Charging toward a sustainable lithium future

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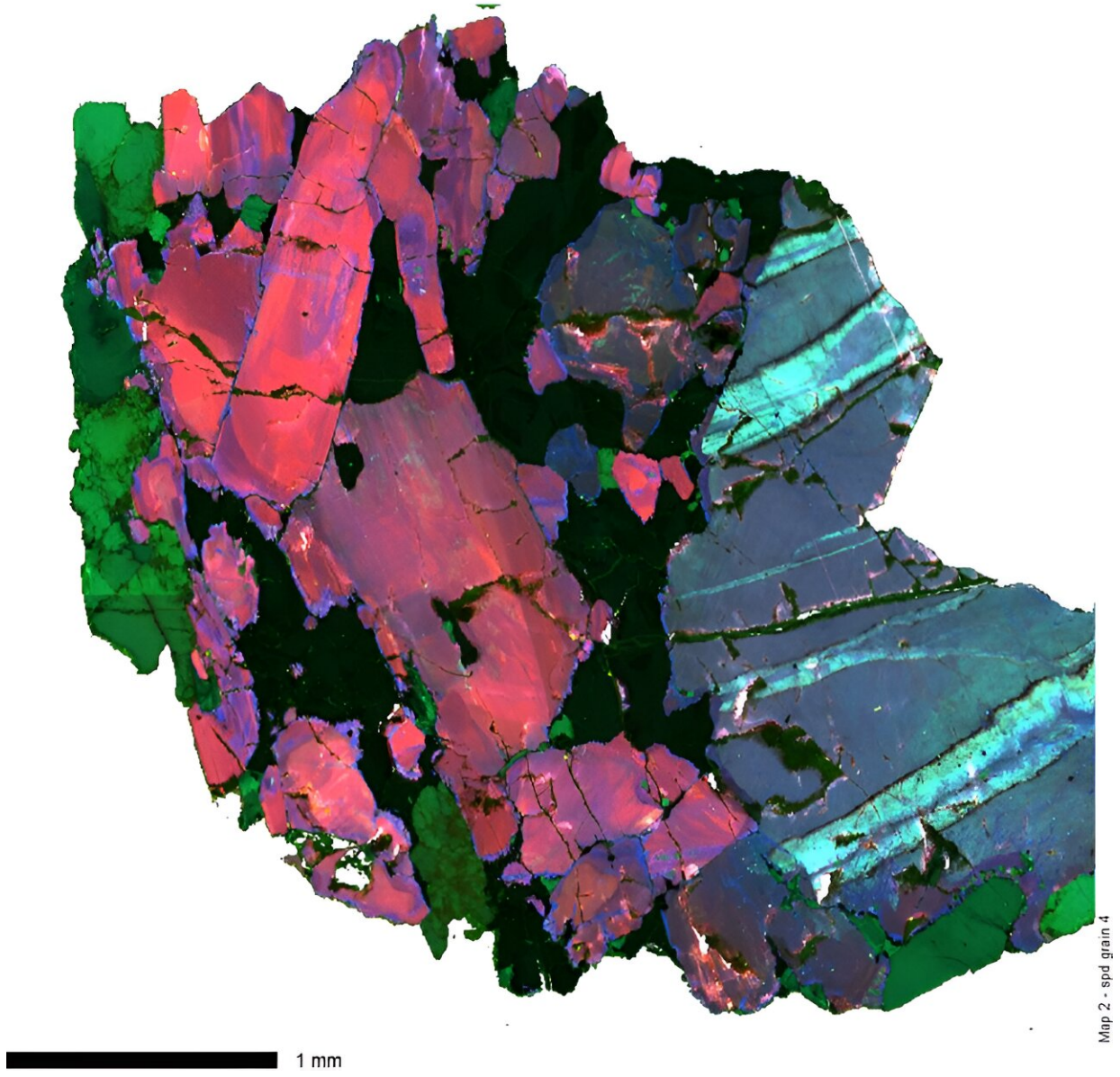

A cathodoluminescence image of spodumene (an important source of lithium)

intergrown with quartz and albite. Credit: CSIRO

More than almost any other substance on Earth, lithium (Li) is valued as a 21st century treasure. But Australia's race to unlock its lithium is challenged by political and economic headwinds both global and domestic.

Lithium capacity is being bolstered with groundbreaking exploration, extraction technologies, and mapping a sustainable pathway for the critical mineral to meet global energy demands.

Why lithium?

Lithium is a critical mineral and is vital to modern technology. It has become synonymous with the future of energy storage, already powering electric vehicles and renewable grids. Thanks to its lightweight, high energy density properties, lithium is ideal for rechargeable batteries.

As more countries transition to cleaner energy and zero emissions, the demand for lithium has skyrocketed. But securing a stable supply of lithium is hard, especially finding it and extracting it efficiently.

Finding lithium can be tricky and processing it harder

Dr. Ryan Manton is a Research Scientist in our Hydrothermal Footprints team. He is no stranger to the barriers of lithium exploration, such as finding deposits buried under cover, and the task of characterizing complex pegmatite mineralogy.

"Most, if not all, hard rock lithium deposits in Australia have been found

in outcrops. This is where portions of the deposits, which are known as pegmatites, stick up above the ground. And many of them have been found by accident or from historical mining of other metals, such as tin oxides or nickel sulfides," Manton says.

"Many recent world-class lithium hardrock deposits have been found this way in Western Australia. World-class roughly means more than 100 million metric tons of resources per deposit, with ore grades of 1.5% lithium oxide (Li_2O). This begs the question: how many large deposits are buried under cover, that are yet to be discovered?"

Meanwhile, petrophysical studies, looking at how the properties of rocks interact with fluids, examine the density, magnetic susceptibility and seismic properties needed to guide geophysical exploration.

Characterization techniques for regolith, the loose ground that covers solid rock, can shed light on what sits above the mineralized lithium pegmatites. It's an arsenal that equips researchers to identify hidden deposits beneath the Earth's surface, potentially unlocking vast, untapped swathes of lithium.

Dr. Donna Liu, a Research Scientist with our Process Development team, is at the forefront of the hunt for lithium.

"The metal holds vast possibilities as a replacement for graphite as an anode material, unlocking potentially enhanced energy density for battery systems," Liu says.

Compared with lithium hydroxide and carbonate, lithium metal's current place in the global metal market is underwhelming. But it's expected to rise in the next decade with the tide of commercialized lithium batteries, especially in vehicles.

"However, obtaining high-purity metallic lithium reliably has proven to be a significant challenge. The current industrial electrolysis process for lithium metal production suffers from severe environmental issues due to emission of toxic chlorine gas," Liu says.

"The process requires highly pure and moisture sensitive lithium chloride feedstock, potentially making it expensive. It is imperative to develop more sustainable and economic processes for metal production to meet the growing demand for this critical metal and ensure a secure supply for sovereign countries."

LithSonic boom

We have a potential gamechanger in LithSonic, a patented metal production process that uses supersonic flow dynamics to enhance the dissolution of lithium from ores.

Our patented technology activates a carbothermic reduction of lithium oxide to generate lithium metal vapor. A carbothermic reduction is a chemical reaction involving the reduction of substances using carbon as the reducing agent.

Next comes a rapid quenching process using a de Laval nozzle (a gas channel that increases the speed of the gas passing through it to supersonic speeds) to directly convert the produced vapor into lithium metal powder. This minimizes any unwanted reversal reaction.

The process has clear advantages over the existing electrolysis route, such as the lack of toxic chlorine emissions.

"It is potentially cheaper too," Liu says, who also heads up LithSonic's development.

"We're aiming to scale it up to mini-pilot plant, which is up to the kilogram-scale, and demonstrate the process in the next six to 12 months."

LithSonic is nearly through early-stage development, whereby a new technology is validated at laboratory scale. While it's relatively early days, Liu confirms widespread interest in the technology, with queries pouring in from across South America and Asia.

"The Australian minerals sector has also shown significant interest, particularly from industry leaders looking to adopt and develop sustainable mining technologies," Liu says.

"Our collaborative efforts with local and international partners help make sure these innovations aren't just theoretical. These are real world solutions driving industry standards."

Analyze this: Lithium's complexities

When the techniques sound like an inventory of tactical gear from a Ghostbusters film—think inductively coupled plasma optical emission spectroscopy (ICP-OES)—it's possible to get a sense of how complex it must be to analyze lithium.

Dr. Nick Wilson is our Team Leader for Electron Microscopy and Analysis. He thinks that ICP-OES is actually one of the more straightforward techniques for bulk characterization of lithium.

"But it's also important to be able to characterize lithium spatially within a sample, so you can see which mineral phases it sits in. There are many techniques that can characterize lithium at different length scales," Wilson says.

At the nano-scale, electron energy loss spectroscopy (EELS) can be used, though it presents challenges. At the micron scale, techniques like SIMS (secondary ion mass spectrometry) and in some cases electron probe microanalysis (EPMA) can be used.

At larger lengths, such as 10 microns and above, laser-based techniques with complicated names such as laser ablation inductive coupled mass spectrometry (LA-ICPMS), and laser-induced breakdown spectroscopy (LIBS) can be used.

"Quantitative analysis remains a challenge due to issues like sample reactivity and accurate mass absorption. We are addressing these challenges through specialized inert sample handling facilities and our hyperspectral soft X-ray collection software called NiCoLiN, and novel matrix correction procedures," Wilson says.

"This integrated approach enhances accuracy in spatial characterization, critical for understanding lithium distribution in complex mineral matrices. These advancements are pivotal in optimizing mining processes and ensuring sustainable resource management."

Australia's lithium landscape

More broadly, our initiatives in lithium-ion battery recycling point to our commitment to using the critical mineral sustainably. Emerging recycling technologies both reduce the environmental impact and recover valuable lithium resources. The circular economic approach echoes the current global spirit of sustainable resource management.

Short-term demand for lithium has dipped despite a global push towards electrification in the automotive industry. Since late-2022, the price of lithium has taken a hit of around 80%. Yet despite the current oversupply, optimism blooms within the industry.

Lithium production will need to lift to support the world's transition to electric vehicles (EVs). Current market conditions aside, future demand is widely expected to increase significantly as EV adoption grows globally.

Australia is rich in lithium, ranking alongside top producers like Chile. With world renowned mining tech savvy and geological expertise, Australia is the envy of most of its lithium competitors. Our research and technological innovation will help determine whether the country's lithium fortunes stagnate or surge.

Along with nickel and cobalt, lithium is precious to a world electrifying transport and cutting emissions, an existential step towards global climate targets.

Provided by CSIRO

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