

The Promise and Perils of Recovering Lithium and Other Critical Minerals from the Salton Sea Geothermal Brines

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Summary

The nature and origin of hot, metalliferous basinal geothermal brines in the Salton Trough rift are described, along with the potential and challenges of economic extraction of Li and other critical minerals from them, via DLE technologies that are being adapted to existing geothermal brine power production infrastructure.

Geologic background

Within the Salton Trough active continental rift, repeated infilling and desiccation of saline lakes derived from the meandering Colorado River over the last several million years have deposited a series of lacustrine-deltaic sediments rich in continental evaporites and Li-rich smectites (Humphreys et al., in press). Evaporation of the lake waters has generated a saline basinal Na-Cl brine that normally sits at depths of 5-4 kms within the northern portion of the Trough (Williams and McKibben, 1989). In regions that have been heated by Holocene rift magmatism (bimodal basalt-rhyolite) located above *en echelon* East Pacific Rise spreading center fragments, the sediments and brines are hydrothermally metamorphosed to form greenschist and amphibolite facies fractured hornfels reservoir rocks permeated by evolved Na-Ca-K-Cl brines rich in metals leached from the mudstone protoliths (McKibben and Hardie, 1997). The heated metamorphic brines have advected to depths as shallow as 0.5km above the hottest portions of the reservoir, where geothermal operators extract brine to produce electricity from steam.

Reservoir metals content

Brine production from commercial wells has been very consistent over the last two decades, averaging just over 120 million metric tons per year since 2004 (Dobson et al. 2023). Given the average lithium brine concentration of ~200 ppm, the total amount of dissolved lithium contained in these currently produced brines is estimated to be 127,000 metric tons of lithium carbonate equivalent (LCE) per year. The total dissolved lithium content in the well-characterized, produced portion of the Salton Sea Geothermal Reservoir is estimated at 4.1 million metric tons of LCE, and the estimated total resource increases to 18 million metric tons of LCE if assumptions for porosity and total reservoir size are increased to reflect the probable resource extent based on geophysical data (Dobson et al., 2023).

In addition to Li, these saline (30 weight percent after flashing) hot (225-250°C at the wellhead) brines, once they have been clarified of precipitates via established seeding and settling facilities, contain K (20,100 ppm), Mn (1690 ppm), Zn (610 ppm), and Sr (540 ppm) that may be amenable to co-production along with the Li, enhancing the total potential revenue stream from the brines.

Application of DLE technologies to geothermal brines

The three geothermal operators that are currently focusing on geothermal power and critical minerals production from these brines are in the midst of testing and proving their adapted DLE technologies at scale, with all of them currently centered on the use of dual layer aluminate adsorbents in fixed columns, followed by LiCl elution with water. Conversion to LCE and LHM are being considered as marketable products.

Critical minerals recovery from the Salton Sea geothermal brines faces some unique challenges due to their high temperatures, high salinities, high brine flow rates and significant precipitation issues, all of which are currently handled by patented reactor-clarifier technologies that have been in operation at the field since the 1980s (McKibben and Stringfellow, 2025). However, some distinct advantages that accrue to extracting Li from geothermal brines can be seen as advantageous over Li from other brine and rock resources and include:

- No drilling, blasting, grinding, rock leaching, tailings piles or evaporation ponds.
- Brine production and handling infrastructure is already capitalized and in place.
- Low areal footprint (~ 50 acres per Li extraction plant).
- Can self-supply low-carbon renewable electricity from geothermal power plants.
- Can self-supply carbonate from CO₂ in steam for making LCE.
- Can self-supply fresh water for Li processing from clean steam condensate.

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