Surface Technology White Papers
108 (5), 8-12 (May 2021)

Searching for Gold

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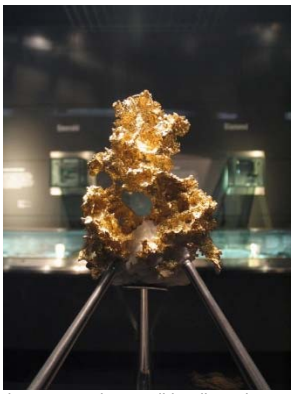
Editor's Note: Over many years, well-regarded AESF/NASF contributor Jack Dini contributed a series of fascinating columns to *Plating & Surface Finishing*, under the title *Fact or Fiction*?. The year 2020 saw a return of Jack's writings from time to time, and here, he offers more material for 2021.



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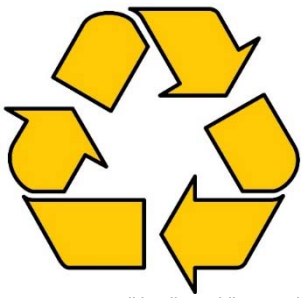
The Earth is the first place most folks would consider the place to find gold. And mining, where deep holes are dug into the Earth to extract gold, is the major source of this valuable material.

However, gold can be found in a number of other places: recycling, sewer sludge, oceans and ocean floors, volcanoes, and even one person thought it could be found in urine. These topics are the subject of this report.

Gold recycling

Recoverable gold or at least usable traces of it are found in a number of places: in dental gold, in old, faded and no longer worn jewelry, but above all in defective technical equipment, industrial fittings as well as electrical scrap.



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Most recycled gold - about 90% - comes from jewelry, according to the World Gold Council. Gold can be recycled from old, or unwanted jewelry. Once the purity is determined, the jewelry is melted at more than 1,900°F and then poured into bars based on the gold's purity.

One challenge with the use of gold in very small quantities in very small devices is loss of the metal from society. Nearly one billion cell phones are produced each year and most of them contain about fifty cents worth of gold. Their average lifetime is under two years and very few are currently recycled. Although the amount of gold is small in each device, their enormous numbers translate into a lot of unrecycled gold.[1]

Forty scrap mobile phones can provide nearly as much gold as can be mined from a ton of gold bearing ore. A ton of old computer circuit boards produces more than 200 grams of the precious metal. Whereas gold from jewelry brings a 90 percent recovery, gold from electrical scrap is at present only about 15 percent. The majority of scrap equipment is shipped to Asia or Africa to be salvaged, where it mostly remains hidden.[2]

Gold in sewage sludge

Scientists have struck gold in an unlikely place: Swiss sewage and wastewater treatment plants. A study, commissioned by the Swiss Federal Office for the Environment, involved surveys of 64 wastewater treatment plants across the country. An estimated 95 pounds of gold, worth around $2 million, is flushed through Swiss sewage systems each year, along with over 6,500 pounds of silver (around $1.8 million).

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The researchers believe the tiny flecks of gold flow into the wastewater system from the country's famed watchmaking industry and gold refineries. "Concentrations of gold in sewage sludge are sufficiently high for recovery to be potentially worthwhile," the researchers wrote.[3]

Scientists at the Arizona State University, in Tempe, quantified the different metals in sewage sludge and estimated what it all might be worth. The upshot: there's as much as $13 million worth of metals in the sludge produced every year by a million-person city, including $2.6 million in gold and silver.[4]

One city in Japan has already tried extracting gold from its sludge. In Suwa, in Nagano Prefecture, a treatment plant near a large number of precision equipment manufacturers reportedly collected nearly 2 kilograms of gold in every metric ton of ash left from burning sludge. This is a far higher gold content than Japan's Hishikari Mine, one of the world's top gold mines, which contains 20 - 40 gm of the precious metal per ton of ore.[5]

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Gold in the oceans

The National Ocean Service reports our oceans hold some 20 million pounds of gold, suspended in normal seawater. The concentration is around 10 parts per trillion; so as the NOAA puts it, "Each liter of seawater contains, on average, about 13 billionths of a gram of gold." There are also gold deposits within the sea floor, and this will be discussed in the next section.

Many folks have been tantalized by the idea of claiming some of this bounty. Here are two examples: one a charlatan and the other an eminent chemist.

Prescott Ford Jernegan was a Baptist minister who preached in different states through the early 1880s and 90s. During this time, he made important connections that would prove useful in his future as a con artist. He showed off his new discovery, a special zinc-lined bucket, which he called a 'gold accumulator' with the ability to extract gold particles from seawater. After adding some mercury to the bucket, it was lowered off the pier and a battery was switched on. As it remained underwater overnight, gold particles floating in the ocean attached themselves to the mercury in the bucket. Investors, impressed by what they had seen, bought in, and thus began one of the greatest gold hoaxes in history.

Jernegan's accomplice, Charles Fisher, was an excellent diver, and at night would dump out the mercury and replace it with mercury-infused gold. After seeing that the gold was real, investors provided the start-up money and Electrolytic Marine Salts Company was born. At the peak of their operation the firm had over 100 employees and over 200 gold accumulators.

A third accomplice, William Phelan, demanded money to keep his silence and threatened to expose Jernegan and Fisher. After the two men refused, Phelan made good on his threat and published a story in the *New York Herald* revealing the operation as a con, and the jig was up.

Fisher was never heard from again. Jernegan fled to Europe and eventually sent back $85,000 to the investors he had swindled. In total, investors were paid back 36 cents on the dollar. The charlatans had duped investors of almost $27 million dollars by today's standard.[6]

Fritz Haber
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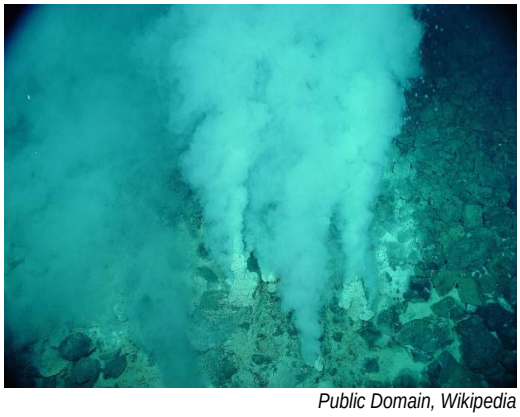
Fritz Haber is co-inventor of the Haber-Bosch process, which is arguably the most significant development of the 20th century. The process, the industrial synthesis of ammonia from nitrogen and hydrogen, has been claimed to be of greater fundamental importance to the modern world than nuclear energy, space flight or television. Without the Haber-Bosch process for synthesizing ammonia, only about 60 percent of the world's population could be fed.[7]

Haber, winner of the 1918 Nobel Prize of Chemistry, thought that it would be possible to extract enough gold from the sea to repay the punitive reparations of 20 billion marks imposed on Germany by the allies after World War I. Unfortunately, he estimated the concentration in sea water to be 10 ppb, which is 1000 times higher than it really is, and his scheme came to grief. One more example of those who have attempted to reclaim gold from the sea and failed to do it economically.[8]

Gold from the ocean floor

Vents on the ocean floor support colonies of undulating tubeworms, giant clams, eyeless shrimp and hairy tennis ball sized snails, and are also conduits for valuable metals fresh from the earth's interior. As the water cools, material coming from the vents, minerals precipitate out, leaving behind concentrations of metals - gold, copper, nickel and silver, as well as more esoteric minerals used in electronics - that make the richest mines on dry land look meager.[9]

This has led to a new industry - deep sea mining. While deep sea mining has not started in any part of the world, 16 international mining companies have contracts to explore the seabed for minerals in the Eastern Pacific Ocean, and other companies have contracts to explore for nodules in the Indian Ocean and Western Pacific Ocean.[10]



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Gold around volcanoes

Water thick with gold and other metals is heated by magma and forms deposits in volcanoes. Gold ore is formed in the rocks of active volcanoes this way. An example: geoscientists have uncovered a mother lode of gold and silver enriched water in reservoirs inside a series of New Zealand volcanoes. Gold concentrations in the water topped 20 parts per billion and silver concentrations reached 2,000 or more parts per billion. Tapping one of these water reservoirs could yield as much as $2.71 million of gold and $3.6 million of silver annually, researchers estimate.[11]

The continuously erupting volcano, Mont Erebus, in Antarctica, spews forth gold dust and is unique among volcanoes in this respect.[8]

Gold in urine

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Perhaps nothing better typifies the strange and often accidental nature of chemical science in its early days than a discovery made by a German named Henning Brand in 1675. Brand became convinced that gold could somehow be distilled from human urine. The similarity of color seems to have been a factor in his conclusion. He assembled fifty buckets of human urine, which he kept for months in his cellar. By various processes, he converted the urine first into a noxious paste and then into a translucent waxy substance. None of it yielded gold, of course, but a strange and interesting thing did happen. After a time, the substance began to glow. Moreover, when exposed to air, it often spontaneously burst into flame.

What Brand discovered was a new element, phosphorus, the first to be discovered in hundreds of years. It turns out each human excretes a minimum of 1.5 grams of phosphorus in their urine per day.[12]

Eventually, Brand sold the secret of how he made the material to alchemist Robert Boyle who not only refined the method of producing phosphorus but realized that the element could be used to create fire on demand. It was Boyle who first placed phosphorus on the tips of wooden splints. Today, we call them matches.

Most importantly, Boyle chronicled his methods and shared them with his colleagues. He even wrote them down in a book, *The Skeptical Chemist*, which is today recognized by many scholars as the first true chemistry book. Through his actions, Boyle introduced a revolutionary notion into the secretive underground world of alchemy, that ideas should be shared openly.

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About the author

Jack Dini earned a Bachelor of Metallurgical Engineering degree from Cleveland State University and began his career in the 1950s with Cleveland Supply Co. (now Pavco). He spent a few years at Republic Steel's research center and Battelle Columbus Laboratories. In 1962, he joined Sandia Laboratories, Livermore, CA, where he was involved with electrodeposition projects for 18 years before moving to Lawrence Livermore (LLNL) in 1980. He was section leader, fabrication processes. Responsibilities included direction of activities in five groups: electroplating and metal finishing, vacuum processes, metal fabrication, plastics and optics.

Mr. Dini is a prolific scientist. He is the author or coauthor of some 180 technical papers and, while many researchers are content to specialize in one or two fields, he made significant contributions to more than

half a dozen disciplines in surface finishing. He is the author of two books, *Electrodeposition- The Materials Science of Coatings and Substrates*, and *Challenging Environmental Mythology: Wrestling Zeus*. The scientific community is fortunate that he carefully documented his work, sharing it with others around the world. It includes plating uncommon metals, alloy plating, printed circuits, chemical milling, electrojoining and gathering electrochemical/property data.