Minerals in Afghanistan

Lithium in Afghanistan

Introduction

Lithium, despite being called a ‘rare metal’, is not that rare in the Earth’s crust and its crustal average is about 35 ppm. Until recently lithium has been used only in small niche markets in the glass and ceramics industry, in high temperature greases and in the chemical industry. Lithium has now become an important element in the emerging, digital and low-carbon economy and lithium batteries will probably power the next generation of electric cars, causing demand for this ‘rare metal’ to grow rapidly over the next 10 years. At the present time (2011) supplies are broadly in balance with demand, partly because of the global downturn, and partly because several suppliers have excess production capacity. Demand is predicted by many forecasters to exceed supply in 2020.

The two main sources of lithium are hard rock sources in pegmatites and in solution within continental brines, both of which are present in Afghanistan.

Geology of Afghanistan

Afghanistan has a complex geology due to its position on the junction between the Indo-Pakistan and Eurasian crustal plates. Its geology is composed of a series of terranes that broke away form the main Gondwana supercontinent before colliding, with each other or, with the Eurasian plate. Ultimately, all the terranes became accreted onto the southern margin of the Eurasian plate. The accretionary events started in the Cretaceous and have continued until recent times. The final closure of the Neo-Tethys ocean between the Indo-Pakistan and Eurasian plates produced the Himalayan orogeny. In the Hindu Kush region of NE Afghanistan downward buckling of the intervening crust and later uplift of these metamorphosed remnants produced high-grade metamorphic rocks, anatexis and S-type granites. Li-bearing pegmatites are, in the main, restricted to the Nuristan area in NE Afghanistan adjacent to the Laghman granite complex (Figures 1 and 7).
The bulk of the world’s supply of lithium comes from salt or playa lakes, also called ‘salaris’ after their Spanish name. Afghanistan has similarities with the South American deposits in the so-called ‘Lithium triangle’ of Argentina, Bolivia and Chile – elevated enclosed basins, high evaporation rates and, in some cases, young volcanic rocks. Afghanistan has a number of similar lakes (Figure 2). Reconnaissance sampling (Figure 3) by the Department of Defense (DoD, 2011) indicated high Li levels in lake sediment (Table 1). The lakes have not been systematically sampled for lithium or other potentially economic elements, such as K, B, Rb or Cs, so it is impossible at the present time to give any estimates of resources. The readily available figures are given by Abdullah et al. (1980).

Examination of the known salt lakes (Figures 4-6) on the detailed Landsat ETM+ images on the USGS GIS (Davis, 2007) shows that the water shows a blue reflectance and the area of this reflectance has been taken as the present surface area of the lake (Figure 4). White areas around the lakes are probably salt flats, but they could be gypsum, which normally shows a light blue colour on the 7-4-2 band image.

### Table 1 Analyses of Afghani lake sediments from reconnaissance sampling (DoD, 2011).

<table>
<thead>
<tr>
<th>Lake</th>
<th>B ppm</th>
<th>Na %</th>
<th>Li ppm</th>
<th>Sr ppm</th>
<th>Mg %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chankansar, (Nimroz)</td>
<td>1.54</td>
<td>49</td>
<td>560</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td>Dasht-e-Nawar</td>
<td>110</td>
<td>10.5</td>
<td>99</td>
<td>894</td>
<td>8.7</td>
</tr>
<tr>
<td>Gowde Zareh West</td>
<td>87</td>
<td>36.0</td>
<td>25</td>
<td>568</td>
<td>2.8</td>
</tr>
<tr>
<td>Gowde Zareh East</td>
<td>110</td>
<td>25.1</td>
<td>36</td>
<td>358</td>
<td>1.7</td>
</tr>
<tr>
<td>Namaksar-e-Herat</td>
<td>48</td>
<td>30.3</td>
<td>41</td>
<td>461</td>
<td>0.8</td>
</tr>
<tr>
<td>Crustal Abundance</td>
<td>9</td>
<td>2.27</td>
<td>18</td>
<td>384</td>
<td>2.8</td>
</tr>
</tbody>
</table>

The DoD team recently returned to Namaskar-e-Herat and drilled to 10m at multiple locations (DoD, 2011). The team believes samples were collected in the halite zone, a key indicator of correct sample location, and found signs of hydrothermal activity at the sites.
The currently worked salar deposits in the world are found:

- in relatively large lakes, the smallest being the DXC deposit in China with an area of 55 km²
- at high altitude
- in areas with high evapotranspiration rate (ETP).
- in areas with young volcanic rocks (South American salars).

The seven major lakes (>50 km²) in Afghanistan were ranked for favourability on these four criteria (area, altitude, volcanics and ETP) and the average rank calculated. The two lakes near Ghazni, Ab-i-Estoda and Dashte Nawer, rank equally with Gowde Zereh.
Pegmatite Sources

Pegmatites are coarse grained igneous rocks formed by the crystallisation of post-magmatic fluids. They can occur in close proximity to large magmatic intrusions or in high grade metamorphic rocks. Lithium containing pegmatites are relatively rare and are often associated with beryl, tin and tantalite mineralisation. The principal lithium pegmatite minerals are spodumene, petalite (both lithium-aluminium silicates) and lepidolite (a lithium mica). All can used directly in the glass and ceramic industries, provided the iron content is low, and they can also be used to produce lithium chemicals. This process involves beneficiation to a spodumene concentrate, calcination to produce acid-leachable beta spodumene, reaction with sulphuric acid and the reaction of the lithium sulphate solution with sodium carbonate. This conversion is energy intensive and expensive and, at present, there are few, if any, Li-pegmatite deposits worked solely for the production of chemical grade lithium carbonate.

The Soviet-Afghan teams prospected a number of pegmatite fields for economic lithium deposits (Figure 7) and this work is summarised in Abdullah (1980). Potentially economic concentrations of lithium were found in the Parun (Paron), Shamakat, Tagawlur, Eshkashem, Ailingar, Marid and Nilaw-Kulam fields. The Parun district, with a geologically estimated resource of 3 Mt of Li2O, is the most extensive (Figure 8). Some of the veins are 20 to 40 m thick and extend for 1.0 to 1.5 km. The spodumene content in spodumene-albite bodies varies from 15 to 35 %, and the average content of lithium oxide in the deposits of the Parun district is 1.5 %. These figures indicate that the Parun area could well contain workable Li pegmatite deposits but their current economic viability needs to be examined in much greater detail. The work to prove the size and grade of the deposits will involve surface geological mapping, trenching, drilling, sampling and analysis. The lack of infrastructure in Afghanistan and the distance to market may yet prevent their exploitation.

Commercial concentrations of lithium have been encountered in the Parun, Shamakat, Tagawlur, Eshkashem, Ailingar, Marid and Nilaw-Kulam fields of rare-metal pegmatites. Many of the spodumene-bearing pegmatites also contain columbite-tantalite, which increases their economic significance. The Greenbushes mine in Australia, for example, produces both Li and Ta from two phases of the same pegmatite.
Pegmatites can occur in fields with many small bodies distributed over a wide area and it can be difficult to assess their economic potential. A small scale operation can work one small body and then move rapidly to the next. A large mechanised operation needs a much larger orebody, which can be worked to greater depth and has more consistency in grade. Abdullah et al., (1980) report a number of economically viable pegmatites or pegmatite deposits in Nuristan (Table 2). Many pegmatites are quite extensive with strike lengths on the order of 2 to 5 km and widths ranging from 1 to 60 m. Exploration and assessment for economic concentrations of rare metals may be facilitated by their size and probably excellent exposure in the mountainous terrain. However, access to this area is limited by the mountainous terrain and by a poor road network.

Table 2. Inferred rare-metal resources calculated to 100m depth for some Parun pegmatites (Peters et al., 2011)

<table>
<thead>
<tr>
<th>Pegmatite</th>
<th>Li₂O (t)</th>
<th>Li₂O %</th>
<th>Ta₂O₅%</th>
<th>Te₂O₃%</th>
<th>Rb+Cs %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasgusta</td>
<td>1,050,000</td>
<td>2.14</td>
<td>0.002</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Drumgal</td>
<td>253,000</td>
<td>1.38-1.58</td>
<td>0.03</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Jamanak</td>
<td>450,000</td>
<td>1.83</td>
<td>0.006</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Pasgusta-lower</td>
<td>124,000</td>
<td>2.2</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Pashki</td>
<td>127,000</td>
<td>1.46-2.1</td>
<td>0.01-0.02</td>
<td>0.01-0.02</td>
<td>NA</td>
</tr>
<tr>
<td>Yorigal</td>
<td>130,000</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
**Summary of the potential for Li-brines in Afghanistan**

- Li, B, Rb, and Cs brines have been recorded in Afghanistan
- The salt lakes in the country have a similar altitude, area, evaporation rate and geology to those in the Li triangle in South America
- Lake Ab-i-Estoda, Lake Dashte Nawer, (near Ghazni), Lake Namaksar (Herat) Chakansar (Nimroz) and Gowde Zereh (Helmand) have the highest potential
- DoD (2011) estimates a total resource of 350,000 t of Li in Afghan Lakes

**Summary of the potential for Li-pegmatites in Afghanistan**

- Large number of recorded spodumene-bearing pegmatites in several fields around the Laghman granitic complex
- Parun field has the best known resources
- Pegmatites are 20 to 40 m thick, extend for 1.0-1.5 km at an average grade of 1.5% Li$_2$O
- Nb-Ta concentrations could add additional value
- Li and Gem pegmatites can be worked by SMEs

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**Sources of Information**


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**Contact Details**

For More Information Please Contact:

**Investment Promotion Directorate**

Ministry of Mines

Kabul, Afghanistan

Telephone: +93 (0) 752 076 483

E-Mail: miningenquiries@mom.gov.af

Website: http://www.mom.gov.af

**Director General**

Afghanistan Geological Survey

Kabul, Afghanistan

Tel: +93 (0) 75 200 1714

E-mail: ags@mom.gov.af

**PMU Director**

Afghanistan Geological Survey

Kabul, Afghanistan

Tel: +93 (0)796 216 251

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