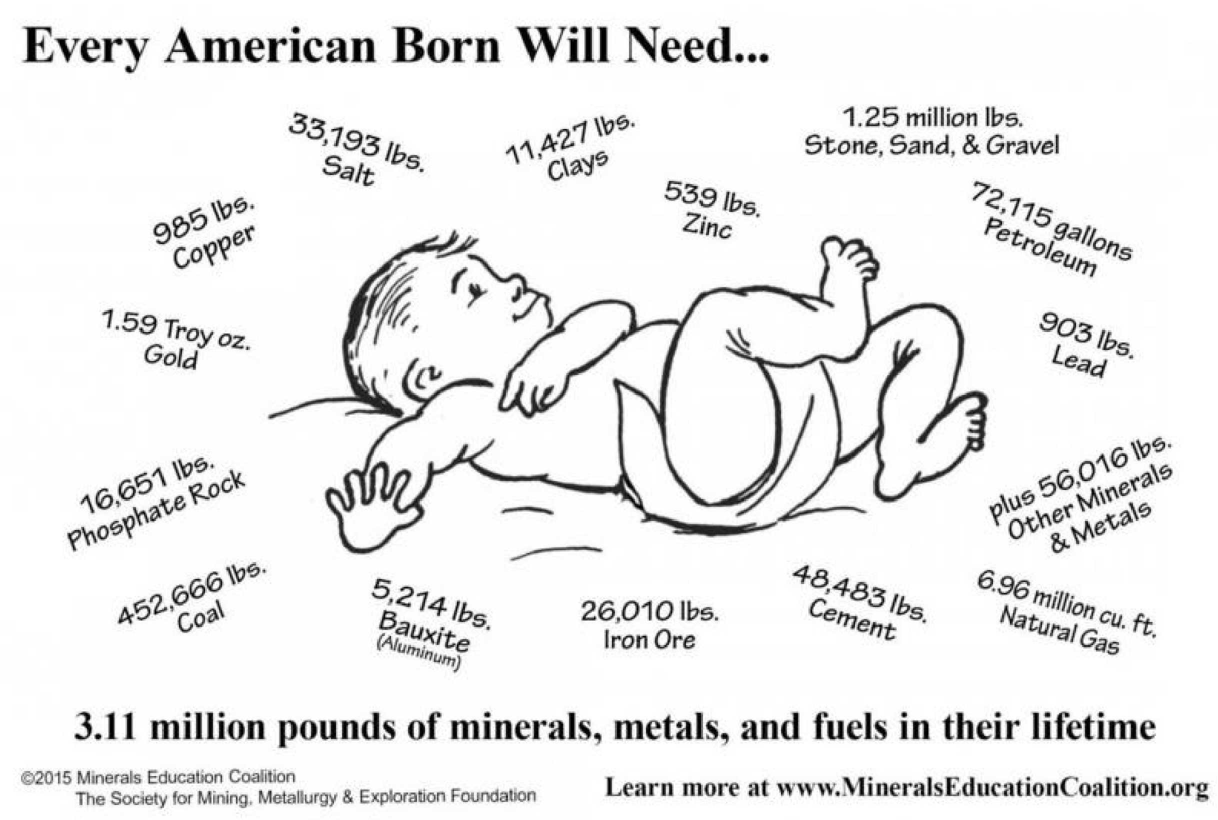
Mining for metals in society's waste

October 1 2015, by Kathleen S Smith, Geoffrey Plumlee, And Philip L Hageman



What minerals, metals and fuels will an average American use in a lifetime? Credit: Minerals Education Coalition

Metals are crucial to society and enable our modern standard of living. Look around and you can't help but see products made of metals. For instance, a typical gasoline-powered automobile contains over a ton of iron and steel, 240 pounds of aluminum, 42 pounds of copper, 41 pounds of silicon, 22 pounds of zinc and more than 30 other mineral commodities including titanium, platinum and gold.

Metals and minerals are natural resources that human beings have been mining for thousands of years. Contemporary metal mining is dominated by iron ore, copper and gold, with 2 billion tons of iron ore, nearly 20 million tons of copper and 2,000 tons of gold produced every year. Tens to hundreds of tons of other metals that are essential components for electronics, green energy production, and high-technology products are produced annually.

But metals are a nonrenewable resource; while advances in technology allow us to mine lower-grade mineral deposits, there's ultimately a finite supply of what metals we can economically and technologically mine out of the Earth. So we and our colleagues at the US Geological Survey (USGS) are hunting for gold and other metals in some unconventional places, including in sewage sludge and the waste rock from old inactive metal mines.

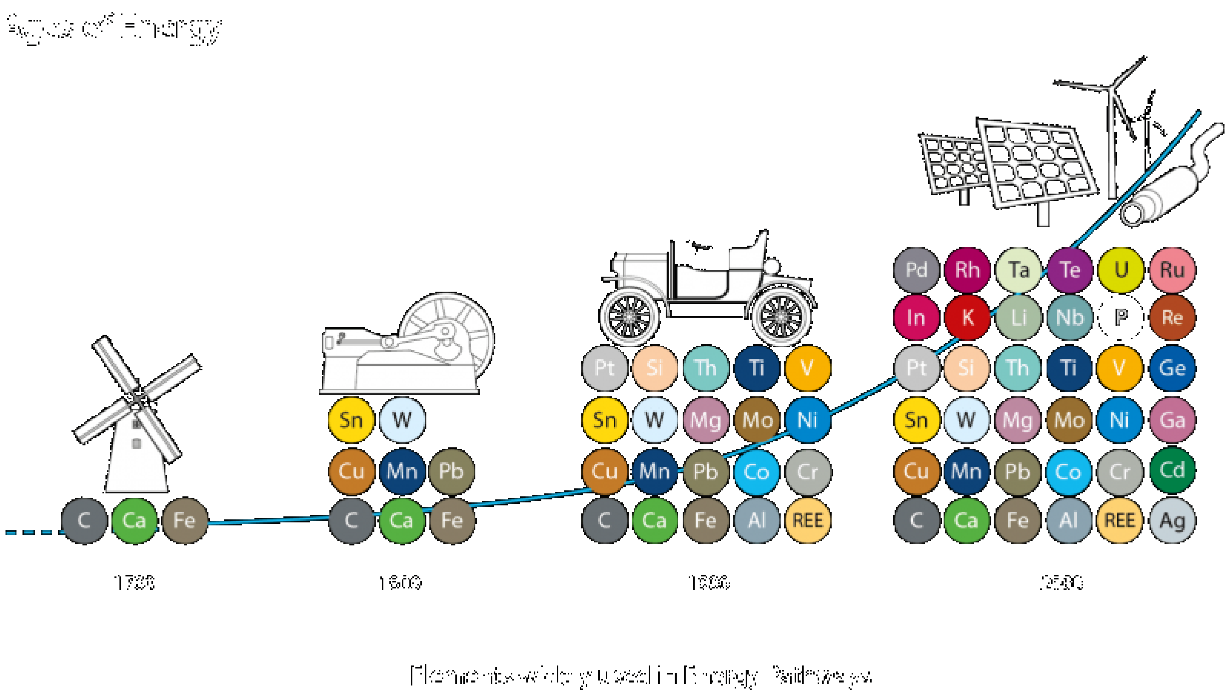
We've hit scientific pay dirt, so to speak, in our initial attempts. The next step will be figuring out how to economically recover metals from these underutilized sources. So far we're just determining which metals are present and don't yet know the scale of what might be out there in waste, waiting to be mined.

Waste as a sustainable resource?

We can obtain the metals modern society needs in two ways: by mining them from mineral deposits in the Earth's crust or by reusing society's discarded metals. Metals are finite and do not decompose in the environment. The main issues related to mining them from the Earth's crust include supply, scarcity and the costs of extraction, concentration and purification. Moreover, there are potential environmental consequences related to their extraction, processing, use and disposal.

The General Assembly of the United Nations Environment Programme says sustainable development

meets the needs of the present without compromising the ability of future generations to meet their own needs and does not imply in any way encroachment upon national sovereignty.



As technology advances, more and different metals are needed. Credit: Zepf V, Reller A, Rennie C, Ashfield M & Simmons J, BP (2014): Materials critical to the energy industry

Finding sources of metals that might be "mined" from society's wastes can reduce our need for primary resources, reduce our need to import some metals, offset waste disposal costs and conserve space in landfills, reduce dissemination of potentially harmful metals into the environment, and contribute to a sustainable society.

Prospecting in sewage

Municipal biosolids are a mixture of a lot of stuff sent down the drain by homes and businesses that wastewater treatment plants then turn into treated sewage sludge. Currently a little more than half of the biosolids generated in the US are used as fertilizer, with the balance disposed of in landfills or by incineration.

But beyond human waste – ok, poop – we knew there was other useful stuff in these municipal biosolids. We and our colleagues at the USGS have measured gold, silver, platinum, copper, zinc and other precious and industrial metals in biosolids. Scientists at Arizona State University also report finding numerous metals in biosolids.

We are still trying to determine the ultimate sources of many of these metals in biosolids. For example, gold could be coming from food products (both eaten and disposed down the drain) that include it as an additive, dental fixtures or perhaps medical facilities. (Gold is used to treat arthritis and cancer as well as in some surgical and diagnostic procedures.) Silver could be coming from some of those same sources. Also, microscopic silver particles are used in a variety of consumer products due to their antibacterial properties, and so could go down the drain with laundry water.

It's not like we're modern-day "forty-niners" finding visible gold flakes and nuggets at wastewater treatment plants. But we are able to measure concentrations of some metals in the biosolids material – about one part per million of gold, for example – that greatly exceed naturally occurring soil metal concentrations. If this gold were in rock instead of biosolids, the amounts we're finding would be similar to the concentrations measured in low-grade, currently subeconomic gold deposits. We've even identified a few very tiny, microscopic gold particles we call "nanonuggets."

Recycling historical metal mining waste-rock piles

Old, inactive hardrock mines in the western US are a result of the California gold rush of the mid-1800s and the other mining booms that followed. Hardrock miners focused on certain metals – including gold, silver, copper, lead and zinc – that were essential for the industrial revolution in the eastern US, and later for war efforts such as the Civil War and World Wars I and II. Near mining sites, piles of waste rock were often left behind.

This waste rock could contain metals with concentrations that were too low to be economically recoverable at the time or metals that weren't of interest then, but that now have new high-tech applications. At many old inactive mining sites, waste-rock piles and tunnels driven into the hills can be sources of mine drainage waters that may contain high levels of environmentally detrimental, but potentially useful, metals.

There's gold in them… sewage treatment pools? Credit: SA Water, CC BY-NC-ND

There are potential environmental and safety issues and costs associated with any kind of work at these historical mining sites, as demonstrated by the recent Gold King mine spill into the Animas River in Colorado. From 1997 to 2008, federal agencies spent at least US$2.6 billion to clean up abandoned hardrock mines on federal, state, private and Indian lands. And there are many more abandoned mining sites on federal lands that remain to be inventoried and assessed. Metal recovery from waste and drainage waters at some of these abandoned hardrock mining sites might help offset clean-up costs.

We have measured in samples from waste-rock piles some metals – such as indium, tellurium and some rare earth elements – that are needed for industrial, green industry and high-tech applications. Not all mining waste-rock piles are the same, because they come from different geological sources and contain various combinations of different minerals and metals. We're investigating whether, by knowing about the geology and mining history of these sites, it may be possible to predict which ones will have elevated levels of useful metals. We have also looked at whether waters draining from mines and mining wastes with appropriate geological characteristics can be targeted for economic recovery of useful metals.

Recovering and reusing metals from these sites could possibly offset the need for some new mining. There'd be less metal that we'd need to mine from virgin sources and a decrease in the associated environmental costs. That could increase sustainability by offsetting reclamation costs and reducing the amount of waste material that needs to be reclaimed.

Can we scale up this kind of recovery?

Knowing that metals are present in waste is just the first step. Next we need to investigate whether the metals can be extracted from the waste and recovered in a usable form.

We are currently leaching samples of biosolids and mining wastes in the laboratory using chemical solutions that are similar to extractants used by the mining industry to recover metals from hardrock ores. For example, dilute sulfuric acid is used by the mining industry to leach copper ore, and thiosulfate is sometimes used to leach gold ore.

We mix our ground-up samples with these chemical solutions in a container for different amounts of time (from minutes to several hours), pour off or filter the leachate solutions and then analyze the solutions to see which metals have been dissolved. Our results so far show some promise. For biosolids, leaching may provide the additional benefit of extracting some metals, such as copper and zinc, that presently limit the use of some biosolids as a fertilizer.

Thus far, we've shown what's possible at a very small scale in the lab. We hope our work will spark additional interest in metal recovery from wastes on the part of experts in metal and mineral processing. Potential liability concerns have hampered re-mining and metal-recovery activities at historical mining sites. To reduce these liability obstacles, successful projects will likely need to involve partnerships between federal and state regulatory agencies, private entities, and the mining and mineral processing industries.

Source: The Conversation

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