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MAGAZINE

This metal is powering today's technology—at what price?

As demand soars for powerful batteries, Bolivia dreams of striking it rich by tapping its huge lithium deposit. But will its people benefit?

While the indigenous Aymara population harvests and sells salt
salt flat, the much more lucrative lithium is dissolved in brine for

BY ROBERT DRAPER

PHOTOGRAPHS BY CÉDRIC GERBEHAYE

This story appears in the [February 2019](#) issue of *National Geographic* magazine.

ONE EARLY SATURDAY morning in La Paz, Álvaro García Linera vice president of Bolivia, greets me in the spacious salon outside his c overlooking Plaza Murillo. The debonair, silver-haired 56-year-old politician is known in his country as a committed Marxist ideologue. I today he presents himself as a capitalist pitchman.

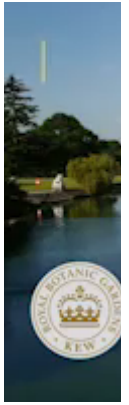
The pitch in question involves lithium. García Linera speaks of h country's natural resource in a simultaneously factual and awestruck Lithium, essential to our battery-fueled world, is also the key to Bolivi future, the vice president assures me. A mere four years hence, he predicts, it will be "the engine of our economy." All Bolivians will ben he continues, "taking them out of poverty, guaranteeing their stability the middle class, and training them in scientific and technological fiel so that they become part of the intelligentsia in the global economy."

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But as the vice president knows, no pitch about lithium as Bolivia's economic salvation is complete without addressing the source of that lithium: the Salar de Uyuni. The 4,000-square-mile salt flat, one of the country's most magnificent landscapes, will almost certainly be altered—not irreparably damaged—by mining the resource underneath it.

Evaporation pools carved out of the Salar de Uyuni create a colorful mosaic at the Llipi lithium pilot plant facility began making lithium carbonate in 2013. Lithium-rich brine is pumped from as far as 65 feet beneath the surface into pools. Eventually, the plant will have 200 of them.

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García Linera thus speaks of it reassuringly, even reverently. Leaning in very close, he asks, “Have you been to the Salar de Uyuni?”

When I reply that I’ll be heading there soon, the vice president dispenses with his air of mentholated detachment and seems awash with nostalgia. “When you go to the Salar,” he instructs me, “go there one night. Spread a blanket in the center of the Salar. Turn on some music.

He is smiling now but emphatic: “Pink Floyd. Turn on Pink Floyd. And stare up at the sky.” The vice president then waves his hand to indicate that the rest would become evident.

Incahuasi, “House of the Inca” in Quechua, was an island when the Salar was a lake in prehistoric times. A remnant of a volcano, it’s covered in cacti, some towering 40 feet, and fossilized algae. Extracting lithium under the salt flat is certain to alter the spectacular landscape.

The daylong drive from the world’s highest capital city to the world’s largest salt flat provides a roadside tour of South America’s poorest country. From downtown La Paz, perennially clogged with cars and political demonstrations, the road shoots up to El Alto, the working class stronghold of Bolivia’s second largest indigenous group, the Aymara migrants from the high plains of the Andes Mountains. Over the next seven hours, the route travels steadily downhill—through villages wh

effigies of would-be thieves are tied to trees in warning, through the mining city of Oruro—until leveling out, at about 12,000 feet, into a mostly vacant stretch of scrubland occasionally animated by llamas and their lithe cousin, the vicuña. By late afternoon, the pale shimmer of the salt flat yawns across the plain.

I reach the Salar, Spanish for “salt flat,” just before sunset. For about a mile I drive along its smooth and firm surface until its middle-of-nowhereness becomes evident.

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Stepping out of the SUV and into a gnashing chill, I regretfully conclude there will be no blankets spread beneath the stars accompanied by a trippy Pink Floyd soundtrack. Still, the spectacle is hallucinatory: miles of bleached terrain, relentlessly level and divided into vaguely trapezoidal shapes like a mad giant’s checkerboard, its starkness perfected by the cloudless blue sky and towering mahogany Andean peaks in the distance. Motorcycles and 4x4s scud across the roadless surface, destinations unknown. Here and there solitary beings lurch about as if in a postapocalyptic stupor, gazing in what the Bolivian vice president calls “the infinite table of snowy white

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Somewhere out of sight on infinity's edge, bulldozers are plowing evaporation pools in the Salar—long and geometrically precise, as if they create a grid of enormous swimming pools. The bulldozers will be moving this way—how soon, no one can say with any certainty.

To create an evaporation pool at the lithium pilot plant in the Salar, workers roll out sheets of felt and t plastic. Brine, pumped from the ground, is evaporated and treated with chemicals to obtain lithium sul

Here is what we do know. First, that underneath the world's big salt flat lies another wonder: one of the world's greatest lithium depo perhaps 17 percent of the planet's total. Second, that by exploiting its lithium reserves, the government of Bolivia—where 40 percent of the people live in poverty—envisions a pathway out of its cul-de-sac of misfortune. And third, that this pathway slicing through the largely pristine Salar de Uyuni is at the same time wholly uncharted and—to Bolivians living in a country replete with plundered holes and cheatec aspirations—suspiciously familiar.

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Lithium 101

Bolivia today is still shackled to its past. The country's first Aymara president, Evo Morales, who took power in 2006, cited in his most recent inaugural address the "500 years we have suffered" as a result of Spanish colonialism—a brutal reign of enslavement and cultural expungement nonetheless ended nearly two centuries ago. Geography and bad governance thereafter conspired to thwart its reinvention. Bolivia's economic prospects suffered when it gave up its coastline on the Pacific

Ocean in 1905 after losing a war with Chile. While its neighbors Brazil and Argentina slowly grew more prosperous, Bolivia endured decades of military coups and corruption. The two major indigenous populations, Quechua and Aymara, are still relegated to lower-caste status by the ruling elite of European ancestry.

In sum, Bolivia has been a country of sagging self-esteem, latent hostilities, and no shared sense of national destiny. Meanwhile its economic history is one of endless boom-and-bust cycles. Though this is common among countries dependent on their natural resources, some Latin American countries, such as Chile, have managed theirs competently. The Bolivian government, by contrast, has frequently sold away its mineral rights to foreign firms in the interest of quick but fleeting profits. As the vice president told me, “Throughout our history, we have not created a culture that combines our raw assets with intelligent thinking. This has produced a country which is rich in natural resources and socially very poor.”

Workers at the lithium pilot plant use hammers to break up a layer of salt that periodically clogs the pipes transporting brine with lithium into the evaporation pools. Dried salt collects around the edges of the pipes.

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Bolivia remains, among Latin American nations, curiously indistinct, its history neither iconic nor volatile. The cameo role it pla

in *Butch Cassidy and the Sundance Kid* could be seen as a metaphor for its semi-anonymity. Bolivia, in that now classic film, was the somnolent final refuge of two American bank robbers. Glammed up by Hollywood, the outlaws symbolize something appreciably less romantic in Bolivia—namely, the remorseless fleecing of its resources by gringos from far wealthier nations.

A bullet-riddled train the duo are said to have robbed is a featured attraction in Pulacayo, once a bustling mining town. Today Pulacayo is a ghost town. The grand residence of the German mining baron Moritz Hochschild is now a seldom visited museum featuring vintage photographs of the hardships borne by his laborers—many of them women and children. Documents discovered recently revealed that Hochschild helped thousands of Jews leave Nazi Germany and resettle in Bolivia. Oscar Ballivián Chávez, a Bolivian geologist, dryly observed, “Hochschild was the Schindler of Bolivia—except not to the Bolivians.”

Pulacayo's mines were shut down by the government in 1959, throwing the miners out of work. The town's demise was expected to be the fate of Uyuni, a mining distribution center 12 miles away. But one day in the 1980s, while searching for a tourist destination to rival Lake Titicaca, a La Paz tour operator named Juan Quesada Valda laid his eyes on the Salar.

José Edmundo Arroyo, a construction worker at the lithium pilot plant, finishes his shift. The local indigenous population has so far seen only modest benefits from the plant, which has primarily hired its skilled workers from La Paz or Potosí.

Until then, the salt flat had been regarded by Bolivians as not more than a geographical anomaly. According to a local myth, the Salar was formed from breast milk and salty tears that flowed from Tunupa, a volcano looming over it, who cried when her two daughters were kidnapped. But while Tunupa and other surrounding mountains are venerated in indigenous lore, “the Salar has never had cultural significance,” said Uyuni’s mayor, Patricio Mendoza. “People were afraid that if they took a walk on it, they might get lost and die of thirst or that llamas would damage their hooves on the salt.”

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When Quesada beheld the Salar, he experienced a revelation, said his daughter Lucía: “You can find lakes anywhere. But you cannot find a salt flat like this anywhere else in the world. He knew he could sell the place.”

An architect by training, Quesada proceeded to build the first of several hotels made almost entirely out of blocks of salt in Colchani, a village at the eastern edge of the Salar. Adventurous foreigners began

show up to bask in the great pale desert. Weddings, yoga tutorials, and drag races would eventually be staged on it. Today the salt hotels are routinely full, while Uyuni has become a somewhat mangy, pizzeria-filled vacationland bustling with college-age backpackers.

“Maybe 90 percent of our economy is tourism,” Mendoza said.

All of which is to say that in Bolivia’s long, morose history of economic disappointments, the Salar provides a happy if modest exception.

But now comes Bolivia’s future, in the form of lithium.

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What gold meant to earlier eras, and petroleum to the previous century, lithium may eclipse in the coming years. Long used in medicine to treat bipolar disorders—and in items as varied as ceramics and nuclear weapons—it has emerged as an essential component for the batteries in computers, cell phones, and other electronic devices.

The global market’s annual consumption of lithium was approximately 40,000 metric tons (a metric ton is 2,205 pounds) in 2016, representing a roughly 10 percent increase year by year since 2015. Meanwhile, between 2015 and last year, lithium prices nearly tripled—a clear reflection of how fast the demand has been rising.

That will likely intensify as electric cars become more popular. (C

version of the Tesla Model S runs on a battery pack with about 140 pounds of lithium compounds, or the equivalent of what's in 10,000 cell phones, according to Goldman Sachs. The investment firm also projects that every time electric-vehicle sales replace a percentage of all vehicles sold, the demand for lithium increases by 70,000 metric tons a year. Considering that France and the United Kingdom have already announced that they will ban the sale of cars running on gas or diesel by 2040, it would seem evident that a country abounding with lithium need never fear poverty.

A soldier keeps a lookout at an observation post that guards the entrance to the lithium pilot project.

road to the left leads to the plant. All drivers must stop and fill out forms at the table before entering the facility.

Though lithium-mining operations exist on every continent except Antarctica, up to three-fourths of the known lithium reserves are in the Altiplano-Puna Plateau, a 1,100-mile-long stretch in the Andes. The salt bed deposits are concentrated in Chile, Argentina, and Bolivia, known as the “Lithium Triangle.” Since the 1980s Chile has produced lithium from brine, and its Salar de Atacama is now the preeminent source of the chemical in Latin America. Chile’s government has been the most hospitable to foreign investors, and its mining sector, as the world’s largest exporter of copper, has extensive experience. Argentina also began extracting lithium from brine in the late 1990s, exploiting its Salar del Hombre Muerto.

Bolivia’s lithium reserves match those of Chile’s highly productive Salar de Atacama, but until recently, their potential had gone untapped. “In Argentina and Chile, they’ve always had a culture of public-private partnerships,” said Ballivián, who in the 1980s was among the first geologists to study the Salar’s lithium potential. “Here this government doesn’t want to accept private investment. There’s a hostility to capitalism.”

At the pilot plant, a worker checks lithium carbonate to see if it's dry, the final stage before the chemical is packed in sacks for delivery. The state-run facility has about 250 employees, who wear red jumpsuits and work in adjacent prefab houses. Hundreds more work in construction and services at the plant.

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The election of Morales was a symbolically potent one for the indigenous Aymara population. But the new president's rhetoric and actions also had the effect of repelling foreign capital. Morales moved

quickly to nationalize the petroleum industry and has taken steps to nationalize some mining operations.

Two years after their election, in 2008, Morales and García Linera turned their attention to the lithium reserves in the Salar de Uyuni, a previous administrations had. “The other governments never produce any lithium,” García Linera said. “And what they wanted to do was reproduce the whole scheme of a colonial extraction economy. The Bolivian people do not want this. And so we started from scratch.”

From the outset, the new government’s operating principle was “100% Estatal!” or complete control by the Bolivian state. “We decided,” said García Linera, “that we Bolivians are going to occupy the Salar, invent our own lithium extraction method, and then partner with foreign firms that can bring us a global market.”

The “100% Estatal!” slogan carried additional meaning when uttered by an Aymara president. It happens that Aymaras make up a large part of the population around the Salar. To declare that the salt flat would become the epicenter of Bolivia’s economic revolution was to signal that jobs and deliverance from hardship would at long last come to the country’s indigenous people.

García Linera audaciously promised that Bolivia’s lithium would “be the fuel that will feed the world.” By 2030, he vowed to me, the country’s economy would be on a par with those of Argentina and Chile. Morales confidently predicted that Bolivia would be producing lithium batteries in 2010 and electric cars by 2015. These estimates would prove to be w

off. As Morales and García Linera would come to learn, lithium mining is an expensive and complicated process, requiring significant capital outlays as well as technological sophistication. Going it alone was never an option for a developing country like Bolivia. At the same time, attracting a foreign firm that would willingly cede control to the state would be challenging for any nation, particularly one with nationalizing tendencies.

“You will surely understand, most industries would love to exploit the Salar,” García Linera said, insisting, “We’re saying no, the Salar must be fully controlled by Bolivian technicians. And so that has generated some tension.”

A worker who builds evaporation pools at the lithium plant rests on his lunch break. The job is exhausting, but it pays well and comes with a sense of national pride from being part of forging Bolivia's future.

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Trusting nonetheless that the promise of the Salar de Uyuni's reserves would surmount any doubts, the Morales administration stated that Bolivia would have a foreign partner to assist in industrial-scale

lithium production by 2013. This, too, proved to be a rash prediction. companies opted out. So did a top Korean firm. Not until 2018 did Bo find a partner: ACI Systems Alemania, a German firm that reportedly invest \$1.3 billion in exchange for a 49 percent stake in the venture.

The most daunting hurdle for Bolivia is a scientific one. Producing battery-grade lithium from brine involves separating out sodium chloride, potassium chloride, and magnesium chloride. This last contaminant is particularly expensive to remove. The Salar receives significantly more rain than its counterparts in the lower altitudes of Argentina and Chile, which can slow the evaporation process. Its lithium deposits also have a higher magnesium content. “While the ratio of magnesium in Chile is 1 to 1, in Uyuni it’s 21 to 1. Four times the concentration,” Bolivian chemical engineer Miguel Parra said. “So it’s a much simpler operation for them. For us, separating magnesium from lithium is the biggest challenge.”

I met Parra one morning at Bolivia’s Llipi lithium pilot plant, situated on a former llama pasture at the end of a long dirt road. Parra has been the plant’s director of operations since shortly after the project began in November 2008. Harsh winds and severe rainfall delayed engineers for several years before they succeeded in constructing a 10-mile causeway connecting the plant to the salt flat where lithium is mined.

At a plant in Brussels, Belgium, a worker looks over the lithium-ion battery that will power the Audi e-tron electric SUV. The liquid-cooled battery is made up of separate modules integrated into the floor of the vehicle. Rising electric-vehicle sales have spurred a significant increase in lithium extraction.

Aside from a tiny pilot plant that makes batteries in the mining town of Potosí, the multimillion-dollar Llipi plant, which started producing lithium in January 2013, is all the Morales government has to show for its decade-long pursuit of lithium-fueled prosperity. The smallish state-run compound has an all-Bolivian workforce of about 250 employees, most of whom originate not from nearby Aymara villages but from La Paz or Potosí. They wear red jumpsuits and live next to the plant in prefabricated

houses.

Quality control director Victor Ugarte walked me through the fenced and guarded plant. The tour took only a few minutes. The process begins with workers drilling through the hard surface until they reach the brine. The brine is then piped to pools where it's concentrated by evaporation. And chemicals are added that cause lithium sulfate to crystallize.

Tankloads of dissolved lithium sulfate are then ferried across the causeway to the three-story plant's uppermost floor. The liquid is first mixed for an hour with lime trucked in from Potosí. This, Ugarte told me, "is the most difficult part—it's how we extract the magnesium so that it can arrive at the purity level we need."

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At a BMW plant in Leipzig, Germany, Marcus Hänsel checks the alignment on the door of an i3. Powered by a lithium-ion battery, it's the automaker's first fully electric vehicle.

After the magnesium compounds are removed as a gray paste, the remaining liquid is moved to the second floor, where calcium sulfate is filtered out. Chemicals are added to the cooled liquid to create lithium carbonate, which is dried for two hours and loaded into white bags labeled “Carbonato de Litio.” About 20 percent is driven 190 miles to Potosí battery plant. The rest is sold to various companies. “We started producing about two tons per month,” Ugarte told me when I visited.

“We’re now up to five tons.” (Since then, plant officials say, they’ve reached 30 tons a month.)

I asked the quality control director what the Llipi plant’s ultimate production goal was. “Industrial level,” he said, “will be 15,000 tons annually.” I tried to imagine this unprepossessing little facility somewhere within the next five or so years, ratcheting up to hit that ambitious goal while maintaining 99.5 percent purity, the industry standard for battery grade lithium.

Looking around, other questions come to mind as well. Such as: What does Bolivia intend to do with these imposing gray heaps of magnesium waste? The government points out that magnesium chloride can be used to deice roads, but it stretches credulity to imagine that it being put to such use. For that matter, to separate the magnesium from the lithium, lime is the most economically viable means. The Bolivian government claims that it has a unique processing method that will somehow reduce residual lime waste. But just how much is speculative. According to Bolivian geologist Juan Benavides, “The environmental impact in Chile and Argentina is low. But we’re not able to extrapolate really, because the magnesium content in Bolivian lithium is very high we know is that lime is going to be used in greater quantities and that lithium regulations and laws in Argentina and Chile are more stringent than in Bolivia.”

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Wilmer Flores, his face shielded to protect against sunburn, collects salt, as do many Aymara and Quechua who live near the Salar.

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“We’re very proud of the preventive measures we’ve taken to reduce any impact,” García Linera told me. “They’ve cost us a lot of money, in fact.”

But it’s nearly impossible to assess how an industrialized version of its lithium facility will change the Salar de Uyuni. Among the greatest concerns is how much water will be required to extract the lithium. Two rivers, the Río Colorado and the Río Grande de Lípez, flow into the salt flat. The former is thin enough to be a creek; the latter, shallow enough to wade across. Both are crucial to the local growers of quinoa, of which Bolivia is the second largest supplier, after Peru. Though the Bolivian government insists that 90 percent of the water it uses will come from surface water rather than underground aquifers, some experts are skeptical that the groundwater supply will be unaffected. “Year after year, the water is going to be the major resource that is needed,” Ballivián said. “They’ll need vast quantities, more than any other mine in Bolivia.”

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And finally, there's the still mostly unspoiled surface of the Salas y Armada National Park in Chile. Though revered by human visitors for its seemingly boundless austerity—disrupted only infrequently by patches of cactus-covered, islandlike mountains—it's also a breeding ground for Chilean flamingo. “Our plant is located far away from these sanctuaries,” García Linera adding, “This demonstrates our commitment to the environment.”

Several dozen evaporation pools, some more than 10 football fields long, pock the salt flat, far from where a visitor might encamp some s evening with a blanket and a cell phone blaring Pink Floyd. But these obscure indentations are meant to accommodate what is now a mere fraction of Bolivia's intended annual exploitation of the Salar.

Furthermore, as a vice minister of energy, Luís Alberto Echazú Alvarado indicated to me, "Our vision is this is a long-term project. So you have mix poor and rich brine so as to exploit the whole Salar."

"So the government will always drill throughout other parts?" I asked.

"Right, right," Echazú said, nodding vigorously. "Always."

Flags left by tourists from around the world flutter in the wind on the Salar. Drawn by its austere beauty, visitors to Bolivia have flocked to the remote region. Tourism has become the economic mainstay of new towns, such as Colchani and Uyuni.

As I traveled to the dusty villages abutting the Salar de Uyuni—Colchani, Tahua, Chilitaico, Llica—occasional signs of support for Morales would materialize on public walls: “Evo Sí!” But on the subject of Morales’s lithium brainchild, residents responded with a weary skepticism, sometimes tinged with worry.

Many Aymara in the region work as *saleros*, harvesting salt and selling it to processing plants. A salt farmer named Hugo Flores, sitting beside his half-rusted pickup truck, told me, “We’ve received no information from the government. We don’t even know what lithium is or what its benefits are, what its effects are.” More pointedly, a councilwoman in Tahua named Cipriana Callpa Díaz said, “No one in this municipality is working on the lithium project. We thought there’d be work for our people here, with good salaries. It’s very disappointing.” When I relayed this sentiment to Parra, the Llipi plant director shrugged helplessly and acknowledged that there were few jobs for unskilled workers in lithium processing. “Children are advised to go to university and come back with degrees,” he said.

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Three generations of the Copa family live in four one-room buildings in Chilitaico near the northern edge of the Salar. Like many of the Aymara who live in the region, the family makes money by collecting salt from a small plot, often laboring 12 hours a day in intense sunlight and brisk wind.

Perhaps the most vehement dissatisfaction was expressed by Ricardo Aguirre Ticona, who is the council president of Llica—the cap

of Daniel Campos Province. Almost the entire Salar lies within the province.

“We understand that once the plant is fully up and running, it will be a multimillion-dollar business,” he said one afternoon in his cluttered office. “The skepticism is whether we’ll get any of that. Those who should benefit first are the ones where the production is taking place... And it’s not just cash benefits. There should be a faculty of chemical science established here, or scholarships, so young people can have a future. It’s been three years we’ve been asking for this. Now we’re asking for an audience with the president. He hasn’t been here for a long time.”

Aguirre measured his next words carefully. “The Bolivian population is patient,” he said. “But if necessary, it will take measures to be heard.”

In Bolivia, his statement needs no elaboration. In 1946, the population decided it had no more patience for President Gualberto Villarroel, who initiated labor reforms but enforced repressive measures when miners made more demands. Angry Bolivians raided Villarroel’s palace and killed him. They strung his body to a lamppost in Plaza Murillo—the square adjacent to the palace where I’d met with the vice president to discuss the latest plan to reform Bolivia’s economy. I thought about that dark reminder from the past as I left Llica in the SUV and barreled once again through the colorless daydream of the Salar, an illusion of simplicity that could go on forever but in fact does not. 🟡

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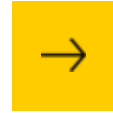
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