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Cu

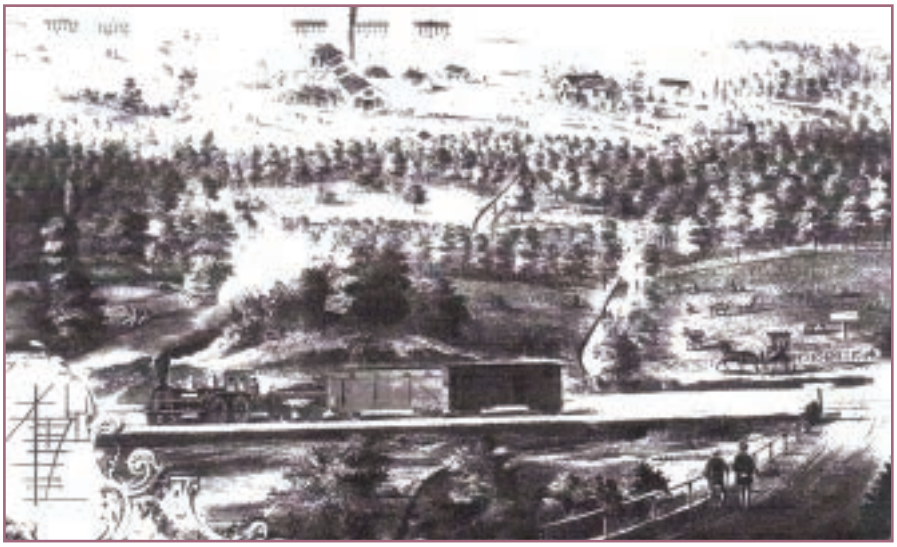
PROVING

Copper mining continues to be an important and profitable industry around the globe

BY ALAN H. FEILER

Not far from where I live, among the hills of jagged rock formations and winding creeks nestled amid suburban sprawl, are the remnants of the Bare Hills Mining Co. Bare Hills was a copper mine that was founded in 1845 and closed four decades later, only to reopen for a short period around 1905. In its day, the Maryland mine reportedly produced 32,500 tons of copper and featured a 900-foot shaft.

Today, the mine at Bare Hills is long built over (a massive apartment complex sits where it once was located), and the only indications that copper minerals were ever extracted in the region are a few allusions among the local street signs, such as Coppermine Terrace and Copper Ridge Drive.



A view of Bare Hills Copper Mine, drawn by engravers Schmidt and Trowe, ca. 1870.

Occasionally, you might spot a few old-timers and mineral enthusiasts combing the area, searching for chromite and magnetite crystals and other relics of a bygone era.

For years, Harold D. Levey, a mineral enthusiast since age 14, spent his off-hours poking around Bare Hills. "It was quite an extensive mine in its day," says Levey, a retired quality control manager for an electronics company. "By the time I started collecting there as a youngster during the Depression, the mine shaft was long gone."

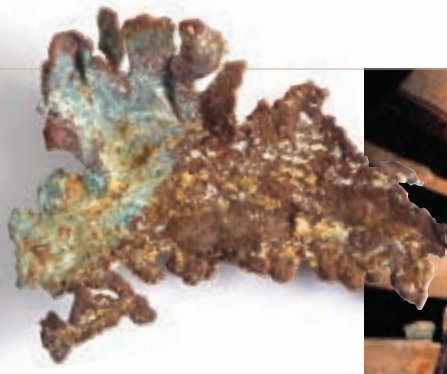
His friend and fellow amateur geologist Jake Slagle recalls, "It looked like a big garbage dump, but with rocks on top of it. As a child, I went there to collect minerals, some of which I still have and sell today."

Levey adds with a chuckle, "I'm 87, so I spend my days raking leaves now. I don't get over there much anymore. But at one time, Maryland was a big mining state. Of course, now there's nothing."

That may be largely true for the Old Line State, but copper mining continues to be a major industry throughout the United States and across the world. In 2011, according to the U.S. Geological Survey (USGS), the U.S. produced 1.1 million metric tons of copper—worth an estimated $10 billion—placing the U.S. as the

ITS METAL

Transporting heavy loads at a copper mine in Utah.



COPPER

Chemical symbol – Cu
Atomic number – 29
Relative atomic mass – 63.546
Density (at 20 c) – 8.96 (g/cm3)
Melting point – 1083.4 c
Boiling point – 2567 c

Source: World Book 2012

world's fourth leading copper producer, after Chile (5.42 million metric tons), Peru (1.22 million metric tons) and China (1.19 million metric tons).

Among the leading copper-producing U.S. states are Arizona, Utah, New Mexico, Nevada and Montana, according to the USGS.

Since prehistoric times, copper has been essential to human existence and it has played a critical role in the development of many civilizations, from the ancient Egyptians and the Romans to Native American tribes and contemporary cultures.

In his new book *Boom, Bust, Boom: A Story About Copper, The Metal That Runs the World* (Scribner, 2012), Bill Carter writes: "For the greater part of human history, getting copper from the ground involved people picking up the red metal and beating it with a rock or hammer to separate the metal from the rock. Mining got more serious around 5,000 years ago, with a steady supply of slave labor in place to beat the metal out of the rocks on a large scale. Remember the Romans roaming Europe and northern Africa looking for gladiators, women and wine? They were also looking for metal, specifically tin and copper. All those quarries that exist in biblical tales and in movies about Spartacus and gladiators are mostly copper or tin mines. Carthage, in modern-day Tunisia and the namesake of the famous battles with Rome, was home of a large copper mine, the very reason the Romans wanted to conquer it."

ORE WHAT?

So what's the big deal about copper? After all, mention copper to most people and the first thing they usually think of is the penny bearing Abe Lincoln's visage.

But copper's significance goes a lot further back than old Honest Abe. For millennia, copper has been used for medicinal purposes, even as a "cure" for such health woes as mental illness and hangovers. Some hospitals today are using anti-microbial copper to fight off *Staphylococcus aureus*, a staph infection that kills 20,000 each year, according to the Copper Development Association, a U.S.-based nonprofit organization representing the interests of the global copper industry.

Copper and its alloys have been used as a pesticide and fungicide, as a lining for wooden ships (used by Columbus, as well as the British Armada), for weaponry, for tools and household items (cups, platters, plates and goblets), for electricity and modes of communication (just ask Thomas Edison and Samuel "What hath God wrought?" F. B. Morse), for construction and transportation. Even for electronic guidance for space rockets. You name it.

And copper is a part of us. *Literally*. We have copper coursing through our veins and in our blood, and without copper we would cease living (and with too much of it we would perish as well).

Also, copper is a part of our diets. It's found in such foods as shrimp, beans, mushrooms, walnuts, almonds and sunflower seeds. And it's in the clean water that we drink.

Simply put, copper is *everywhere.*

And it's indispensable.

"Copper is invaluable to our lives or, more accurately, to our lifestyles,"

Left to right: A mine with a hand-dirting machine; a giant electric shovel that can scoop 98 tons of ore per shovelful; copper sulphide slurry pours from a machine in a processing facility at Katanga Mining Ltd.'s copper and cobalt mine in Kolwezi.

writes Bill Carter. "That much is simple. Without it, we would have to agree, collectively, to give up all our modern appliances and almost all forms of electricity. There would be no Internet without copper because there would be no satellites, electric cables or computers. ... We would be a civilization of walking beings and, as in the Dark Ages, isolated within our small communities."

FROM THE GROUND UP

Of course, getting the red stuff out of the earth has never been an easy feat. Back in the old, old days, copper mining was done via drilling by hand and by blasting with black powder. This was dangerous, tedious, time-consuming work, often requiring many hours of labor with precious little in the way of results. Premature explosions were always a risk when drilling holes and tamping in fuses.

With the advent of the Industrial Age (and particularly in the latter half of the 19th century), copper productivity increased when mining companies developed new equipment and techniques. Safety guidelines improved as profits began to soar. Many mining outfits began using dynamite for blasting, and the excavation and production of copper was accelerated by the usage of compressed air "one-man" drills, steam and gasoline engines. Illumination in the mines improved with electric lights and headlamps, and communication was greatly enhanced with telephones and other means.

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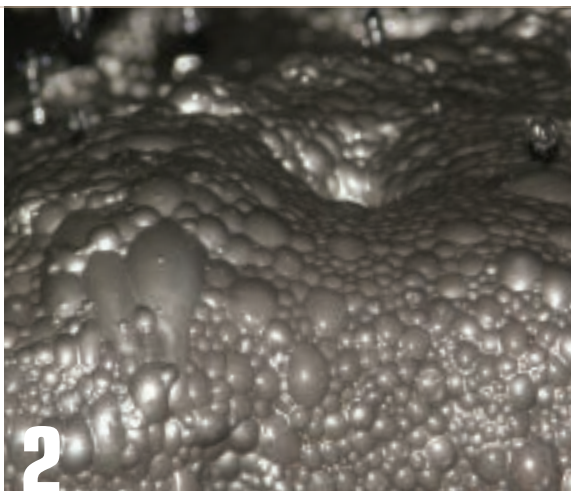
Today, the production of copper—from underground ore to what we find in just about everything in our lives—requires several stages of execution. The extraction techniques include a series of physical, chemical and electrochemical processes, and methods tend to vary from nation to nation, depending on ecological regulations, the ore source and other factors.

When copper is mined from an open-pit mine, large power shovels are used to load the ore (often in the form of large boulders) into railroad cars or trucks. Once transported to a mill, the copper ore is extracted from the waste rock to remove the copper and other metals (gold, silver and nickel) in the mixture. At the mill, a crusher breaks the ore into small, acornlike pieces. Then water is added to form a souplike substance called slurry.

The slurry is transferred into drum-shaped, rotating cylinders called ball mills, which are partially filled with iron



1. A 20-foot diameter ball mill rotates at a copper mine's underground processing facility in Chile. This process breaks copper-bearing ore from golf-ball sized pieces into dust. 2. Froth 3. Only a very small percentage of copper is removed from tons of ore dug out of this Chilean copper mine, the world's largest open-pit mine. The overburden, or leftover slag, is a heavy sludge that is disposed of in enormous man-made mountains. 4. Melted copper. 5. Copper cathode in electrolysis. 6. Thousands of sheets of copper are grown in an enormous acid bath at a mining processing facility in Chile.

balls. The balls grind the ore into fine particles that pass through a screen with 10,000 openings per square inch.

The slurry goes through a flotation process that concentrates the mineral-laden particles. After passing into tanks called flotation cells, the slurry is mixed with oil and chemicals and then agitated with air, thus creating a bubbling effect. The bubbles form a froth, which is skimmed off and dried. This copper concentrate contains from 15 to 33 percent copper. The remaining waste material is emptied into storage ponds.

In a furnace, the concentrate burns and melts, releasing impurities in the form of sulfur dioxide gas. The molten material falls to the bottom of the furnace and is separated into slag (solid waste) and copper matte.

Next, the copper concentrate is blown with air and pure oxygen into a smelting furnace. The flash furnace can smelt as much as 3,000 tons of copper concentrate daily. In a furnace, the concentrate burns and melts, releasing impurities in the form of sulfur dioxide gas. The molten material falls to the bottom of the furnace and is separated into slag (solid waste) and copper matte. The slag is removed, while the copper matte (which contains 50 to 75 percent copper) goes through a converter process. Blowers shoot air through

it and silica is added, combining with impurities to form new slag. The new slag is skimmed from the top, and the new mixture is called blister copper (because its surface blisters as the copper cools off).

It is then refined in a fire-refining furnace, which removes the rest of the impurities (largely oxygen). Natural gas is blown into the molten copper.

The fire-refined copper is cast into cakes in an electrolytic process. The copper anodes are placed into tanks containing copper sulfate and sulfuric acid. When an electric current passes through the tank, the anode bars gradually dissolve, depositing copper on negative poles called cathodes. After electrolysis, the copper cathodes are melted in a furnace and cast into different shapes and sizes (cakes, ingots, billets and rods).

Subsequently, a leaching method is utilized to recover copper from ores that don't react to the chemicals used in the flotation process. Water with sulfuric acid or other chemicals circulates through the ore and dissolves the copper. The solution is then mixed with a kerosene solvent containing chemicals that extract the copper. The solution is placed into a tank and undergoes an electrolytic-electrowinning process.

The result: copper that is 99.9 percent pure.

With its bright metallic luster, copper—and its alloys, brass and

Did You Know...

- Copper ranks third, after iron and aluminum, in terms of quantities of metals consumed in the United States
- The name copper derives from the Greek word *cuprum*, meaning the island of Cyprus. Cyprus was well-known in antiquity for its copper resources
- Arizona is the leading copper-producing state in the U.S. More than 60 percent of newly mined copper in the U.S. comes from Arizona
- The most common uses of copper are in copper sulfate, hammered copper, tubing, pipes, plumbing, wire, electromagnets, statues, vacuum tubes, steam engines, musical instruments, coins, cookware and cutlery
- The U.S. Geological Survey estimates that during their lifetime every American will use 1,309 pounds of copper for necessities, lifestyles and health
- Policemen in the United States are nicknamed "cops," reportedly because their uniforms used to feature copper buttons
- Utah's Bingham Canyon Mine claims to produce more copper than any mine in the world. It is called "the richest hole on earth," and since 1906 has yielded 17½ million tons of copper metal

Copper nuggets ready to be melted.

Copper wire reclaimed from computers, motors and circuit boards.

bronze—is highly regarded by scientists and industrialists alike because it is malleable, ductile and a good conductor of heat and electricity. In fact, it's second only to silver in terms of electrical conductivity.

In recent decades, because of the high expense of extracting and manufacturing copper, there has been an emphasis among many industry producers on the recycling and reuse of copper. Copper does not degrade or lose its physical or chemical properties during the process of recycling. Besides lowering costs, recycling can aid countries in their goal toward more sustainable production and consumption. More than 30 percent of copper consumption in 2010 came from recycled copper, according to the International Copper Study Group. However, because of high demand, recycling copper cannot replace the need for processing mineral ores.

Copper mining and processing use a wide variety of Dixon products, including:

- Cam & Groove
- Boss Fittings
- Boss Clamps
- Holedall Fittings
- King Combination Nipples

SEEING RED

Of course, silver and gold are the glitzy minerals that tend to get all the attention, all the accolades and interest from economists, geologists and others. But copper, contends Bill Carter in *Boom, Bust, Boom,* is what largely drives economies today. He notes that many Wall Street types respectfully and reverentially call it "Dr. Copper," since they tend to closely monitor the fluctuations of copper's prices.

"When copper is up, the economy must be expanding, as industry uses more copper to build buildings, cars, and infrastructure," he writes. "And when the price of copper takes a dive, it means the industries that drive economic growth are slowing down."

But Carter and others warn that as today's big copper mining operations have largely taken over the industry (and supplanted the old, small mining outfits), they are building enormous open-pit mines to produce a copper that contains a smaller percentage of actual copper ore. Some environmentalists charge that such open-pit mining—which is conducted in scores of countries around the world—irrevocably damages the landscape and causes health hazards. Proponents of open-pit mining note that it is safer for workers—cave-ins are virtually eliminated and there is no buildup of toxic gases that can cause explosions. With proper planning, they argue, it is possible to mitigate the environmental impact; measures can be taken to remediate surface and groundwater, for instance, and reclamation efforts can solve problems related to drainage control, erosion and segregation of waste material.

Is there a way for the copper mining industry to continue extracting minerals from the earth and enhancing our lives while somehow minimizing damage to the environment? Thus begins only the latest chapter in the millennia-old saga of copper.

Still, it's hard to disagree with the statement that copper remains a metal with a bright future.

A GLOBAL LOOK AT COPPER

- About 15 million metric tons of copper are mined each year around the world
- Every continent has copper deposits
- The leading copper-producing countries are Chile, Peru, China, the U.S., Canada, Mexico, Indonesia, the Russian Federation and Australia
- Much of the world's copper comes from mountain ranges stretching from Alaska to the tip of South America
- In some places around the world, copper mining is conducted in mines below the earth's surface. Elsewhere, the mining—known as open-pit mining—is done through the removal of copper from huge open pits at the surface. Most copper mining in the U.S. is the latter
- The U.S. uses more copper than it can mine. It annually imports copper from Chile, Mexico, Canada and Peru
- Large copper deposits also exist and are mined in Kazakhstan, Poland, Iran, Brazil, Papua New Guinea, Laos, Mongolia, Bulgaria, Argentina and Zambia
- Major users of copper by region in 2010: Asia (62 percent), Europe (22 percent), North America (10 percent) and Latin America (6 percent)

Above: Sheets of copper cathode are seen at the copper cathode plant inside the La Escondida copper mine near Antofagasta, Chile.

Source: The World Copper Factbook 2012, published by the Lisbon, Portugal-based International Copper Study Group