Lithium

Analysis in Pegmatites, Jadarite, Clays, Carbonates, Sediments and Brine

After its discovery in 1817, Lithium wasn't popular until the 1990s when the first commercial examples of lithium batteries were introduced to the market.

It received a lot of attention between 2006 and 2009 when several automobile manufacturers advertised their hybrid or electric cars with lithium-ion batteries. After a long and quiet period, lithium metal is becoming popular again leading to a renewed interest as a target element for mineral exploration.

Lithium, the lightest metal on earth, has an atomic number of 3 and a weight of 6.9. Lithium has exceptionally small and light atoms, with a high charge/radius ratio. It is now regarded as an exciting market commodity, with high specific heat capacity and high electrochemical potential, making lithium ideal in heat transfer technology where it is used in welding and metallurgical applications. High electrochemical potential and lightweight properties make it amenable to battery applications.

Batteries made with lithium have three times the energy of nickel hydride at one-third of the weight, and they operate at very low temperatures with a longer battery life.

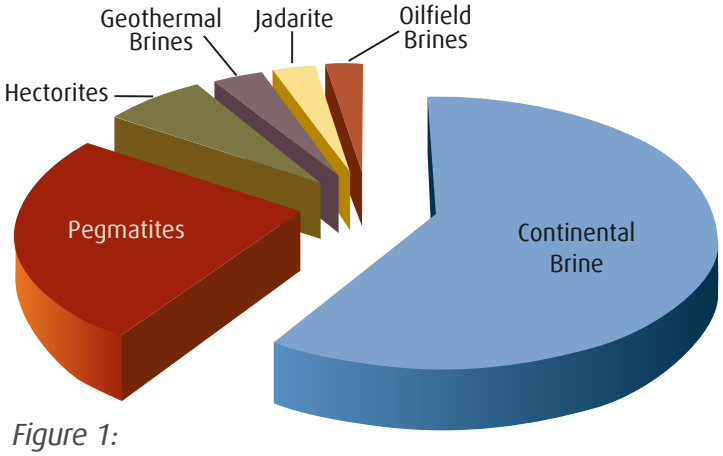

Figure 1:

Geologic Source of Global Lithium Resource. Estimates from Keith Evans (2009).

Lithium occurs in continental brines, geothermal or oilfield brines, and in pegmatite rocks or hectorite-rich claystones.

Lithium-Bearing Pegmatites and Jadarite

Pegmatite is an igneous rock with variable and coarse grained minerals. Lithium containing pegmatite rocks host Li in spodumene, petalite, and lepidolite (mica) minerals, with Li also substituting for Mg+2 in tourmaline and alumino-silicate minerals. Within pegmatites, an early deposition of Quartz-feldspar may be followed by a later deposition of spodumene or petalite, possibly with some contribution from late stage gaseous phases. Although there are some other pegmatite types, the majority of economic lithium deposits are associated with LCT (Lithium-Cesium-Tantalum) pegmatites, connected to collisional orogenies. LCT pegmatites are the most differentiated and the latest stage of crystallization of a parental granitic melt. They are often mineralogically and texturally zoned, and have the lithium bearing minerals with beryl, columbite-tantalite, pollucite, elbaite and perthite in intermediate and core zones. LCT pegmatites are enriched in Li, Cs, Ta, Rb and Nb. Explorationists use the ratios of some of those elements to distinguish the Li-fertile pegmatites from uneconomical ones.

Jadarite is an unusual occurrence of lithium. Although it is associated with evaporitic sedimentary rocks, it is grouped under this category because it contains Si in its structure. This mineral is unique to its type locality in Serbia and there is currently no other location known that hosts this unusual mineral. It is a Li-Na borasilicate that was discovered in 2004, that contains up to 3.40% of Li.

Pegmatite and jadarite minerals might not completely dissolve in acid digestions, which may under-report the element content if used, making sodium peroxide fusion the decomposition method of choice for these deposits.

ANALYTES & RANGES	DESCRIPTION	CODE
Li 2ppm-2.5% various other elements, method precision is 10%	Lowest detection limits using Na_2O_2 fusion and ALS's super trace ICP-MS methodology. A package suitable for exploration in pegmatites prospective for Li and accessory commodities. Boron may be added at an additional cost. The digestion and sample introduction is carried out with glass-free labware to avoid B contamination.	**ME-MS89L** **B-MS89L** (add-on only)
Li 0.01-10% various other elements, method precision is 7.5%	Economical exploration method for Li-bearing pegmatites using a Na_2O_2 fusion and ICP-AES finish. Includes all major elements and some key trace elements in addition to lithium.	**ME-ICP89**
Li 0.01-10% various other elements, method precision is 7.5%	A package combining Na_2O_2 fusion, ICP-AES and ICP-MS determination for exploration of ore grade Li pegmatites with associated trace level commodity elements such as Cs, Rb, Nb, Ta, and others.	**MS91-PKG**
Li 0.002-10% B 0.02-10% method precision is 5%	Low level ore grade Li and B by Na_2O_2 fusion and ICP-AES analysis. Ideal for jadarite and Li/B-bearing pegmatites.	**ME-ICP82b**

Lithium-Bearing Clays, Carbonates, and Sediments

Montmorillonite and other clays can also accumulate the small highly charged element. Hectorite is a type of smectite clay that can contain up to 0.7% Li. These clays are often associated with alteration of volcanic ash deposits by hydrothermal or paleo-lake waters. There are various identified Li-clay deposits in the USA and Turkey. Even though these deposits have high grades of lithium, the technology is lacking to extract lithium economically when compared to low-cost brine extraction processes.

Lithium hosted in these deposit types, including the swelling clay hectorite, may be determined either via roasting and four-acid digestion or aqua regia digestion. The appropriate method depends on complex interactions with sample mineralogy and ALS recommends testing to determine which method performs better in your particular project. Lithium carbonates and evaporites may provide better results via aqua regia digestion.

ANALYTES & RANGES	DESCRIPTION	CODE
Li 0.2ppm-1% various other analytes, method precision is 10%	Lowest detection limits using Na2O2 fusion and ALS's super trace ICP-MS methodology. A package suitable for exploration in pegmatites prospective for Li and accessory commodities. Boron may be added at an additional cost. The digestion and sample introduction is carried out with glass-free labware to avoid B contamination.	**ME-MS89L** **B-MS89L** (add-on only)
Li 10ppm-1% method precision is 10%	Intermediate level Li analysis suitable for exploration of Li-bearing sediments. Four-acid digestion and ICP-AES finish, including Li-specific CRMs. Multi-element package also available.	**Li-ICP61**
Li 10ppm-1% method precision is 10%	Intermediate level Li analysis suitable for exploration of Li-bearing sediments, carbonates and evaporites. Aqua regia and ICP-AES finish, including Li-specific CRMs. Multi-element package also available.	**Li-ICP41**
Li 0.01-10% Method precision is 5%	Ore grade Li by specialized four-acid digestion and ICP-AES finish, with Li-specific CRMs. Best suited to Li-bearing silicate sediments.	**Li-OG63**
Dry roasting pre-treatment	Roasting hectorite samples prior to analysis may increase Li recovery due to insoluble salt formation.	**RST-21**

Lithium Brines

Continental brine accumulations host Li within the remnant brine itself. In general, these are perennial lakes in arid climates with brines of often volcanic origin containing dilute lithium solutions.

Within the same system lithium can be deposited as a result of evaporation. These lithium depositions contain salts, carbonates, phosphates, borates, sulfate and clay minerals where intercalated with evaporative minerals. There are salars in the world with economical lithium concentrations in Chili, Bolivia, USA and China. The Chabyer salt lake in the Tibetan region is host to one of the largest known concentrations of Li with high grades of 0.12% Li occurring as the carbonate mineral Zabuyelite. Potash operations often produce the by-product Li. Brines have been one of the predominant sources of lithium today due to its abundance and low-cost operations. ALS provides the following methods for analysis of brines for lithium exploration.

ANALYTES & RANGES	DESCRIPTION	CODE
Li 0.1-10mg/L various other elements, method precision is 10%	Trace level analysis of Li in brine samples, run as-is on the ICP-MS. If lab filtration or acidification is required, please indicate this on the submittal form.	**ME-MS14b**
Li 10-3,000mg/L various other elements, method precision is 10%	Intermediate to high level analysis of Li and other elements in brine samples, run as-is on the ICP-MS. If lab filtration or acidification is required, please indicate this on the submittal form.	**ME-ICP15**
pH, Conductivity, Total Dissolved Solids, Alkalinity	Physical parameters and alkalinity of lithium brines.	**Li-BRPKG**
Li 10ppm-1% Method precision is 10%	Aqua regia digestion and ICP-AES finish for salt crusts associated with brine deposits. Multi-element package also available.	**Li-ICP41**

Lithium Background Concentrations

- Natural waters: 1-3 ppb
- Sea water: 170 ppb
- Sedimentary rocks: 53 ppm
- Soil samples: 20-200 ppm depending upon underlying host rock
- Ultramafic rocks: 0.5 ppm
- Granitic rocks: 40-100 ppm
- Micaceous schists: 50-200 ppm
- Pegmatities: 100-2,000 ppm
- Continental brines: 50 ppb-2,000 ppm
- Great Salt Lake: 60 ppm Li
- Salton Sea: 200 ppm Li
- Chabyer salt lake: 0.12% Li
- Salar de Atacama: 200 ppm-0.18% Li

Exploration for lithium may be aided by the pathfinder geochemistry of K, Mg, B, F, Na, Ca, Li/K and Li/Mg where ratios may be of interest. Brine water samples may also be analysed for general chemistry including pH, conductivity, alkalinity, total dissolved solids, and Cl or Br. Vegetation samples show anomalous Li in response to elevated groundwater, and indicator species may provide a useful exploration medium (Cannon, 1975). Enriched brine occurrences require three factors for economic accumulation: an enriched Li host source rock, a transport mechanism, and concentration, trapping or sorption mechanism. Exploration considerations should include Li-enriched sources such as differentiated rhyolitic or granitic terrane, a groundwater or gaseous mechanism for Li transport and accumulation, and concentration or trapping via evaporation or clay sorption.

ALS has extensive experience in analysis for lithium. From brines to pegmatites and jadarite, ALS has been the preferred laboratory for many clients in the lithium market. Please let us know the details on your programme and we will assist you to choose the most suitable analysis method.

First and foremost, please indicate on your sample submittal form that the commodity target is lithium, particularly when selecting multi-element packages. This allows ALS to insert lithium-specific Certified Reference Materials for the highest quality results and transparency in lab performance.

Contact:

Please contact an ALS laboratory in your area to discuss how we can help with your exploration project. For contact information for our laboratories around the world, visit our website.

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16GE048-001 Rev B