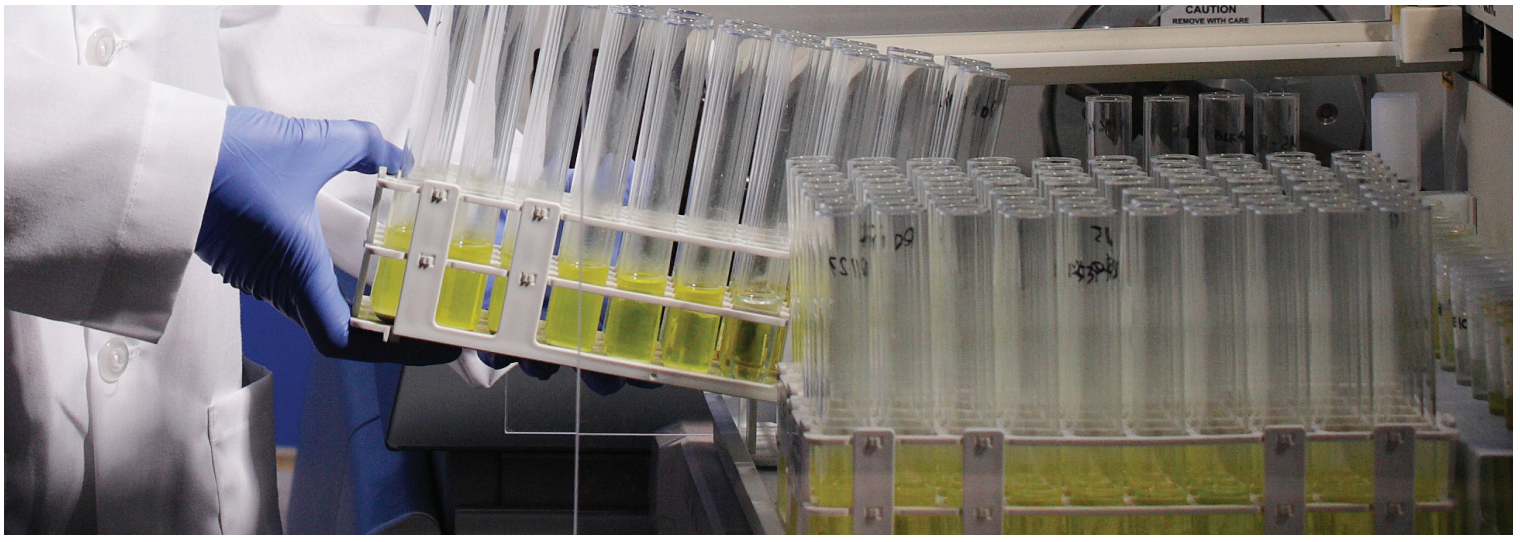
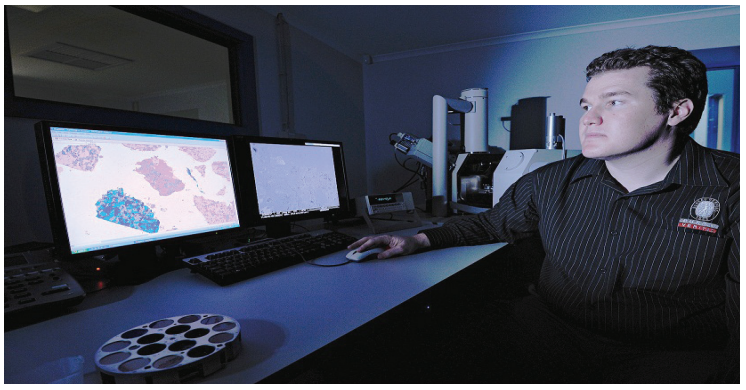
BUREAU VERITAS
Metals & Minerals





Lithium Testing

Tests & Techniques

BUREAU VERITAS
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MINERALS

Where is your Lithium?

Global lithium supplies are obtained from two primary sources.

Brines and Evaporites

Lithium is liberated by weathering or may be derived from hydrothermal fluids from a variety of rock sources. Ground water brine solutions containing dissolved lithium accumulate in closed basins. Economic brines typically contain 200 – 4000 mg/l of lithium, and are pumped to the surface and concentrated by evaporation.

Hard Rock

The most common and economic lithium-bearing minerals are shown in the following table.

Mineral	Formula	Member	Li (%)
Spodumene	$LiAlSi_2O_6$	Pyroxene	3.7
Lepidolite	$K_2(Li)_{3-4}Al_{8-5}Si_{6-8}O_{20}(F,OH)_4$	Mica	1.4-3.6
Mica Group	$X_2Y_{4-6}Z_8O_{20}(OH,F)_4$ X = K, Na, Ca, Ba, Rb, Cs Y = Al, Mg, Fe, Mn, Cr, Ti, Li Z = Al, Si		
Petalite	$LiAlSi_4O_{10}$	Feldspathoid	1.6-2.3
Amblygonite	$(Li,Na)Al(PO_4)(F,OH)$	Amblygonite	3.4-4.7
Triphylite-lithiophilite	$Li(Fe,Mn)PO_4$	Olivine	4.4

Assay Techniques

Brines and Evaporites may be analysed by:

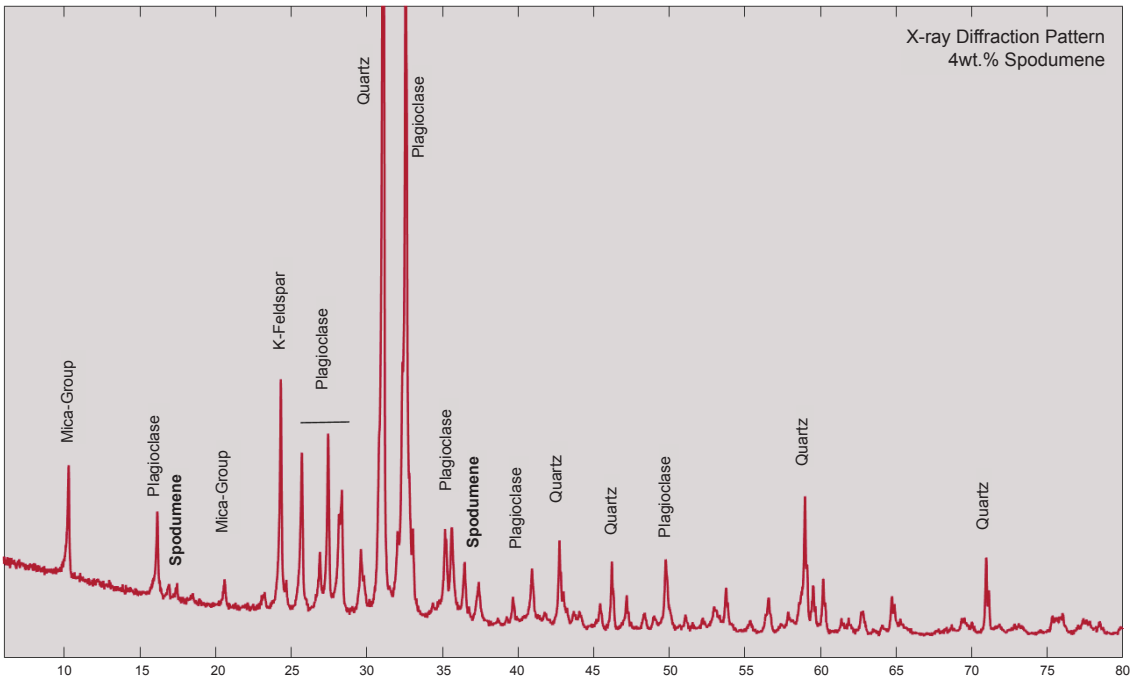
- ICP-ES for Al, Ba, Ca, Fe, K, Li, Mg, Na, and SO_4 and other minor elements
- ICP-MS for Br, Cs, I, and Rb and other trace elements.
- Volumetric methods for Cl, HCO_3 and NH_4
- Colorimetric methods for Cl, NO_3, and PO_4
- Ion Selective Electrode for F.

Hard Rock:
Geochemical analysis of lithium bearing pegmatite ores can be obtained using a peroxide fusion. The sample is fused with sodium peroxide in a zirconium crucible. The melt is dissolved in dilute HCl and the solution analysed by ICP-ES and ICP-MS. Key pathfinder elements are highlighted.

ICP-ES (ppm)								
Li (50)	Al (100)	Ca (1000)	Fe (100)	K (1000)	Mg (100)	Mn (10)	P (100)	Ti (100)
ICP-MS (ppm)								
Li (1)	**Cs (1)**	**Rb (0.5)**	Sn (10)	**Ta (0.5)**	W (5)			

Mineralogy

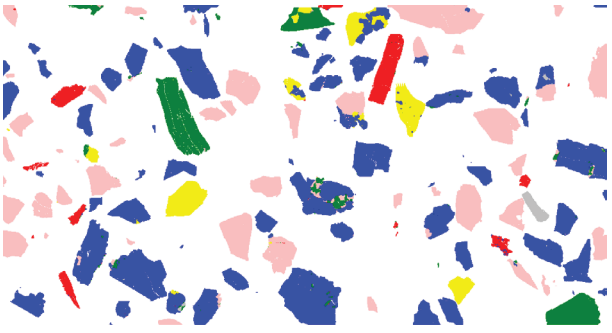
The XRD pattern of a hard rock exploration sample containing 0.24% Li (by chemical assay) is shown. XRD clearly identified the primary Li bearing mineral is Spodumene at a concentration of 4wt.%, however it cannot detect solid solution elements, such as Li in the mica. The Li content of the sample calculated from QXRD was 0.16%.



In most cases, automated mineralogy using QEMSCAN/MLA will be able to determine element deportment, however, it is not possible to detect Li by QEMSCAN/MLA due to the limitations of the XRF detector.

The deportment of Li was determined in the sample by Laser Ablation ICP-MS spot analysis.

The Laser Ablation results indicate that up to 30% of the Li content is deported to the Micas. This was undetectable by QEMSCAN, XRD or chemical assay, and is critical information for determining metallurgical processes.



Red - Spodumene
Green – Mica-Group
Yellow - K-Feldspar
Blue - Plagioclase
Pink – Quartz

Mineral	Li (%)	Cs (ppm)	Rb (ppm)	Ta (ppm)	Al (%)	Fe (%)	K (%)	Si (%)
Spodumene	**4.0**	0.4	1	30	14.9	0.1	<0.1	29.4
Mica-Group	**1.5**	1340	27600	112	16.7	1.3	8.6	22.1
K-Feldspar	**<0.1**	620	16300	<0.1	0.2	<0.1	13.6	29.2
Plagioclase	**<0.1**	<0.1	6	<0.1	11.2	17.3	<0.1	31.2
Quartz	**<0.1**	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	46.8

Metallurgical Testing and Flow Sheet Development

Brines and Evaporites

- Characterisation of brines and Evaporites (chemical assay, QXRD, QEMSCAN)
- Crystallisation trials – Controlled crystallisation of salts
- Flotation testwork – upgrade of key Li minerals by flotation or reverse flotation
- Beneficiation methods – pilot plant test work

Hard Rock

- Mineralogical characterisation – XRD, QEMSCAN, Laser Ablation ICP-MS
- Comminution testwork
- Head assay and size fraction assays – potential to reject sub-economic fractions based on size
- Gravity beneficiation – separation of impurities based on mineral density
- Flotation beneficiation – upgrade of key Li minerals by flotation or reverse flotation

Bureau Veritas Minerals holds the key to finding your Lithium. Contact one of our experts today.

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