

## Overview

As noted in *issue 30*, many industry analysts have seized on recent statistics for lithium supply and demand as indicative of long-term market trends. Some forecast a glut in supply that would send the value of lithium – and the chemicals produced from it – tumbling. Closer examination reveals this is far from the truth, but – and it's a big 'but' – how can 'infinite lithium' supply be achieved?

## Alternative sources

Current mining expansion won't meet lithium demand longer term, and as the mines mature production will dwindle. New mines sourcing lower grades can come on-stream to fill the gaps, but alternative sources of lithium may prove more attractive as genuine supply shortages put pressure on conventional production. So, what are some of those sources?

As Earth's 'throwaway society' matures and (hopefully) develops a culture of custodianship for the planet, recycling will replace new materials as the preferred source of supply. When the market matures to the point of product saturation, with continual expansion no longer required, demand for, and the recycling of, lithium will synchronise. If that does happen, newly mined material will only be necessary to top up that regained through recycling.

Such a scenario seems a long way off though, and if global population continues to increase by around 1.07% a year (82 million people), it may never be realised. In the meantime, meeting the exponentially increasing demand for lithium has many in the industry scratching their heads at how to achieve this.

Potential sources of lithium to meet future demand include:

- seawater;
- geothermal and oilfield brines;
- recycling of spent lithium-ion batteries;
- lithium clays;
- waste from conventional spodumene processing, and
- lithium micas found in pegmatites and greisen.

## Part 2

# Infinite Lithium

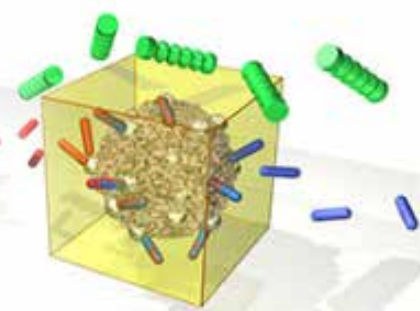
## ■ Seawater

Seawater contains lithium in very low concentrations (around 0.17 parts per million) but has attracted interest as a potentially commercial source. Approaches that involve evaporation ponds won't work, due to the large volumes of water required. Also, seawater contains many other dissolved minerals, so traditional separation technologies like membrane filtration, ion exchange (a reversible chemical reaction to remove dissolved ions from solution and replace them with other, similarly charged ions) and reverse osmosis would involve not only huge energy consumption but also fouling of the filtration media and/or regenerants.

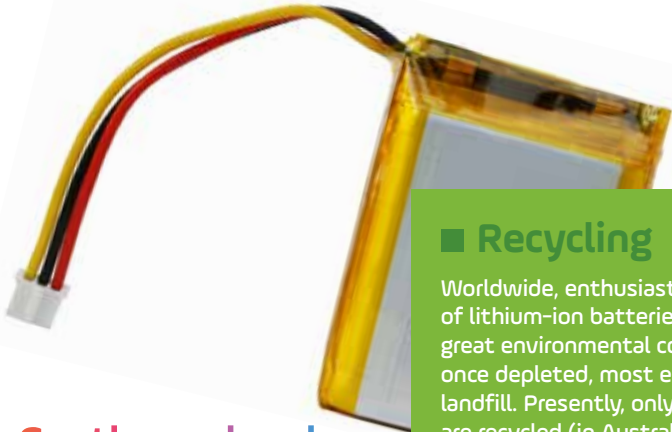
The amount of lithium in solution can certainly be boosted through evaporation, adsorption (where atoms, ions or molecules adhere to a surface to create a film) and electro dialysis (where ions are driven through a selective membrane, then separated and concentrated under the influence of an electric field), followed by purification and, finally, the precipitation of lithium carbonate. Viable lithium recovery is certainly achievable where the medium contains higher initial lithium concentrations.

Metal-organic frameworks (MOFs) could be another approach. MOFs are crystalline powders full of molecular-sized holes. Made of metals joined by organic linkers, they can store, separate, release or protect just about anything.

In addition to seawater, MOFs have the potential to recover lithium from both produced water and wastewater streams, though they have not yet been implemented on a large scale.



Here, the large green molecules are excluded from the MOF and don't interact with it. The smaller red molecules do, and are changed into blue molecules by it. [Source: CSIRO.]



## ■ Geothermal and oilfield brines

The recovery of lithium from geothermal and oilfield brines has been much studied. Usually, the solution phase is targeted, although sludge and scale precipitated as a result of changes in pressure and temperature have also been evaluated. Recovery techniques investigated include ion exchange, adsorption, membrane filtration, and precipitation.

Again, the low concentrations of lithium in such sources are challenging in terms of processing and, in the case of oilfield brines, the expense of pumping from great depths.

Although lithium has been recovered from geothermal brines in Japan and New Zealand, bids to recover it and other metals from the Salton Sea geothermal field in the United States (where lithium could be considered a by-product of geothermal power) have not succeeded.

In the Cornish tin belt in the United Kingdom, tin and copper – as well as other volatile and incompatible elements, including lithium – are found in hot springs in many mine workings. This has led to assessments of mine water as a potentially commercial source of lithium and prompted regional exploration for other lithium brine occurrences.



## ■ Recycling

Worldwide, enthusiastic adoption of lithium-ion batteries is causing great environmental concern since, once depleted, most end up in landfill. Presently, only around 9% are recycled (in Australia, it's less than 3%!) to recover the valuable metals they contain. In fact, the huge quantities of batteries discarded globally could prove a significant lithium resource.

Belgium, South Korea, China and Canada recycle the most spent batteries, usually by smelting. However, the extreme volatility of this form of processing is disadvantageous in terms of recovering lithium, which is usually lost in flux or off-gas. Flux is generally used as aggregates and fillers rather than reprocessed, precluding reuse of the lithium, but research into recovering lithium via condensation of smelter off-gas is now being undertaken.

Meanwhile, the shortfalls inherent in battery recycling are spurring research and development into alternative, more efficient processes.

## ■ Lithium clays

Lithium clays, albeit low-grade in comparison with more conventional hard-rock lithium deposits, have also garnered attention in recent times. Deposits in Mexico have already been metallurgically assessed and future production from the region is anticipated. Other lithium clay deposits – including in Nevada – contain both lithium and boron. All such clay deposits are challenging in that lithium recovery can be very energy-intensive.

## ■ Spodumene processing

Spodumene (hard-rock) mining and concentrate production are other areas in which alternative methodologies could facilitate resource utilisation and production of considerably more lithium from each tonne of ore extracted. With conventional processing, only relatively coarse spodumene is converted into lithium chemicals, while finer particles are discharged as waste. Now, new processing technologies that improve recovery and utilise material unsuitable for conventional lithium conversion are in development. They present the industry with a great opportunity, since their implementation could supply battery manufacturers with far more lithium chemicals without any increase in mine production.



## ■ Lithium micas

Lithium micas are the world's most abundant lithium minerals. Lepidolite in particular is commonly associated with tin, tantalum and tungsten mineralisation. Mining operations for those elements often discharge vast quantities of lithium micas as waste ... and that waste seems an obvious target for lithium production, since the costs of extraction and some processing are already covered by exploitation of the primary minerals. That said, innovative processing technologies are required to turn lithium micas into a practical source of critical metals. Indeed, they could even see the lithium element of such mining operations become the initial target, with the tin (or other metals) a by- or co-product.

## "To infinity and beyond"

If demand for lithium-ion batteries grows beyond the pundits' wildest expectations, which it seems it may, then conventional sources of lithium supply simply won't cope with demand. Unconventional sources will have to fill the gap. How, and when, those will be exploited is the fundamental question.



## And finally ...

Bentley's EXP 100 GT – a "car that connects with its passengers" – is still at the concept stage, but the jury's out on this one!

Which Perth-based company is exploring several unconventional sources of lithium supply?



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