INTERNATIONAL LITHIUM ASSOCIATION (ILiA)

THE LITHIUM VOICE

The journal of the International Lithium Association (ILiA)
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In conversation with Prof. David F. Boutt

Who discovered lithium?

Dr Luis Lucero, Secretary of Mining for Argentina

SALARS

An essential source of lithium

ILiA Connections

ILiA Founding Chairman Anand Sheth presenting at the Lithium Summit, Hyderabad, India, in June 2024 (Credit: CMA India).

Secretary General Roland Chavasse meets Mr Wang Zeshen, Secretary-General of CIAPS (China Industrial Association of Power Sources) at the China International Battery Fair (CIBF) 2024.

ILiA members and guests networking at the annual membership meeting in Las Vegas, NV, USA, held during Fastmarkets Lithium Supply and Battery Raw Materials 2024 conference.

The ILiA team attending the Fastmarkets Lithium Supply and Battery Raw Materials 2024, Anand Sheth, Julia Watson, Martin Ma and Roland Chavasse.

Roland Chavasse meeting Thomas Näsström and Klas Helmerson at the Utö Gruv- & Hembygdsmuseum, Utö, Sweden, to learn about the place where petalite and spodumene were first discovered.

Astrid Karamira visits Companhia Brasileira de Lítio (CBL) in the Jequitinhonha Valley, in northeastern Minas Gerais, Brazil. (Credit: CBL).

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Contributors
Anand Sheth
Roland Chavasse
Rowan Halkes
Andrew Hughes
Evi Petavratzi
Thomas Butcher
David Merriman
Adriana Carvalho
Daniel Jiménez
Astrid Karamira

Advertising
info@lithium.org

Creative
GF PROJECTS

Translation
mind translations
mind over translation matters

** references available on request*

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Chair's WELCOME

Welcome to the 7th edition of *The Lithium Voice,* with a cover story all about salars. These are one of most critical resources of the lithium that is required to meet the global target of a renewable and a decarbonised economy. The British Geological Survey (BGS) explains how salars are created and what differentiates water and hypersaline salar brine, which is a frequently misunderstood point.

We are honoured to talk with Dr Luis Lucero, Secretary of Mining for Argentina, about the criticality and importance of lithium not only to Argentina but to the world. Argentina is the second largest producer of lithium in the world and is part of the 'lithium (brine) triangle'.

This quarter we are *In Conversation* with Prof. David Boutt from the University of Massachusetts Amherst and an Honorary Fellow of ILiA. He discusses why an understanding of hydrogeology, physics and geology all contribute to modelling the complex dynamics of salars, and what first attracted him to lithium.

As you may recall, ILiA released Product Carbon Footprint Guidance earlier this year which was very well received. Now we have commenced a Product Water Scarcity Footprint project and the Sustainable Subcommittee provides us with an update on the progress they have made so far.

The article "Who discovered lithium?" takes us on the interesting journey of its discovery and history, that I am sure you'll enjoy! This was to coincide with a trip our Secretary General recently made to Utö Island in Sweden, where lithium minerals were first discovered.

And finally, don't forget to visit our website **www.lithium.org** to find all the latest information on lithium conferences and events around the world!

Anand Sheth
Founding Chairman

Feature

Lithium and Argentina

A BRIGHT FUTURE TOGETHER


Photo credit: Secretaría de Minería, Argentina

The *Lithium Voice* was recently granted an exclusive interview with Dr Luis Lucero, Secretary of Mining for Argentina. Prior to his appointment in March 2024, Dr Lucero worked as an industry lawyer and partner at the law firm Marval O'Farrell Mairal.

Secretary, thank you for making time to talk to the *Lithium Voice.* In your first speech as Secretary of Mining, you were very optimistic about lithium. How would you summarize your vision of the lithium industry in Argentina?

The lithium industry in our country has been driving development in three northwestern provinces, in particular benefiting those communities neighboring the projects, many of which are located in the Puna region, a historically neglected area. I was directly involved in the recent launch of the Centenario Ratones project, giving me first-hand insight into what a mining project of this scale entails. For the local communities, it represents a socio-economic asset that enhances infrastructure, develops local suppliers, and creates well-paid jobs and public services. It's a virtuous cycle that must be sustained.

There are nearly 50 different lithium projects in Argentina, ranging from exploration to production. What message do you have for anyone considering investing in Argentine lithium assets?

This is an extraordinary opportunity for those seeking to invest in our country. The eyes of the global mining investment community are watching Argentina, which is very promising for us. A prime example is the recent decision by BHP, one of the world's largest mining companies, to invest in Argentina. We are working on regulatory frameworks to ensure our competitiveness both regionally and globally.

Since 2020, mining companies have announced investments totaling some USD 10.9 billion for various stages of lithium project development, underscoring the country's potential in this resource. Argentina must now rise to the occasion, supporting the coordinated development of these activities in the provinces to fully seize this emerging window of opportunity.

In July, you announced a new regulatory framework (the Investment Incentive Regime, known as RIGI in Spanish) aimed at streamlining the approval process for lithium mining projects. When will the new regulatory framework for lithium mining be ready, and what specific benefits do you anticipate? What impact will it have on foreign direct investment (FDI)?

The implementing presidential decree regulating the RIGI was signed and announced this past August 22nd. With the regulation issued, the regime is ready to be applied to the projects which owners decide to submit applications to be admitted in the regime. Several provinces (namely: Jujuy, Mendoza, San Juan, Río Negro and Chubut, although the latter excluded mining in their adherence) have already adhered to the scheme while others are considering it at legislature level.

We are convinced that this regime will be a decisive driver to increase FDI in our country.

How is your department coordinating the Milei administration's national strategic vision for lithium with the provincial governments, especially as it relates to the RIGI?

We maintain constant coordination with provincial authorities, which is crucial in mining since these resources are owned by the provinces. We have already signed tripartite collaboration agreements with the Argentine Geological and Mining Service (SEGEMAR) and the provinces of San Juan and Mendoza, and expect to continue with other provinces. At Government level, we are involved in the Lithium Working Group, including the northwestern provinces of Jujuy, Salta and Catamarca, as well as the Copper Working Group, where the northwestern provinces are joined by the Cuyo region of San Juan and Mendoza.

We are actively collaborating with COFEMIN, the Federal Mining Council, which includes all provincial jurisdictions plus the National Government, as well as with the Mining Committees of the Chamber of Deputies and the Senate whose plenary sessions we have attended. We believe that working together within an institutional framework is vital to help the provinces develop their mining industries. This is a key goal for our administration.

How confident are you that Argentina and the United States can find a way for Argentine lithium to qualify for the U.S. market under the IRA?

Argentina is willing to work together with the US authorities to find ways to have the Argentinian lithium qualifying under IRA as we are at the moment. We are confident that such cooperation will bring us to a satisfactory outcome soon.

What steps are Argentine authorities taking to ensure high environmental and social standards are maintained as more lithium operations are developed?

The ongoing coordination efforts pursued by the Secretariat of Mining with the provinces are a fundamental pillar of our management strategy, reinforcing these principles that are an intrinsic aspect of mining activities. We are committed to continuously improving the standards of development of both new projects and those already in production. Recently, I attended the annual meeting of the Extractive Industries Transparency Initiative (EITI), of which Argentina is a member. This reflects the importance of transparency and accountability in the mining sector for us.

What is your opinion of the draft bills on state intervention in the lithium market (reference prices and the nationalization of lithium)?

I fully agree with the President of the Nation's stance. We strongly oppose any form of state intervention in the lithium market. The National Constitution clearly states that natural resources belong to the provinces, so we do not support the nationalization of provincial resources either.

Where do you see the lithium industry in Argentina by 2030, and what could this mean for economic growth and job creation?

Even from a conservative standpoint, projections indicate not only an increase in production, but also a growing share of lithium in both mining exports and in the overall exports of our country. We envisage this growth being accompanied by a steady rise in job creation leading up to 2030. The evidence of our mining potential, coupled with strong investment commitments and the world's rising demand for the critical minerals that Argentina possesses, point to a highly promising outlook for the years ahead.

Argentina has 50 lithium projects at different stages of development, located mainly in the provinces of Salta, Catamarca and Jujuy. Currently, there are four projects in operation. Another project, Sal de Oro, to begin production in October, and 8 projects expected to start in the next 6 years. This will not only generate more sustainable jobs but also increase the volume of exports.

In addition, according to the latest figures from S&P, in 2023, mining companies allocated USD 139.9 million for lithium exploration, marking a 91% year-on-year growth rate.

This places Argentina in third place globally as regards the allocation of budgeted funds for exploration, after Australia and Canada. This investment in exploration is crucial as it drives the development of new projects, secures the long-term sustainability of the sector, and helps to shape the country's future export profile. Additionally, for projects currently in production, exploration in nearby areas also represents a critical resource for extending their operational lifespan.

Photo credit: Secretaría de Minería, Argentina

From left to right: Luis Lucero, Secretario de Minería de la Nación; Romina Sassarini, Secretaria de Minería de Salta; and Benjamin Gallezot, Interministerial Delegate for the Supply of Critical Minerals, France.

Feature

SALARS: A SHORT INTRODUCTION

Authors: **Rowan Halkes, Andrew Hughes, Evi Petavratzi at the British Geological Survey (BGS)**

Introduction

Forecasts for lithium demand over the next few decades suggest an exponential growth in production. Half of global lithium resources are found in the salar deposits of South America, an area known as the "Lithium Triangle". This region, spanning parts of Argentina, Bolivia and Chile (Fig. 1), will be crucial in providing the lithium required for global decarbonisation and electrification. This article will briefly introduce how these deposits are formed, where they are found, how lithium is produced, and also touch upon on some of the associated complexities.

An introduction to salars

Salars are the remains of ancient lakes that formed over hundreds of thousands of years, driven by the climate cycling between wetter and drier periods. Not all salars contain lithium resources, in the form of lithium-rich brine, those that do are referred to as salar deposits. The formation of salar deposits is a complex process, requiring specific geological and environmental conditions as well as long time periods.

Salars are some of the most complex natural systems in the world, combining interactions between the atmosphere, the hydrosphere and the lithosphere.

Broadly, there are six factors needed to form a salar deposit; 1) arid climate; 2) closed basin containing a salar (salt crust) and/or a salt lake; 3) associated igneous and/or hydrothermal activity; 4) tectonically driven subsidence (creating space for continued inflow/infill); 5) suitable lithium sources; and 6) sufficient time to concentrate lithium.

The salar is divided into the nucleus (centre) and the transitional (or marginal) zone at the edges, contained within a wider basin (Fig. 2).

Notable salar deposits include the Salar de Uyuni in Bolivia, Salar de Atacama in Chile, and Salar del Hombre Muerto in Argentina (Fig. 1). Lithium is also produced from salar deposits in China, as well as North America; but it is those of South America that are of most significance to global lithium supply, providing 34% in 2022.

Located at 2,300 – 4,000m above sea level in the Andes, the combination of elevation, solar irradiation, and aridity make the salars some of the most extreme environments on Earth. These conditions mean salars have unique flora and fauna, including microbes, which in turn form diverse and rare ecosystems. They also frequently host communities of Indigenous people, who have strong social and cultural relationships with the salars. Given the aridity of the area, access to and use of water for all users in the watersheds where salars are located (which can include other mining projects, tourism and agriculture) is a concern. Furthermore, salars are often situated within or adjacent to protected areas for wildlife, e.g. internationally recognised RAMSAR wetland sites.

Geologically, salars consist of sedimentary rocks, such as clays, silts, sands and evaporite minerals like halite (NaCl) salt. These are one of the most important features of salars, as the pores (small spaces) within these rocks can store the brines and freshwater*. Furthermore, it is the connection between these pores that allows fluid movement, enabling the brines and freshwater to move and collect over time, as well as to be pumped out.

The salars of the Lithium Triangle were formed, and are hosted in, a highly active geological system. The surrounding Andes were created above a tectonic subduction zone, where significant amounts of magma were generated to form these volcanic mountains.

The volcanic rocks, which surround salars, have elevated levels of lithium, although not enough to merit being mined. Over time, lithium is leached from them and transported into the salar by surface waters, groundwaters, and geothermal waters at depth (Fig. 2, page 8). Due to the high elevation, aridity and solar irradiation these waters are significantly concentrated by evaporation, forming brines with high levels of lithium and other salts such as potassium, sodium, and magnesium (Table 1). The lithium concentration varies across the region from, 16 - 1,570 mg/l, with an average of ~336 mg/l. This variation can be attributed to several factors, including the variance in the volcanic rocks, and the variation of the

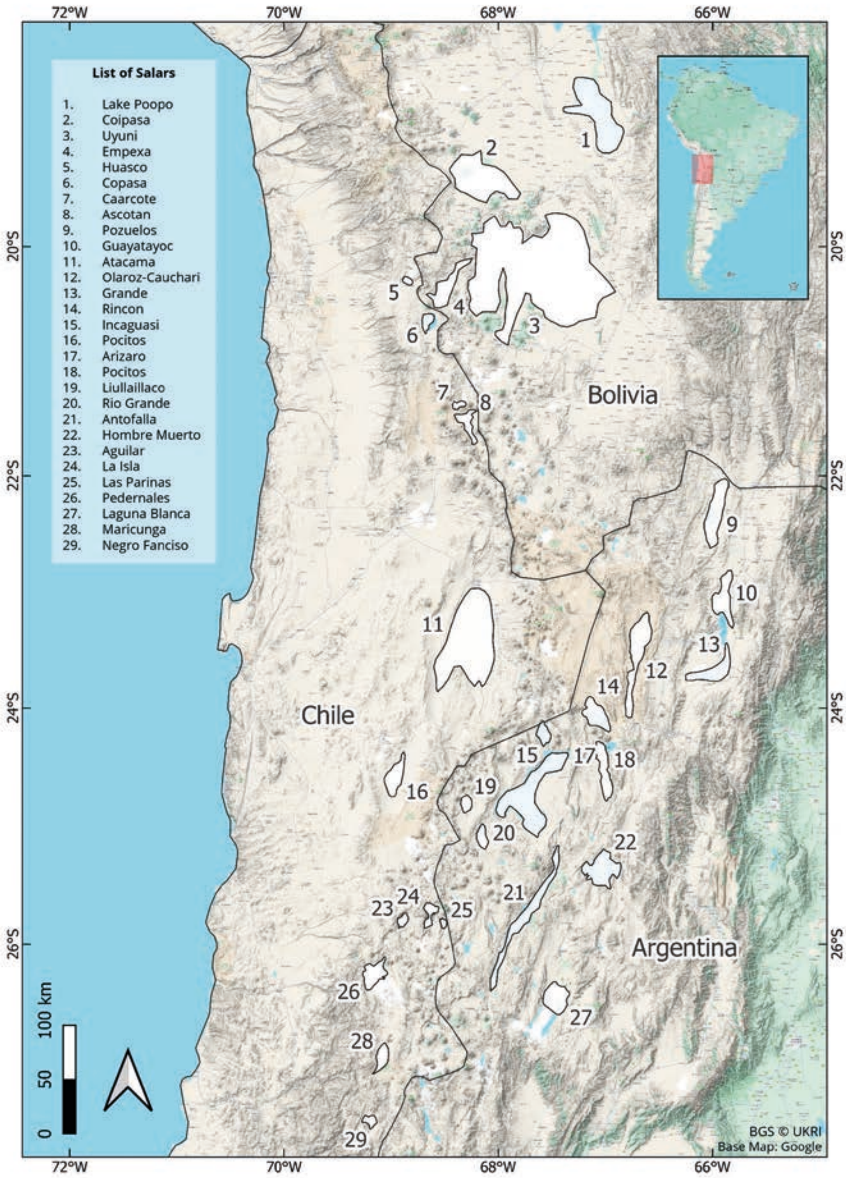

Figure 1: Map of the Lithium Triangle of South America, covering parts of Argentina, Bolivia and Chile with key lithium-bearing salars deposits highlighted. Note the list of salars is non-exhaustive. Base topography sourced from Google Earth.

chemistry of the magma that they were formed from.

Broadly, there are two types of water found in salars: brine and freshwater. Whilst brine is being formed continuously, the lithium takes hundreds of thousands to millions of years to become concentrated to economic levels, and surprisingly lithium constitutes only a small amount of these brines (<1%), with water comprising ~75% (Table 1). This water contained within the brine, in addition to freshwater, means salars contain significant amounts of water. However, the brines are extremely saline (Table 1), and are not usable as drinking water or for irrigation. Whilst lithium can increase in concentration with depth, lithium-bearing brines are primarily pumped out from shallow wells, typically 20 – 40m below the surface of the nucleus, but this varies (Fig. 2); the nucleus is where the greatest lithium concentrations and extraction operations are located.

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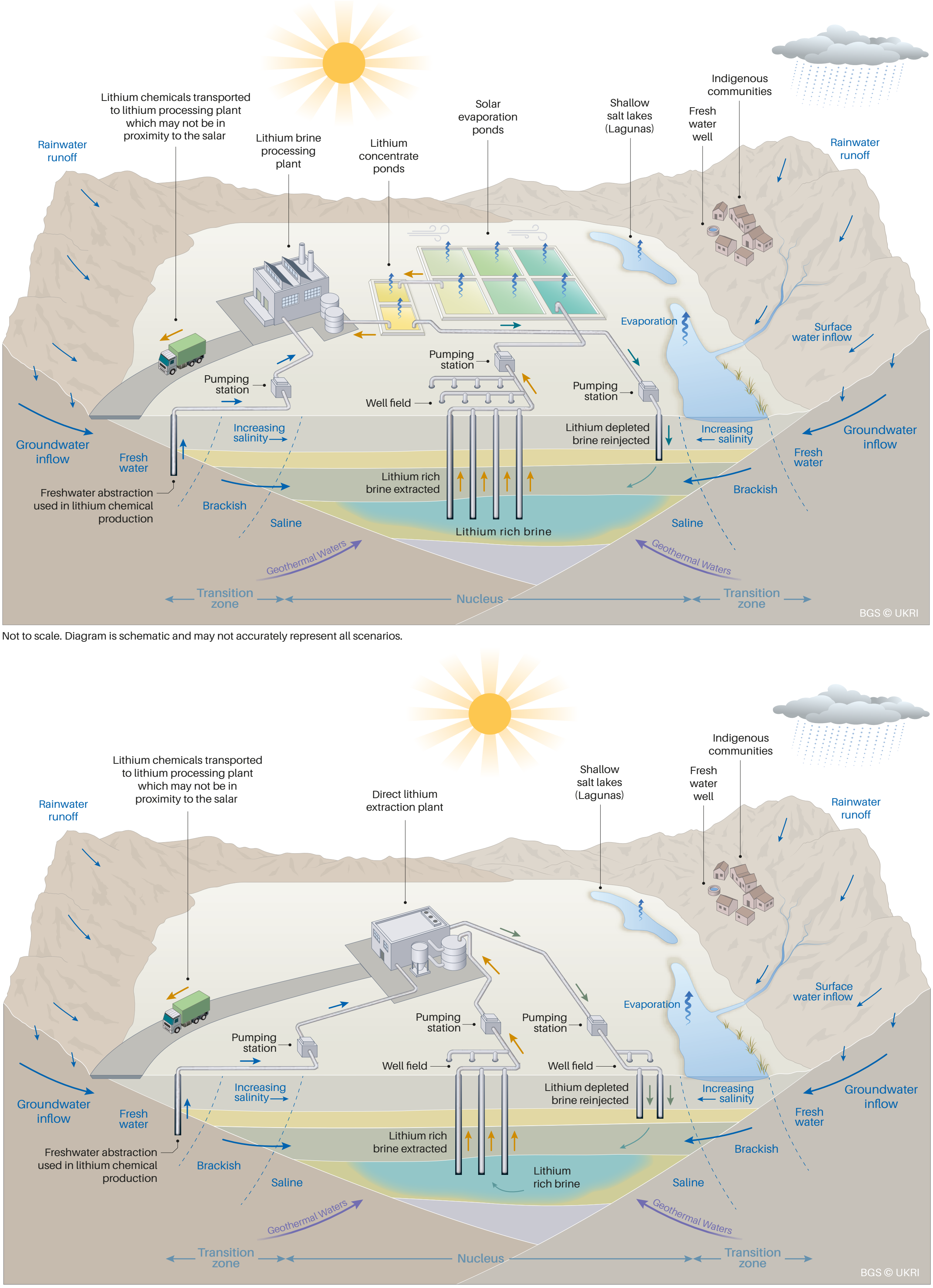
*In this article 'freshwater' refers to water that has a low concentration of dissolved solids and may be generally acceptable for withdrawal and/or conventional treatment to produce drinkable water.



Not to scale. Diagram is schematic and may not accurately represent all scenarios.

Not to scale. Diagram is schematic and may not accurately represent all scenarios.

Figure 2: Schematic block diagram of a salar illustrating brine extraction and concentration with a) evaporation processes (EP), b) direct lithium extraction (DLE). Hydrogeological and other salar features are also displayed. Note diagram is not to scale and is schematic, so may not accurately reflect all scenarios. The position and nature of extraction and reinjection is indicative.

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Salar complexity

Salars are some of the most complex natural systems in the world, combining interactions between the atmosphere (e.g. rainfall patterns), the hydrosphere (e.g. groundwater and surface water) and the lithosphere (e.g. lithium release and transport from rocks) along with solute concentration by evaporation.

The size and source of water inputs are hard to determine and each salar differs in the type and amount of freshwater inflow. Usually the main sources of freshwater are surface and ground waters, which whilst small, can be significant for the salars' water balance and maintaining lagunas (ponds or small lakes, Fig. 2). Precipitation is typically very low, but periodic flooding can also help sustain the water balance. Evaporation is the main natural outflow, and in some cases, this can exceed present-day inputs. Evaporation is also key for cycling freshwater through the system and concentrating brines, while geochemical processes can be important in brine evolution and determining the subsequent distribution of lithium.

There are complex interactions between these inflows, outflows and water types in salars. For example, brine is not static within the nucleus. Large-scale convection cells form

Contrasting landscapes at Salar de Rincon, Argentina (above) and Salar de Uyuni, Bolivia.

(due to the sinking of the denser brine) and influence freshwater inflows and brine-freshwater interactions in the transitional zone. This area, made up of lagunas, wetlands and peatlands, is the most environmentally sensitive part of salars. The lagunas, key parts of ecosystems, are created when fresh groundwater encounters the high-density brines forming an effective barrier and/or convection cells from the nucleus and is forced to the surface. They are therefore sensitive to any changes in inflows as well as to variations of brine levels in the nucleus.

The complexity of salars also extends beyond three dimensions, they are highly dynamic with temporal aspects ranging from hourly (rain events) to millions of years (brine and halite formation). They are in flux from the influence of climate change, which is likely to increase temperatures but have variable impacts on rainfall. It may also cause changes in the balance of water inflows and outflows over time. However, the exact impact that climate change is likely to have, now and in the future, upon salars is unclear.

While there are similarities between salars in the Lithium Triangle, there are also significant differences. Each is unique in terms of brine and water chemistry (Table 1), microclimate, geomorphology, geology, hydrogeology, elevation, and the surrounding socio-economic situation to name but a few examples. It is also worth noting that the Salar de Atacama in Chile, where much of our understanding comes from, while not an outlier, is an "end member" on the distribution of salars – being hotter, drier, at lower elevation and having higher lithium concentrations than others. Therefore, care needs to be taken when transferring understandings from here to other salars.

Just as ***'All people are different people', 'All salars are different salars'***.

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Table 1: Comparison of different salar brines and water types

Salar/Water Type	**Region/Country**	**Total Dissolved Solids (TDS)** (% w/v)	**Li** (mg/l)	**Mg** (mg/l)	**Ca** (mg/l)	**K** (mg/l)	**Na** (mg/l)
Uyuni	Potosi, Bolivia	35.10	694	15,365	540	12,197	88,641
Atacama	Antofagasta, Chile	37.50	1,570	9,650	450	23,600	91,100
Hombre Muerto	Salta/Catamarca, Argentina	34.09	535	1,091	766	4,681	43,376
Sea water	-	3.50	0.18	1,300	400	380	11,000
Bottled water	-	0.03	0.005	26	80	1	6.5

Salar brine data is drawn from varied sources and is not directly comparable. This table is to demonstrate variability, rather than make comparisons.

Uyuni data: Risacher and Fritz, 1991; Atacama data: López Steinmetz and Salvi, 2021; HM data: López Steinmetz et al., 2020; Brine TDS data: Ericksen and Salas, 1987; Sea water data: Riley and Tongudai, 1965; Petrowiki; Bottled water data: Evian; Parnell and Armstrong, 2023.

Feature

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Lithium production from salars

The discovery and extraction of lithium in the salar brines of South America revolutionised the sector, providing abundant resources that are relatively easy to extract via a low-carbon process. However, production from salar deposits differs from 'traditional' mining projects with the system hosting the ore, or brine in this case, being very much still in flux and a 'live' system.

The salars with the longest history of lithium production are the Salar de Atacama in Chile and Salar del Hombre Muerto in Argentina. Initially, potassium nitrate was produced at Atacama, before lithium production was added later in the late 1980s / early 1990s, while Hombre Muerto has been producing since 1997. Operations within the Lithium Triangle have seen rapid expansion with the growth of electrification and lithium demand over the last decade. Over time, as pressures have mounted over environmental concerns and given the need to increase production there has been a greater focus on processing technologies used to recover lithium from the brines, alongside a growth in responsible mining practices.

Most operations in South America follow a common processing framework:
1) brine abstraction (pumping),
2) concentration and purification, and 3) chemical processing to produce lithium carbonate or hydroxide. Concentration and purification typically occur 'on-site' at the salar, while chemical processing usually takes place 'off-site' at a separate facility. Two types of technologies are used in the concentration and purification stage, evaporative processes (EP) and direct lithium extraction (DLE) (Fig. 3). EP is the most common and traditional method, with DLE being a somewhat newer alternative, but they can be applied together, such as at Salar de Hombre Muerto. With each brine having a unique composition, a tailored processing method is required. What may be appropriate, or optimal, for one salar may not be elsewhere.

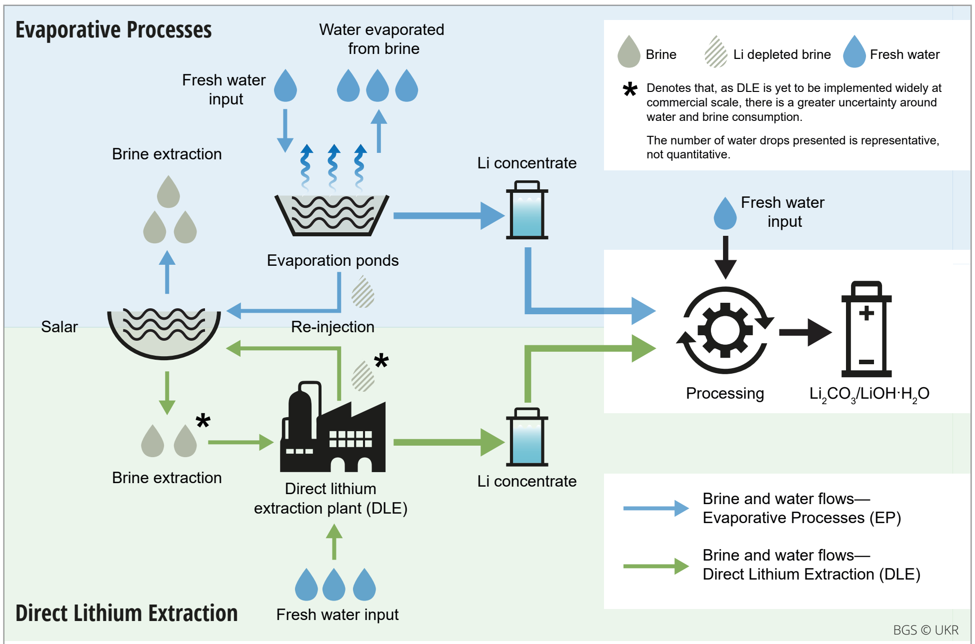


Figure 3: Schematic diagram showing the different lithium production pathways and brine/water usages per unit of lithium battery chemical production from salars using Evaporative Processes and DLE. The number of drops used is representative of the quantity that is thought to be used, it is not quantitative.

During EP, after brine pumping, solar and wind-driven evaporation progressively concentrates the brine in a succession of evaporative ponds (Fig. 2). This process is made possible by the naturally high aridity, altitude and solar irradiation, resulting in low energy requirements and carbon footprint. Different salts may be harvested as they precipitate e.g. potassium, and impurities removed. The process takes 12 – 18 months with a lithium recovery rate of 30 - 50%, while 85 - 95% of the water contained within the brine is evaporated.

DLE is a blanket term used to refer to several different technologies, which actively concentrate lithium. Although the direction of travel is towards the use of DLE over EP, as it is not yet widely implemented at a commercial scale in South America, there a degree of uncertainty regarding its efficiency and impacts. DLE has a recovery rate of 70 - 95% and the potential to reduce brine use, shorten production timelines and allow development of deposits that were previously uneconomic. Challenges include freshwater and energy requirements, embodied environmental footprint, and greater reinjection of depleted brine. For more information about DLE see the *Lithium Voice Volume 6*.

After concentration and purification, lithium-depleted brine may be reinjected into the salar (Fig. 3). For EP, this can be ~15–20 % of the original brine. DLE is expected to offer a higher return rate of lithium, though exact values vary for each process type and between each salar. Reinjection returns the majority of the brine pumped out albeit depleted in lithium, helping maintain the system's chemical properties. Additionally, reinjecting between the wellfield and sensitive locations (lagunas) may partially mitigate the impacts of brine pumping by reducing water/brine table drawdown and subsequent effects (Fig. 2). However, depleted brines will be of a different chemical composition to raw brine, especially those from DLE due to the chemical interactions and processes. This may alter the geochemistry of the system resulting in difficulties in returning the brine to the salar; there are also concerns reinjection could cause dilution of the lithium in the brines and/or disruption to the stratigraphic structure (layers of rock & sediment).

When considering the overall sustainability benefits of EP and DLE, there is currently no clear advantage to one or the other, in terms of the overall impact on the hydrogeology of salars or availability of water to communities and ecosystems. These impacts will not only be influenced by the technology used, but also by lithium concentration and impurities in brines, local hydrogeology and climatic conditions, among others. Thus, the technology used, and its merits and drawbacks, require thorough assessment on a case-by-case basis.

Impacts of lithium production

The future development of lithium production in South America has the potential to deliver significant positive impacts, economically and also at the local, regional and global scales. There have been promising improvements in responsible mining practices, though work remains to be done.

There are significant concerns regarding brine and freshwater use, and the associated environmental and social impacts, of lithium production. Numerous salar features need to be considered in understanding environmental impacts, including the quantity and nature of water inflows and interaction with lagunas, the nature and properties of the salar, and the characteristics of abstraction (pumping). As with all extractive industries, to maximize benefits for local communities and avoid disputes, communication and consideration are required to ensure projects can be 'good neighbors'.

Any impacts will be unique to each salar and project. The hydrogeology, hydrology, geomorphology, geology, elevation and technology used will all influence how impacts may materialise. Furthermore, determining impacts is difficult due to the aridity of the region, system complexity, variation of climate conditions and the system's response potentially taking years or even decades to materialise at sensitive environmental features such as lagunas.

Additionally, human-derived impacts can only be accurately understood and attributed after accounting for the influence of natural variations and climate change. Impacts also require consideration in the wider context of other water users, such as tourism, agriculture and other mining projects e.g. copper mines. It is also vital to take into account the potential cumulative impacts that can arise from multiple lithium projects in the same salar.

In conclusion

Once the lithium has been concentrated and purified it is transported, usually in the form of a lithium chloride solution, to a processing facility. Here it is turned into lithium carbonate, and then lithium hydroxide if desired. These compounds are then exported into global supply chains to go on and be used in batteries, ceramics, and medicines among other uses.

The time available for scaling up this lithium production process to meet decarbonisation demands is soberingly short with the rapid electrification of industry and transport. Lithium from the salars of the Lithium Triangle has a pivotal role to play in global decarbonisation. However, complex economic, environmental, social and governance matters need to be navigated carefully and collaboratively, striking the right balance between a suitable business environment, equitable development, environmental protection and social justice if this opportunity, for both the Lithium Triangle countries and the world, is to be realised.

This article represents the opinions of the authors and does not necessarily reflect the views of the British Geological Survey or ILiA.

The Statesman, The Industrialist, The Nobleman, The Bourgeois, The Englishmen and The German

WHO DISCOVERED LITHIUM?

In November last year, *The Lithium Voice* (vol. 4) celebrated "A Century of Industrial Lithium", marking the fact that the first industrial production of lithium had only taken place a century prior. Perhaps surprisingly, lithium had only become a "named" element just over a hundred years before that.

But who actually discovered lithium? Well, depending upon how you define "discovered", the following characters each played a key role in the mineral drama "Lithium in its Early Days".

Dramatis Personae (in order of appearance)

The Statesman
José Bonifácio de Andrada e Silva
(1763–1838)

The Industrialist
Eric Thomas Svedenstjerna
(1776-1825)

The Nobleman
Baron Jöns Jacob Berzelius
(1779-1848)

The Bourgeois
Johan August Arfvedson
(1792–1841)

The Englishmen
Sir Humphry Davy
(1778–1829)
William Thomas Brande
(1788–1866)

The German
Robert Wilhelm Bunsen
(1812-1899)

Other Scientists
Augustus Matthiessen
(1831–1870)

Statue of José Bonifácio de Andrada e Silva in Bryant Park, New York City, NY, United States.

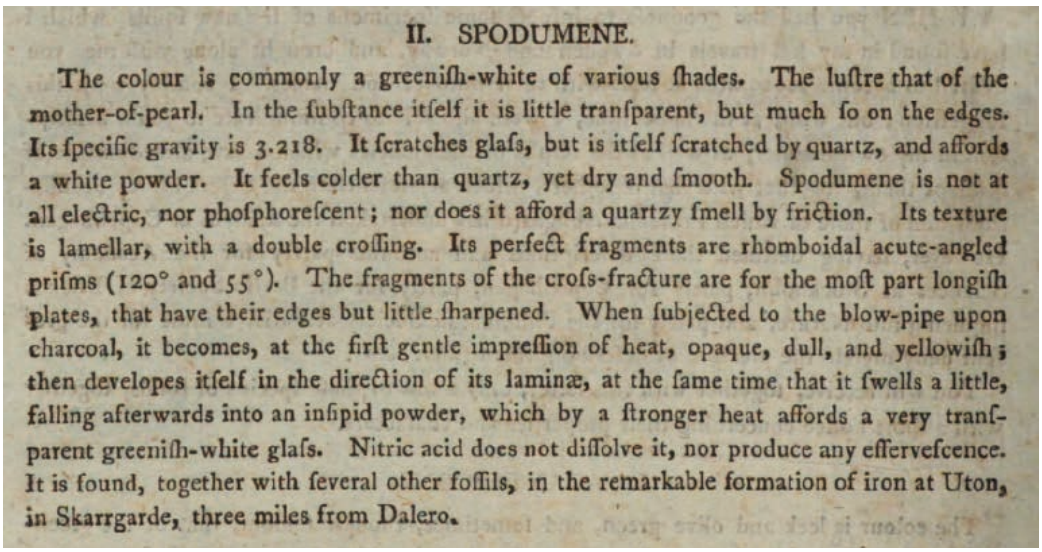
The Statesman

Except for those of us working in the world of lithium, José Bonifácio de Andrada e Silva is probably much better remembered for everything he achieved other than as a scientist and mineralogist, the primary one being a revered statesman. He was the patriarch of Brazilian independence and, at one stage, almost its prime minister.

Andrada was born in 1763 into an aristocratic Portuguese family in Santos, São Paulo in Brazil, then part of the Portuguese empire. Like many from his social strata at the time, he went back to Portugal to go to university, completing his studies in philosophy (1786) and law (1788) at the University of Coimbra. Turning his back on these (for the time being anyway), he moved into the world of "natural philosophy", as science was then called.

In 1790 he married his Irish bride, Narcisa Emilia O'Leary, and immediately set off with her on a 10-year fact-finding and study journey around Europe.

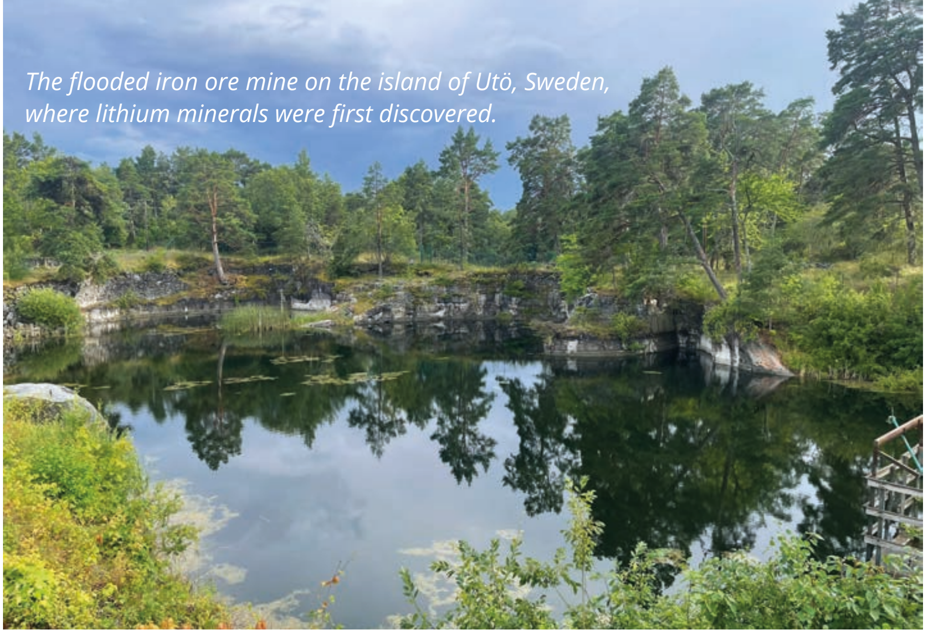
Andrada spent four years from 1790 to 1794 studying mineralogy and visiting mines and metallurgical industries in France and Germany. He followed this with a further five years exploring mines in Austria, Denmark, Hungary, Italy,



II. SPODUMENE.

The colour is commonly a greeniſh-white of various ſhades. The luſtre that of the mother-of-pearl. In the ſubſtance itſelf it is little tranſparent, but much ſo on the edges. Its ſpecific gravity is 3.218. It ſcratches glaſs, but is itſelf ſcratched by quartz, and affords a white powder. It feels colder than quartz, yet dry and ſmooth. Spodumene is not at all electric, nor phoſphoreſcent; nor does it afford a quartzy ſmell by friction. Its texture is lamellar, with a double croſſing. Its perfect fragments are rhomboidal acute-angled priſms (120° and 55°). The fragments of the croſs-fracture are for the moſt part longiſh plates, that have their edges but little ſharpened. When ſubjected to the blow-pipe upon charcoal, it becomes, at the firſt gentle impreſſion of heat, opaque, dull, and yellowiſh; then developes itſelf in the direction of its laminæ, at the ſame time that it ſwells a little, falling afterwards into an infipid powder, which by a ſtronger heat affords a very tranſparent greeniſh-white glaſs. Nitric acid does not diſſolve it, nor produce any efferveſcence. It is found, together with ſeveral other foſſils, in the remarkable formation of iron at Uton, in Skarrgarde, three miles from Dalero.

Description of spodumene from August 1801 edition of "A Journal of Natural Philosophy, Chemistry and Arts".



The flooded iron ore mine on the island of Utö, Sweden, where lithium minerals were first discovered.

Photo credit: ILiA

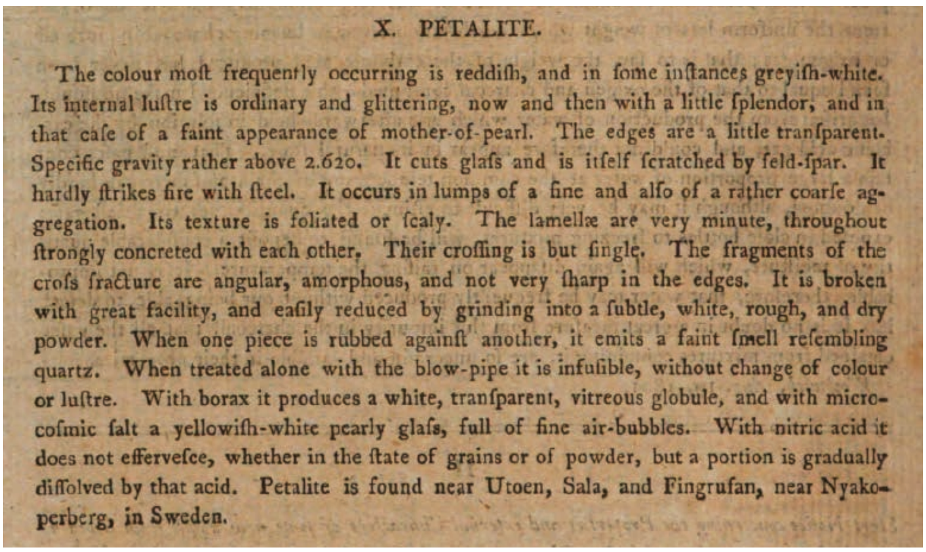
Norway and Sweden (where he was elected to the Royal Swedish Academy of Sciences in 1797), recording his observations in his logbook. And it was at an iron ore mine on the island of Utö, some 45 km south of Stockholm in Sweden, that Andrade made, for us anyway, his most important observations, identifying two new minerals: petalite and spodumene.

First described in Scherer's "Allgemeine Journal der Chemie", published in Leipzig, Germany in 1800, in England the same observations, in the form of a letter to a "Mr. Beyer, Master of the Mines at Schneeberg", appeared, in translation, in the August 1801 edition of "A Journal of Natural Philosophy, Chemistry and Arts".

While it is safe to assume that Andrada's friends and colleagues in Berlin, Copenhagen, Paris and Stockholm all received physical specimens of his rocks to be amazed by and to study, nothing more is heard about them for the next nearly 20 years.

The Industrialist

Had it not been for one Eric Thomas Svedenstjerna, a contemporary close in age to Andrada, perhaps nothing more would have been heard of either petalite or spodumene. A Swedish aristocrat, mountain researcher and member of the Royal Swedish Academy, Svedenstjerna was both a keen minerologist and in the iron business.



X. PETALITE.

The colour moſt frequently occurring is reddiſh, and in ſome inſtances greyiſh-white. Its internal luſtre is ordinary and glittering, now and then with a little ſplendor, and in that caſe of a faint appearance of mother-of-pearl. The edges are a little tranſparent. Specific gravity rather above 2.620. It cuts glaſs and is itſelf ſcratched by feld-ſpar. It hardly ſtrikes fire with ſteel. It occurs in lumps of a fine and alſo of a rather coarſe aggregation. Its texture is foliated or ſcaly. The lamellæ are very minute, throughout ſtrongly concreted with each other. Their croſſing is but ſingle. The fragments of the croſs fracture are angular, amorphous, and not very ſharp in the edges. It is broken with great facility, and eaſily reduced by grinding into a ſubtle, white, rough, and dry powder. When one piece is rubbed againſt another, it emits a faint ſmell reſembling quartz. When treated alone with the blow-pipe it is infuſible, without change of colour or luſtre. With borax it produces a white, tranſparent, vitreous globule, and with microcoſmic ſalt a yellowiſh-white pearly glaſs, full of fine air-bubbles. With nitric acid it does not effervеſce, whether in the ſtate of grains or of powder, but a portion is gradually diſſolved by that acid. Petalite is found near Utoen, Sala, and Fingruſan, near Nyakoperberg, in Sweden.

Description of petalite from August 1801 edition of "A Journal of Natural Philosophy, Chemistry and Arts".

The story goes that, perhaps in his line of duty as director of bar iron forging and raw iron bluff in Sweden, he rediscovered the two minerals, once again picking up samples on Utö and, then, in 1817, sending samples of petalite to various colleagues around the world. One of the recipients was his famous teacher and countryman, Baron Jöns Jacob Berzelius.

While history does not relate whether or not Svedenstjerna remained interested in the two minerals, we do know that, faced with personal bankruptcy as a result of his doomed business ventures in cobalt, he tragically took his own life on 14 January, 1825.

Photo credit: ILiA

The Utö iron ore mine's tailings where Andrada first found samples of petalite and spodumene.

The Nobleman

Considered one of the fathers of modern chemistry and yet another member of the Royal Swedish Academy of Sciences, Berzelius (a Swedish nobleman) was born in Östergötland in 1779. Although he actually started his working life as a physician, his greatest contributions to science were in the field of chemistry.

continued on page 14

continued from page 13

Berzelius was a keen, methodical and thorough empiricist: perhaps one of the reasons that he personally established the law of constant (definite) proportions.

While Berzelius himself may have discovered cerium and selenium, it was the students and friends in his private laboratory at the German Baker's House in Stockholm who discovered not only lanthanum and vanadium, but also lithium, with the laurels for lithium resting firmly on the head of one Johan August Arfvedson (sometimes written as 'Arfwedson').

The Bourgeois

The son of a rich factory-owner and merchant father, Arfvedson was another player in our story who held a law degree. But he also had a degree, more relevantly, in mineralogy and a friendship with Berzelius, who let him use his laboratory in Stockholm.

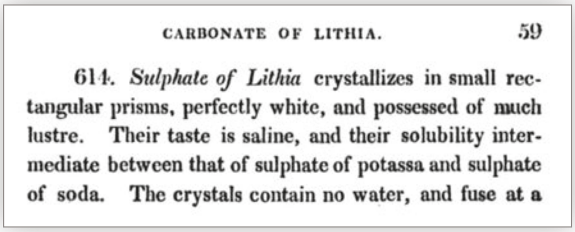
And it was to Arfvedson that his friend and mentor, Berzelius, gave the sample of petalite he had received from Svedenstjerna.

Working with the petalite ($LiAlSi_4O_{10}$), Arfvedson was able successfully to determine its alumina and silica content. However, to his consternation, in the sample he was working on, these only accounted for some 97% of the mineral's weight, leaving the remaining 3% unidentified. Changing direction in his experimentation, Arfvedson found that the new element formed compounds similar to those of sodium and potassium, but that its carbonate and hydroxide were less soluble in water and more alkaline.

This result in hand, he and Berzelius decided that the missing percentage (being too small to be sodium) must be some new alkali metal. Berzelius proposed that the metal be named lithium, from the

The German Baker's House, home of Berzelius' laboratory in Stockholm, Sweden, before being demolished in 1907.

Greek word *lithos* meaning stone. (The reasoning being that it came from a mineral source, whereas the other two common Group 1 elements, sodium and potassium, were discovered from plant sources).



CARBONATE OF LITHIA. 59

614. *Sulphate of Lithia* crystallizes in small rectangular prisms, perfectly white, and possessed of much lustre. Their taste is saline, and their solubility intermediate between that of sulphate of potassa and sulphate of soda. The crystals contain no water, and fuse at a

Following its identification, both Arfvedson and German chemist Christian Gmelin made several attempts to separate lithium from its salts, but neither succeeded. However hard they tried, for example, with attempted reductions by heating the oxide with either iron or carbon, neither was unable to isolate the element in its metallic form.

And there matters stood for a number of years.

The Englishmen

Finally, in 1821, both Humphry Davy and William Thomas Brande, were able to use the electrolysis (in a process pioneered by Davy and with which he had isolated potassium and sodium) of lithium oxide (Li_2O) to isolate a small amount of pure lithium in the form of tiny beads which, however, burnt in air within seconds. Upon performing the experiment, Davy also observed that the new element emitted a red flame (first observed by Gmelin in 1818) that resembled that of strontium.

As co-author of "A Manual of Chemistry: Brande has great descriptions of how to produce various compounds of lithium. He even includes a "taste test", which readers should not attempt to repeat.

The German

While Brande and Davy were able to isolate small amounts if pure lithium metal, in was only in 1855 that German chemist Robert Bunsen, working together with English chemist Augustus Matthiessen at the University of Heidelberg, came up with a way of using electrolysis to produce enough of the metal for it to be studied in detail.

This process, which produced lithium through the electrolysis of lithium chloride, marked the beginning of the commercialization of lithium.

Lithium was discovered by...

So, who do you think really discovered lithium? Was it just one out of all these scientists? Or was it really all of them? Whatever your choice, all of them were outstanding in their day and each of their contributions to its discovery were vital. Most textbooks record Arfvedson as being the first to perceive the element, but perhaps if one had to choose just one protagonist, then the story of how lithium was discovered must surely start with José Bonifácio de Andrada e Silva: scientist, statesman, professor, naturalist, poet and abolitionist.

Opinion

View from EUROPE

From David Merriman of Project Blue

Europe continues to grapple with its imbalance between domestic lithium resources and the looming demand for refined lithium products to meet targets set in the EU Critical Raw Materials Act (CRMA).

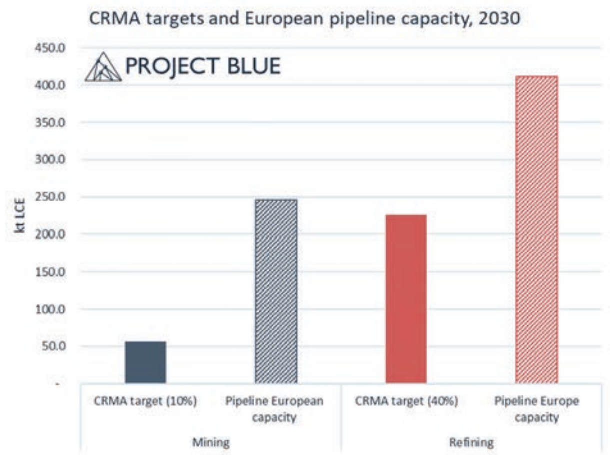
The CRMA sets out aggressive domestic lithium production targets for the EU. By 2030, the EU aims for 40% of its refined lithium demand to come from within the EU, as well as 10% of its mined production. Project Blue forecast this refined demand will equate to roughly 230kt LCE lithium products by 2030.

The re-election of Ursula von de Leyden as President of the EU commission suggests continuity of existing EU energy transition policy and developing European lithium supply chains, at least for the coming 5 years. While European based 'pipeline' capacity appears sufficient to meet CRMA requirements, successful financing, development and licencing will be difficult to achieve in the 2030 timeframe for several prospective lithium miners and processors.

After negotiations with the EU Commission and the German Chancellor, the Serbian government has reinstated a mining licence for Rio Tinto to develop the Jadar project. The reinstating of the licence has precipitated significant protests against the U-turn on Serbia's lithium mining ban announced in 2022. The lithium mining ban was deemed unconstitutional in a 2024 court hearing. Jadar has a potential capacity of nearly 60ktpy LCE, making it the largest lithium project in Europe by targeted output, though with permitting expected to take at least two years according to the Serbian Ministry for Mining and Energy production from Jadar is not likely until approaching 2030.

In Germany, Vulcan Energy Resources announced first production of lithium chloride from its Lithium Extraction Optimisation Plant (LEOP) in Landau using their proprietary aluminate-based adsorbent (VULSORB®) DLE process. Vulcan also began commissioning of their lithium hydroxide optimisation plant near Frankfurt in August.

AMG Lithium continues to construct the Bitterfeld lithium hydroxide plant in Germany, which will process spodumene concentrates from AMG's operation in Brazil and recycled lithium compounds from Fortum Battery Recycling's Harjavalta plant in Finland.



Notes: CRMA targets based on Project Blue European demand forecast for 2030 (July 2024).

In France, Lithium de France and the Bureau de Recherches Géologiques et Minières (BRGM) strengthened collaborative efforts to develop geothermal brine projects within the Alsace region. Imerys extended a public consultation for the development of the Beauvoir lithium project near Echassières, France until end-July 2024, with a report for the project development now being compiled by the Commission nationale du débat public (CNDP).

Finally, although the EU looks to bolster its domestic extraction and processing of lithium products to support its energy transition technologies, the potential classification of lithium carbonate, chloride and hydroxide as "known human reproductive toxicants" by the European Chemicals Agency's Risk Assessment Committee could prove a potential hurdle to developments, especially since several countries, including the USA, Australia, Chile, Argentina and the UK have written to the EU disagreeing with such a classification (*see Lithium Voice #6*).

View from Europe represents the opinions of Project Blue and does not reflect the opinions of ILiA.

PROJECT BLUE

View from NORTH AMERICA

From Adriana Carvalho, Senior Managing Editor, Metals
S&P Global Commodity Insights

Quest for critical materials fuels growth of North American battery hub

North America is on the brink of becoming a battery production hub that will help power the global energy transition, while expanding the region's fleet of electric vehicles.

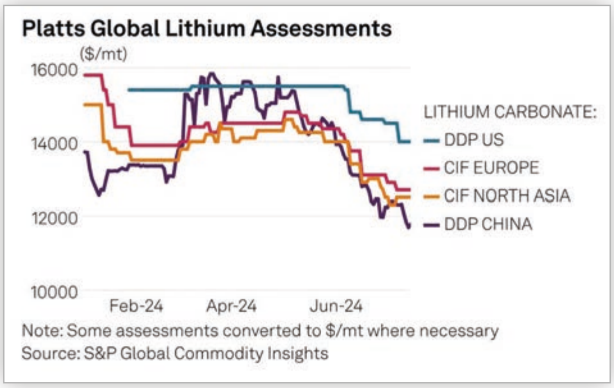
Automakers, spurred by US government support for the sector and their own goals to expand EV model offerings, have announced more than USD100 billion in new investments for the development and production of EVs in the nation over the coming years.

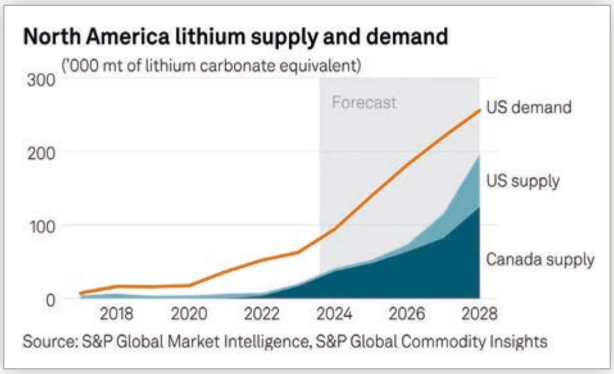
Additionally, the Department of Energy announced in July that USD1.7 billion will be provided to modernize and convert US traditional auto manufacturing facilities to produce EVs and their components.

Battery manufacturing is likewise seeing a dramatic influx of funds, with an estimated USD50 billion being poured into battery production facilities across the continent through the end of this year. Companies including Panasonic, LG Energy Solution, and Samsung SDI are establishing or expanding their operations, signaling a robust future for battery supply chains within North America. These facilities are projected to support a cumulative battery production capacity of 1 terawatt-hour (TWh) by 2030.

The State of Critical Materials

Securing a stable supply of critical materials is essential for the success of this expansion. Investments in lithium and nickel projects are projected to reach around USD10 billion by the end of the decade. However, approximately 75% of the lithium used in US electric battery production is expected to be sourced from abroad, according to the US Census Bureau.





Despite this, there is limited spot activity for lithium salts in the US, as most companies are locked into long-term agreements or those focused on ramping up their pilot pCAM/CAM plants are procuring small trial lots.

According to S&P Global Commodity Insights (SPGCI), there are at least 35 electric battery manufacturing facilities in the US that are planned, under construction, or currently operational. Six companies involved in developing these facilities have committed more than USD11 billion in the next five years to future lithium iron phosphate (LFP) production, alongside several announced nickel-cobalt-manganese (NCM) projects, highlighting significant investments in both areas.

In 2023, lithium carbonate accounted for 89.4% of raw material costs for LFP cathodes, while lithium hydroxide made up 62.9% of costs for NMC-811 cathodes, according to SPGCI data. A decline in battery metal prices contributed to a 30% drop in the average battery pack cost year over year.

Approximately 125 lithium extraction projects are underway in the western USA. These face challenges beyond low prices, such as complex regulations, lengthy permitting processes, environmental concerns, and a lack of commercial-scale extraction technology.

Nonetheless, Stardust Power has announced plans to enter the US lithium supply chain by constructing a large lithium refinery in Muskogee, Oklahoma, capable of processing various brine inputs and producing up to 50,000 mt per year.

View from North America represents the opinions of S&P Global Commodity Insights and does not reflect the opinions of ILiA.

View from SOUTH AMERICA

From Daniel Jiménez of iLiMarkets

In South America, the lithium industry saw notable developments throughout the second and third quarter of 2024 in Chile, Argentina, Brazil, and Bolivia.

Chile's National Lithium Strategy Advances: In Chile the government continued implementing its National Lithium Strategy. From a total of 69 salars two will be controlled by state-owned enterprises, five will involve public-private partnerships, 27 will be open to private enterprises and the remainder are or will be under environmental protection.

State-owned copper producer Codelco will maintain a majority stake in key lithium projects at Salar de Atacama and Salar de Maricunga. Codelco and SQM agreed to form a 50-50 JV to operate SQM's Atacama operation until 2060. SQM's original lease would have expired by 2030. At Salar de Maricunga, in which Codelco holds a Special Lithium Operation Contract (CEOL), it has consolidated large portion of the mining property by acquiring the Salar Blanco project for USD244 million from Lithium Power International and receiving SQM's mining property as part of the Atacama deal.

Codelco is also seeking a strategic partner with a potential 49% stake. Possible mentioned candidates include Eramet, Ganfeng Lithium, Rio Tinto, and Aramco. ENAMI, another state-owned company, is also moving forward with the Salares Alto Andinos project, which includes four salars. A search for a partner is ongoing, with a final decision expected by March 2025. Meanwhile, exploration campaigns are underway at the Aguilar, Grande, and La Isla salars, and an Indigenous Consultation process has been initiated to review CEOL requests. Interest in Chile's lithium sector remains high, with 88 expressions of interest from 54 companies across 10 countries submitted through a Request for Information (RFI) process. Contracts are expected to be finalized by mid-2025.

During this quarter, Albemarle ramped up production at La Negra, boosting total annual export volumes to 53 kMT lithium carbonate equivalent (LCE). Finally, on their second quarter earnings, SQM also posted record exports and sales volumes.

Argentina: Delays Amid Price Pressures: Argentina faced delays in project developments due to low lithium prices and financing challenges. Argosy Minerals suspended operations at its Rincon Lithium Project, citing market conditions and a need for capital preservation. Eramet announced a delay in the startup of its production at its Centenario lithium plant, original plans was to start in June, but now November is the date. The goal is to reach 24 kMT LCE annual capacity by mid-2025. Arcadium Lithium reported, reported delays in expanding their Fenix facility and Sal de Vida project, further reflecting broader market uncertainties. Zijin Mining also appears to be delayed due to technical reasons.

The Cauchari-Olaroz project, co-owned by LAAC and Ganfeng Lithium, which started production in Q3 2024 announced to be producing at about 70% of its name plate capacity of 40 kMT LCE per year, expecting to produce 20 to 25 kMT LCE in 2024, in line with previous forecasts.

Brazil: Consolidation Trends: In Brazil, the market is seeing consolidation, notably with Australian Pilbara Minerals acquiring Latin Resources, a spodumene project. The move signals increasing interest in Brazil's growing role in the lithium supply chain. In the case of Lithium Ionic, it successfully finalized a USD20M royalty agreement with Appian Capital Advisory LLP. The funds will be used to advance development and construction of the company's Bandeira Lithium Project in Brazil's Lithium Valley, known for its rich concentration of lithium-bearing pegmatites, and for general corporate purposes and working capital.

Bolivia Moving Forward: In August, Bolivia's Yacimientos de Litio Bolivianos (YLB) and China's CITIC GUOAN presented feasibility studies for a new Direct Lithium Extraction (DLE) industrial plant in northern Salar de Uyuni. The presentation to Coroma's local leaders showed the project's technical and financial viability, emphasizing sustainable water use and regional development opportunities.

In summary, South American lithium industry is seeing the declining lithium chemical prices leading to project delays and slower expansions due to financing difficulties. Despite the challenges, there remains strong interest in lithium extraction since production costs are, in general, at the low end of the cost curve.

View from South America represents the opinions of iLiMarkets and does not reflect the opinions of ILiA.

iLi MARKETS

SPOTLIGHT ON SUSTAINABILITY

Community engagement at Lithium Business in Araçuaí, Minas Gerais, Brazil. There are many conferences for the lithium industry, but few focus on community engagement as much as Lithium Business. ILiA's Astrid Karamira reports.

Boarding my flight from Lisbon to Belo Horizonte on July 1st this year, I could not have imagined how the days ahead would turn out.

It was my first time visiting Brazil and I was going to attend the second edition of the Lithium Business conference in Araçuaí, a small mining town in the state of Minas Gerais. The organizer, Prof. Rossandro Ramos, had invited ILiA to speak at the conference and as the lusophone on the team, I was the lucky one to represent the association at this event in the lithium valley of Jequitinhonha.

Two flights and 5 hours by car later I reached Araçuaí still thinking this would be another typical lithium conference like many others – but by no means. The venue was Araçuaí's tennis club, meaning large parts of the conference were open air. Everything that happened on the main stage – key notes, talks, panel discussions – was streamed to a big screen outside, in an area that felt like a public viewing space for a football match during the World Cup.

Most major lithium mining companies active in the 'Lithium

Valley' region – Companhia Brasileira de Litio (CBL), Sigma Lithium, Latin Resources, Lithium Ioniq – had exhibition stands and a big focus was on education; not simply about lithium, but also about the lithium sector in a broader sense, including impacts on and benefits to the local community.

Visiting the different exhibitors, I suddenly found myself among stands where people sold gemstones, jewellery, honey and cachaça. A key part of the conference concept was to bring lithium miners and the communities together in one place. This also explains the location – in the 'Lithium Valley' and not in Belo Horizonte or another large Brazilian city. Lithium Business provided the space for everyone to mingle and to learn more about each other and it worked very well. The lady selling her cachaça (one of the best in Brazil, as I was told) and the gentleman selling gemstones, visited the stands of the miners and learnt more about lithium extraction in the region, while the representatives of mining companies bought jewellery, cachaça and gemstones in return. A prime example of mutual benefits and an excellent way to get the "social licence to operate" not only for one company, but for an entire region.

In the evening a local band played Samba and many participants brought out their dance moves.

Lithium Business 2024 demonstrated how community engagement in lithium mining can be done well from the beginning and others could learn from this kind of co-creation and co-education. It was great to meet so many of our members – AMG Brazil, CBL, Latin Resources and Sigma Lithium – in person and I look forward to being a part again of next year's edition of Lithium Business in Araçuaí!

Interview

In conversation with
DAVID F. BOUTT, PHD

Professor of hydrogeology at the Department of Earth, Geographic, and Climate Sciences, University of Massachusetts Amherst, and an Honorary Fellow of ILiA

How did you come to study salars?

I've always been drawn to complex challenges and, from an early age, growing up in the Detroit suburbs, I've been drawn to water, even though when I was growing up in Detroit most of my classmates and family were in the car industry.

Initially I was drawn to study geology as I was fascinated by deep time and how mountains, volcanoes and beautiful landscapes are formed. But at Michigan State University, where I was an undergraduate, it's the mid-West and there wasn't a big mining industry so most geologists went into oil and gas.

I've always found societally relevant problems to be very interesting, and studying water, and groundwater in particular, it was natural to progress from geology to hydrogeology. I moved to New Mexico Institute of Mining and Technology for my PhD because it has one of the top hydrogeology programs in the US. It's a desert landscape and I was exposed to a lot of questions about groundwater recharge, especially in arid conditions.

In New Mexico I first met LeeAnn Munk [see *Lithium Voice* Vol.3] and several years later, when she was studying Clayton Valley, Nevada, and the Salar de Atacama in Chile, she reached out to me and immediately I was hooked. Salars are truly spectacular and to understand a salar you need to look at both the geology and engineering sides of hydrogeology, as well as all the sub-disciplines of geology, from vulcanology to sedimentology, from geochemistry to structure and minerology. Everything is relevant in these salar systems! That's what excites me, the complexity.

Do you remember your first visit to a South American salar?

Absolutely! I'd been to a lot of closed valleys in the US, like Death Valley, but actually arriving in Salar de Atacama completely blew me away; the immense scale of the basin and the stark topography of the mountains.

Ever since then, I've done as much field work as possible. For example, we're currently working with a project in Argentina and every time we visit it we learn new things about how the system works. You can't study a salar without visiting it!

Do you have any advice to developers looking at salars?

Look at the full picture, not just the brine. A lot of our most important advances in understanding have come from looking at the full length of the flow, from the brine all the way up to the edge of the watershed. For example, at what stage is the lithium picked up from the rocks and washed down to the basin as in-flow waters?

The availability of fresh, unsalty water is very important too, as shown by the mining companies Albemarle and SQM even talking about transporting desalinated sea water to their lithium operations in Salar de Atacama.

> ***"On a technical level, it's really important to remember the age and convection processes in a salar. The brines have evolved over millions of years and don't stand still.***

What does the future hold for lithium production from salars?

Most of the brines which have been pumped since the 1980s have come from the top 30m or so of salars, but there are lithium-rich brines deep in the subsurface too, both in Salar de Atacama and the Argentinian salars. These could be really good targets for exploration and would be more like the work being done to develop lithium from geothermal or oil-field brines.

What challenges does salar hydrogeology face?

I'm in this to discover new information and our group prides itself on publishing in the top journals. However, not everything which is published about salars is good quality. We often find ourselves playing whack-a-mole with people with political or commercial points to make who publish wrong information.

On a technical level, it's really important to remember the age and convection processes in a salar. The brines have evolved over millions of years and don't stand still. For example, in the Salar de Atacama, after a rare rain storm, the salt on the surface dissolves, changing the hydraulic conductivity and creating new pathways through which liquids can flow, but over a decade these flows will cease.

Although we know that some of the water in salars is very old it is hard to date it exactly. Fresh rainwater has tritium, a radioactive isotope of hydrogen with a half-life of around 12 years, but this effectively disappears after a century. It's possible to make estimates based on inorganic carbon dissolved in the water, but the risk of doing this in an area of high volcanic activity, such as the Andes, is that carbon that is very, very old, from deep within the Earth, contaminates the readings.

Credit: D.F. Boutt

Credit: D.F. Boutt

What makes a good hydrogeologist?

In hydrogeology there are three pillars, modelling, hydro-geochemistry and physical hydrogeology, and they complement each other. LeeAnn and I work well together because she brings a geochemistry expertise and I bring a more physical hydrogeology background. We challenge each other and our different approaches each tell part of the full story.

To someone looking to get into hydrogeology, a good understanding of modelling groundwater flows, coupled with geophysical understanding is a great starting point.

It's important to recognize that hydrogeology is a team game and the work which LeeAnn and I do is possible because we have help from great students and former students, in addition to excellent company partners too, which is unusual in academia. For example, we work very closely with Albemarle and Lithium Americas to help them understand their resources, and in return our understanding and salar models improve too.

Is brine water?

You're asking the wrong question! [he laughs]. It's not a fair question to equate a litre of brine to a litre of water, they are extremely different things and they have very different roles and places in a salar environment. Water, brine and all the shades of brackish liquids in between each have different purposes in a highly complex system.

Do you own an electric vehicle?

Not yet, I'm making the most of the embedded emissions in my current cars before making the trade!

I definitely will though. Recently when my family and I were mountain-biking in the mountains of southern Poland we could only rent electric models. I'd not ridden one before, but we had a blast!

Feature

NEW LITHIUM LCA GUIDANCE (PART 2)

New Guidance on Product Water Scarcity Footprint in the Lithium industry

Life cycle assessments (LCAs) are increasingly important to industry and regulators. Currently, the only standardised guidance for a lithium LCA covers the product carbon footprint (see *Lithium Voice* Vol.5 and Vol.2), but this is set to change with a new industry initiative, the *Product Water Scarcity Footprint for Lithium Products (PWSF)*, managed by ILiA's Sustainable Lithium Subcommittee.

LCAs are becoming a standard piece of documentation for many products. Although an LCA typically describes more than ten 'environmental impact factors' with the Global Warming Potential (or Product Carbon Footprint) attracting most attention, water footprint in lithium production is increasingly becoming a matter of interest as claims about global or local impact of water consumption in the lithium industry are more often being made based on limited scientific data.

The aim of ILiA's project is to promote comparable declarations of the product-level water consumption and the water scarcity footprint to complement voluntary and/or required corporate-level reporting. It is important to point out that the project focuses on blue* water product-footprints (delineated from brines) and does not address local ecological or social impacts. The water scarcity footprint is a metric quantifying the potential contribution of direct blue water demand to water scarcity across the production areas of the product value-chain. Blue water refers to water extracted from lakes, rivers and underground reservoirs, and not "green water", which refers to precipitation that readily evaporates and does not replenish groundwater levels. It should be noted that this does not entail water ready for human consumption.

This project is the first global effort to define how Product Water Scarcity Footprint (PWSF) of lithium products could be calculated and explicitly does not substitute corporate-level reporting.

Even though reporting on water usage in mining is not yet widely spread, new regulations will include aspects on water usage in the future. For example, provision of a PWSF declaration is expected to become a requirement for access to the EU market for battery-grade lithium products under the EU Eco-design for Sustainable Products Regulation (ESPR) as of February 2027.

Why the new guidance?

- Members would have a more complete set of tools to consistently address the diverse concerns of customers, investors, NGOs, standard-setters and legislators.
- Voluntary use of the ILiA PWSF Guidance for externally facing statements will conform to global standards because it interprets them within the context of the lithium industry, without creating an additional reporting burden.
- Understanding the PWSF of a production process drives continuous improvement and innovation.

WHAT IS AN LCA?

A life-cycle assessment (LCA) is a process of evaluating the effects that a product has on the environment over the entire period of its life thereby increasing resource-use efficiency and decreasing liabilities. It can be used to study the environmental impact of either a product or the function the product is designed to perform. An LCA is commonly referred to as "cradle-to-grave" analysis.

The key elements of an LCA are to (1) identify and quantify the environmental loads involved; e.g. the energy and raw materials consumed, the emissions and waste generated; (2) evaluate the potential environmental impacts of these loads; and (3) assess the options available for reducing these environmental impacts.

United Nations Environment Programme

Our proposal for lithium

The proposed lithium PWSF Guidance will consider the following aspects:

- It will define the methodology specific to the lithium production industry and refer to existing standards where possible.
- It will align with existing standards, such as ISO and the EU's Environmental Footprint methodology, the ICMM's Water Reporting good practice guide, and The Water Footprint Assessment Manual of the Water Footprint Network.
- It will be limited to cradle-to-gate boundaries, excluding the use-phase and lithium recycling.

- It will be a practical and easy-to-use guide that is agnostic to production route, technology or geography.

ILiA's membership of the International Council on Mining and Metals (ICMM) and the Global Battery Alliance (GBA) helps ensure our lithium guidance is aligned with other battery raw materials too.

Where we are and the road ahead

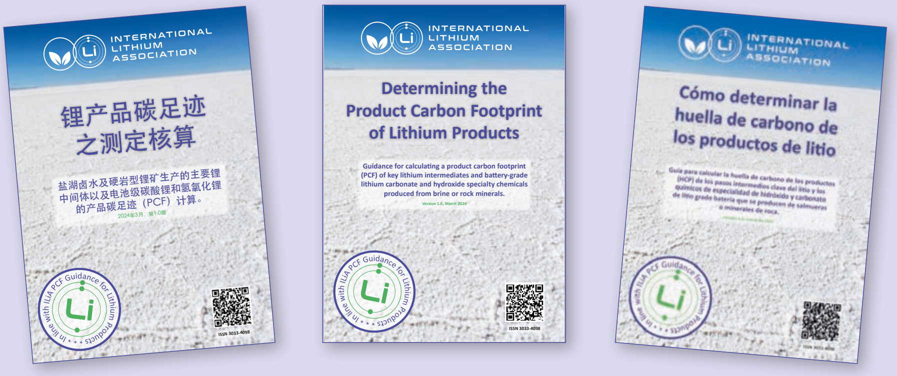
The project started in May 2024 and is led by the Association's Sustainable Lithium Subcommittee and supported by the PWSF Working Group which has wide representation from across the lithium industry, including many non-members and academic experts. Participation is open to both ILiA members and non-members and interested parties are still welcome to join. This structure follows a similar design to the Product Carbon Footprint project that was completed earlier this year (see *Lithium Voice Vol.5*).

The draft guidance document will be written by Johannes Drielsma, an independent project leader with vast experience in the creation of carbon footprint guidance documents and the management of complex multi-stakeholder processes. The first workshop of the working group was held in mid-June and the second workshop was held in mid-September, with two more rounds of consultations and workshops to follow.

The Sustainable Lithium Subcommittee aims to complete the final draft of the guidance document in early 2025. It seeks to set a good starting point and is intended to be revised and refined in line with future experience.

The Sustainable Lithium Subcommittee of ILiA is Mark De Boer (Chair, Albemarle Corp.), Dana Graves (Arcadium Lithium), Austin Devaney (Piedmont Lithium), Eulogio Almanza (Pilbara Minerals), Rajini Janardhan (Rio Tinto), Renaud Thiard (Sibanye Stillwater), Valentin Barrera (SQM), and Christina Wang (Tianqi Lithium).

*Blue water is defined as fresh surface and groundwater, the water in freshwater lakes, rivers and aquifers (WFN, 2011) having a concentration of dissolved solids of up to 1000 mg/L (USEPA, 1979; EU, 1998; WHO, 2011): surface and groundwater flows or stocks of water excluding rainfall and surface soil moisture (Hoekstra et al., 2012 in Northey, 2018).



Product Carbon Footprint (PCF) guidance for lithium products now available in English, Spanish and Chinese

ILiA's landmark guidance on calculating the PCF of lithium products is now available in English, Chinese and Spanish as part of the Association's mission to share relevant information about the lithium industry as widely as possible. All three editions are available from **www.lithium.org**.