to wait, probably until hell freezes over. It's better to get acquainted with the idea that there may not be a definite answer. Just look at **Çrockü**, an ancient guy, who carved some nice green rock he found (happened to be malachite) into a bead or pendant for his sweetheart, one Ms. **Nölüdyæ** (they did have funny spelling then). This was a rather routine thing to do for Çrockü, he had done it many times before. But this time he didn't notice (or care) that his workpiece had some elemental copper *inside* its green shell. 12 000 years later we find it and declare: "There is worked native copper! The very first one!" Is Çrockü now really Mr. "*The First*"? This may have happened, by the way.

But how about that lead (Pb)? Well, a **lead bead** was supposed to have been found in Çatal Höyük, one of the earliest *cities* ever unearthed. That lead bead dates to the seventh millennium BC and provides a major, major puzzle! Since lead can *only* be obtained by *smelting*, it provides a starting point for smelting technologies at about 9000 years ago in Çatal Höyük - and that date simply doesn't match with everything else we know about that. It is *several* millennia too early!
If you have never heard of Çatal Höyük: use the link hub! You will find a great many details about Çatal Höyük and a number of other very early places of interest.

Link Hub

Early places

Well - as it turned out in 1990 [1)], that bead was *not* made from lead (Pb) but from galena or lead sulfide (PbS). Galena is abundant in nature. It's lead ore, the stuff you make lead from, and it does *look* a bit like (shiny) lead. Lead has been confused before (and even nowadays) with graphite or galena, so history repeats itself.

Now it only remains to solve the puzzle of the **lead bracelet** from the sixth millennium BC, found at Yarim Tepe I, in what is now Iraq. It is about 1 000 years younger but still too old. So how about that?
It appears that it has never been properly investigated; an onerous distinction it shares with many famous metal artifacts. So it may be lead - or possibly not.

Pursuing the question from above does lead into a fascinating if somewhat confusing journey into Anatolia and parts of the Middle East. Out of the kindness of my heart I give you a lot of details about a number of those early places where metal could have been found but wasn't, where it was erroneously believed to have been found, and where it really was found.
If you take the tour (via the link hub above), you will not only get closer to the answer of our basic question but also find out that ancient man (and woman) was seriously whacky, a bit like Californians. The men were into **sex**. That's normal, you might say. Yes - but with turtles? The woman were into jewelry and home decoration. That's normal, too - as long as you don't put the (spiffed up) skulls of your former loved ones on the mantelpiece!

But now let's get going. No more confusing the issue: Who used the first metal ? Was it copper or what? When and where?

The answers today in short are:

- The first metal used by humans was *native* **copper** (Cu), indeed. It was probably not used intentionally but "on the side" when some native copper happened to come along with a new delivery of "**greenstones**" like malachite.
- The oldest (always small) copper objects are from around 8 000 BC, making them about 10 000 years old; see the time-line here
- The first towns where copper was definitely found are: *Asikli Höyük*, *Cayönü Tepesi* and maybe (but probably not) *Nevali Çori* - all of them in Anatolia, Turkey, see the map

Should that induce us to declare a *Native Copper Age* from 8 000 BC - ????? BC? I say: No! As far as I can tell, native copper usage was slight, and the material was of no importance for the life of those ancient people. I can think of three reasons for this:

1. There just wasn't all that much of the stuff around (with the exception of the "Old Copper Complex" around the Western Great Lakes in the USA).
2. Hammer shaping (including, maybe, hammer welding but probably not), even with a bit of "pyrotechnology" (see below) just won't get you very far. And melting + casting hadn't been invented yet.
3. Native copper just wasn't very useful. One could make beads and pendants for jewelry from it, or other small things like awls and hooks. Those copper things would turn green, and that might have made them more desirable for jewelry. But native copper is rather soft and not very useful for tools; it is far inferior to the highly developed flint and obsidian tools around by then.

Now let's look at that in some more detail. For plenty of details use the link

First Copper and Neolithic Society

The people in *Asikli Höyük* and *Cayönü Tepesi*, who left us some copper beads and stuff, started to settle down around 10 000 BC. They first built some simple "hole-in-the-earth plus wattle and daub" [5)] houses, forming small towns, and stopped roaming around the countryside as major style of live. The were still hunters and gatherers, however, living in what we like to call "**neolithicum**" or New Stone Age. Domesticating animals like sheep, goats and pigs, as well as tending (and breeding) crops like wheat, emmer, barley and einkorn, came later.

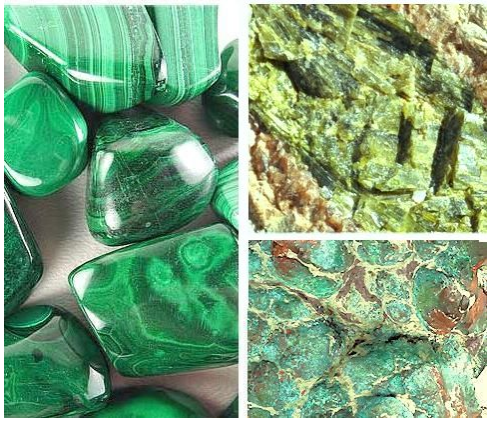
Nevertheless, people now became "sedentary", meaning settled down, after roaming around or huddling up in caves for many thousands of years. That was a complete change of their basic behavior and thus known as the "**Neolithic revolution**". Our old friend Çrockü from above wouldn't have seen himself as a revolutionary, though. The neolithic revolution took place during a time period of a thousand years or so, and it only looks like a "sudden" change in behavior on large time scales.
Çrockü might have been a neolithian but he wasn't a dummy. He knew that it is beneficial to men if the wife (Nölüdyæ; by now he had married her) is happy and thus quiet [4)], and that this involves giving her jewelry and the occasional little sculpture that reminded her of his outstanding virtues.
The catchword is "**jewelry**" or amulets, same thing. Necklaces or other things made by stringing up beads were found in pretty much all neolithic places, often as grave goods with female remains. All kinds of materials were used for beads, here is an example with intricately carved bones.
The most prominent material for making jewelry was "**greenstone**". Here are a few examples from the general time and area:

Greenstone beads and pendants, about (0.5 - 2) cm in size

Source: Daniella E. Bar-Yosef Mayer and Naomi Porat: "Green stone beads at the dawn of agriculture", PNAS June 24, 2008 vol. 105 no. 25 p. 8549
With friendly permission

There are many "green stones" you can find out there: Apatite (some calciumphosphate; most of the beads above), Fluorapatite, *Chrysocolla*, *Malachite Turquoise*, Amazonite, Serpentinite, and so on. Whatever all that is, the three *red-lettered ones* are *copper compounds* or ores. Best known is **malachite**, below are examples. Those colorful copper ores (including blue azurite and many others) are typically found on the upper reaches of copper ore bearing

strata, above groundwater levels and with exposure to air. It's what you see when you roam around the mountains: rocks with green and blue veins. When you start digging there, chances are that you encounter native copper a little lower down. It is not necessarily present in the form of nice big nuggets but might be embedded unobtrusively in the malachite / azurite "rocks".



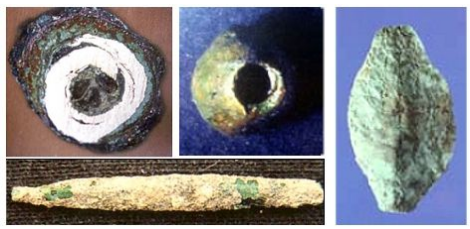
Malachite. Nice solid examples, greenish rock, and with embedded native copper

- Çrockü and Nölüdyæ, like everybody else in the so-called "**fertile crescent**" - what is now Turkey / Anatolia, Iraq, Iran, Israel, Lebanon and so on - "*made great efforts at obtaining green minerals for the production of beads and pendants*" around 12 000 BC. *A little later* - say (10 000 - 8 000) BC "*this trend expands*" write Daniella E. Bar-Yosef Mayer and Naomi Porat. Both of them subscribe to the good / bad color hypothesis [2)]. People then even mined for good greenstones and traded the stuff far and wide.
  - *A little later* than 12 000 BC, Çrockü's descendants had fully settled down. They lived no longer in wattle-and-daub huts but in large and complex stone houses. They had domesticated some animals, cultivated plants (probably made beer) and performed strange rituals in large complex stone temples or ritual buildings. The men were still into sex but now preferred women to turtles, it appears. They left lots of figurines around with clear meanings. Take the trip to learn more.
  - Now to the punch line:

Those guys could not avoid to get some native copper on occasion with their "greenstones"

The question is what they did with it. Who knows. They might not have noticed that their greenstone contained some copper inside (see the "Shanidar cave pendant"), chucked out the faulty lot, tried to do something with the stuff and failed, or figured out some way to deal with it. Maybe only a few of those guys cared for working native copper or actually could do it. The copper beads and so on in those neolithic towns typically were found in only one or two houses.

- What some of them did sometimes was to bang some copper into a thin sheet and then roll it up. The pictures tell it all



Copper beads and an awl from Cayönü Tepesi and Asikli Höyük

Source: Courtesy of Ünsal Yalçin

  - On the upper left is a cut-open bead, and the rolled structure is clearly visible. On the bottom is an awl.

Now go to your basement shop, get some copper, and bang it into a sheet. It will be easy if you take a piece of copper wire from some electric cable, while you might fail with a piece of copper tubing. It depends a lot on how pure the copper is. Electric wires usually use rather pure and therefore soft copper; copper tubes are alloyed to some extend for hardening (you know the drill by now). Your copper, upon cold hammer forging, might develop cracks before you achieve the thin sheet you are after. So what are you going to do?

- Right. You anneal the structure in between hammering. Shape it some but no more than the material will take before cracking. Then put it into the fire and anneal it. Driven by the *diffusion* of *atoms* via *vacancies*, the *dislocation* density will go down, *grains* will grow, and so on. You know where to look for the explanation of the fancy terms by now; I will not set links anymore.
  When you now continue hammering, you can deform your copper some more without encountering problems.

  The great-great-...-great grandson of Çrockü and Nölüdyæ, one **Frodü**, who made some of those copper beads and other stuff, knew that too. At least some of those copper artifacts were done by using "**pyrotechnology**", to use the fancy word for some annealing in between hammering. Annealing typically commences at temperatures around 2/3 of the melting temperature. For copper (melting temperature 1084 ^{o}C; 1982 ^{o}F) this means temperatures around 600 ^{o}C (1112 ^{o}F), easily reached in a regular fire.
  How do we know this? By looking at the microstructure - an example is given below; details can be found in the link

Link Hub

Pyro-technology

There is much that you can make from thin metal sheets - if you are a good smith. If you can even hammer-weld two pieces together, you can do even better. So how about hammer-welding copper? Try it in your basement. It didn't work for me. Definitely not with cold copper, and neither with hot (but not very hot) copper. I'm not saying it can't be done; I'm just saying that it is not easy, in contrast to hot iron or (pure) gold. Gold isn't easy either but for a different reason. Do some experiments with some 24 ct gold stuff of your spouse (best done when said spouse is far away) and you see what I mean. Seriously now: "native" gold typically comes as "dust" - try to hit that with a hammer!

- Frodü couldn't hammer-weld copper either - at least I didn't see any evidence for that. The best he and his cronies could come up with (as far as we can tell from what we found) is the famous **mace head from Can Hasan**:

Mace head from Can Hasan
Diameter about 5 cm

Source: Courtesy of Ünsal Yalçin

D. French, the guy who dug out Can Hasan in the 1960ties, pronounced this mace head to have been *cast*, and this caused no end of confusion. This particular artifact dates back to 6 000 BC, and there was just no way that people then could have *cast* copper (or anything else) for a very simple reason: they hadn't invented *pottery* yet!

Çrockü, Nölüdyæ, Frodü, and everybody else living from roughly 10 000 BC - 6 000 BC are called "PPNA" or "PPNB" people in polite scientific circles, with "PPN" being short for "**Pre-Pottery neolithics**". They burnt lime (rather amazing!), shaped clay and hardened it some in a fire, made mudbricks and dried them in the sun, hollowed out stones to get bowls, and so on - but they did not make "hard-fired" pottery! And if you don't have that, you simply do not have a vessel or *crucible* in which you can melt copper at 1084 °C (1982 °F), always provided you have a *mold* and can get the temperature up this high in the first place (they could not). It's as simple as that. For casting you need some special hardware (see the link), and if you don't have it, you don't cast.

Basic Link

Hardware

So **Ünsal Yalçin**, an eminent archeometallurgist from Bochum, Germany, when he was allowed to investigate the mace head, duly found out 3) that the this artifact was hammered and not cast. The pictures above clearly show not only the seam but also that the two pieces did not weld properly at the seam.

Microstructure of mace head from Can Hasan

Source: Courtesy of Ünsal Yalçin; from 3)

Looking at the microstructure as shown above makes clear (to anybody familiar with typical microstructures of copper) that the object did not solidify (no dendrites), i.e. was not cast. It has been deformed ("pressure twins") and annealed (large grains, straight grain boundaries, few defects in the grains).

What happened after bead making started about 10 000 years ago in Cayönü Tepesi and Asikli Höyük? Almost nothing for about 2000 years. Then some more beads and the mace head appear about 8 000 years ago in Çatal Höyük and Can Hasan. The nothing again for another thousand or 1500 years.
To be sure, there is the occasional copper artifact that was found between 8 000 BC and 5000 BC somewhere in Europe, the Middle East or in other places, and most certainly only a tiny part of what had been produced has been found. Nevertheless, there simply was never a native copper *industry* that was of any importance to the people in the Middle East and Europe. There wasn't all that much native copper around, and whatever there was ended up cold-worked / annealed into some not-so-useful items, and that was that. Copper tools just could not compete with stone tools, and copper jewelry, that sooner or later turned green, was not that much better than the easy-to-make greenstone stuff. The big step in early metallurgy involved smelting, melting and casting of copper around 5000 BC. It was a huge step to take, and the old (and possible long forgotten) "native copper" experience was of no importance whatsoever.

Interestingly, things in **America** went differently. The native North-Americans (sometimes called "Indians") around the Western Great Lake area had discovered huge deposits of copper ore, including *large amounts* of native copper, often in rather large pieces. They used it for several millenia since at least 4000 BC, and made a very large number of copper artifacts, including large pieces like axes and spear points. This is known as the Old Copper Complex, this link provides for details.
Racial bias prevented proper investigation of the Old Copper Complex until the (later) second half of the last century because nobody (with a white background) believed that primitive Indians could have developed a metal technology. Well - they did. However, it remained a rather primitive technology forever. Smelting, melting and casting was not discovered in North America.
The "High Cultures" of Meso- and South America did have some copper and bronze technology, including smelting, melting and casting. It came into being a few thousand years after the copper and bronze age in the Old World and remained rather primitive, possibly because these cultures never invented bellows, absolutely necessary for large-scale smelting.

Where Does That Leave Us?

- Now that I have answered the basic question in some detail, let me ask *you* a question: "Are you satisfied?" Neither am I. While it is clear enough that during the neolithic revolution the occasional copper bauble was made by some "artist", copper was clearly not important to the PPN people. The first discovery of metals did not cause a revolution in human culture and civilization, as has been often assumed.
  - Looking at early metal artifacts *properly*, i.e. scientifically, rather caused a revolution in the way technical artifacts are treated by archeologists now. Until not so long age the eminent and God-like top-dog digger just *looked* at the object, pronounced what it was, how it was made, and when. Then he or she put it into a box - never to be opened again in most cases. If we are lucky, he or she eventually described the details of the dig where the artifact was found in some detail. Quite often. however, Mr. or Mrs. VERY IMPORTANT never got around to that.
    Archeometallurgy, closing ranks with materials scientists who command a large arsenal of advanced analytical tools, has changed all that by showing that a wealth of quantitative information can be obtained even from tiny fragments. Many old mistakes and misunderstandings have been corrected in recent years, and more insights are to follow for sure. New mistakes will be made for sure too, and fresh misunderstandings will evolve. Such is (scientific) life. Nevertheless, progress will be made.
    It would be naive, however, to expect that eventually we will get simple answers to our simple questions. The big picture that starts to emerge is even more colorful and far more complex that the old "three-age paradigm" so treasured by a bygone era.
- If you scanned through the many additional modules I have provided, you couldn't fail to realize that a lot of work still needs to be done. Just a tiny part of the metal artifacts hoarded in (the basements) of museums has been properly investigated at present; more in some countries than in others. We might know quite a bit about early metallurgy in some part of the globe but in other parts major work still needs to be done. Iran, for example, has been all but cut-off from modern developments and international exchange of results and ideas in the last 30 years or so - but will have much to offer for sure.

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1) G. Sperl: "Zur Urgeschichte des Bleies", Zeitschrift für Metallkunde, 81 (1990) p. 799 - 801

2) "*We propose that the green color mimics the green of young leaf blades, which signify germination and embody the wish for successful crops and for success in fertility*"

3) Ünsal Yalçin: "Der Keulenkopf von Can Hasan", Metallurgica Antiqua, Der Anschnitt, Beiheft 6, 1996, p. 279 - 289.

4) In todays (June 2013) sunday newspaper, a Turkish emigrant (possibly a descendent of Frodü), who has lived in Germany for many years and in between married a women his parents picked for him in Turkey, summed it up in ungrammatical but nevertheless very precise German: "*Guck ich immer türkische Fernsehen. Frau immer türkisch schauen, so ich müssen auch. Langweilig, aber Ruhe! Wenn Frau Ruhe - besser.*" (Always watch Turkish TV. Wife always watch Turkish, so must I. Boring but peace and quiet. Wife quiet - better).

5) I had to look it up, too. "Wattle and daub" means that "a woven lattice of wooden strips called *wattle* is *daubed* with a sticky material usually made of some combination of wet soil, clay, sand, animal dung and straw." In other words: The same construction as the walls of the barn behind the house of my parents.