LATIN AMERICA'S LITHIUM:

PERSPECTIVES ON CRITICAL MINERALS AND THE GLOBAL ENERGY TRANSITION

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Photo Credit: Patricia I. Vásquez

INTRODUCTION

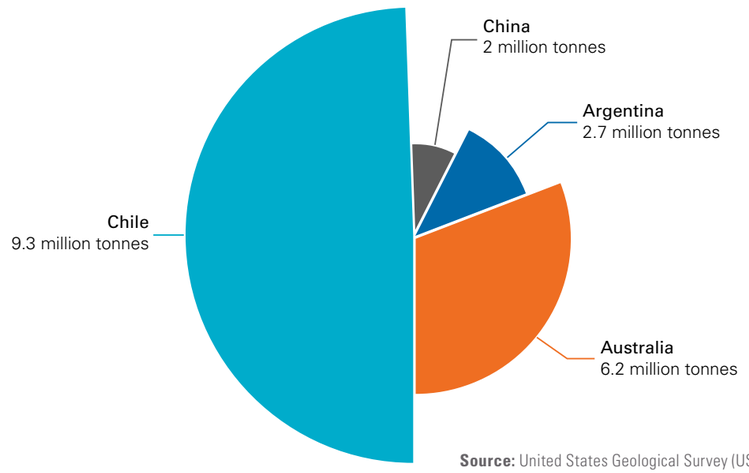
Patricia I. Vásquez

In the 1800s, a general led an army across the Andes mountains from Argentina to Chile in one of history's most heroic crossings, liberating both territories from Spanish rule. José de San Martín and his Andes Army encountered dramatic weather and stark landscapes on both sides of the Andean Altiplano (high plateaus). They traversed mountains as high as 13,000 feet above sea level, across the dry, yellow steppe of the humid and windblown Argentine Altiplano to arrive in Chile's barren, frigid desert.

More than 200 years later, the extreme climate of the Andes is at the center of yet another epic revolution, one that will transform a global economy that runs on contaminating fossil fuels to one fueled by renewable energy. The same Andes that forged Chile and Argentina's path to independence are today enabling that global energy transition and spurring local economic growth. That is because energy transformation is only possible thanks to the lithium-ion battery (LIB) that allows for the storage of renewable energy. Small LIBs store energy in the portable electronic devices we depend on daily, while larger ones power electric vehicles (EVs).

Chile has the world's largest known reserves of lithium, followed by Australia, Argentina and China (Figure 1). Lithium is found in three types of deposits: clay, hard rock, and brines. Today, lithium is primarily produced from hard rock in Australia, and high-altitude brines in Chile and Argentina. China has both hard rock and brine deposits.

Figure 1: Lithium Reserves Per Country (2022)
(Million Tonnes)



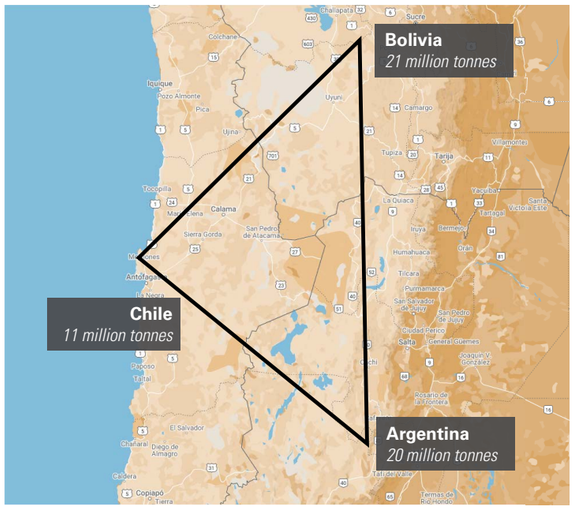
Source: United States Geological Survey (USGS), *Lithium*, 2023

High in the Andes, surrounded by volcanoes, vicuñas, and flamingos, where oxygen levels are low, howling winds are constant and solar radiation relentless, lie the most extensive brines in the world. They contain the world's largest amount of the most sought-after lithium reserves. Chile's 9.2 million metric tonnes of lithium reserves are located in the Atacama Desert, and Argentina's 2.2 million tonnes are in salt flats scattered throughout the country's Altiplano.[1] [2]

Further north in the Andes, the world's largest identified lithium resources, 21 million tonnes, are in Bolivia, sometimes called "*the Saudi Arabia of Lithium*."[3] But unlike Chile and Argentina, the commercial potential of Bolivia's lithium deposits has not yet been determined. Bolivia does not produce lithium at any significant volume. The Bolivian government is in the process of engaging foreign companies to develop its lithium.[4] Similar attempts failed in the past. In January 2023, the government announced that a consortium of private companies led by China's CATL had won one of the bidding rounds. CATL is the world's number one manufacturer of batteries for EVs.

These three countries – Argentina, Bolivia and Chile – comprise the Lithium Triangle, home to almost 60 percent of the world's lithium resources, 52 million tonnes. (Figure 2)

Figure 2: Lithium Resources in the Lithium Triangle (2022)



Source: United States Geological Survey (USGS), 2023

Lithium has started to shape world energy geopolitics and is at the center of the climate change debate. The pandemic and Russia's invasion of Ukraine led to the realization among Western nations of the dangers of depending on one source of imports for critical materials, be it surgical masks from China or natural gas from Russia. In response, President Biden launched the Inflation Reduction Act (IRA), a $369 billion initiative to develop the whole lithium value chain in the U.S. and in so doing, reduce outside dependence.[5]

For now, China dominates the world production of battery parts, such as cathodes, anodes, and batteries themselves, using lithium from Australia and South America. The U.S. government is set on reducing China's overwhelming presence in the lithium downstream portion of the value chain. To get there, the IRA offers tax credits for battery production at home, provided the necessary critical minerals are mined and processed in the United States or in countries with whom the U.S. has free trade agreements, such as Chile.

Besides dominating the downstream, China has also taken the lead in making sure it has access to the lithium supplies it needs to build the batteries. Chinese companies have already invested billions of dollars in lithium extraction projects in Argentina. Even Chile, which has tighter restrictions on private investments in its lithium industry, has opened up to China's Tianqi Lithium Corporation, which acquired 26 percent of Chilean lithium company SQM, the world's second-largest lithium producer.[6]

Two of the world's largest and most established lithium mining companies --Albemarle and Livent-- are from the U.S. and have been operating in Chile and Argentina for decades. But there is still a lot of room for the Biden administration to expand U.S. presence in the Lithium Triangle, be it in the form of new investments, technology transfer, or scientific research, to name a few. Lithium offers the U.S. a unique opportunity to reclaim its leadership in the region, where production of the metal is expected to expand beyond the Lithium Triangle frontiers in the near future.

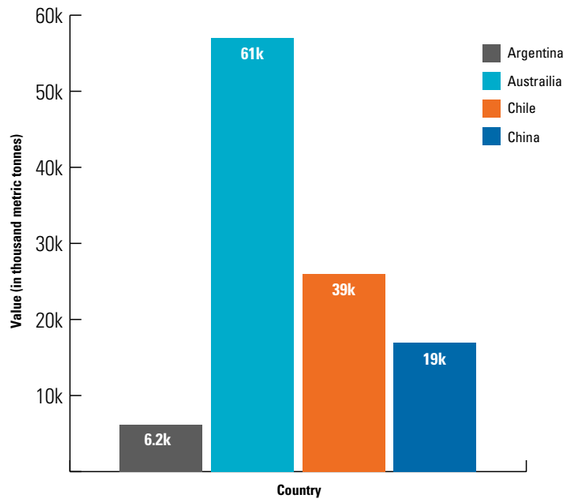
Besides Chile, Argentina, and Bolivia, other countries with lithium potential in Latin America include Brazil, Peru, and Mexico. A hard-rock lithium project in Brazil –Grota de Cirilo-- operated by Sigma Lithium is well advanced, and the country is expected to become a significant producer in the near future.[7] In Peru, American Lithium is in the process of obtaining the necessary permits for developing its Falchani hard-rock lithium project, while China's Gangfeng has been developing the Sonora lithium project in Mexico. Lithium resources in Mexico are mainly found in clay deposits, a kind of reservoir that no one has ever mined at a commercial scale. Earlier this year Mexico announced the creation of a state-owned lithium company and nationalized the country's lithium.[8] That left the Chilean and Argentine sprawling Altiplano brines as the most promising opportunity for rapidly ramping up global lithium production.

By some estimates, world demand for lithium is expected to increase fortyfold by 2040, mainly for use in EVs and batteries for renewable energy storage.

By some estimates, world demand for lithium is expected to increase fortyfold by 2040, mainly for use in EVs and batteries for renewable energy storage.[9] As a result, Argentina has been flooded by private lithium investments. Investment announcements in lithium projects have reached almost $4.2 billion since 2020, lured by attractive tax incentives and relatively low royalties.[10] In Chile, the country's two lithium operations are expanding their output, and exploration has started in undeveloped areas.

Almost a decade ago, Australia topped Chile as the world's number-one lithium producer.[11] In 2022, Chile produced 39,000 tons of lithium compared to Australia's 61,000 tons. China is in third place, followed by Argentina, producing 19,000 tons and 6,200 tons, respectively (Figure 3).[12]

Figure 3: Lithium Production per Country (2022)



Source: United States Geological Survey (USGS), *Lithium*, 2023

Despite holding the largest lithium reserves in the world, Chile's production has stagnated during the past decade as a result of strict private investment restrictions. Chilean law deems lithium a strategic resource that can only be developed by the state or by private companies in association with the government. Chile also imposes caps on lithium brine extraction, and companies are required to sell 25 percent of their output locally at below-market prices, to producers that commit to developing the lithium value chain within the country.[13] The 25 percent requirement has not yet been applied because there are no offers to produce lithium-related products in Chile.

There are two companies producing lithium in Chile, in the *Salar de Atacama*, Chilean SQM and American Albemarle. Both negotiated increased production quotas in 2018 and are expanding output. SQM is allowed to produce 180,000 tons of lithium carbonate equivalent (LCE), the chemical that results from processing lithium found in brines, and which is used in batteries. Albemarle's production quota is 145,000 tons of LCE. In both cases, the quota expires at the end of their contracts, 2030 for SQM and 2043 for Albemarle.[14] [15] In addition, state-owned copper company Codelco has started lithium exploration in the *Salar de Maricunga*.

In Argentina, the two projects in production – Fenix and Olaroz, operated by Livent and Allkem, respectively – are in the process of being expanded, while another 36 are at different stages of development.[16] A law that guarantees fiscal stability for 30 years has been particularly important for attracting investors, given Argentina's infamous macroeconomic instability and frequent regulatory changes.[17] If all these projects come to fruition, the government says current production of 37,500 tons of LCE could increase tenfold in coming years.[18]

The main driver behind skyrocketing lithium demand is EVs. In 2012, just 120,000 EVs were sold worldwide. That same amount was sold in one week in 2021.[19] That EV dynamism is rooted in government incentives, as a growing number of countries have committed to rapidly phasing out internal combustion engines. As EV manufacturing and lithium demand have increased, so have lithium prices, up by almost 900 percent since 2020.[20] That is good news for lithium investors and for countries holding certified lithium reserves, such as Argentina and Chile.

Lithium Triangle brines have the highest relative concentrations of lithium in the world. Producing lithium from brines is relatively cheap and less damaging than hard rock to the environment because it relies upon solar energy. Brine pumped from underground is placed in large evaporation ponds, where it is exposed to the desert sun and winds until the water evaporates and a lithium concentrate is formed. During the process, other salts contained in the brine crystalize and are periodically harvested from the ponds and stored in stockpiles for use in other applications or for disposal.[21] Lithium concentrate is then sent to processing plants, where the remaining impurities are removed. The drawback of the evaporation process is that it is long, it could take from six to 18 months.

There is also concern about the impact of lithium extraction on brine ecosystems. The evaporation process requires large quantities of water, which is particularly problematic in desert areas, such as Chile's Atacama and Argentina's Altiplano, where water is in short supply. Indigenous communities in the Atacama argue that water that is evaporated to concentrate lithium is lost to the atmosphere.[22] Experts are still determining the impacts on brine water sources: some see damage to the brine ecosystem, as well as to local fauna and nearby communities,[23] [24] while others have found that lithium extraction has a lower impact on brine freshwater than activities such as traditional mining and agriculture.[25]

The accelerated pace of lithium development is a concern among governments, companies, and local communities due to its potential environmental and social impacts. For that reason, scientists are exploring technologies known as direct lithium extraction (DLE) in search of faster and more environmentally friendly production techniques that could replace the evaporation ponds. In Argentina, Livent already uses a mix of evaporation ponds and DLE. Other projects in Argentina, such as Eramet's *Centenario-Ratones* and Lake Resources's *Kachi*, will deploy proprietary DLE processes.

This is the first in a series of flagship reports that will discuss the enormous potential in Latin America to meet the world's lithium needs and help drive the global energy transition. This publication and subsequent flagship reports will also address challenges to achieving that goal, including important environmental and social considerations. In addition to expert analyses, these flagship reports will also include reliable statistics to help policymakers, scholars, and civil society organizations better understand this rapidly changing industry.

This first flagship report includes three articles: Henry Sanderson, of Benchmark Mineral Intelligence, describes how the transition to clean energy is reshaping geopolitics as China takes advantage of a "distracted" United States to scoop up lithium resources in Latin America. John Graham and John Rupp, of the O'Neill School of Public and Environmental Affairs at Indiana University, write that South America's lithium potential could be jeopardized by opposition from local communities and environmental defenders. They explore how other mining countries, such as Australia, have addressed these considerations, and whether there could be lessons there for the Lithium Triangle. Finally, Ana Elizabeth Bastida, of the University of Dundee, looks into water use in the production of lithium from brines. She suggests that legal and institutional weaknesses prevent the efficient management of water in the lithium industry in Chile and Argentina.

Photo Credit: Patricia I. Vásquez

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Photo Credit: Patricia I. Vásquez

GREAT POWER COMPETITION IN THE LITHIUM TRIANGLE

Henry Sanderson

When President Biden finished his opening address calling for unity at the Summit of the Americas in Los Angeles last June, Argentina's president stood up and chastised the U.S. leader. President Alberto Fernández said the United States should not have decided who was invited, after Washington had excluded Cuba, Nicaragua, and Venezuela. He also called for the continent to "develop our enormous energy and mineral potential critical to the ecological transition.[1]"

His remarks were a reminder of Argentina's large reserves of lithium, highly sought after in recent years, particularly by Chinese investors. Two months earlier, Fernández had visited Beijing, where he met with President Xi Jinping, laid a wreath at Mao Zedong's memorial in Tiananmen Square and signed up to the Belt and Road Initiative. A month after the Los Angeles summit, a Chinese company, Ganfeng Lithium, agreed to buy an Argentine lithium project for almost $1 billion. It was the second time in the past year that a Chinese company has spent more than $500 million in Argentina's lithium sector.[2]

Argentina's lithium deposits have become a key battleground for the energy transition, as companies from Australia, China, the United States, and Great Britain vie to develop projects in Latin America's third-largest economy. The country's pro-mining policies, including low royalty rates, have accelerated the trend. By comparison, Chile's political move leftward, along with strict rules on lithium exploitation, has frozen private investment there.

Western companies, still the largest lithium producers in Argentina, are lagging behind their Chinese counterparts in investments in new supply. Chinese companies have invested $2.7 billion in recent years in lithium acquisitions in Argentina, compared to less than $1 billion by Western companies.[3] At the same time, countries such as Argentina and Chile are being drawn into China's political orbit by the Belt and Road Initiative, by the "vaccine diplomacy," and by trade.[4]

Lithium is becoming a key part of the emerging geopolitics of the energy transition. Russia's invasion of Ukraine hastened the realization in the West that relying on a potential adversary for critical imports is undesirable, which accelerated a move to reduce dependence on China. Yet China's presence in the battery supply chain is dominant and only growing, especially in countries like Argentina, making it increasingly difficult to strengthen U.S. supply chains without further U.S. investment in South America.

In August, Biden introduced a plan to build a US battery supply chain, a key part of his Inflation Reduction Act (IRA). To succeed, the United States will need a renewed focus on Latin America. The legislation includes significant support for U.S. battery manufacturing, as well as the processing of battery materials. It also sets ambitious targets for critical minerals to be extracted from North America, or from countries with free trade agreements, such as Chile. In particular, it discourages the inclusion of Chinese companies in critical supply chains.

Geopolitics of the Energy Transition

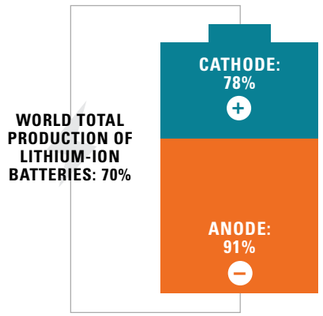
The transition to clean energy will reshape geopolitics.[5] It will "disrupt some economies and cause new dependence on others," as The Economist put it.[6] It will also reconfigure many elements of international politics, leading to competition and confrontation.[7]

Key beneficiaries will be what The Economist dubs "electrostates," countries that produce metals such as copper and lithium. Lithium production is highly concentrated: Australia is the largest producer, Chile the second largest, and China and Argentina come in third and fourth place, respectively. Chile is also the world's number-one copper producer.

Today, most of that lithium is exported to Asia, especially to China, where it is processed into lithium carbonate or lithium hydroxide, primarily for batteries for electric vehicles. Almost all of the lithium from Australia is exported to China in the form of spodumene rock to be processed into the high-purity lithium carbonate and lithium hydroxide used in batteries.

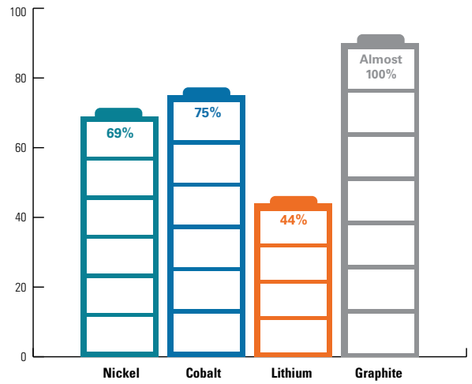
China dominates the processing of battery raw materials. It processes 69 percent of nickel, 75 percent of cobalt, 44 percent of lithium, and produces almost all of the graphite that goes into batteries.[8] China also controls the production of battery components, such as cathodes and anodes, and of batteries themselves. In all, 78 percent of the world's cathode production comes from China, as well as 91 percent of anodes, and 70 percent of lithium-ion batteries.[9]

Figure 4: Percentage of Battery Components Made in China (2022)



Source: *Benchmark Mineral Intelligence*

Figure 5: Percentage of Battery Raw Materials Made in China (2022)



Source: *Benchmark Mineral Intelligence*

China's dominance of clean energy technologies has galvanized the Biden administration's action. The first climate law in U.S. history,[10] the IRA, is an effort to "put the nation on track to lead the clean energy market," according to Secretary of Energy Jennifer Granholm.[11] "If we succeed, the world will take on climate change using technologies dreamt up by American innovators, built with American materials, and assembled by American workers," she said.

The IRA[12] includes tax credits for electric vehicles provided that a certain percentage of a battery's critical minerals are mined and processed in the United States or by countries that have signed free trade agreements with the United States. It also sets restrictions on the use of critical minerals for the manufacturing of electric vehicles by "foreign entities of concern," such as Chinese companies.

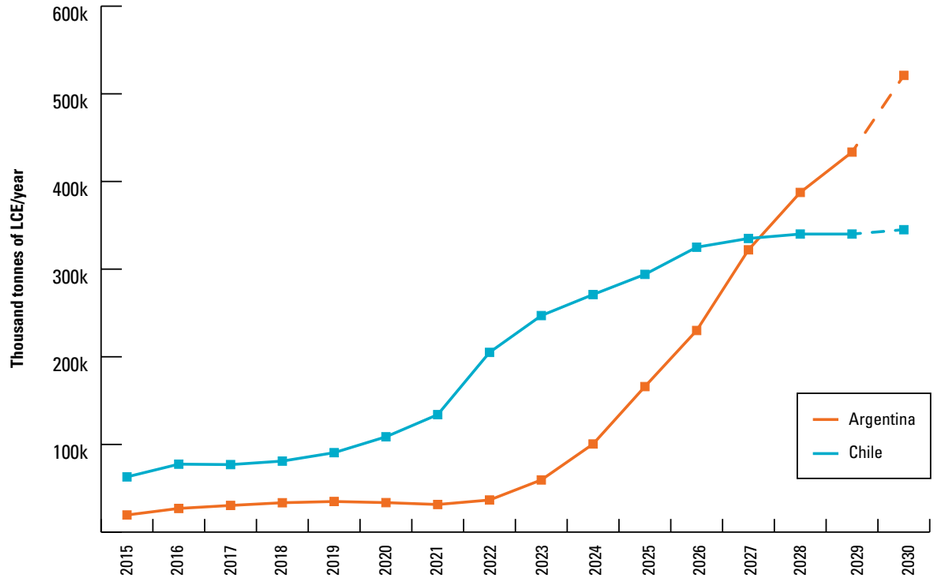
To be eligible for the first half of the $7,500 tax credit for electric vehicles under the IRA, automakers must ensure that by 2024, at least 40 percent of the value of a battery's critical minerals is sourced from North America, or from countries with a free trade agreement with the United States. That rises to 50 percent throughout 2024, 60 percent in 2025, 70 percent in 2026, and 80 percent in 2027. To qualify for the second half of the tax credit, automakers must gradually increase the number of locally produced battery components, such as cathodes, anodes, and copper foil.[13]

The legislation is ambitious, and by some estimates, unlikely to meet its targets in the near term.[14] In order for U.S. automakers to produce electric vehicles that qualify for the tax credit over the next several years, they will need about half of all lithium output from Chile and Australia during that period,[15] as both countries have free trade agreements with the United States. Still, given the importance of the tax credits to automakers in the US, the bill will likely increase the sourcing of critical minerals from free trade agreement countries such as Chile. The country could be a key beneficiary of the legislation if it is able to increase lithium production to meet rising demand, an uncertain prospect for the moment.

Lithium production in Chile has grown from around 63,000 metric tonnes of lithium carbonate equivalent (LCE) in 2015 to over 200,000 tonnes in 2022, according to Benchmark Mineral Intelligence. But its output will only increase to some 325,000 tonnes by 2026, mainly thanks to the expansion of projects already in production. By comparison, production in Australia has surged from 65,000 tonnes of LCE in 2015 to over 300,000 tonnes in 2022, and it is set to almost double by 2026. (Figure 6)

By the end of this decade, Argentina is set to overtake Chile, as its output is expected to grow from 19,500 tonnes of LCE in 2015 to over 230,000 tonnes by 2026, and over 500,000 tonnes by 2030.[16] By the end of the decade, only 40 percent of Argentina's output will come from existing projects, and the rest will be new greenfield developments.[17]

Figure 6: Forecasted Lithium Production for Argentina and Chile



Source: *Benchmark Mineral Intelligence's Lithium Forecast*

In Chile, lithium was declared a strategic resource by former dictator Augusto Pinochet in 1979, which means the country's nuclear commission needs to grant approval for export quotas. In addition, new lithium projects need to get approval via a special lithium operation contract (CEOL, by its letters in Spanish) from the mining ministry. That has kept new investors at bay. The two largest producers, SQM and Albemarle, lease access to the country's salt flats in the *Salar de Atacama*, under agreements with Corfo, the country's economic development body. The contracts are limited by time as well as production volumes. After the leases end, control of the land reverts to the Chilean government. Albemarle has an agreement that expires in 2043, whereas SQM's expires in 2030.[18] Among other investors, some have concessions that pre-date 1979. Lithium Power International is looking to develop production of lithium in Chile's *Salar de Maricunga*, where state-owned copper miner Codelco is also exploring for lithium. But there are few other projects set to rival Argentina's growth.

An auction to attract new lithium investments by former President Sebastián Piñera in early 2022 was rejected by a Chilean court just before the election of president Gabriel Boric in March of that year. Boric, a left-wing former student leader, campaigned on the promise to create a state-run lithium company. Chileans recently rejected a draft constitution that would have incorporated new environmental regulations and expanded indigenous land rights in ways that would have discouraged investment in the lithium industry.[19] The country is now working on the next steps in the constitutional reform process.

For now, Chile applies a sliding scale royalty system for lithium, which increases to 40 percent when the price of lithium carbonate exceeds $10,000 a tonne, or when the price of lithium hydroxide passes $11,000 a tonne. SQM reported an average selling price of $54,000 a tonne for the second quarter of 2022.

Argentina, in contrast, imposes a relatively low, flat 3 percent royalty on lithium – a legacy of Carlos Menem's 1990s free-market government. As a result, Argentina is likely to be Latin America's key source of growth in lithium supply this decade amid a wave of investment in the country, according to Benchmark Mineral Intelligence. Argentina will probably become the largest lithium producer in Latin America by the end of the decade.

Unlike Chile, Argentina does not have a free trade agreement with the United States, although its lithium could be processed in the United States to be eligible for incentives under the IRA. In fact, U.S. producer Livent already processes in North Carolina some of its lithium extracted in Argentina. For that reason, Argentina could play a key role in meeting U.S. demand. Before passage of the IRA, a number of U.S. automakers had signed lithium supply deals with companies in Argentina, including Ford with Lake Resources and General Motors with Livent. By 2025, Livent expects to deliver GM all of the lithium hydroxide it produces using lithium extracted from Argentina.[20]

That said, U.S. Livent has been slow to expand its production capacity in Argentina over the last two decades, one example of how Western lithium producers are ceding ground to their Chinese rivals with stronger financial capacity and willingness to invest in new projects. The U.S. could fail to enjoy the full potential of the IRA to expand its lithium supply options, unless Western lithium producers start stepping up their investments in South America to expand production there.

A Dragon in the Lithium Triangle

In coming years, Livent could lose the dominant market share it enjoyed for over 20 years. The U.S. major was the earliest lithium producer in Argentina, beginning in 1994 at its plant in the northwest *Salar del Hombre Muerto* salt flat. At the time, Latin America was undergoing a mining boom driven by investor-friendly policies in Peru, Chile, and Argentina. U.S. mining companies were some of the largest investors in gold, silver, and copper in the region.[21]

The *Salar del Hombre Muerto*, which was initially to produce 7,700 tonnes of lithium carbonate a year, was producing 15,000 tonnes a year by 2017. Yet five years later, despite high lithium prices and the rapid expansion of electric vehicles, Livent is forecast to produce just 20,000 tonnes a year, due to a lack of investment in new production and expansion. Today, that amounts to 55 percent of Argentina's output. But by 2030, despite Livent's plans to expand production capacity, it will likely account for only 14 percent of the country's output, due to increased competition mainly from Chinese companies.[22]

Chinese companies are the leading investors in greenfield lithium projects in Argentina, where they have invested over $2.7 billion, led by Ganfeng Lithium and Zijin Mining.[23] By 2030, at least 26 percent of the country's lithium will originate in projects with Chinese involvement, according to Benchmark Mineral

Intelligence. Last year, for example, Zijin Mining bought Canada's Neo Lithium for $737 million, and Tsingshan, the world's largest producer of stainless steel, announced it would invest $375 million to build a lithium plant in Argentina, alongside the French mining company Eramet. Neo Lithium has rights to the T*res Quebradas* project in Argentina's Catamarca province.

Earlier this year, Ganfeng Lithium – China's largest lithium producer – agreed to pay $962 million to acquire Lithea, which owns assets in the *Pozuelos* and *Pastos Grandes* salt lakes, both in the province of Salta. Also in Salta, Ganfeng owns the *Mariana* lithium project, in the S*alar Llullaillaco*. And in the province of Jujuy, Ganfeng holds a 51 percent stake in the *Cauchari-Olaroz* lithium project, alongside Lithium Americas. *Cauchari-Olaroz* is set to start production this year. A host of smaller Chinese companies have also invested in Argentine lithium, including Chengxin Lithium, Tibet Summit Resources, Zangge Mining, and battery producer Gotion.

Across the border in Chile, Chinese companies have also invested in lithium production, although on a lesser scale, given the country's production and investment restrictions. In 2018, Tianqi Lithium bought a 24 percent stake in SQM for $4 billion.

Chinese lithium largesse in South America seems to have a few strings attached.

Chinese Political Overtures in the Lithium Triangle and a "distracted" U.S.

China's investments in South America's lithium parallel its efforts to boost its political engagement in the region. Over 20 Latin American countries have signed onto China's Belt and Road Initiative (BRI), including Chile and Argentina. The region was not on the radar when President Xi Jinping established the BRI in 2013,[24] but China invited Latin America to join in 2018.

That same year, the Chinese government became involved in a high-profile lithium investment in Chile when lithium giant Tianqi Lithium acquired a 24 percent stake in Chile's SQM, one of the world's top five lithium producers. Chilean authorities initially feared the purchase would grant the Chinese near monopoly power. But China's ambassador to Chile, Xu Bu, warned against blocking Tianqi Lithium from acquiring a stake in SQM, saying it would have "negative influences" on Chile-China ties. Between 2015 and 2019, Chinese Foreign Minister Wang Yi visited Chile four times.[25] A Chilean antitrust court ultimately approved the deal.

In addition to the BRI, Argentina hopes to join the BRICS grouping of Brazil, Russia, India, China, and South Africa.[26] Argentina's growing ties to Beijing have contributed to the sense that the United States has "lost" Latin America.[27] To Kevin Rudd, the former Australian prime minister, China is benefiting from "a distracted America no longer actively committed to the Western Hemisphere, and allowing China" to fill that opening.[28]

China's advances in Latin America and the advent of electric vehicles are causing the United States to refocus. U.S. Southern Command Commander Army General Laura Richardson told the Aspen Security

conference last year that the United States needed to act not like the region's "big brother", but as its partner.[29]

While Chinese investment in Argentina has been dominant, Western companies have not been entirely absent and have lately started to take a more dynamic role. Rio Tinto, for example, agreed to buy the Rincon lithium project in Salta province for $825 million in late 2021. Also in Argentina, Canadian company Lithium Americas beat Chinese battery company CATL to acquire Millennial Lithium for $400 million, giving it access to the *Pastos Grandes* brine project. North Carolina-based Albemarle is the second-largest producer of lithium in Chile after SQM. The company has said it will build a lithium refinery in the United States with an annual capacity of 100,000 tonnes by the end of the decade, an essential step towards further integrating Latin America into U.S. supply chains.

A key opportunity for the United States could be to help Argentina create more value from its lithium by supporting the construction of lithium processing, battery, and manufacturing facilities in the country. So far, however only China has made moves in that direction, by taking advantage of Argentina's desire to add value to its lithium by increasing its role in the global battery supply chain, and by building more local manufacturing.

The last time China's demand for the region's commodities increased, in what analysts call the "China Boom," the region failed to take advantage of the good fortune to invest in long-term sustainable growth.[30] Will that be different with lithium? The results have been mixed for now.

In Argentina's Jujuy province. The provincial lithium company, Jujuy Energía y Minería Sociedad del Estado (JEMSE), signed a deal in June with the Chinese battery producer Gotion to construct a lithium carbonate refinery plant in Jujuy, and use the lithium in locally produced batteries. Another Chinese battery company, Sunwoda, said it would invest in lithium mining in Argentina through a joint venture with Jinyuan EP and Guizhou Chanhen Chemical.

Similar attempts in Chile were less successful. In 2017, the country's economic development body, Corfo, offered battery manufacturers supplies of lithium at preferential prices to encourage the industrialization of the mineral. While there was initial interest from Samsung and Posco, among others, the attempt failed.[31]

For now, Argentina and Chile are benefiting from the increasing value of lithium exports. This year, for example, lithium revenue in Chile exceeded government earnings from state-owned copper giant Codelco.[32] By some estimates, by 2040 worldwide lithium exports could exceed $500 billion annually, including $193 billion for Argentina, and $97 billion for Chile.[33]

Lithium carbonate prices, which rose by 400 percent in China in 2022, could give countries such as Argentina and Chile significant leverage to build industries that depend upon lithium.[34] Still, it could be difficult for South America to be competitive with battery makers in Asia, given its distance from major markets, among other factors.

What's Next

Biden's Inflation Reduction Act (IRA) is a key opportunity for the United States to refocus on Latin America and its rich natural resources. To meet the goals of the legislation, the United States will need the lithium produced by Chile and Argentina.

That means that the United States will need to step up investments in the region to ensure there is enough supply not controlled by Chinese firms. So far, the West is lagging behind China in new investment in Argentina, which is expected to be the region's biggest producer by the end of the decade.

Moreover, geopolitical competition between the United States and China could benefit the region by providing further incentives for Western investment. Argentina's lithium is already a key battleground, where companies from the United States, Australia, Canada, and China are jostling for deposits.

Photo Credit: Patricia I. Vásquez

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LITHIUM MINING IN SOUTH AMERICA: THE QUEST FOR SUSTAINABLE SUCCESS

John D. Graham, John A. Rupp

Recent estimates are that global lithium production will need to grow by almost fourfold by 2030 to meet the projected global demand for lithium-ion batteries (LIBs).[1] The world is not running out of lithium; there are ample amounts of lithium reserves that could be extracted to satisfy global demand.[2] Since roughly half of global reserves reside in what is known as the Lithium Triangle – formed by Chile, Argentina, and Bolivia – it is natural to expect that mines in this region will satisfy much of the global lithium demand by 2030.

The global auto industry is under its biggest transformation since the demise of the horse and buggy. A complete phase-out of the internal combustion engine could occur between 2030 and 2050 to combat global climate change, reduce oil insecurity, and improve urban air quality. Lithium is needed for the cathodes in the LIBs used in electric vehicles (EVs). In 2020, three million plug-in EVs were sold worldwide; that number is projected to increase to 40 million by 2030.[3]

The global transition to EVs cannot be realized without lithium. Even the most promising replacements for LIBs (solid state, lithium metal, and lithium-sulfur) also require lithium. Progress is being made toward recycling LIBs and/or their components, but those processes are not yet economical and, even if recycling were profitable, the stock of LIBs now in use is not large enough to rely on recycling to meet the surge in demand for LIBs between now and 2030.

Will South American countries expand their lithium mining significantly between now and 2030?

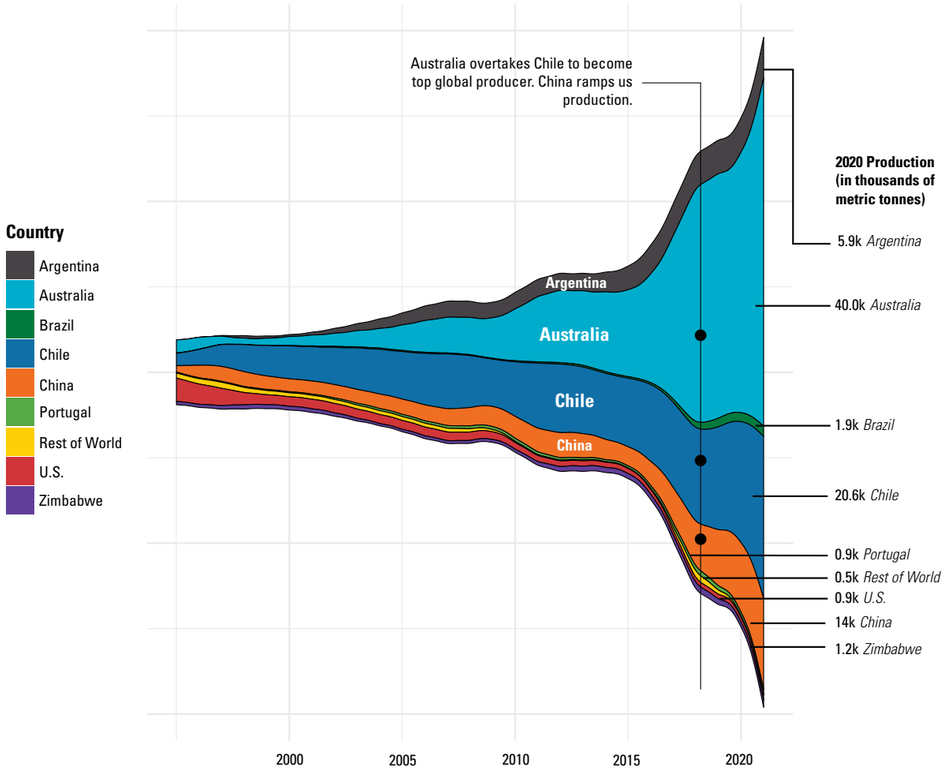
Our analysis suggests that the future of lithium mining in South America is uncertain, even if national political leaders support mining. Insofar as lithium production expands significantly, it will do so only through more successful efforts to understand and minimize the environmental and local economic risks of mining, thus enlisting the support – or at least cooperation – of local communities near mine sites. Well-designed policies are needed to ensure that nearby communities capture tangible, durable benefits from lithium mining.

Lithium mining techniques

Commercially produced lithium is extracted from brines (salares) mainly located in The Lithium Triangle, or from hard-rock in Australia. Lithium found in clay deposits, such as in Mexico, has yet to be developed commercially.

As recently as 2016, Chile was the world's leading producer of lithium, but it has since been overtaken by Australia.[4] Chile's lithium brine operations are technically different and have different ecological impacts and production costs from Australia's predominantly conventional hard-rock mining. In 2020, more than 60 percent of global lithium production came from hard-rock mines, and the remainder from brine operations (Figure 7).

Figure 7. Worldwide Lithium Production by Country (1995-2020) (in Thousand Metric Tons)



Source: *Data from BP Statistical Review of World Energy (June 2022)*

Hard-rock lithium mining may soon occur in South America. A Canadian company, Sigma Lithium, is developing the Grota do Cirilo lithium project in Brazil, the largest hard-rock lithium deposit in the Americas.[5] [6] Also, in Peru's Puna district, American Lithium Corporation operates the Falchani project.[7]

Comparing Different Mining Techniques

Brine operations entail the drilling of wells in a salt flat that is underlain by lithium-rich liquid brines. Brine is then pumped to the surface and directed to nearby large ponds, where exposure to the hot sun and dry desert winds for six to eighteen months leaves behind a lithium-rich salt. The salt is then harvested and transported to a processing facility, where it is converted to lithium carbonate equivalent (LCE) or lithium hydroxide, for use in LIBs.

The capital and energy costs of brine operations are lower than those of hard-rock mining, making the total cost per tonne of LCE lower than the cost of the lithium hydroxide obtained from mining rock.[8] From a greenhouse-gas emissions perspective, brine operations are cleaner than hard-rock mining, as the sun and desert winds do much of the work.[9]

But there are some environmental disadvantages of brine operations. The evaporative ponds occupy large areas of desert land. The concession for the Fenix lithium mine in Argentina's *Salar del Hombre Muerto*, for example, covers 126,000 square miles in the province of Catamarca. Operations also utilize large amounts of brine: for example, for each tonne of LCE produced, approximately 2 million liters of brine are evaporated. Although brine is not a source of drinking water, it is an important part of the hydrological system of this very dry region, and its withdrawal may impact the associated potable sources of water.

More than a dozen developers worldwide have been experimenting with alternative methods of lithium mining that might reduce or eliminate the need for evaporation ponds. The most promising technique is direct lithium extraction (DLE), where lithium is separated from the brine and then the brine is returned to the reservoir.[10] DLE is not a single technology, but rather an approach that uses a variety of different solvents and techniques to separate the lithium from the brine.[11] The process could be less costly and more sustainable than brine because it eliminates evaporation ponds and thus land reclamation, and with less waste, the cost of managing it is lower. However, some DLE technologies consume large amounts of freshwater and generate significant quantities of byproducts that require management. Most DLE projects are at the pilot stage, far from large-scale commercial production, and are unlikely to make a major contribution to global lithium production in the next decade.[12] The only commercial-scale application of DLE is currently at Livent's Fenix project, in Argentina, where the company also continues to use evaporation ponds. At the Fenix facility, the DLE technique applied uses freshwater to separate the lithium from the brine, in a process known as selective absorption. The brine at the *Salar del Hombre Muerto* has an unusually high lithium content and few contaminants, which makes the separation process easier.

Hard-rock mining has its own advantages and disadvantages. It produces lithium hydroxide desired for use in low-cost batteries. The time it takes to start production from a new site is much shorter –some 3-4 years— than for brine operations, which takes some 7-10 years. Regulators and communities are often familiar with hard-rock mining because similar techniques are used for other materials, such as for example copper and nickel. In comparison to brine operations, hard-rock mining utilizes less land, though the land and hydrology are more severely disrupted. In addition, hard-rock mining consumes more freshwater and energy, has a larger carbon footprint and as mentioned, has an overall higher production cost per tonne of LCE.[13]

Opposition to Lithium Mining in Argentina and Chile

Beginning in 2015, the Chilean government, in cooperation with SQM and Albemarle, made efforts to expand lithium mining in the country. Those efforts triggered intense, well-organized opposition from indigenous groups, along with local and international environmental groups. There are varying motives

for the opposition, but the most common theme is concern about scarce water resources.[14] The Chilean government also became concerned in the past about SQM violating its brine use permitted quota.[15]

The Atacama region is one of the driest places in the world: meaningful rainfall of about 1.5 inches occurs only once per century on average. Despite the dry conditions, the region is home to protected wetlands, extraordinary wildlife, endemic animals, and unique microorganisms. High volumes of brine withdrawal have been associated with measurable changes to regional hydrology and increases in local temperatures, putting lithium mining activities as one of the major stressors leading to local environmental degradation.[16] [17] [18]

Environmental concerns were first expressed by leaders of indigenous groups. They reported anecdotal evidence of diminished productivity of desert farms near lithium mining sites. They also reported harm to desert and wetlands wildlife. Recent evidence revealed a 10 percent decline in flamingo populations near brine operations in Chile. Insofar as the anecdotal reports reflect a pattern of ecological disruption, the pattern may not be due entirely to lithium mining, as climate change can have similar disruptive effects.[19] [20]

A more ecological study of brine operations is a priority.[21] A group of international companies with interests in lithium for EVs – including BASF, Mercedes-Benz, Daimler Truck, Fairphone, the Volkswagen Group, and BMW – formed the "Responsible Lithium Partnership" in 2021.

Recent evidence revealed a 10 percent decline in flamingo polulations near brine operations in Chile.

One of its first actions was to commission an additional scientific study of water issues in the Atacama region. The Partnership hopes that the new scientific findings can inform corporate decisions about the sourcing of lithium.[22] Already, the Chilean government has imposed tighter restrictions on the amount of water used by both SQM and Albemarle. Those restrictions, in combination with a temporary 2018 slump in lithium prices, and a market shift from lithium carbonate to lithium hydroxide (for lower-cost batteries), caused SQM and Albemarle to delay temporarily their ambitious plans to more than double lithium production in Chile. Those plans have resumed with the recent surge in lithium prices. Given the major changes in governance occurring in Chile, where a debate over constitutional reform is underway, the country's lithium regulatory system may undergo additional changes in the near future.

In Argentina, the government is keen on expanding lithium mining, beyond the two mines currently in production. Argentina has 36 lithium projects at various development stages, contributing substantial foreign investment.[23] [24] The Mina Fenix and Salar de Olaroz mine, located in the province of Catamarca and Jujuy respectively, are the only two producing operations. Earlier this year, American Livent announced a $1.1billion expansion of its Fenix mine, which has been operating for more than 20 years, with the goal of tripling its current annual production to 60,000 metric tonnes of lithium carbonate by 2025.[25] Salar de Olaroz is operated by Sales de Jujuy, a joint venture between Australian Allkem, Toyota, and Jemse, Jujuy's provincial lithium company. A third project --Cauchari Olaroz—also located in Jujuy, is expected to be the next to start producing. Cauchari is a partnership between Canadian Lithium Americas,[26] Chinese Gangfeng, and Jujuy's provincial lithium company Jemse. And the state-owned oil company YPF has announced its intent to prospect in Fiambala in the Western Catamarca province, a partnership with local mining firm Catamarca Minera y Energetica.[27]

Lithium mining is not as controversial in Argentina as it is in Chile, in part because Argentina's mining sector is newer and much smaller. However, the rapid expansion of lithium mining could stimulate more controversy in Argentina. One of the most commercially promising areas for brine operations is Jujuy, where there are at least ten different indigenous groups.[28] Many of these groups oppose brine operations for the same reasons opposition groups express in Chile.[29]

Lessons from Australia

Australia has not experienced the intense local opposition to hard-rock mining that other countries have witnessed recently. In Portugal, Serbia and North Carolina, promising recent plans for hard-rock lithium mines were abandoned or delayed indefinitely due to well-organized opposition by local communities and environmental groups.[30] [31] [32]

Why is hard-rock mining acceptable in Australia but not in some other countries? Several factors are relevant. The hard-rock mining occurs in Western Australia, far from the prosperous population centers of Sydney and Melbourne. Western Australia has a pro-mining culture because citizens have been familiar with mining for more than a century and appreciate the economic stimulus in a region with relatively low household incomes and poor community infrastructure. Surveys show that Australians see mining as more than a source of job creation; it leads to improved roads, ports, and community facilities.[33]

Australian miners have also generally tried to respond to local concerns when they arise. Highly effective dust-suppression systems protect Australian miners and local communities from dust exposures.[34] In some cases, mining companies have trucked wastes 250 miles away from the mine sites rather than disposing of the wastes in the communities where mining occurs. And the non-profit sector in Australia is brokering improved dialogue between miners and indigenous communities.[35]

But Australian mining operations are not free of controversy. For example, the disposal of lithium-mine tailings is a source of community concern in small towns in Western Australia.[36] [37] There are also concerns about Chinese ownership of Australian mines and the implications for Australia's relationship with the central government of China.

One should not assume that a vibrant hard-rock lithium mining industry will emerge in Brazil or Peru as it has in Australia. That will depend in large part on whether developers in Brazil and Peru can manage local community concerns at hard rock mines.

Expect Some Opposition to Any Large Mining Operation

The reactions of local communities to mining are based on risk perception, which is influenced partly by a community's previous experiences with mining and industrial projects.[38] Perceptions are also related to the

quality of the communications between the developer, the government, representatives of non-profit groups, the news media, and community leaders. Developers and the government must focus at least as much on public perceptions of risk as those risks demonstrated by scientific evidence.[39] Overall, some opposition to any mining is inevitable, although the extent of opposition will be site specific, and the opposition may have nothing to do with the commodity being recovered or the specific technologies used to mine.

Lessons Learned for the Lithium Triangle

Since the success of any new mining venture is dependent on the support of numerous local and distant stakeholders, the operator's relationship with those groups is key to the overall success of the operation. Operators must fully engage with stakeholders and invest in the welfare of host communities. It is crucial that operators demonstrate their dedication to stewarding the natural resources and protecting the impacted ecosystems close to their operations.

In the Lithium Triangle, developers need improved water management systems to ensure its efficient use during lithium operations in brines. It is technically feasible to generate more lithium output from the same amount of brine. Both SQM and Albemarle are moving in this direction.[40]

Fruitful mining governance calls for effective and enforceable statutes that regulate mining from initiation to post-operations closure and the reclamation of the mined lands. The conditions in each mine operator's permit should be highly specific, measurable, and enforceable in an objective manner. Adequate financial surety bonding requirements and closure procedures are necessary to ensure that a mined site will be properly cleaned and restored even if its developer goes bankrupt.

Strict regulations are also in the interest of the mining industry. Failure to regulate adequately leads to harmful incidents that breed hostility in the host community. A stigma may apply to a specific mine and company and an entire mining sector. Once mining is stigmatized, it is very difficult for that stigma to be removed.[41]

Since South American countries do not have a history of strict regulatory governance, are there additional ways of ensuring responsible lithium mining practices? The answer is yes, thanks to the increasing importance of traceability in lithium operations. Global automakers are under increasing pressure from shareholders and other investors to certify that their supply chains satisfy rigorous environmental and social protection standards. For example, when Ford and BMW accept lithium from mines in Argentina, they can insist upon independent, third-party certification that the mines engage in best practices. Companies such as Underwriters Laboratories and NSF International, which already perform certifications of the safety of engineering and food systems, can play a similar role in certifying responsible mining practices.

To minimize adverse public reactions to mining operations, mining companies must also inform and regularly consult with local community leaders, environmentalists, nearby residents, and businesses.[42] [43] [44] Consultation needs to occur throughout the entire life of a mine, from when the initial plans are developed to when a site is cleaned and closed. A successful example is the Community Environmental Monitoring Program at the Eagle Mine in Michigan.[45] A consultation allows mine operators to understand community concerns and devise countermeasures that address them before a mining operation is stigmatized in the local community.

Good consultation practices have not always been present in Chile's lithium projects. The Atacama Indigenous Council, representing 18 desert communities, has denounced lithium companies and the Chilean government for not adhering to best consultation practices when developing new or expanded mining operations.[46] The Supreme Court of Chile sided with the indigenous groups in a recent ruling about consultation practices.[47] Given water scarcity, the Council has also recommended a moratorium on new lithium mines until water issues are resolved. The Chilean mining ministry is trying to reassure investors after two lithium-mining contracts were voided due to opposition from indigenous groups.[48] [49] [50] Both SQM and Albemarle are implementing new sustainability strategies to reduce brine withdrawals and freshwater use while increasing lithium production.[51] [52]

Providing Benefits to Host Communities: Examples from the Lithium Triangle

While the mining of metals in many nations has historically not resulted in significant benefits to host communities, that is beginning to change.[53] In some cases, residents of local communities are hired to work at mines, which provides tangible benefits to the community. In Argentina's Olaroz flat, operator Sales de Jujuy has hired about two-thirds of its workers from nearby indigenous communities and offers salaries of approximately $1,000 per month, well above average for the region, in addition to providing medical and dental services, and micro-loans.[54] That said, one cannot always count on employment benefits because employees at a mine may be primarily recruited from outside a host community.

Beyond employment, a significant share of the wealth generated by mining should flow to a host community and to nearby communities that incur some of the downsides of mining operations. There are different mechanisms to facilitate wealth transfer, such as taxes and royalties. In Pennsylvania, revenue from creative "impact fees" was funneled to local communities that hosted unconventional natural gas operations, such as fracking. The result was greater community acceptance.[55]

Ideally, this wealth transfer should be integrated into a community's economic development plan, leading to infrastructure and other improvements that enhance the functioning of a community beyond the life of a mining project. In Chile, 3 percent of the total royalties paid by US lithium company Albemarle go to finance projects designed by the Atacama Indigenous Council, and .5 percent are destined to research and development for the Council.[56] Lessons may also be learned from Anglo-American's success at its Quellaveco copper mine in Peru, where 300,000 tonnes per year are mined, while the company's operations help finance the sustainable development of host communities. If a proposed mining operation will not contribute to a community's long-term well-being, community opposition is perfectly understandable. The definition of well-being is not simply economic; it also encompasses values and culture that are unique to a community.

Unless they successfully address environmental and social opposition, South American countries might miss the full extent of the economic potential of their lithium resources. Opposition may limit the development of the lithium industry if communities block projects physically or through the courts, if opposition becomes violent, or if private operators refrain from investing due to the perception of high risk. South American countries have a history of violent protests in local mining communities that failed to enjoy the benefits of mining but suffered its negative externalities. Therefore, governments and developers will need to address the perception of communities living close to lithium operations or they will encounter the same problems. Otherwise, these countries run the risk of not taking advantage of the economic opportunity that lithium resources provide for prosperity in the global energy transition.

Photo Credit: Patricia I. Vásquez

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IN NEED OF A NEW WATER BLUEPRINT FOR GOVERNING SALT FLATS FOR LITHIUM PRODUCTION

Ana Elizabeth Bastida

Metals support the decarbonisation of energy systems. Among these, lithium, the lightest metal, is a key input for the lithium-ion batteries used for electromobility.[1] It is well-known that the salt flats (*'salares'*) of the Central Andes' *Puna* Plateau straddling Argentina, Bolivia, and Chile -an area known as the "Lithium Triangle"- contain the world's largest reserves of lithium, mostly in the form of brines. Lithium in Argentina and Chile, the countries with ongoing operations, is extracted by pumping saline groundwater and letting it evaporate for months in the sun.

Two different tales of the energy transition supply chain have been made visible through contrasting images: on the one hand, carbon neutral, futuristic, and expensive electric cars, and on the other, depleted water sources for communities and ecosystems as pumping might impact the water balance of the salt flats.[2] These divergent images have spearheaded actions, research, and the understanding that something needs to radically change to advance toward a sustainable and just future for all.

Water is at the center of concerns with regard to lithium extraction from Andean salt flats, which are located in some of the driest areas of the planet. The *salares* constitute closed hydrological basins, which store minerals and chemical elements in brines and are greatly affected by climate change.[3] Being fragile and dynamic natural ecosystems, the inadequate management of lithium extraction from brines can affect the water balance within the basin and its surroundings.[4] Many of these salt flats harbor wetlands that are protected under the 1971 Ramsar Convention on Wetlands of International Importance.

Decisions about brine lithium extraction from the Andes salt flats should be steered towards safeguarding their water balance. Decisions should be based on comprehensive scientific knowledge about the dynamics of each hydrological basin, how it interacts with the physical environment where it is located, and how it impacts nearby communities.[5] This information should be the basis for allocating exploration rights and environmental and water permits for lithium extraction from brines, and for the overall regulation and oversight of the lithium extraction process. It should also serve to inform the processes of participation and consultation with local communities. Decisions related to lithium extraction should be also sensitive to the cultural and symbolic values the *salares* may have for indigenous and local populations. In addition, companies operating in the *salares* should strive to introduce technical innovations to minimize the water footprint of their operations, comply with all norms and with the highest Environmental, Social and Governance (ESG) standards, report openly and systematically about water use and impacts, make information transparent, and contribute to the overall water stewardship of the salt flats.

Argentina and Chile, the two countries responsible for the world's largest lithium production from brines, present a range of shortcomings when it comes to making decisions that are coherent with the goal of

safeguarding the water balance of the *salares*. They are also at different stages of the development of policies that set a common direction to take to achieve that goal.

In Argentina, laws that apply to lithium extraction from brines enable the concession of extraction rights on contiguous allotments. The legal and institutional framework that governs environmental and water permitting and oversight, as well as that which applies to the process of consultation with local communities, present several gaps across provinces. Furthermore, some projects have been approved in spite of an overall lack of comprehensive knowledge about the dynamics of the salt flat where they are being developed. There is a good understanding of the way forward in the scientific community and in a few scattered initiatives, but these have not yet percolated into a common vision and policy.

Chile, on the other hand, relies on a contractual system for granting lithium extraction rights and its environmental institutions are stronger than in Argentina. The policy debate about the environmental and social governance of the salt flats has gone much farther. But there is an understanding of the existence of wide asymmetries between the knowledge about the *salares* held by government agencies versus that of operating companies, and of the fact that government learning of the dynamics of salt flats must expand for better regulation and oversight.

In both countries, the instances of infringements by companies operating in salt flats provide a glimpse into the complexities of the task of regulatory agencies, and of the role that ESG initiatives can play to ensure greater accountability. Bolivia, where lithium projects are still at a pilot stage, and more environmentally-friendly technologies are still being tested, could benefit from the experience of its neighbors to design from scratch the basis of a legal and institutional regime applicable to salt flats in ways that safeguard their balance.

The prospect of increased global demand for lithium is expected to bring several new projects into operation soon, particularly in Argentina. That will likely exacerbate existing sustainability challenges and demand urgent solutions. Very high expectations are sometimes placed on the role that ESG guidance and standards applied in mine operations can play in driving lithium production towards sustainable outcomes.

ESGs play a key role in the governance puzzle that leads to sustainability, but it is not enough. Besides ESGs, the governance puzzle should be anchored on deep scientific knowledge of the *salares*, on technical innovations, on a strong institutional design which includes structures at the watershed level, and on multilevel collective actions to spur cooperation. All these elements hold the key to a new water blueprint for governing salt flats in a manner that guarantees sustainable lithium production. The costs for public administrations to generate this kind of knowledge and to establish the administrative structures needed to guide decision-making towards sustainability outcomes have generally been overlooked.

The stakes are tremendously high and call for all actors, including not only host governments, communities, and mine operators, but also car makers, technology companies, and the global community as a whole to steer efforts towards achieving a sustainable stewardship of the water balance of the *salares*.

Multi-stakeholder initiatives based on ESG goals are starting to emerge around *salares* watershed and are making steps in the right direction.

What we know about *salares* and why knowledge is crucial to safeguard their balance

Salt flats are hydrogeological systems which often host fragile lake and wetland ecosystems.[6] Salt flats contain brines or salty water within their perimeter and fresh water in their borders. Lithium is recovered from brines through a process that consists of pumping saline groundwater to the surface for its transportation to evaporation ponds. There, lithium decants by solar and wind evaporation, facilitated by a combination of natural factors as high altitude and extreme low rainfall, a relatively low-cost production process.

Brine pumping can impact the water balance of the basin and disrupt these fragile ecosystems. Experts say that mining companies should strive to prevent the interconnection between brines and freshwaters, not only as a matter of sustainability, but also to preserve lithium reserves. This is the case because pumping can cause freshwater to mix with the salty liquid, which in turn will dilute the lithium content of the brine.[7]

Various factors are thought to determine the impacts of lithium extraction, including the frequency of pumping and the distribution and the location of pumping wells.[8] In addition, current technology for recovery is chemical-intensive and generates large volumes of waste. All salts, other than lithium carbonate, are often discarded as waste.[9] The loss of water through evaporation and the practice of reinjecting residual brines into the salt flats have also raised questions regarding their impact on the salt flats.

Solid knowledge of the hydrology of each salt flat and its water sources is crucial to ensure that lithium is extracted from brines in ways that consider the delicate balance of the *salares*. This information, which is very costly and requires extensive research, can help to determine the operational design of the project, including the location of pumping wells and thresholds for the extraction of brines and water use.

Why institutional design and strengthening is the cornerstone of a water blueprint

Well-resourced, adaptable, and resilient institutions are essential for ensuring sustainable resource management. More coherent institutional design and implementation models are evolving. But in many countries, the laws and institutions that promote investment, and those that protect the environmental and human rights still work in a fragmented manner.

That was the case of Argentina and Chile back in the 1980s and 1990s, when both countries adopted very attractive investment incentives for private companies interested in developing natural resources in their territories. Both countries had general concession systems for granting mineral rights that were managed under rules established by their respective Mining Codes, pursuant to constitutional provisions. During the 1990s, both countries allocated rights for lithium extraction on the basis of specific contracts which were

poorly drafted and disadvantageous for the state and for local communities. Furthermore, the enabling conditions to attract natural resource investments preceded the establishment of institutional and regulatory settings for safeguarding ecosystems, for upholding environmental rights, and for ensuring participatory practices as defined by international environmental and human rights treaties signed by both countries.[10]

Today, Chile and Argentina have different systems for granting rights for lithium extraction, that might impact water stewardship and the sustainable management of salt flats in different ways. In Argentina, there is no specific regime that differentiates the treatment of lithium in brines from other minerals, so that lithium is subject to a common concession system under the Mining Code. Argentina's Mining Code dates from 1886 and was subject to several reforms throughout the years. It establishes a general system for granting exploration rights and concessions that is largely inadequate for lithium in brines. The inherent features of the concession system and the status of concessions as real property have proved attractive to private investment because they provide strong protection to title holders. However, its technical basis is outmoded because it was conceived for vein deposits, that is deposits where the minerals are well-defined in specific rock formations.[11]

Because Argentina is a federal country, provinces own natural resources in their territories and hold jurisdiction over general environmental and water matters. The Mining Code applies nationwide. Back in 1995, the Mining Code incorporated a basic and uniform environmental framework that consists of filing environmental impact assessments for each phase of the activity. Experts have stressed various problems with this framework some of which specifically apply to lithium projects, such as: (1) Some projects have been approved without the prior existence of baseline studies that could provide detailed data of the hydrological composition of the basin;[12] (2) The environmental studies required for the approval of projects generally lack a comprehensive vision of the salt flat in question;[13] (3) Water permits are issued by provincial authorities pursuant to provincial water codes, which in many cases need to be updated; (5) Some of the wetlands within salt flats are protected under the 1971 Ramsar Convention that Argentina ratified in 1992, but there are no specific mechanisms to implement the Convention, which incidentally, does not contemplate

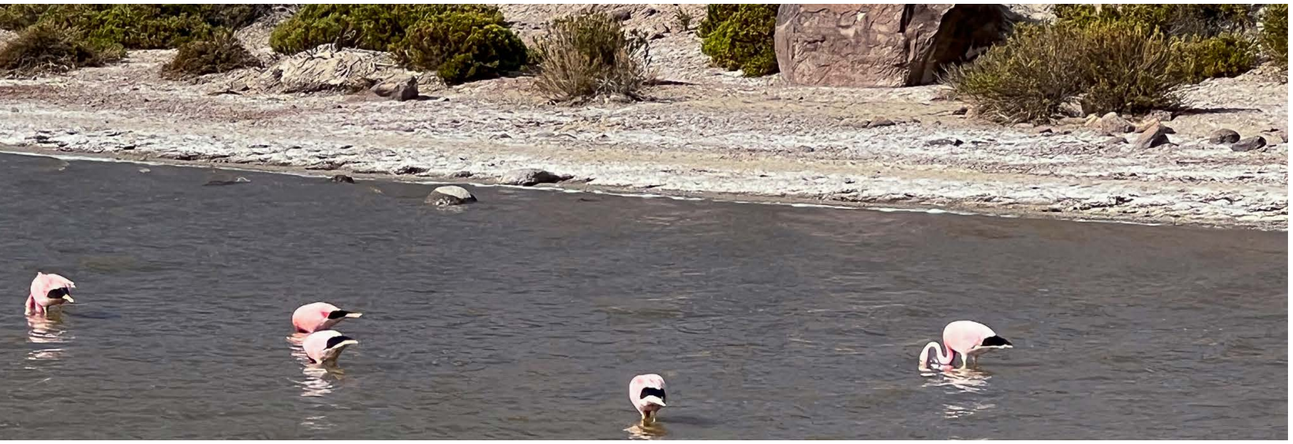

Photo Credit: Patricia I. Vásquez

pumping prohibitions;[14] (6) Citizen participation instruments for mining projects is often limited;[15] There are no legal instruments to implement the obligation of prior consultation with nearby indigenous people pursuant to the Convention 169 that Argentina ratified in 2000; and lastly, (7) Argentina lacks a binding mine closure regime, which typically serves to ensure funds are available following the end of the mine life cycle.

No doubt, there are significant gaps in Argentina's regulatory framework and in its current methodology for environmental assessments. New, more comprehensive, instruments are needed, such as the strategic environmental assessment, the evaluation of the cumulative impact of multiple projects, territorial planning,[16] and institutional structures for integrated management at the watershed level. Argentina urgently needs to redesign the regime so that it is suitable to lithium in brines.[17] There is a good understanding of the way forward in the scientific community and in various initiatives, many receiving support from international organisations, but these have yet to crystallise into a common vision and policy.

Chile's lithium exploration and exploitation regime is different from Argentina's. Since 1979, these activities can only be pursued by the state or its enterprises, or otherwise through administrative concessions or special operating contracts on a case-by-case basis. Lithium is exempted from the general concession regime for granting mineral rights established under the 1983 Mining Code. Two companies have operations in the Atacama salt flat, Albemarle and SQM, under long-term lease agreements with state development agency *Corporación de Fomento de la Producción* (CORFO). Initially, these agreements contemplated modest benefits for the central government, but in 2016, they were renegotiated to increase royalty rates perceived by the authorities and contributions to research and development, and to local communities. The 2016 renegotiations also expanded brine extraction quotas for companies.

The approval of environmental impact assessments of lithium projects is done by the Environmental Evaluation System, in coordination with regional bodies and with input from various public agencies that have environmental competencies. Among these, the Water General Directorate reviews the hydrogeological models of companies operating the projects and decides on brine extraction rates.[18]

In reviewing lithium projects, Chile's environmental agencies try to take a comprehensive approach to water issues so that projects that fall within a same hydrogeological basin must consider overall cumulative impacts and cannot be assessed independently from each other. The main grounds for rejecting environmental assessments is the impact of lithium extraction on the hydrology of the salt flat, particularly due to the lack of credible baseline measurements and hydrogeological models, which help to more accurately predict possible lithium extraction impacts.[19] The environmental assessments of lithium projects have strengthened over time. There have been various instances of administrative sanctions and judicial proceedings against lithium operators SQM and Albemarle for overdrawing brine or water beyond their allotted quotas, and also against copper companies operating in the same salt flat.

But regardless of a seemingly stronger institutional coordination, Chile's management of lithium extraction from brines shows shortcomings. A recent study showed that water extraction allocations in the Atacama salt flat exceed the rate at which it can be replenished, and that water uses derive mostly from relic groundwater in local and regional aquifers.[20] And in 2014, Chile's National Lithium Commission said that the

country's institutional structure supporting lithium extraction from brines failed to reflect the fragility of salt flats' ecosystems.

The Commission stressed the need for coordinated public institutions with adequate resources and specialized technical and legal expertise to fulfil the policymaking, regulatory, and supervisory roles of the national government. It said those roles should remain grounded on the principle of sustainable and inclusive governance of the salt flats, a concept coined by the Commission. It also underlined the need to improve capacities for compiling, gathering, and updating the scientific knowledge of salt flats, in order to determine the steps necessary to protect them, and for building a repository of brine information with data provided by public and private entities.[21]

The new government that took office in March, has announced that it is working on the design of a national lithium company following a new business model and renewed mechanisms for engaging with local communities. It said efforts will be placed on improving water management.[22] The Ministry of Mines has entered into a strategic alliance with the Consortium of State Universities to contribute to the strengthening of Chile's lithium policy. Under works is the development of a network of researchers to generate knowledge and to contribute to building capacities on lithium development and on salt flats. The government also announced the creation of a National Lithium and Salt Flats Institute.[23]

Why cooperation is important

We said earlier that the location and distribution of pumping wells and the understanding of the types of waters that circulate in salt flats are necessary for safeguarding their water balance in view of lithium extraction. Structures for public-private cooperation and collaboration at the watershed level are essential to preserve the integrity of salt flats.

In Argentina, lithium projects in the *Salar del Hombre Muerto*, located in the province of Catamarca, are a good illustration of the centrality of cooperation. Livent's *Fénix*, one of two lithium projects currently producing in Argentina, started to operate in 1996. The companies Posco and Allkem hold rights on other portions of the same salt flat and their projects are currently in the construction phase.[24] The simultaneous operation of all these projects places on the spotlight the need of cooperation between companies, between provinces and with the central government.[25]

The *Salar del Hombre Muerto* straddles the border between the provinces of Catamarca and Salta. The concession held by Posco coincides with an area of unresolved border conflict between these two provinces. The fluid nature of brines means that the impact of pumping can easily extend beyond the boundaries of a specific concession. Cooperative practices that could for example resemble unitization practices common to oil fields could be used for preventing conflicts between concessionaires.[26] Regarding the transboundary salt flats lying between the provinces of Catamarca and Salta, a recent sign of cooperation came from the governors of the three provinces most active in Argentina's lithium operations –Jujuy, Catamarca, and Salta--, who created a Lithium Mining Region, an effort to coordinate actions on matters of lithium development.[27]

Likewise, the transboundary salt flats across the border between Argentina and Chile also call for regulating shared resources in a cooperative, equitable, and reasonable manner.[28]

Solid regulatory frameworks, well-resourced, and well-coordinated institutions are crucial to support lithium extraction in ways that safeguard the water balance of salt flats and its ecosystems and considers the needs of local communities.

In Chile's *Salar de Atacama*, lithium and copper companies and other users operating in the salt flat are required to cooperate and collaborate.[29] Companies are expected to operate in accordance with the highest ethical, environmental, and social standards. But Argentina shows deficits of instruments of environmental and social management and visible gaps in the information on which authorities ground their decisions. There are also cooperation weaknesses shown by companies. In the case of the *Fénix* project mentioned above, for example, that means overcoming a legacy of past operational practices allegedly based on a poorly drafted contract whereby the company did not pay any water fee to the province for almost 20 years, or until the renegotiation of its contract in 2017.

Chile in turn, has a more robust environmental management system, but decisions still seem to fall short of a comprehensive knowledge of the *salares* and their ecosystems. Furthermore, the frequency of judicial and administrative proceedings involving lithium companies places a question mark on these companies' operational standards.

A sustainable stewardship of the water balance of salt flats calls for institutional innovation based on the design of platforms that include systems for the compilation of scientific data. This should be done with the participation of water users, and supported by institutional structures at the watershed. Cooperation is crucial for safeguarding the water balance of the salt flat and is of essence for the continuous viability of lithium harvesting.

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What role for ESG guidance?

Mining companies are increasingly required to report about the ESG impacts of their operations due to market demand and in order to be able to access funding. Companies that operate in salt flats generally report on their water use in their Sustainability Reports. For example, in Argentina, Livent stated in its 2021 report that its *Fenix* project applies "a comprehensive approach" to manage and record water flows, chemical transportation, and salinity levels, in order to ensure the sustainable use of water resources. The company also said it works with third–party experts to model both the freshwater aquifer and the salar to make sure it draws brine and water at rates that keep the natural balance of the salar.[30] In Chile, Albemarle's 2021 report stated that its goal is to reduce the intensity of freshwater use by 25 percent by 2030 "in areas of high or extremely high water-risk".[31] For its part, SQM notes in its 2021 report that it is committed

to reducing the use of continental water by 40 percent in 2030 and 65 percent in 2040. SQM also has a dedicated website[32] that offers environmental monitoring data of the *Salar de Atacama*.[33] Implementation of the website was resulted from a decision by the Environmental Court and was part of the company's 2016 renegotiation of its contract with CORFO.

As more information about the challenges of lithium extraction from salt flats becomes available, it becomes clear that ESG reporting on water use needs to be more detailed and has to be made accessible to local water users. More collective efforts need to be directed at increasing the knowledge about possible impacts of lithium extraction and at coordinating actions regarding salt flat watersheds.

A group of car makers has started to set high expectations on the ESG standards mining suppliers should meet.[34] These expectations draw on the wisdom gained from a collective initiative called *Drive Sustainability* whose goal is to produce guidance for integrating sustainability in the procurement processes of the automotive industry.[35] The guiding principles of the initiative include the expectation that water consumption will be minimized; the protection of ecosystems, especially those within key biodiversity areas, will be enhanced; and that the right of minorities and indigenous peoples to decent living conditions and to Free, Prior and Informed Consent (FPIC) when they or the land they inhabit are impacted by developments will be respected.

Under the initiative, a "Raw Materials Observatory" was set to develop a toolbox for identifying risks, impacts, and opportunities for collective action.[36] The Observatory was created in response to the need to access reliable and current data and analyses on the environmental and social dimensions of material production. The Observatory also resulted from the complexity and lack of transparency of the automotive supply chain, which the website identifies as one "...of the biggest obstacles in setting strategies" on this matter.[37]

Car companies, together with a few technology firms, recently launched 'The Responsible Lithium Partnership[38]', a multi-stakeholder platform that aims at gathering key actors in Chile's *Salar de Atacama* watershed, including government agencies, mining companies, civil society groups, and indigenous communities. The platform acknowledges the need of collaboration to address water-related risks and seeks to promote dialogue and solutions, and to compile scientific data.[39] The initiative shows a shift from mere reporting to achieving concrete impacts on the ground through collaboration, towards the common goals of water stewardship and data disclosure.

In need of a new water blueprint for the governance of the *salares*

A new water blueprint for the governance of the *salares* for lithium extraction is starting to emerge. The new blueprint must be grounded on strong institutions and will be structured as a coordinated ecosystem of governance and innovation supported by robust data and with the power to anticipate processes and outcomes coherent with the Sustainable Development Goals embraced by the United Nations Agenda 2030.[40] The watershed provides the right scale for common collective action to marry the goal of energy security with water security and climate action.

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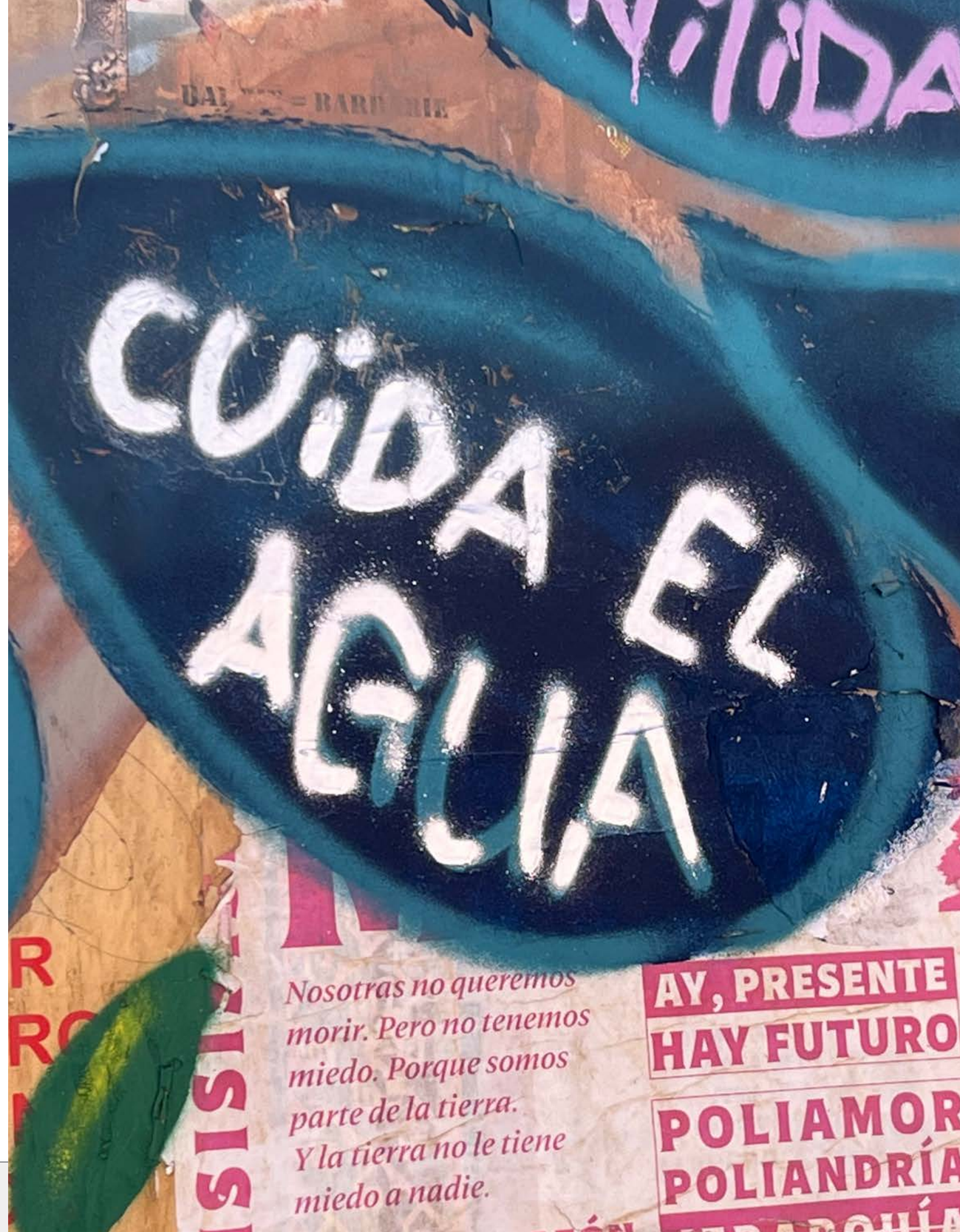

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