Lithium Brine Project Development

Challenges and Lessons Learned

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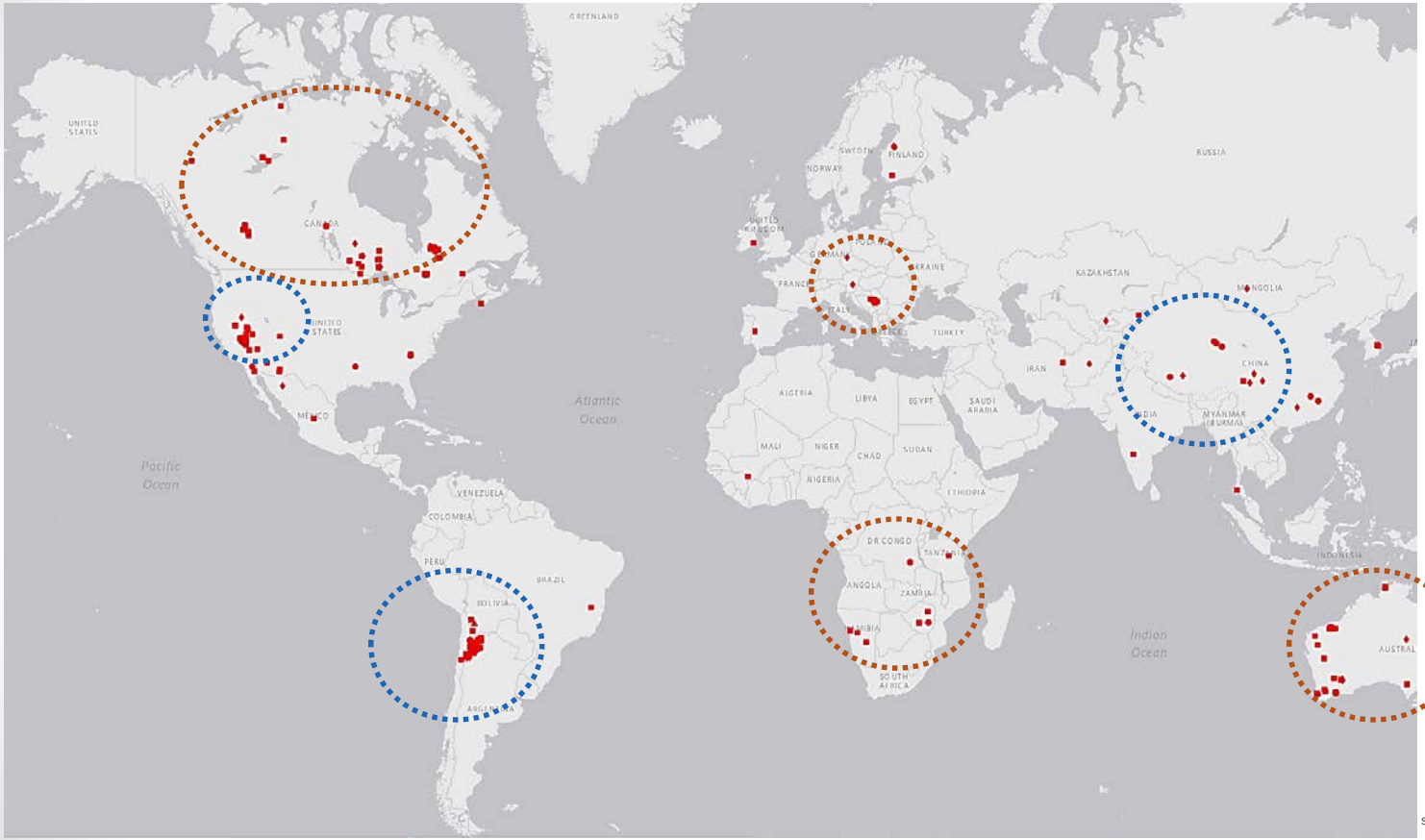
Location: The Geological Society (Burlington House) - April 9, 2018

srk consulting

LITHIUM DEPOSITS

Lithium Projects Worldwide



Primary Commodity

Lithium

Mining Properties

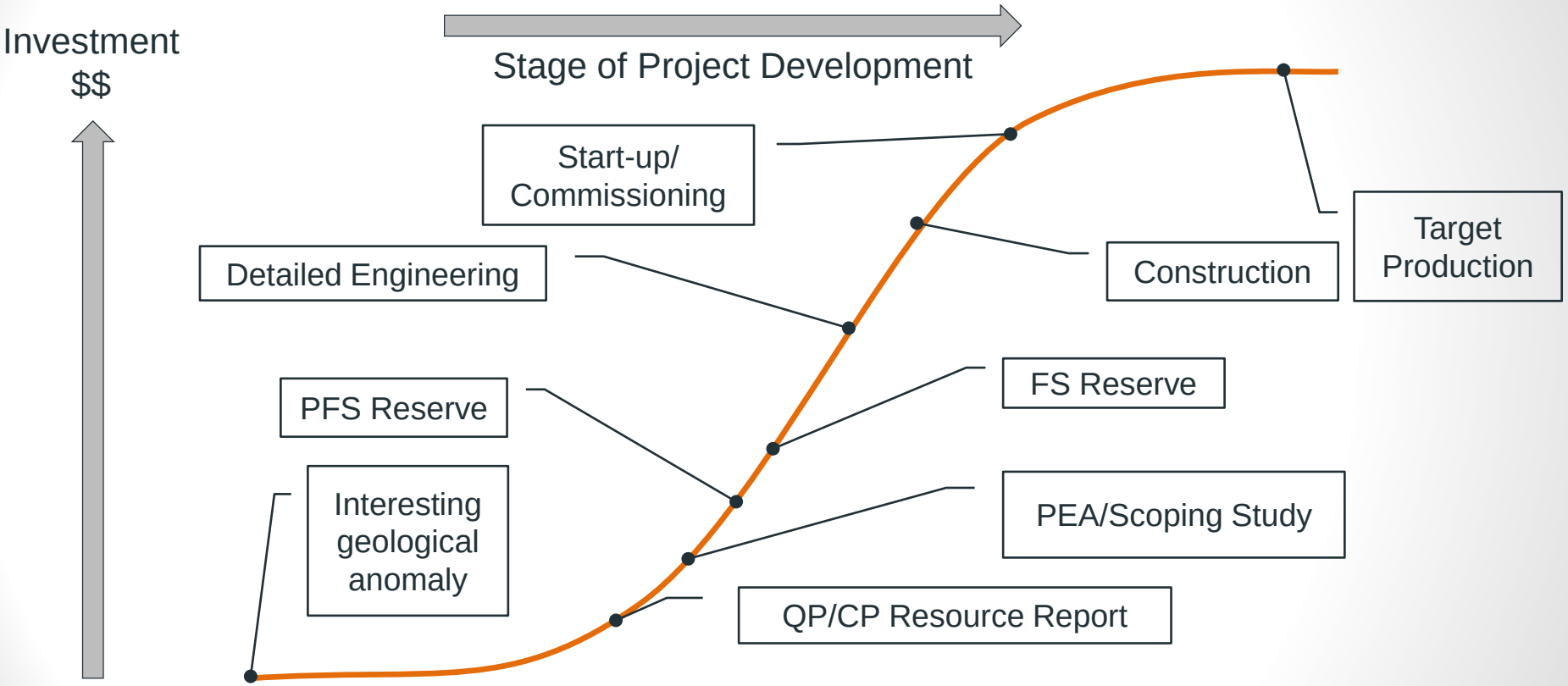
Development Stage

- Exploration
- Operating
- Grassroots
- Reserves Development
- Target Outline
- Advanced Exploration
- Feasibility
- Prefeas/Scoping
- Preproduction
- Expansion
- Satellite
- Limited Production
- Construction Started
- Feasibility Complete
- Feasibility Started
- All Others
- NA

Source: Extract from 2018 S&P Global Market Intelligence, a part of S&P Global, Inc.

LITHIUM BRINE PROJECT DEVELOPMENT

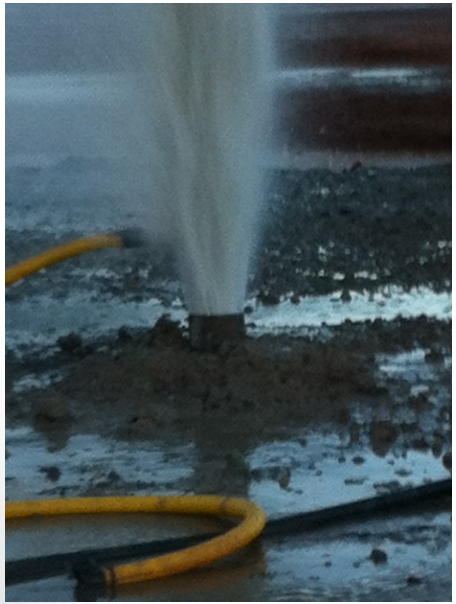
Value Creation



EXPLORATION

Brine Deposits Exploration

Historical Data
Shallow Pits
Geophysics



Exploration Target Definition

Exploration Holes

- Brine Samples
- Core Samples
- Initial Hydraulic Testing
- Borehole Geophysics

Pumping Wells

- Medium to Long Term Testing
- Pilot Production Testing

Models

RESOURCE ESTIMATION

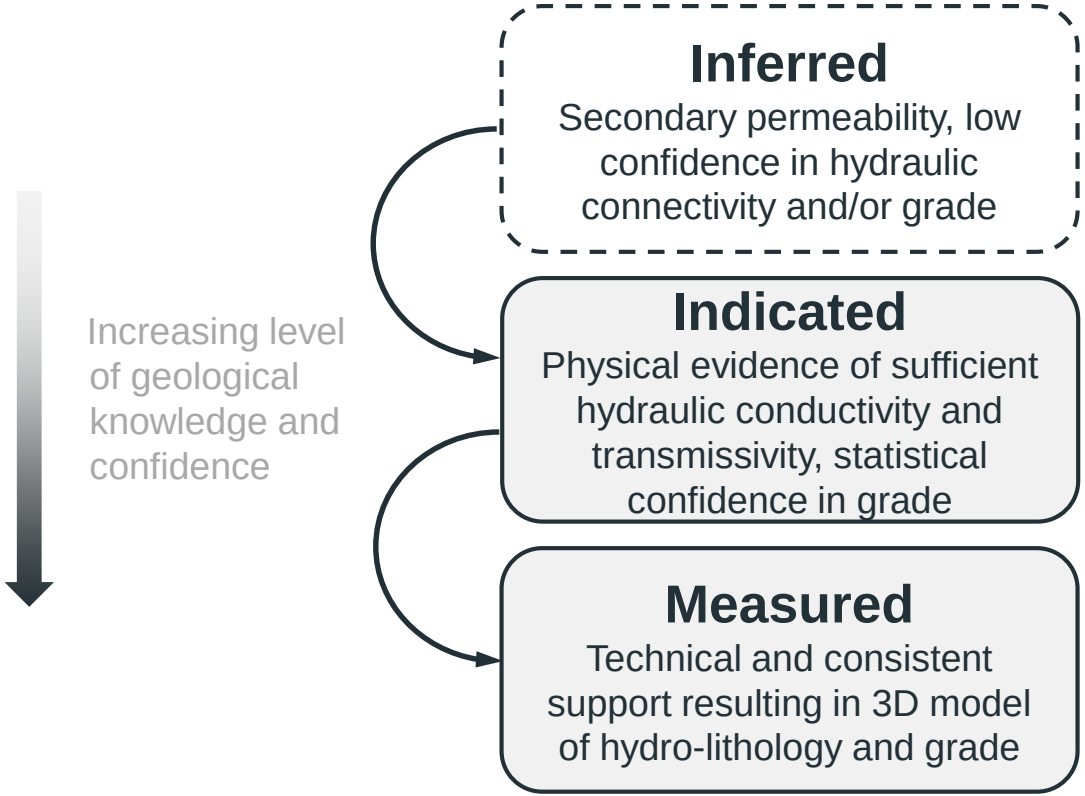
What are we looking for?

- ✓ **Brine Volume**
  - ✓ Lateral boundaries
  - ✓ Vertical distribution
  - ✓ Specific Yield (Sy) or specific storage (Ss) for confined zones
  - ✓ Effective porosity (ηe)
- ✓ **Transmissivity, Hydraulic Conductivity** (lateral and vertical)
- ✓ **Dispersivity** (longitudinal and transversal)
- ✓ **Assays** (Li, K, B, etc.)
- ✓ **Dilution** (e.g. presence of fresh water, brackish, low grade)

$$Resource = S_y \cdot Concentration \cdot Volume$$

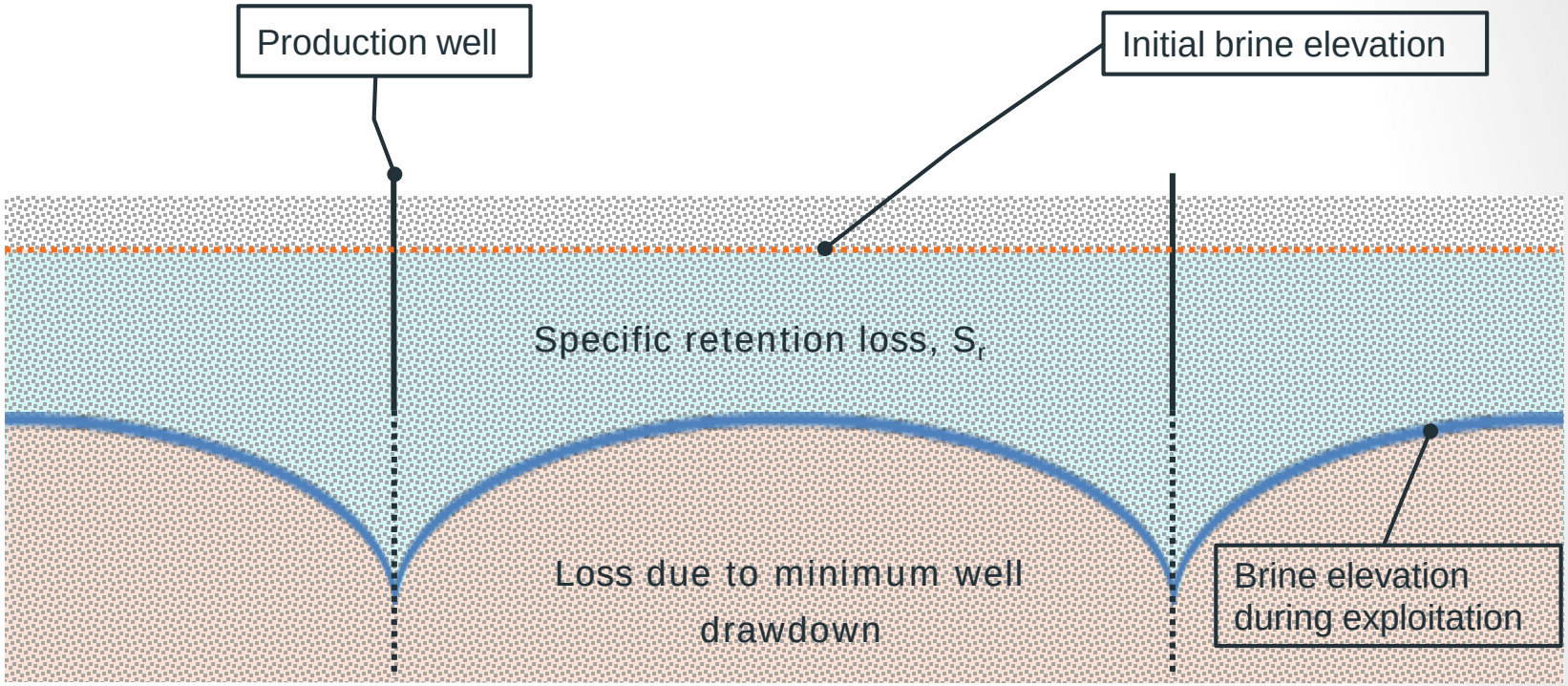
- **Sy: Specific yield** (varies within and between lithologies)
  - RBRC, core sampling, long term pump tests
- **Concentration:** Li, K, Cl, Mg, etc. (varies within and between lithologies)
  - Brine samples
- **Volume of Lithologic Unit**
  - Lithology, thickness, transmissivity

An interpretation of mineral resource classification

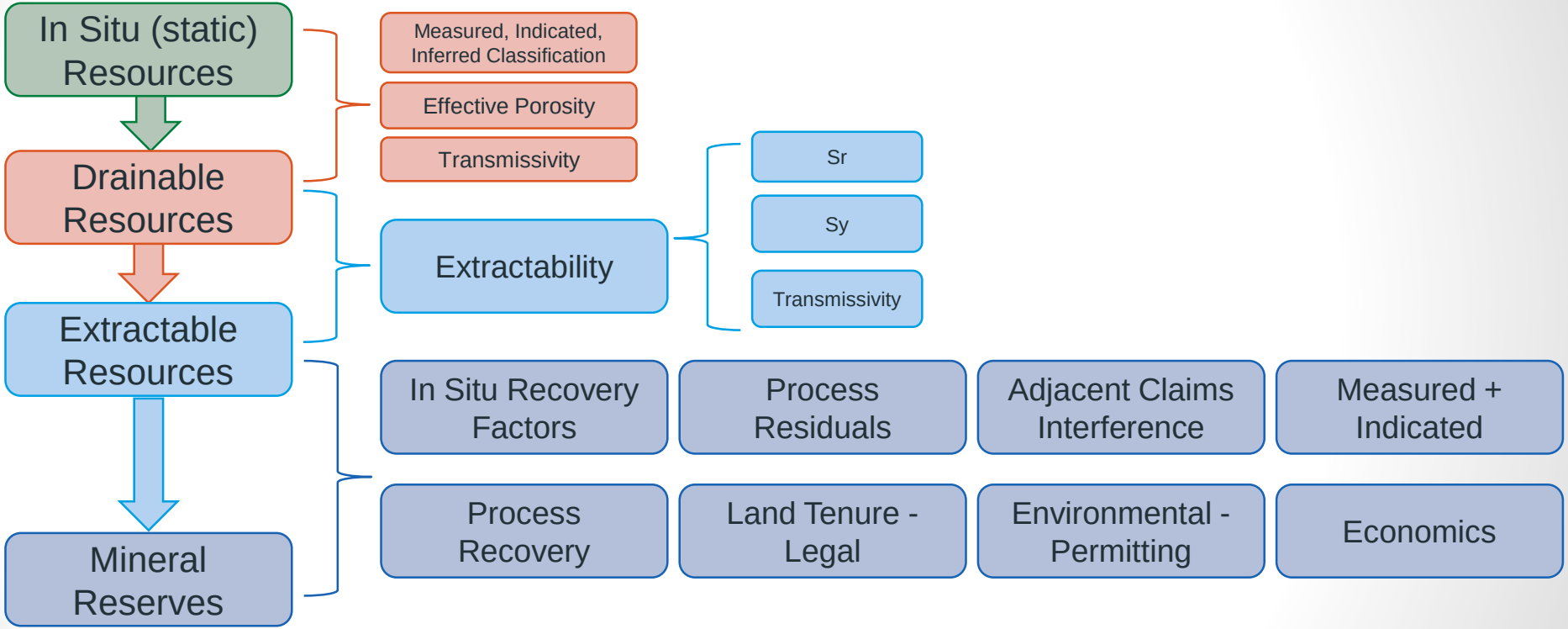


RESOURCES TO RESERVES

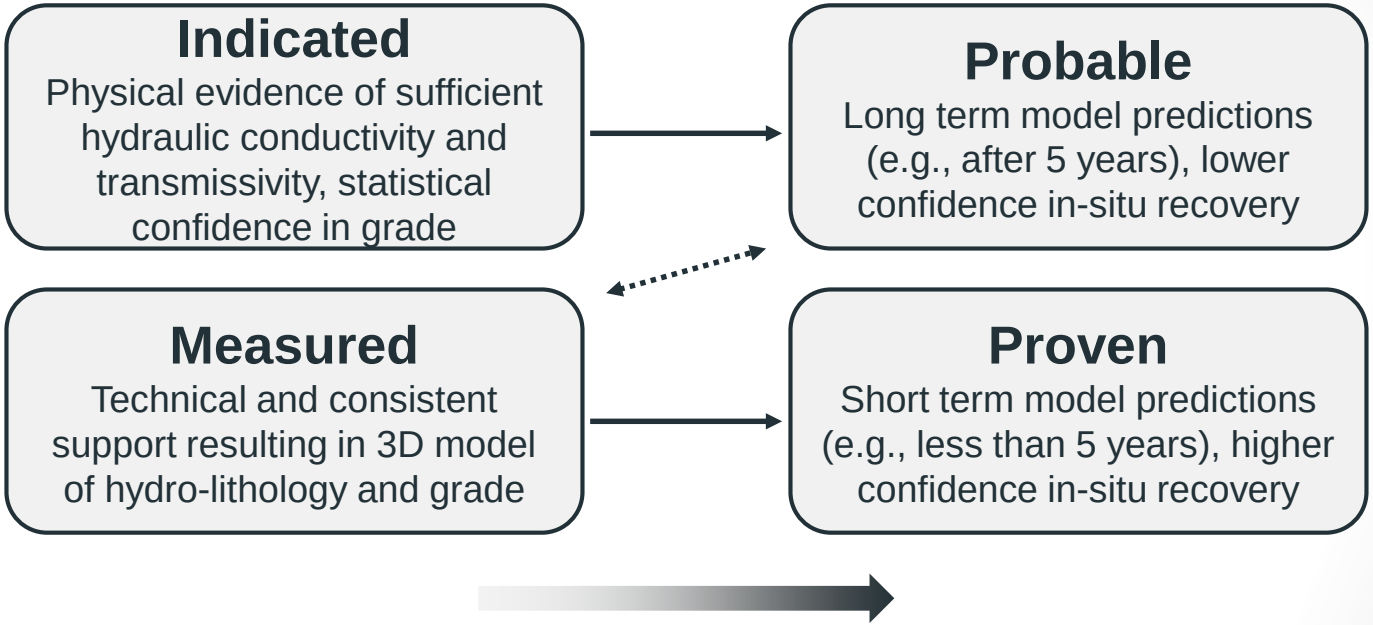
Extractable reserve



Brine Deposits - Resource to Reserve Conversion



Mineral resource to mineral reserve for brine deposits



Modifying Factors: consideration of mining, processing, economics, marketing, legal, environmental, social and governmental factors

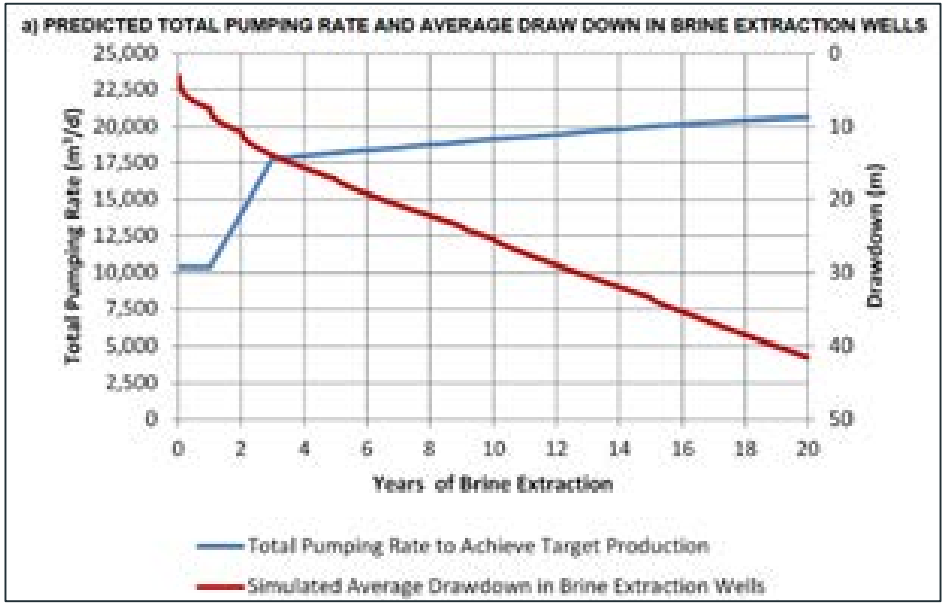
NUMERICAL MODELING

Groundwater

Geochemistry

Numerical Groundwater Model for Brine Projects

- Numerical model is used for brine projects as “dynamic” resource model to support mineral reserve estimates.
- Model is used to predict extracted brine volume over time.

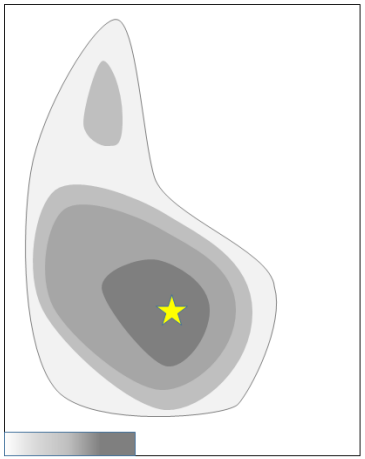


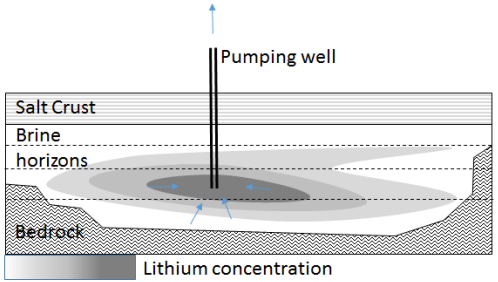
Geochemical predictions – A question of solubility

Geochemistry uses a combination of mass balance and numerical predictive calculations to model reality.

It functions with:

- Operations conceptual model
- Chemical and mineralogical data from the field
- Hydrological data



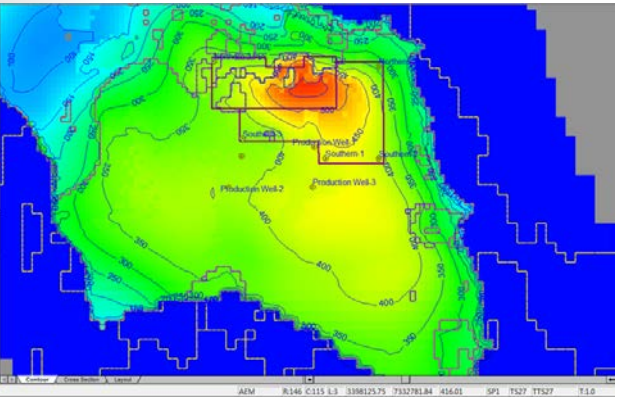


Idealised view of lithium concentration in plan and cross section in a salar

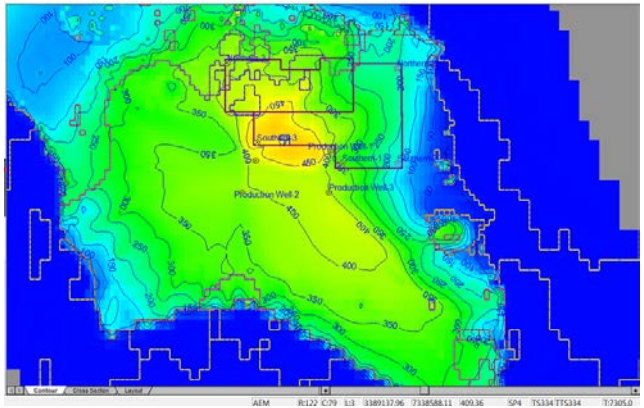
Geochemical calculations can help you:

- Predict Li grade evolution when inflow occurs
- Calculate mineral stability within the salar
  - Impurities
  - Geotechnical stability

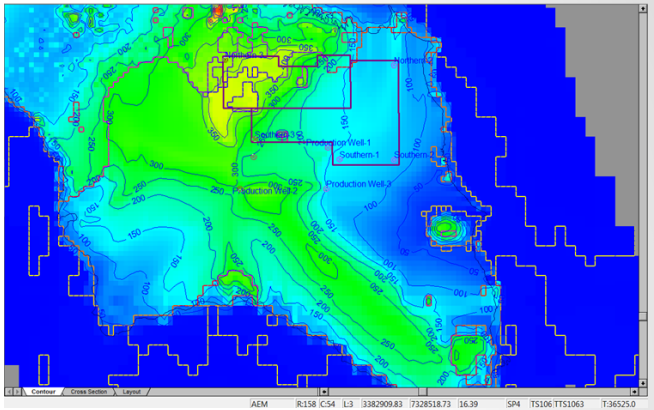
Lithium Concentration over Time



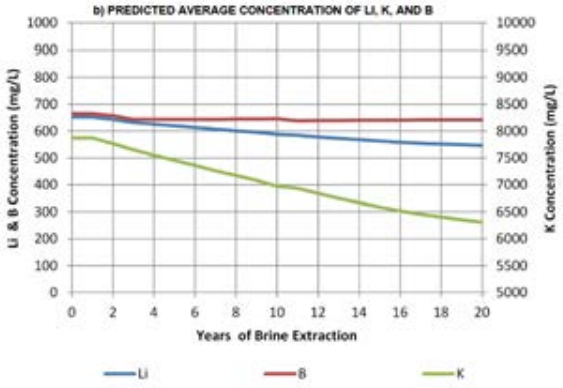
Year 0



Year 20

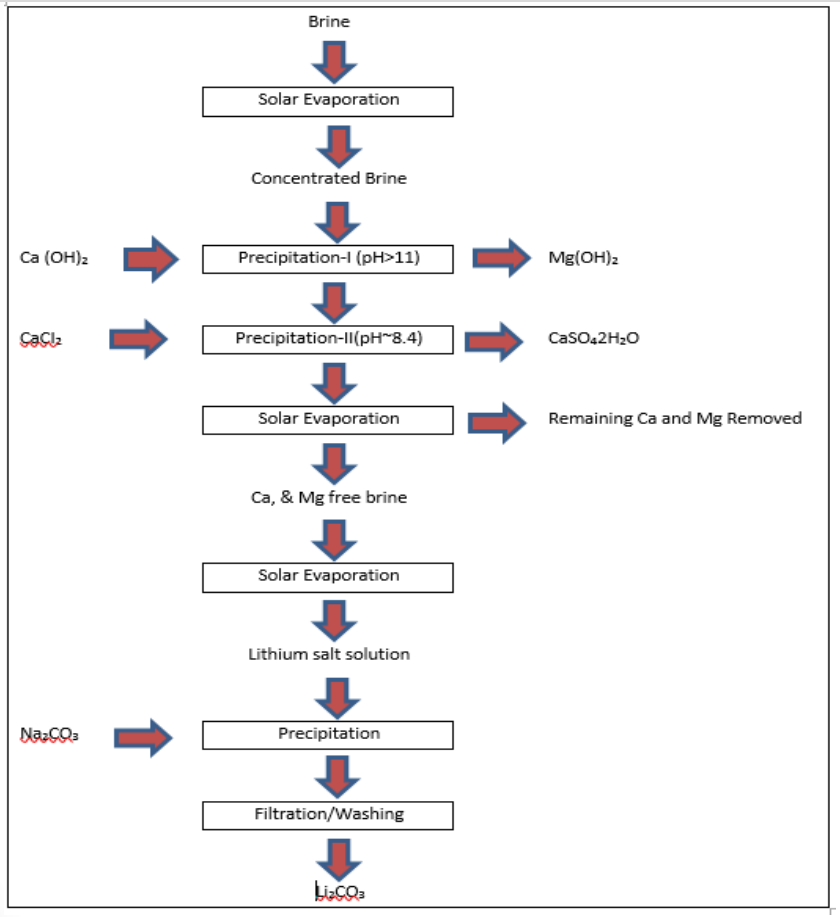


Year 100



- Predicted lithium concentration over the life of the project
- Goal: maintain a steady Li production with minimum dilution of the resource
- Dependant on well positioning, pumping rate…

Geochemistry - Processing



Generalized Process for Lithium Bearing Brines (e.g. Garrett, 2004)

- Geochemistry can model the Lithium process
  - But why?
- Predict Brine Chemistry through the process
  - As a function of evaporation
  - As a function of reagent addition
- Define the chemistry of the brine, and not just the Li grade.
- Optimise the amount of reagent used.
- Allow the consideration of various disposal options on the basis of the spent brine chemistry
  - Can it be reinjected? When? Where?
  - What happens if we re-inject the brine?
  - Can it be discharged? Where?

CONCLUSIONS

Take Home Message

- Brine moves!
- Technically complex exploration and resource estimation; but not impossible
- Choice of process that fits the situation, brine chemistry, weather, etc.
- Properly built numerical models (GW and geochem) are key to resource/reserve estimation and production planning
- It takes time to develop a lithium brine project