Homo metallicus: Copper Mining Through The Ages

[This was written as an argument for a total mining moratorium. -- jam, 2007]

[First published in *Midwest Headwaters Journal*, 1995.]

Nothing can be more self-evident than that we mine copper because we need it.

Than that the sun goes around the earth. Than that as soon as we iron out a few last wrinkles, nuclear power will be too cheap to meter.

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Native Americans in Wisconsin made points and knives of it.

Though the first mirrors were nothing more than pools of clear still water, reflecting trees and sky, by about 5000 years ago they were of hammered copper. A thousand years later they were of bronze, an alloy of copper and tin.

Since copper occurs naturally with other non-ferrous metals like tin, lead, zinc, even gold and silver, we found our way to using other metals, and making alloys.

The human history of mining and metallurgy is a reflection of our attitudes toward the world and our place within it.

The Mesopotamians ushered in the Age of Bronze by making of it a statue of a bull. Bronze is harder than copper, holds an edge better, and is also more resistant to corrosion.

In the earliest fortified towns it was used for shields and helmets, and battle axes, for attacking both humans and trees.

Bronze was also formed into chisels, dagger blades, awls, pendants, sickles, bracelets, swords, and tweezers. 4000 years ago the Chinese made early coins of bronze, shaped like tools.

By 3000 years ago copper, bronze, and iron were in widespread use in the middle and near east, for knives, razors, hammers, axes, always axes.

The Assyrians used armor of leather strengthened with bronze, and cast an ornamented bronze bell.

By the Han Dynasty 2000 years ago, mirrors were cast in "white bronze," an alloy of copper, tin, and lead, and highly polished.

The Greeks and Romans made armor of bronze and of steel.

Copper alloyed with zinc produced brass, long used for locks, door-knockers, and chandeliers.

In the Middle Ages, as advances in weaponry relegated chain mail to the status of underwear, bronze- and steel-plated armor evolved. Bronze was hammered into huge cathedral doors, and cast into bells that rung out alarms and devotions.

Brass artillery and good bronze cannons followed in the wake of gunpowder that became widespread in the 16th century.

The ships of war were bottomed in copper against corrosion, then clad in iron against artillery attack.

Somebody discovered that if you throw molten lead through a sieve off a tower, the droplets form into spheres as they fall. Hardened with antimony, lead in such form was used as shot for muskets. At first the cartridges were made of paper, but about 1850, metal cartridge casings--of copper, and later brass for hardness, appear.[1]

Upholsterers used brass tacks. Coopers used copper for barrel hoops. Bronze was used in bearings, gears, and ship screws and propellers. Various alloys made an array of kettles, dishes and trays.

Nothing can be more self-evident than that we mine copper and metal because we need it. And our needs were then in their infancy.

The late 19th century development of electricity stimulated demand for copper and other metals as the telegraph, telephone, light bulb, radio, television, and other electric appliances went from curiosities to necessities.

Fine copper wire was wound around armatures for motors and turbine generators for hydroelectric plants, and soon steam-fired ones. It wiggled around the inside of new gadgets and appliances. Outside of them, copper wire and lead-sheathed cables were strung all over the place: inside of rooms and behind walls, between buildings, along streets, across continents, under oceans. Copper is the wire that holds it all together.

A fledgling automobile industry blossomed, consuming fifteen to fifty pounds of copper per vehicle, plus a full metal complement of its sister elements.[2]

On October 30, 1938, when horrified Americans heard of the invasion of New Jersey by aliens from Mars on the infamous "War of the Worlds" broadcast, there were only a few tens of thousands of radios in the world, perhaps half of them in the U.S. Each containing its cache of coiled copper.[3]

World War II increased the worldwide usage of copper and other metals, for everything from bullets to armor to submarines to radios.

After World War II our demand for copper surged to feed a burgeoning market that served the electrical industry, transportation, communications, construction and plumbing, military uses, radios, and the newly developed television.

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But alas, all this copper, lead, tin, zinc, and iron was not handed over on a silver platter. For after the first nearly pure lumps and nodules were hammered or chipped out of rock faces or fished out of streambeds, most of it was acquired only with much greater effort.

It had to be mined, from deeper and deeper in the earth, or farther away. It then had to be concentrated and smelted, from poorer and poorer ores.

Early copper mining used ores as rich as 20%, 30%, or sometimes even 50% copper. The average copper ore mined today is about 1% copper, but ore as poor as 0.3 % is mined.[4] The earliest smelting, for copper and lead, used wood to coax from rich ores the treasured metals.

Wood that fed the fires that fired the bricks, heated the houses, cooked the food, and baked the bread was used also to feed the smelters. Forests receded from the villages, the riverbanks, the hillsides, as they fed the furnaces.[5]

As early as 8000 years ago deforestation-caused soil erosion led to the abandonment of villages in the middle east. Four thousand years ago the Indus valley society's end was hastened by the deforestation required in part by extensive metal smelting.

In the early Bronze Age of Central Europe, a day's work used 13 tons of rock to yield about 600 pounds of raw copper. The transformation was achieved through the use of 25 cubic yards of wood per day as a catalyst.[6]

Settlements grew up around mines, and trees disappeared from wider and wider swathes of the surrounding countryside. The poor woodchoppers of classic Euromyths, the hollow-eyed figures bent double under their loads in National Geographic postures--all scoured the land for wood to burn in the metal works.

Plato describes in his *Critias* the deforestation that occurred in Greece centuries before. Deforestation began around Rome at about the time of Plato.

Roman copper mining laws, probably stricter than what the Wisconsin DNR would apply to Exxon's proposed Crandon (copper-zinc) mine, are preserved for us in the form of bronze tablets.

Applying to the empire's copper mines in Spain's Rio Tinto region, they delineated measures to be taken to maintain the mine, keep tunnels reinforced and follow other safety procedures. Labor laws were aimed at preventing the exhaustion or mistreatment of slaves who worked there. And, (listen up, Wisconsin legislature!) royalties from copper mined went to the state.

However, water in the mines was a constant problem. (Some things never change). At first, slaves formed bucket brigades to keep the tunnels clear. Then, oaken water wheels were installed underground to remove water even faster. Finally, a mile-long drainage tunnel was dug in an effort to keep the mines open. After a time, each method became inadequate to the task.

The Romans left 20-30 million tons of slag, spread over hundreds of acres. Millions of tons of charcoal had been burned in the smelters.[7]

By 1200 most good European agricultural soils had been deforested, as had settlements around mines.

By the 13th century parts of North and northwest China were experiencing wood shortages.

In 1475 in Rhineland one district alone required 5000 woodcutters to make 10,000 tons of charcoal per year to fuel the smelters.[8]

By the 15th century in Europe there was so little wood left for shipbuilding that ships had to be made of imported wood, or made in other places. Another good reason to have colonies!

You can see in Brueghel's pastoral scenes a hint of the extent of the cutting of the forests.

The gunpowder that made projectiles possible also opened the way for the use of blasting for faster mining, and the use of tunnels to mine deeper and to hasten the drainage of pesky acid mine drainage, thereby making even deeper mining possible.[9]

By the 16th century there were wood shortages throughout Europe. Most Portuguese ships were now built in the colonies where there was still wood.[10]

In the late 17th century, coal was used not only for heating, but for smelting and later engines as well. The coal-diggings filled with acid water that seeped or gushed into ruined aquifers, and open-pit mines stained rivers and streams and the watersheds they nourished.[11]

In the 19th century U.S. one blast furnace in Pennsylvania used up 750 acres of wood per year.[12]

At the Rio Tinto Copper mine in Spain, circa 1900, the process of roasting the ore was used to hasten the oxidation of sulphides, and hence concentrate the ore before smelting. The results are familiar.

> Heaps of millions and then tens of millions of tons of ore covered all the available space on the hillsides near the mines. Sulphur dioxide gas from the burning pyrite filled the air with strangling vapors that set men [sic] and animals coughing and killed off every green thing it touched....The clouds of white vapor killed every tree within ten or fifteen miles.[13]

Then oil and natural gas joined the pantheon of fossil fuels fated to fire the smelting. Using a succession of fuels, the smelting of earthen ores in furnaces of fire consumed the land, sullied the waters, and choked the air.

Nothing can be more self-evident than that we mine copper and other metal because we need it.

From beads and baubles to buildings and bullets, humans have been working, mining, and smelting copper for millennia.

By 1000 BC, when many so-called "civilizations" could make iron, and just as many were huddled in fortified villages arming themselves with an array of bronze and iron weapons, humans had mined a mere 10,000 tons of copper.[14]

From that time until about 1800, we needed it still more. But for all the ornamented bronze bells, sculpted bulls, full-length mirrors, dented helmets, and early industrial machinery and engines, we had mined but five million tons of copper.[15]

And for the next century's dose of the red metal, for coppering the bottoms of Spanish frigates, [O.E.D. 'copper'] brass cartridge casings, the machinery of the full force of the Industrial Revolution -- we humans mined more than twice what had ever been mined: 12 million tons of copper for the 19th century.[16]

The next fifty years, encompassing two world wars and the spread of the automobile, the radio, the washing machine, among other cultural signposts, saw us wrest 70 million tons of copper from the earth's crust.[17]

And since 1950 when Picasso made his bronze She-Goat, we have mined another 275 millions tons of copper.[18]

Let's review that. From 6000 years ago to 1000 BC, 10,000 tons. From 1000 BC to 1800 AD, five million tons. 1800-1900: 12 million tons. 1900-1950: 70 million tons. Since 1950: 275 million tons.

Something well over 360 million tons of copper have been mined since humans discovered this art. That means that if we divided it all up, each family now on earth could keep a personal stock of over 720 pounds of pure copper in their refrigerators.[19]

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What exactly was it that we need it for?

There are over 500 million radios in use in the U.S. alone, not including car radios. We purchase 28 million radios annually.[20] In the world there are already over 200 billion radios in use.[21]

There are only about half as many TV's, but then they use more wire.

Then there's the electricity needed to run all of these appliances, electricity generated by using something to turn turbine generators. The armature of a single 500 MW turbine generator uses about 15 tons of copper wire.[22]

Automobiles are heavy users of copper, in radiators, generators, alternators, and other wiring. Since automobiles were invented, the U.S. alone has produced some 500 million cars and trucks, about the same number as have been purchased here, half of them since Nixon was president.[23]

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There's no doubt that we need half a billion radios and over a hundred million cars on the road, any more than we can doubt that the Russians needed the 220-ton Kolokol bell they cast in the Kremlin in 1733, so heavy that it cracked as they tried to hang it and so has never been rung.[24]

But where exactly is the 360 million tons of copper that humans have hauled out of the earth over the last 6000 years?

We'll never find the trees, the charcoal, the coal, the oil and natural gas that produced the copper. In their place are the deforestation, erosion, flooding, contaminated surface and ground water, thousands of miles of abandoned mine tunnels, and open pits (from copper and coal) that are copper mining's calling card.

But the copper itself?

Unlike the billions of trees, the millions of tons of veins of coal, the barrels of oil, burned over centuries, across continents, used to fuel the smelters and the mining machinery and pumps -- most of the copper is still up here, on the surface.

From the time of beating bracelets into knives, melting battle-axes into coins and back again, it has been understood that metals, valued always for their strength, their corrosion-resistance, their malleability -- could be re-shaped and re-formed into whatever suited the needs of the moment, or the era.

Artisans who cast bells through the ages knew to scour the villages for broken bronze vessels, cracked mirrors, discarded brass door-knockers and the like to melt down to cast a new village bell. The Vikings hammered stolen crucifixes into brooches.[25] Eighteenth century churchwardens were accused of stealing the lead from church roofs to sell to plumbers.[26]

Thousand-year-old hammered copper points stolen a century ago from sacred Indian burial grounds still sit behind glass cases in the Wisconsin State Historical Museum. Picasso's She-Goat still thrills sightseers at the Museum of

Modern Art,[27] and most of the cars, radios, and televisions you have owned in your life sit in landfills somewhere.

Except for a tiny fraction that is dissipated (in exploding ordnance or copper in chemical form used in fungicides, herbicides, dyes, etc), the copper is still here.

Museum or dump, it's all the same to an archaeologist or a recycler.

Nothing can be more self-evident than that we mine copper and other metal because we need it. Well, maybe not.

What about all of the metals accumulating above ground? An estimated 50% or more of recoverable copper in the U.S. still goes to waste sites.[28] We have discarded well over 200 million cars in the last 40 years; currently we "retire" 12 million cars annually, each with a cache of approximately 40 pounds of copper in it.[29] Seven per cent of U.S. annual copper consumption is in vehicles.[30]

In the business scrap metal is called secondary metal to distinguish it from primary metal, derived directly from the mined ore. In copper there is close to a 100% substitutability rate of secondary for primary copper.[31]

Scrap is conventionally divided into new scrap and old scrap. New scrap -- about 2/3 of copper scrap -- consists of byproducts, shavings, lumps, and other "fresh leftovers" from industrial and manufacturing processes. Old scrap is metal from already used products.[32]

Depending on how you figure it, from 1/3 to 1/2 of U.S. annual copper production is from scrap.[33]

Much of the cost of scrap is from collecting, sorting, and shipping it -- and not from the recovery costs inherent in the re-smelting and refining processes.[34]

In fact, copper recovery from scrap, compared to mining and processing the primary ore, involves fewer technological steps, less capital investment, and much lower energy costs (from 5% to 33% of the energy costs of using primary ores,depending on the type of scrap input and the end-use desired.)[35] The technological challenges and environmental costs of mining are bypassed completely.

Let there be no mistake: metal smelting and refining, whether it be by chemical solvents, heating, or electrochemical methods, is a nasty business.[36] But it avoids the additional environmental costs of mining. The more complete the recovery of metals -- often zinc, tin, and other metals can be extracted as well -- the less the pollution as these materials are released.[37] And some of the purer scrap, even old scrap -- like copper wire -- requires little more than remelting after insulation and other foreign materials are removed.[38]

Discounting what's now in museums, cars in use, turbine generators, machinery, and telecommunications equipment -- there is still an enormous reservoir of already-refined metal lying around waiting to be recycled -- more cheaply, easily, and cleanly than would be the case in starting with low-grade, primary ores.

Why don't we just do it?

Nothing can be more self-evident than that we mine copper and other metal because we need it. Perhaps. But what about the reservoir of discarded products that harbor perfectly usable metals?

If there's plenty of scrap and it's cheaper and easier than mining and processing primary ores, what's the hold-up?

Government subsidizes the mining of primary copper.[39] The secondary metals industry itself complains about the tax breaks and other government assistance (research, favorable loan terms) that favor the mining industry.[40]

Mining companies can take advantage of the accelerated depreciation for large capital expenditures that was made possible during the Reagan years. And, metal mining "losses" can be used as a tax write-off against the parent company (which just might be an oil company) profits.[41]

The government also subsidizes mining by its lax mining laws (full of loopholes and other opportunities for variances and exemptions, as from ground water protection laws), its lack of enforcement of existing laws, and its policy of allowing exploration and mining activities on public lands without just compensation. Government clean-up of contaminated mine sites constitutes a further subsidy. The largest Superfund site in the U.S. is a copper mine near Butte, Montana, formerly operated by Anaconda.[42]

Another reason why we don't mine our scrap on a full scale is that the presence of a large scrap reservoir serves other purposes.

Since it is in the interests of the U.S. government and a few large producers to control the world copper supply and market, the unused scrap provides a buffer against contingencies such as the nationalization of a nation's copper industry (think of Chile) and subsequent "disruption" of the copper supply. The ensuing scare is also an excuse to raise prices and hence increase profits.[43]

A scrap reservoir also provides for a reserve supply of metal in the case of war--which might disrupt supplies, increase demand, and usually also increase prices. The reserve would prove useful whether the war is against "foreign enemies" or striking workers.

The U.S. is the world's largest single producer of old scrap.[44] We are also the largest exporter of old scrap, our old scrap exports increasing by 1400% in the forty years since 1950. Much of it goes to Asia, where it has been used in the region's increasing industrialization since the 1960s.[45]

Scrap handling and processing is more labor-intensive than recovery of copper from primary ores.[46] Our policies and practices suggest that we would rather subsidize the energy-intensive, capital-intensive and environmentally devastating mining of primary ores than provide jobs in responsible metal recycling.

Nothing can be more self-evident than that we mine copper because somebody stands to profit from it.

Secondary metals are underutilized because their consistent and complete recovery and re-use would cut into the profits that currently accrue to corporations that mine primary ore. Mining is for profits, not need, not providing jobs, not national defense.

And there is a triple irony inherent in our handling of scrap metals.

First, that we continue to mine poorer and poorer grades of ore, at greater and greater environmental cost, instead of the cheaper and cleaner option of regularly re-using our metals, for 6000 years ripped at such cost from the earth.

Second, that the higher-tech corrosion-resistant and temperature-tolerant alloys that we now produce are designed to resist the very processes that we must use to recover the metals for re-use.

And third, that the products we put them in--more and more consumer goods like washing machines, radios, cars, and trucks--are designed not for long lives, but for planned obsolescence, the heart concept of our consumer culture.

We need to recycle the metals, not throw out the products that contain them. How many cars, radios, and washing machines do we need on this earth? And why don't we design them to last, and be easily repaired, instead of to wear out or go out of style and require replacement every few years?

Medieval armorers followed their knights to the battlefield and made repairs and adjustments to keep their armor in service as long as possible.[47] Is there some reason why our radios and cars should be landfilled instead of fixed or improved?

We have made our metals increasingly difficult to re-use while designing the products they go into to fall apart as soon as possible. We need to reverse this equation and design the products for long lives, and their components for easy repair or recycling.

There is more to responsible use of metals than beating the Statue of Liberty into car radiators and cords for blow-dryers.

To a species who conceived of beating swords into plowshares -- one of the earliest and most eloquent pleas for metal recycling--how can it be so inconceivable to melt car radiators into car radiators? To fix our radios instead of dumping them, with their lodes of heavy metals--veritable mini-mines, each one.

Time to relegate planned obsolescence to the scrap-heap of history.

Zero extraction now.

NOTE: Figures for copper production from mines were compiled from numerous sources. Several factors make it impossible to cite these numbers with precision. Among them: 1) numbers for pre-twentieth century amounts are estimates from different sources whose assumptions are either unstated or not consistent; 2) copper production figures sometimes include an undetermined amount of secondary copper (mixed into the smelters); and 3) tonnage is sometimes given in metric tons, sometimes in short tons, sometimes as just plain tons.

[about 4200 words without references]

[In current form, there are general references first, then actual endnotes. In the late 1990s, I mailed out pages of references to anyone who asked. jam]

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[38] G. Wagenhals p. 19.
[39] See Effective Technology p. 7; See Gedicks 1975.
[40] See D. Moberg, "Beware the Long Arm of Oil Money," In These Times, Apr. 1-7, 1981.
[41] See Moberg.
[42] ENR Engineering News Record, 1-16-95, pp. 34-5.
[43] See Al Gedicks, "Raw Materials Strategies of Multinational Copper Companies Based in the United States," pp. 92-108 (chapter 5) in Natural Resources and National Welfare: The Case of Copper, NY: Praeger Publishers, 1975.
[44] C.S. Tan , p. 40.
[45] Jolly pp. 17, 20.
[46] C.S.Tan p. 37.
[47] R. Lister p. 71.