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This is dyprosium—if we run out of it, say goodbye to smartphones, MRI scans and hybrid cars

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Dyprosium. Credit: SPL/Science Source

The next gold rush could be in outer space, but the treasures luring modern-day prospectors won't adorn lavish jewelry.

They are rare earths, a group of 17 chemical elements with tongue-tying names such as yttrium and thulium that are used in televisions, cell phones, laptops, cars, cancer treatment drugs, nuclear reactor shielding, aircraft engines, and weapons. Coveted for their magnetic and conductive properties, they make technologies faster, stronger, lighter, and more efficient.

"Without rare earths and the miniaturization capabilities they provide, computers would be the size of classrooms instead of the size of smartphones," says Julie Michelle Klinger, an assistant professor of international relations at Boston University's Frederick S. Pardee School of Global Studies and an expert in the politics of development, environment, and security in Latin America and China.

In recent years, fears that the earth's reserves of these elements will someday be exhausted have helped fuel a race to harvest them, particularly among countries such as the United States, China, and Brazil. Experts point to Bayan Obo, a mining district in Inner Mongolia dubbed "the rare-earth capital of the world," which could be mined out in 50 years, and they are eyeing untapped sources like the Amazon, and even the asteroids in our solar system.

Klinger, whose research on rare earths and the geopolitics surrounding them will be published in the forthcoming book Rare Earth Frontiers, is less concerned. For one thing, she says, rare earths are not rare. While the elements were believed to be scarce when they were discovered in Sweden in the 18th century, they are in fact "remarkably well distributed in the Earth's crust. We could go dig along the banks of the Charles River in Boston and probably find some traces of them," she says.

According to Klinger, rare earths make up almost one-fifth of naturally occurring elements, and are more than twice as abundant as copper in the Earth's crust. And we don't gobble them nearly as quickly as we have with copper. That's because rare earths are to technology what baking soda is to chocolate chip cookies: a little goes a long way. According to a report from Adamas Intelligence, which publishes research on metals and mining, global consumption of rare earths was just over 120,000 metric tons in 2014, compared to copper at nearly 22 million metric tons.

What does concern Klinger is a "structural scarcity" of rare earths. Only one country—China—produces the vast majority of the elements, and while China's resources are abundant, they're not limitless, as concerns over Bayan Obo's supply show. Klinger says the space race, in part attributed to the quest for rare earths, is really driven by political

agendas—a chance for countries and companies to stake a claim to previously protected territories, gaining wealth and power in the process. Her research has uncovered many historical examples of countries engaging in high-stakes brinkmanship involving rare earths, and she says some global players may be gearing up to do the same again. Such posturing is unnecessary, says Klinger. A better way to keep our computers portable without sabotaging international relations or strip-mining asteroids would be to change the way we currently harvest rare earths. Another may be to stop calling them rare.

Explosive Discoveries

Almost as soon as scientists figured out what to do with rare earths, the elements became essential to daily life—and to warfare. In the 1880s, cerium was used to help create the first gas mantle lantern and later the "flint stone," which sparks when struck and is still used in cigarette lighters, cars, and weapons. Klinger's research shows that as technological progress called for more and different rare earths, they became enmeshed in politics and even war. When Scandinavia's supply could no longer sate the appetites of resource-hungry European powers, imperial masters began digging up colonial lands in the hunt for more. Finding and dominating access to rare earths became even more important as, by World War I, cerium was essential in the manufacture of fuses and explosives. In the 1920s, Klinger notes in a paper for *The Extractive Industries and Society*, Imperial Japan "organized local puppet governments, engaged in prospecting activities and took over heavy industry and munitions factories" in China to gain control of the country's natural resources, including rare earths. In the mid-20th century, rare earths were being used in more sophisticated weapons: neodymium in intercontinental ballistic missiles and laser weapons; samarium in nuclear reactors. The race to control rare earth production was on. In 1948, Klinger notes that India stopped exporting monazite—a mineral rich in rare earths and thorium, an atomic energy source. The United States tried to bargain with grain to relieve the country's famine, hoping to gain a Cold War ally. India refused, crushing US hopes that a deal would help stem Soviet influence in India.

US worries about supply were eased in 1949 with the discovery of a mine in Mountain Pass, California, and from the 1960s to 1990s, America was the dominant rare earth producer.

But it would soon be overtaken by China.

In the 1950s, when China and the Soviet Union were working to build their military, Bayan Obo "received so much Soviet investment, planning, and expertise, and that laid the groundwork for the place to eventually emerge as the rare earth capital of the world," says Klinger. Globalization also played a role in the ascendance of Bayan Obo; in the 1980s, companies around the world began subcontracting aspects of rare earth mining to China to save money—and to avoid the environmental regulations of their home countries. Mining rare earth deposits, which tend to form alongside those of radioactive elements, is difficult and messy work. Pipes used to divert the radioactive waste from processing sites are at risk of bursting—dumping acids, cancer-causing elements, and other harmful materials into soil and groundwater. At Mountain Pass, which Klinger says was using a structurally unsound and unusually long pipeline to divert wastewater containing radioactive salts, there were roughly 60 reported spills between 1984 and 1998.

In 2000, Mountain Pass, plagued by environmental violations and competition from China, shut down. The closure handed market dominance to China, which at the time was mining more than 95 percent of the rare earths used worldwide; it imposed export quotas, which rankled top importers such as the United States and Japan. A decade later, it halted rare earth exports to Japan in retaliation for a maritime border clash, which helped send prices up as high as 2,000 percent.

"The world woke up to its dependence on China," says Klinger. "This unleashed a flood of speculation and prospecting" in locations such as Greenland, Texas, Canada, and Brazil.

Today, with tensions between the United States and China running high over information hacking and territorial disputes in the South China Sea, Klinger says a clash over rare earths could help tip

the countries into an outright confrontation.

"We're at a very critical moment with respect to political and geopolitical relations between the US and China," she says. "There are actors on either side who are intent on engaging in saber-rattling discourses and pointing to one reason or another why conflict between the US and China is either inevitable or necessary. Reliance on China for rare earth elements simply adds more fuel to those fires."

Wealth and Power

The global prospecting sparked by China's export restrictions isn't purely about national security—or even keeping the world's cell phones and x-ray machines switched on—according to Klinger. It's about power. Setting up large-scale mining in the Amazon, for example, would allow the Brazilian government greater control over land currently managed by a federation of 28 indigenous ethnic groups. The federation's power—even the military has to ask permission to cross their land, says Klinger—is "seen as an affront to Brazil's sovereignty because there's a perception among some, including in the Brazilian federal government and in the Senate, that indigenous people are the puppets of foreign governments because so much funding from northern nongovernmental organizations has gone to supporting these indigenous people and their causes."

The interstellar gold rush is little different. In November 2015, Congress passed the SPACE Act of 2015, granting citizens the right to mine and sell material from outer space. The legislation was cause for rejoicing among asteroid mining companies that stand to make a fortune plumbing space for water, industrial metals, and rare earths. These companies have already taken the first step toward mining: In July 2015, Planetary Resources launched a spacecraft to test control systems and other technologies necessary for asteroid prospecting. Klinger attended a 2015 space mining conference where private space industry representatives were "invoking the rarity of rare earth elements, and the fact that we're running out of them here on Earth."

As Klinger sees it, the SPACE Act of 2015 is largely an attempt to place outer space under US jurisdiction. "And if you can cut through all of the fluff about outer space and the great frontier in the transcripts discussing this bill," she says, "what you see is actually this directly undermines" the 1967 Outer Space Treaty signed by the United States, Russia, and other countries. That treaty "enshrines outer space as belonging to all of humankind," she says, and "was explicitly organized to minimize conflict in respect to outer space." She adds, "One of the rather potent and persuasive debates in the US surrounding the promotion and ultimate passage of this law was fear that China would 'colonize' the moon if we didn't get there first." Klinger hopes other countries won't take the SPACE Act seriously, because their doing so could lead to a global conflict.

Undoing the Damage

Klinger believes there are better ways to maintain a steady production of rare earths than cutting down rainforest or launching heavy machinery into space. First, she says, China's efforts to reduce production should be supported—that would broaden the market and relieve the country's environmental burden. After the 2010 panic sparked by China's export restrictions, the World Trade Organization ruled against China's rare earth export quotas, further cementing the country's near monopoly and, says Klinger, contributing to "highly uneven global production done in a way that's devastating" to the environment—and people. She has seen the effects firsthand at Bayan Obo. "The heavy metals, fluorine, and arsenic accumulated in the town's soil and water from decades of mining have slowly poisoned nearby residents and their livestock," Klinger wrote in the Berkeley Review of Latin American Studies in 2013. "Some true locals are tragically recognizable by their blistered skin and discolored teeth."

That doesn't mean Klinger wants to spread the health problems around. "We don't need to dig new holes in the ground," she says. She would like the industry to "change the paradigm of how we get resources" by following the example of the Brazilian firm CBMM, which has a global monopoly in niobium, an element used mainly in steel and other

alloys. That company developed technology to extract rare earths from existing mining waste. Klinger says that, with research, the technology could work in other sites—such as silver or phosphate mines—whose waste includes rare earths. That would require publicity and investment, along with public pressure and tax incentives to encourage major buyers to pay a premium for greener rare earths, but it could nudge more companies to adopt more innovative and sustainable methods.

"Given how important rare earth elements are to everyone," Klinger says, "developing an environmentally and socially responsible means of producing them is something that we should really be working on together. And "if we find ourselves in a situation where we're having conflicts over rare earth resources that look anything like the conflicts we've been involved in related to oil resources in the Middle East, it will have been absolutely and entirely avoidable—and absolutely and entirely of our own making."

A first step to reevaluating the world's approach to rare earths might be to simply stop calling them rare. "Looking at the different ways that rare earths have been used as a bargaining chip in international relations—say, between the US and India during the Cold War, the US and China in the US fight against Communism—calling these things 'rare' imbues them with this political charge," Klinger says. Acknowledging that it's just not necessary to drill the Milky Way to power our cell phones could help keep space exploration focused not on supplying Earth, but seeking worlds beyond it.

More information: Julie Michelle Klinger. A historical geography of rare earth elements: From discovery to the atomic age, *The Extractive Industries and Society* (2015). DOI: 10.1016/j.exis.2015.05.006

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