Development of Lithium Brine Projects

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Lithium Deposits Worldwide

Map showing the distribution of lithium deposits worldwide with different stages of development and primary commodities.
Why brines?

Why not???

Byproduct potential

No mining engineers

Low surface impact

No miners

Low environmental impact

Low OPEX
Lithium Brine Deposits - Overall

Bubble size represents Reported Contained Tonnes of Li Resources

- Uyuni Salt Flat
- Zhabuye
- Dangxiongcuo
- Salar del Rincon
- Antofalla

Brine Grade - Li (mg/L) vs Mg/Li

Bubble size represents Reported Contained Tonnes of Li Resources
Brine vs Hard Rock Evaluation

Hard Rock

• Tonnes
• Grade

Brines

• Extractable brine volume = $V_{aquifer} \times Sy$
• Average brine chemistry
• Permeability which determines brine hydraulic conductivity and transmissivity, to factor how fast the brine can be extracted
Brine Resource Estimate Model

\[ G^{xyz} = S^{zxy} \cdot C^{zxy} \cdot b^{zxy} \]

Where,

- \( G^{zxy} \): Unit Volume tonnage in \( xyz \)
- \( S_y^{zxy} \): Specific yield in \( xyz \)
- \( C^{zxy} \): Elemental concentration in \( xyz \)
- \( b^{zxy} \): Unit “thickness”

RESOURCES is the sum of \( G^{zxy} \)
Factors that matter - Extractability

- Production Well
- Initial brine elevation
- Specific retention loss, $S_r$
- Loss due to minimum well drawdown
- Brine elevation during exploitation

Reserve base subject to an in-situ recovery factor
Factors that matter - Porosity

Pt > Pe ; Pe = Sy + Sr
Porosity: JORC vs 43-101

CIM 43-101

• Guidance updated for brines in 2012
• Requires Sy to be determined using two independent methodologies

JORC

• JORC Table 1 does not include all items significant for brines, or for crystalline evaporites in brine/evaporite systems.
• Could use Total Porosity to estimate a brine resource
Numerical GW Model

Year 0

Year 20

Year 100
Mine planning tool

**Quantity**

- Total Pumping Rate to Achieve Target Production
- Simulated Average Drawdown in Brine Extraction Wells

**Quality**

- Predicted Average Concentration of Li, K, and B
Interpretation of MRMR studies applied to brine deposits

MRMR – Mineral Resource and/or Mineral Reserves
An interpretation of mineral resource classification

Increasing level of geological knowledge and confidence

**Inferred**
Secondary permeability, low confidence in hydraulic connectivity and/or grade

**Indicated**
Physical evidence of sufficient hydraulic conductivity and transmissivity, statistical confidence in grade

**Measured**
Technical and consistent support resulting in 3D model of hydro-lithology and grade
A Mineral Reserve is the economically mineable part of a Measured and/or Indicated Mineral Resource. It includes diluting materials and allowances for losses, which may occur when the material is mined or extracted and is defined by studies at Pre-Feasibility or Feasibility level as appropriate that include application of Modifying Factors. Such studies demonstrate that, at the time of reporting, extraction could reasonably be justified.
Mineral resource to mineral reserve for brine deposits

**Indicated**
Physical evidence of sufficient hydraulic conductivity and transmissivity, statistical confidence in grade

**Measured**
Technical and consistent support resulting in 3D model of hydro-lithology and grade

**Probable**
Long term model predictions (e.g., after 5 years), lower confidence in-situ recovery

**Proven**
Short term model predictions (e.g., less than 5 years), higher confidence in-situ recovery

Modifying Factors: consideration of mining, processing, economics, marketing, legal, environmental, social and governmental factors
Your mineral reserve estimate should...

- Account for in-situ recovery factors for raw brine extraction from the salar
- Be limited to measured and indicated mineral resource classifications
- Include ex-situ recovery factors which must be offset by additional raw brine extraction
- Address spent brine handling and/or process water supply which may impact predicted mine life
- **Remain economic**
Traditional Brine Process

SQM Ponds, Atacama, Chile

Salar del Rincon, NW Argentina
Brine Evaporation Pond Process Simulation

Lithium Concentrations

- Base Case 800 ppm

Li_Concentration (Pond 1)  Li_Concentration (Pond 2)  Li_Concentration (Pond 3)  Li_Concentration (Pond 4)  Daily Precipitation
Value Creation

Investment $$

Stage of Project Development

- Start-up/Commissioning
- Detailed Engineering
- PFS Reserve
- Interesting geological anomaly
- QP/CP Resource Report
- PEA/Scoping Study
- FS Reserve
- Construction
- Target Production

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# Lithium Brine Projects Development Timeline

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Take Home Message

• Brine moves!
• Brines can be very profitable
• Technically complex to explore and estimate resources
• Transition from Static Resource to Dynamic Resource using the continuum of geologic stratigraphy through the use of sequence stratigraphy and onto the final use of HSU’s
• Choice of process that fits the situation, brine chemistry, weather, etc.
• Take good care of your hydrogeologist, you will thank him later