# The Wire China

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### COVER STORY The Cobalt Empire

China controls much of the world's supply of cobalt. Will it give the country an insurmountable edge in developing electric vehicles?

BY TIM DE CHANT - OCTOBER 18, 2020



Illustration by Sam Ward

↑esla's "Battery Day" in Fremont, California, this past September felt like Lollapalooza 1 for energy nerds. As record-breaking wildfires burned just six miles away, underscoring Tesla's mission to rid the world of climate change-causing fossil fuels, the electric vehicle company organized an hour-long celebration of lithium-ion batteries - one of a handful of technological breakthroughs that have made low carbon policies possible.

On a giant outdoor stage, Elon Musk, Tesla's co-founder and chief executive and Drew Baglino, a senior vice president, wore black t-shirts with a close-up image of Tesla's new battery structure as they waxed poetic about the chemistry of lithium ion batteries. With energy-dense, durable and versatile cells, the nearly 50-year-old lithium ion battery now powers everything from laptops and smartphones to electric vehicles. The battery's inventors - John B. Goodenough, M. Stanley Whittingham and Akira Yoshino - even won the Nobel Prize in chemistry last year. Companies around the world are now racing to build ever larger packs to store cheap and abundant wind and solar power.

"Time really matters," Musk said. "This presentation is about accelerating the time to sustainable energy." Indeed, if you think lithium ion batteries are everywhere today, just wait until tomorrow.

But lithium ion batteries have a dirty secret that Musk is hell-bent on avoiding: cobalt. While the mineral has long been a necessary ingredient, lending a measure of stability to the cell's chemical structures and allowing the batteries to charge faster and hold more energy, much of the world's supply of cobalt is concentrated in one country: the Democratic Republic of Congo (DRC), where corruption, child labor and unsafe mining conditions have raised governance and human rights concerns. Cobalt has been called the blood diamond of the electric vehicle industry, undermining the sustainability goals of companies like Tesla.

Moreover, the mineral's supply chain is fraught with uncertainty, in part because it is dominated by China. Since 2007, China has made the electric vehicle (EV) industry a priority, and <u>controlling cobalt</u><sup>1</sup> is seen as a necessary building block in that effort. More than half of the world's cobalt reserves are in the DRC, and twothirds of the world's production of refined cobalt, a prerequisite for large EV batteries, takes place in China.

"There has been an explicit and overt effort [on the part of China] to go out and obtain influence over natural resources, including lithium, cobalt and others," says <u>Allison Carlson</u>, managing director of <u>FP Analytics<sup>2</sup></u>. "This has been a long-term strategy that has worked well for them in terms of really being able to develop the resource capacity and also the supply chain."

#### **Global Cobalt Reserves**



China's long-term strategy has left other countries scrambling. "There's not a lot of options, really, for cobalt," says <u>Gavin Montgomery</u>, director of global metals market research at WoodMackenzie. "It's buy it from the DRC via China or don't buy it at all."

Tesla doesn't want to buy it at all. While researchers have been trying to eliminate cobalt from lithium ion batteries for years, they've only been partially successful. For example, Tesla's Chinese Model 3 sedans will soon use cobalt-free batteries supplied by <u>CATL</u>, a Chinese company, but their range will take a hit. To date, no commercial lithium ion batteries without cobalt can match the performance of those with it.

But at Battery Day, Tesla's Baglino announced the company's new "high-nickel cathode development, which has zero cobalt in it." The more than 100 socially-distanced Teslas parked in front of the stage — a Covid-era audience — all honked their horns in riotous applause.



"It's a big deal," Musk said triumphantly.

At Tesla's annual shareholder meeting, founder and CEO Elon Musk announced the company's plans to integrate a cobalt-free battery into their cars.

"We've looked at the entire value chain and said, 'How can we make this as simple as possible,'" Musk said of Tesla's plans to use nickel, iron and manganese, instead of cobalt. This innovation in the 'cathode' part of the battery, Tesla says, could even lead to huge cost savings for consumers.

"Just localizing our cathode supply chain and production, we can reduce miles traveled by all the materials that end up in the cathode by 80 percent, which is huge for cost," Baglino said, noting that reduced costs of EVs are essential to encouraging mass adoption. Tesla, he said, is three years away from making an EV priced at \$25,000. Whether or not that timeline proves true is another question — analysts say the EV industry is at least 10 to 20 years away from cobalt-free batteries — but the announcement marked a significant possibility nonetheless.

For years, China has had a "<u>secret weapon</u>" in the race to develop electric vehicles. Its longterm bet on cobalt is now paying off: More than 40 percent of electric vehicles sold globally last year were made in China. And it comes at a time when the <u>\$3.5</u> trillion B global automotive industry, a pillar of many advanced economies, is at a crossroads. Countries around the world are looking to ban fossil fuel-powered vehicles, some <u>as early as 2030</u>. While Chinese automakers haven't found much success in foreign markets, Chinese companies are already claiming a significant share of EV revenue. Batteries account for about <u>one-third</u> of an electric vehicle's cost, and today, China has <u>nearly 80 percent</u> of the world's battery manufacturing capacity.

But while China enjoys a leg up in the immediate future, Tesla's Battery Day underscored the fact that companies and researchers around the world are working feverishly on technological advances that would break China's cobalt-clad lock on the EV industry.

#### THE RISE OF CHINA'S COBALT EMPIRE

C hina's <u>position</u> in the cobalt market is the result of nearly two decades of planning. It was a high stakes bet that, if it pays off, could allow the country to swiftly climb the technological ladder while also positioning itself as a climate savior.

Around the turn of the millennium, China began to reckon with the consequences of globalization. China's accession into the World Trade Organization in 2001 quickly transformed the country into an export juggernaut. But as its economy expanded, China needed more energy and resources to sustain that growth. The country also needed better management skills and technology, and one way to acquire that was to do more business overseas and make its companies globally competitive.

As a result, Beijing encouraged Chinese firms to "go global." The idea was to deploy Chinese capital abroad, to lock up more oil, iron ore and minerals. Up to that point, China had accumulated large holdings in U.S. Treasury bonds, which were relatively low yield. The "go global" policy allowed the government to invest in private sector companies while at the same time diversifying its holdings, says <u>Yasheng Huang</u>, a professor at MIT's Sloan School of Management. "The investment projects expanded to commercial projects, such as mining, technology and real estate."



Another motivation was to develop foreign markets for Chinese goods. The Communist Party, according to <u>Min Ye</u>, a professor at Boston University, was "trying to find markets for China's capacity and employment." The country's leaders, at the time, hoped the "go global" policy would provide a jolt to stagnant companies and, Min said, "incentivize these state-owned enterprises to accept reform."

Countries in Africa were early targets. While there were a handful of Chinese-owned mines in Africa by 2005, China's mining industry didn't embrace going out until 2007, when a government strategy announced the prioritization of "new-energy vehicles," including electric vehicles. At the time, it was clear China's auto industry was well behind foreign rivals. Rather than spend decades catching up, Wan Gang, the newly installed Minister of Science and Technology who had spent a decade at Audi, suggested Chinese automakers go all-in on electric vehicles, a race that had only just begun.

"There will be a strategic window for developing electric vehicles over the next 10 to 20 years," Wan <u>said</u> in 2010. "We have to take action now."

The government agreed and set <u>targets for adoption</u> (2) that demanded far more minerals than China had access to, especially cobalt. Between 2006 and 2017, Chinese companies invested \$33 billion in mining across Africa. The investments were well-timed. Around 2010, the main use of cobalt transitioned from niche metals, such as superalloys used in jet turbines and rocket engines, to chemicals for batteries.

Another driver was the 2008 Global Financial Crisis, which <u>hit Western mining companies</u> hard. While Western firms were forced to <u>sell off</u> assets, Chinese firms leveraged their access to state capital to buy mines across Africa.

By 2016, for example, the state-owned China Nonferrous Metal Mining Company (CNMC) had inked a deal with Gécamines, the DRC's state mining company. Gécamines' crown jewel was the Deziwa deposit, which sits about 20 miles east of Kolwezi. Ten years before, a British company, Copperbelt Minerals, had found a whopper at the site: 4.8 million tonnes of copper and more than 400,000 tonnes of cobalt<sup>3</sup> but the deal between Gécamines and Copperbelt fell apart. Saddled with debt, Gécamines turned to Beijing-based CNMC, which promised to finance, build and operate the mine in exchange for nine years worth of mined ore.<sup>4</sup>



Miners pull up a bag of cobalt their colleague is digging underground inside the CDM (Congo DongFang Mining) Kasulo mine.

Credit: Sebastian Meyer, Getty Images

Of course, doing business in the Congo is not without its risks. Though rich in natural resources, the DRC is one of the world's poorest countries, and it's been wracked by war, political instability and corruption. In 2017, the Carter Center, established by former U.S. President Jimmy Carter, published a <u>study</u> D of the Congo's mining sector and concluded it was a mess.

"The DRC's mining sector has attracted billions of dollars in private investment but these deals have generated limited public benefits," Carter wrote in the <u>foreword</u> ."Poor governance has allowed the country's largest state-owned mining company, Gécamines, to engage in opaque mining deals that fail to serve the public interest."<sup>5</sup>

For these reasons and others, including an international outcry over the use of <u>child labor</u>, Western companies have abandoned the country. Arizona-based Freeport-McMoRan and Lundin of Canada, for example, each sold stakes in DRC sites in 2017. Today, Switzerlandbased Glencore is the only major Western company operating in the country, though it shut down one of its two DRC cobalt mines in December, eliminating more than half its production. Today, eight Chinese-controlled mines account for half the country's cobalt output.

And once it leaves the DRC, cobalt usually ends up being processed in China. In fact, cobalt refining capacity in China has swelled 30-fold since 2000. No other country comes close. Today, China produces two-thirds of the world's refined cobalt, with three Chinese firms responsible for 46 percent of the world total, according to <u>Darton Commodities</u>.



Democratic Republic of the Congo. Credit: Encyclopaedia Britannica/Universal Images Group via Getty Images

When discussing why cobalt, a mineral at the base of the value chain, has received so much attention in China, <u>Ye</u> recounts conversations she had with Chinese solar companies that suffered huge losses when state policies led to a supply glut. "And yet the investment in the mines and materials, they were quite profitable," she says.

Chinese companies may be positioning themselves for similar gains with cobalt. "China is very forward thinking," says Jordy Lee, a research associate at the Colorado School of Mines. "They're very aware that these minerals and metals will become incredibly valuable in the next 30 years."

#### INNOVATING AROUND COBALT - AND CHINA

When a lithium-ion battery is charged, its lithium ions and electrons sit waiting inside the negative terminal, known as the anode. Anodes are usually made of graphite, the same stuff found in pencil lead. The lithium ions squeeze into slots between the microscopic layers of graphite. When the battery is used in an electric vehicle, electrons flow out from the anode to the motor and then to the positive terminal, known as the cathode. At the same time, positively charged lithium ions begin to migrate within the battery from the anode toward the cathode, which also has slots for the lithium ions.

Most batteries use cobalt to stabilize the cathode's microscopic structure while packing in as many lithium ions as possible. In the analogy used at Tesla's Battery Day, the lithium ions are like books, with cobalt providing a stable bookshelf. To date, cobalt-free battery cathodes containing nickel, manganese, or aluminum haven't been able to fit as many books on the shelf without it collapsing.

"You need a stable structure to contain the ions," explained Musk, "If it doesn't retain its structure, then you lose cycle life and your battery capacity drops very quickly."



Tesla co-founder and CEO Elon Musk is hoping to sell cars with a cobalt-free battery in just three years, though many in the field say the technology is at least a decade away. *Credit: NASA Kennedy, <u>Creative Commons</u>* 

Which, so far, has been the problem. While just about everyone — the U.S., EU, Japan and China — is working on cobalt-free models, the results don't have the same performance. Existing cobalt-free batteries fall short of expectations since they are heavier and don't pack as much power, and better versions have proven unstable or challenging to manufacture. "There's been a lot of talk about cobalt-free batteries and low-cobalt batteries, but most consumers outside China — in Europe and North America — they want the range and the performance as with a Tesla," Montgomery says. "Typically that requires these nickel-cobalt batteries rather than the cobalt-free batteries."

Battery innovations, however, have been fast and furious. Ten years ago, it wasn't clear how we were going to decarbonize the world's energy supply. While wind and solar were pulling ahead, storing that intermittent power, both for homes and vehicles, was a challenge. But in the last decade, costs for lithium-ion batteries have fallen from \$1,100 per kilowatt-hour to \$156, according to BloombergNEF. Lithium-ion batteries have gone from long shot to frontrunner.

<u>Greg Less</u>, who runs a lab for the University of Michigan, says while significant advances are being made, it could be years before we see cobalt-free batteries used widely in electric vehicles. Electronics companies are usually the first to experiment with new battery types, and if things look good, automakers may follow several years later. "The automotive planning cycle is usually several models ahead. They're not thinking about the next model, but the model after that," Less says.

The impetus is there. Though the price of cobalt is relatively low today, it is high relative to other materials, such as nickel. And it's likely to rise as demand increases. <u>Darton</u> expects cobalt demand to triple in the next 10 years, mostly due to growth in the battery industry. "There is consensus that sales of [electric vehicles] will continue to grow exponentially," says Andreis Gerbens, a trader at <u>Darton</u>. "Even if you take some of the more conservative projections into account, that still represents a significant increase."<sup>6</sup>

China's control of the mineral also raises fears about an insecure supply chain. "They're locking in supply," says <u>Caspar Rawles</u>, an analyst at <u>Benchmark Mineral Intelligence</u>. "Companies outside of China are going to find it increasingly difficult to find a long-term supply of cobalt. I wouldn't say it's too late, but the clock is running out."

Rawles is forecasting a global shortage of cobalt in the next two to three years, ramping up pressure for alternatives.

### The automotive planning cycle is usually several models ahead. They're not thinking about the next model, but the model after that.

### — Greg Less, the University of Michigan

The concentration of the cobalt market has attracted the attention of politicians in the U.S., including <u>Senator Lisa Murkowski</u>, who sponsored legislation in 2019 to shore up supplies of critical minerals like cobalt. "The next decade is a critical time to rebuild our domestic supply chains, and the success of that effort will depend in large part on our willingness to take real steps to reverse our significant dependence on foreign minerals," Murkowski tells *The Wire.* "Failing to take this seriously will put us at an economic and geostrategic disadvantage, especially as nations like China do everything they can to consolidate control."

The old-fashioned way to meet demand for a mineral is to dig for more. With cobalt, it's not so straightforward. The metal is usually found with copper and nickel, which have higher demand. "The cobalt market is very specialized. It's about a 130,000-tonne market," says <u>David Weight</u>, recently retired president of the <u>Cobalt Institute</u>. "You compare that with 25 million tonnes for copper, 40 million tonnes for aluminum." Because of that, companies mine first and foremost for copper and nickel.

"Because it's a byproduct metal; ironically, we don't look for cobalt," says Murray Hitzman, former associate director of energy and minerals at the <u>U.S. Geological Survey</u>.

Still, some companies are trying. Hitzman is an advisor to <u>KoBold Metals</u>, a Bill Gatesbacked mineral exploration startup that's prospecting with the help of artificial intelligence software that analyzes datasets. In July, the company <u>announced</u> it had acquired rights to explore 380 square miles near a nickel mine in Quebec to prove their approach.

Other countries are hoping rocks on the seafloor can tip the balance. So-called polymetallic nodules found there hold high concentrations of minerals, and they are scattered around the world rather than concentrated in one country. But the industry is awaiting regulations from the <u>International Seabed Authority</u>, and the costs of such mining could be prohibitive. Plus, public opinion would likely sour on the issue. "I think there's a knee-jerk reaction to ocean mining," says <u>Suzanne Greene</u>, program manager of <u>MIT's Sustainable Supply Chains</u> project. "I don't know what the public appetite for that is."

A more promising and palatable source of cobalt may be batteries being manufactured today. There's already a small market for recycling phone, laptop and electric vehicle batteries, and in 10 years, analysts say it'll be much bigger. "By 2030, we have about 40,000 tonnes of recycled cobalt coming into the market," says Montgomery, at Wood MacKenzie.

But while recycling may ease the supply crunch, it won't help countries diversify their sources. "Chinese companies are actually at the forefront of [recycling] as well," says <u>Carlson</u> at FP Analytics. Other companies and countries are catching up but a lot of work remains to create efficient and cost-effective recycling supply chains.

With new supplies, recycling and cobalt-free battery chemistries all years or decades away, companies looking to secure cobalt today may be forced to make delicate decisions. "It could become very challenging for manufacturers globally because they would have to align somehow with China," says <u>Michal Meidan</u>, director of the <u>China Energy Programme</u> at the <u>Oxford Institute for Energy Studies</u>. "If the U.S. or Western countries will ask third countries to choose sides, then in the case of batteries and battery supply chains, that could be a very tricky thing to ask of them."

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They may be forced to make that choice sooner than later. This September was the hottest on record, and 2020 is shaping up to be the warmest yet, underscoring the relentless pace of climate change. If countries hope to limit warming, they'll need to cut carbon pollution drastically <u>by 2030 at the latest</u>. Lithium-ion batteries are all but required to accomplish that and, for now at least, China appears to be in the driver's seat.

As Hitzman says:<sup>7</sup> "Whoever controls the cobalt can control how much you can decarbonize."



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#### COVER STORY



### **Pole Position**

#### BY EYCK FREYMANN

In public, Chinese diplomats and climate negotiators deny that they see any link between climate change and geopolitics. But there is a deeply cynical consensus within China's academic and policy communities that climate change creates geopolitical opportunities that China can exploit — and must exploit before its rivals do. Greenland was the proof of concept for this strategy. And it caught the U.S. flat-footed.

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