To explore the possibilities of lithium deposits In Ladakh (India) by studying the Hindu Kush mountain trends associated with lithium deposits of Afghanistan via remote sensing imagery.

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Abstract

In this paper, attempts have been made to locate lithium deposits of Afghanistan through the associated Hindu Kush mountain trend lines & look for their continuation in the Ladakh region to check the possibility of occurrences of lithium in Ladakh.

Introduction

Afghanistan's lithium deposits occur in hard rock pegmatites in the form of spodumene and lepidolite and in dry lake beds in the form of lithium chloride.

Lithium Occurrences in Hindu Kush Mountains, Afghanistan

It occurs with other rare metals such as caesium, tantalum, niobium in three types of deposit mainly:

I. Pegmatites

Rare-metal pegmatites in Afghanistan are associated with Cretaceous-Paleogene granite which is hosted within quartz-mica schist, gneiss, and gabbro-diorites. These have concentrations of Li, Ta, Cs, Be, Sm and precious stones of potential commercial interest.

The eastern Afghanistan is rich in lithium bearing pegmatite fields such as Ishkashim, Paron, Darai-Puck, Shamakant and Nilaw whereas south-central Afghanistan has mainly one pegmatite field in Uruzgan province.

In Eastern Afghanistan, Nuristan Fault Block consists of Lower Proterozoic metamorphic rocks intruded by a series of Cretaceous-Tertiary biotite-granite and granodioritic intrusions known as the Lagman Complex or Lagman Zone. This zone extends for hundreds of kilometres through Badakhshan, Nuristan and Lagman provinces and continues into Uruzgan province.

Pegmatites are spatially related to the margins of the Lagman Zone. They are found to be of seven types ranging from a plagioclase microcline type containing little rare metal mineralisation, to more potassium-rich albitic veins with more abundant rare metals. The rare metal-rich albitic pegmatites contain up to 1.5–2.5 % Li2O or 20–30 % spodumene.

Spatial zonation of pegmatite mineralogy around the granites is commonly observed. High temperature microclinedominated veins generally occur close to the intrusions, while spodumene-bearing veins occur in lower temperature distal settings.

Pegmatites have not been dated but the Oligocene age of Laghman granites suggest a similar age for them.

Economically attractive pegmatites occur on both sides of the most continuous part of Laghman Zone granites trending in NE direction, though pegmatite-bearing zones are associated with Proterozoic rocks as these zones pinch out where the rocks are no longer present to the east of Kabul block. Also a small number of them are associated with granites and granodiorites of the Lagman Zone to the west of the Kabul block.

Twelve pegmatite fields or districts have been found to bear lithium in the form of spodumene namely Nuristan, Badakhshan, Nangarhar, Lagman and Uruzgan provinces.

II. Mineralized springs

Mineralized waters occur associated with volcanic rocks in zones of recent magmatism and faulting. Carbonate-rich fluids that have ascended through faults in fractured carbonate rocks are commonly associated with mineralizing springs containing high concentrations of rare metals.

To the west of Kabul, mineralized springs occur mainly at the junction of the Main and Helmand-Argandab zones in Afghanistan. In the Qala-Gorband-Turkman subzone, a unique thermal water basin occurs with more than 30 springs containing high concentrations of Li of potential commercial value.

Near the mouth of the Namakab River in Qala-Gorband-Turkman subzone, several springs have very high reported concentrations of Li. Springs in the Qala area have a discharge rate of about 10 l/s i.e.10 mg/l Li. Estimates from this work indicate that these springs discharge 3153 kg Li per year. Other springs in the Qala Valley are reported to produce approximately 180 l/s. There is a great possibility of Lithium precipitation.

III. Playa Lakes

The salt deposits in Lake Sar-i-Namak in Takhar province are reported to contain 0.02 % Li, while the lake brine has a lithium content of 350 mg/l. The Namaksar-Herat Lake in the Ghuryan district of Herat province is also reported to contain high levels of Li and B in both the lake brine and underlying salt beds.

Ladakh

Ladakh is the highest altitude plateau region in northern India, straddling the mountain range of Himalayan and Karakoram.

Geologically Ladakh region,from north to south, can be divided into five tectonic belts i.e. Karakoram, Shyok, Ladakh granite belt, India belt and Suru crystalline belt. These belts represent a unique assemblage of rock types from Pre-Cambrian to Tertiary age. The most significant feature of the belt is the presence of melange zone occuring along the plate boundary of Asian and Indian plates.

The pegmatitic veins with which the rocks of the region are criss crossed normally carry minerals. The sedimentary rocks are also fossiliferous.

Methodology:

Data Processing:

- We have used Landsat Multispectral Scanner (MSS) images consisting of four spectral bands, Landsat Thematic Mapper (TM) images consisting of seven spectral bands, Landsat Enhanced Thematic Mapper Plus (ETM+) images consisting of eight spectral bands and Landsat 8 Operational Land Imager (OLI) images consisting of nine spectral bands and imagery from flash earth.
- For applying False Colour combination to do enhanced interpretation and digitization, we must have multispectral layer, so we have done layer stacking in ERDAS IMAGINE 13.

Data Interpretation:

Hindu Kush resembles Karakoram range as both are formed due to collision of Indian-Eurasian Continental Plate collision about 50 million years ago. Hindu Kush Mountain extends from Eastern Afghanistan as Karakoram Ranges in Ladakh so there is continuation of geological trends from Afghanistan to Ladakh as depicted in the Fig A.

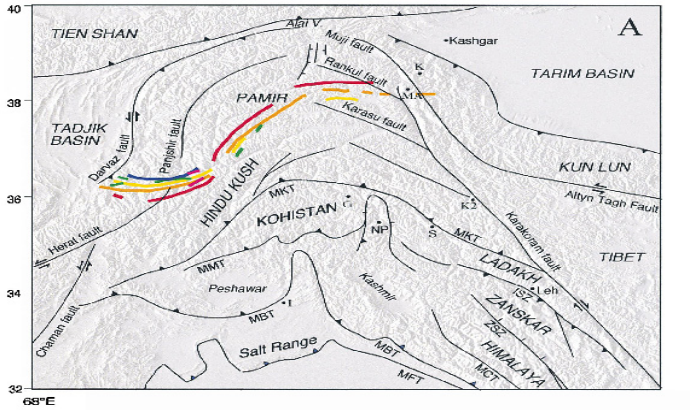
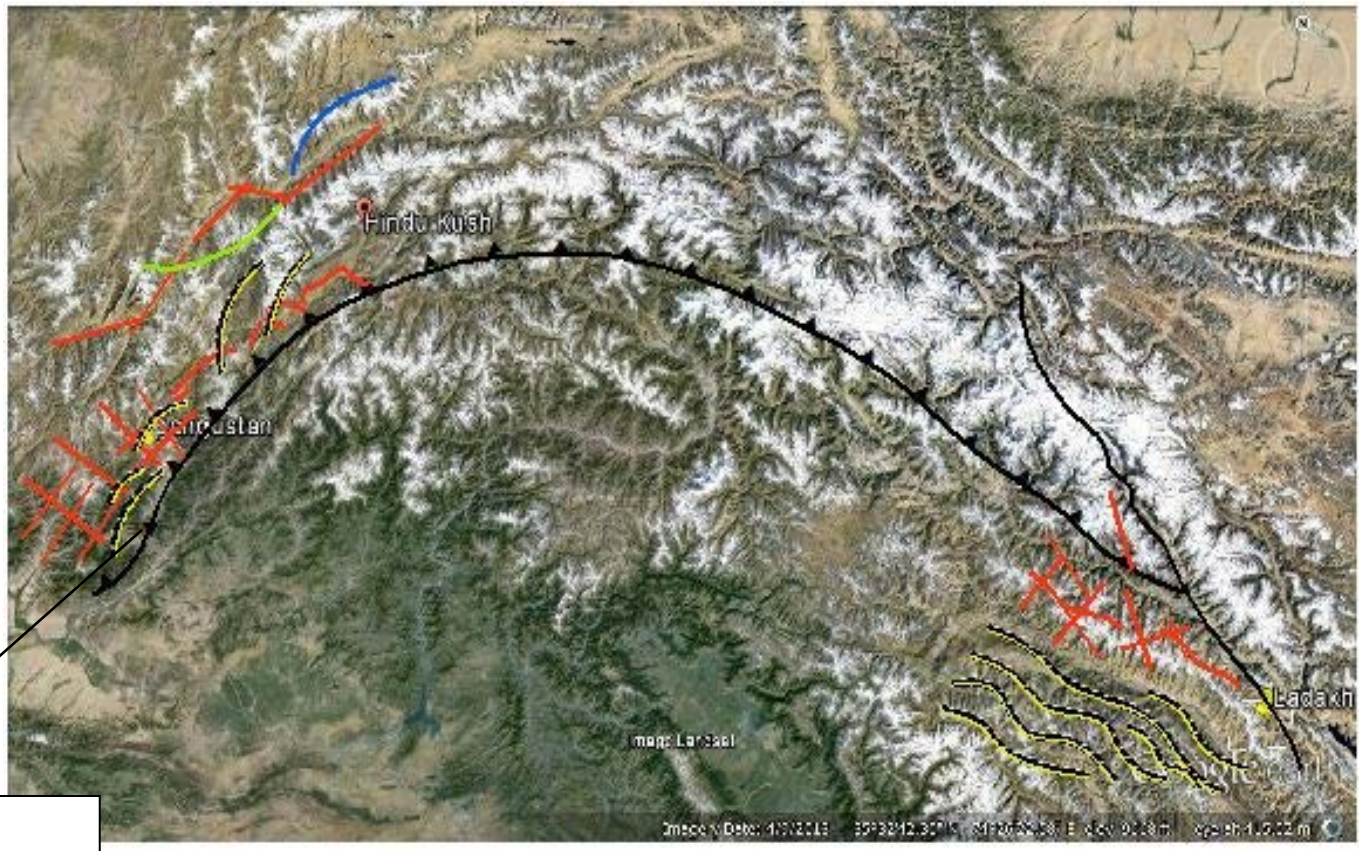


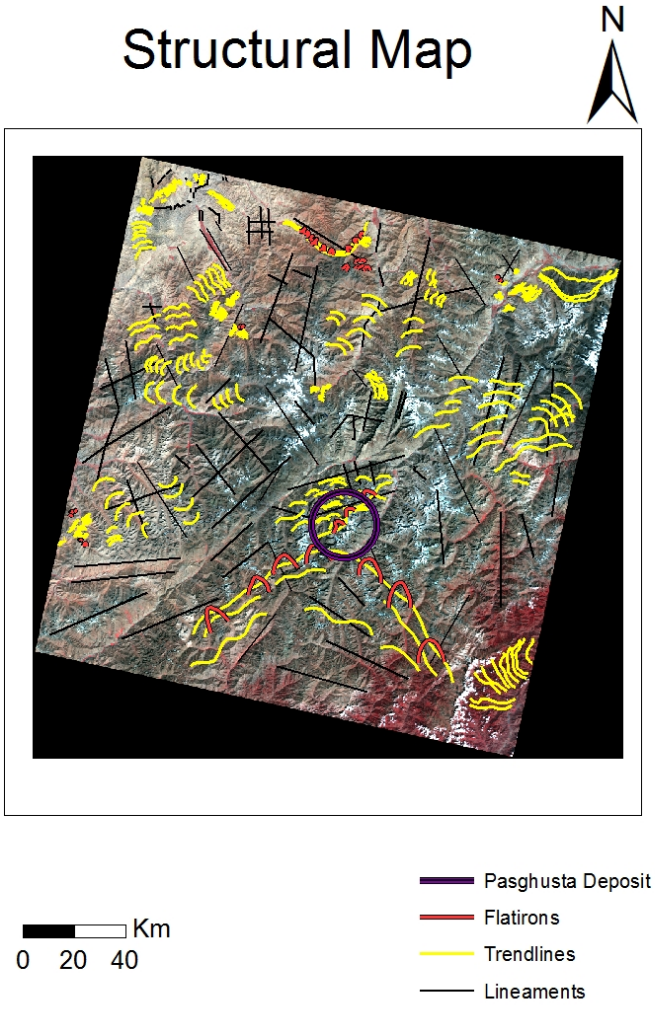
Fig A. shows the continuation of geological trends from Afghanistan to Ladakh

We have interpreted the imagery and marked the trends continuing from Afghanistan to India. We have also marked the trends and lineaments of Phasgusta deposit of Afghanistan which consist of 1.96 % Li2O over 70 m, and 2.14 % Li2O over 20 m.



Pasghusta Deposit

Panjshir Fault
Lineaments
Herath Fault
Karakoram Fault
Trends
MKT



Inferred Lithium Occurrences in Ladakh

The 1200 km long Hindu Kush is the continuation of the Karakoram and represents the western portion of the Himalayan System. (Buchroithner, et al.)

1. Ladakh Batholith constitutes of felsic and associated magmatic rocks trending NW-SE in direction covering an area of 30,000 km^2 and generally, higher lithium contents are observed in felsic rocks such as granites.

   Along Gaik-Kiari-Chuma Thang transect, medium to coarse grained Ladakh Granitoids with randomly-oriented K-feldspar are present and tourmaline bearing leucocratic felsic veins can be observed intruding the Ladakh Granitoid. Also younger felsic magmatic lithounits such as Darbuk granites (~ 21 Ma, Ahmad et al. 2008) are exposed and extended along the Shyok Suture Zone. Furthermore some younger leucocratic felsic magmatic bodies as veins and dykes (~15 Ma, Ahmad et al. 2008) are also exposed along Nubra-Shyok-Tangste valleys within Karakoram Shear Zone.

2. The Pangong metamorphic complex (PMC) outcrops between Muglib and the northern shore of Pangong Tso. It consists of a broad, steeply foliated sequence of metapelites which contains muscovite, biotite, quartz, psammites, calcmylonites and amphibolites.

   Lithium is widely an accessory mineral in potassium rich feldspar, biotite, mica, amphibole and clay minerals such as illite. It can leach out from its primary sources and get accumulated through secondary sources of enrichment.

3. In the Pangong region of northern Ladakh, the right-lateral Karakoram fault splays into two branches, a south-western strand (Tangtse fault) and a north-eastern strand (Pangong fault). In this region orthogneisses and amphibolites have been intruded by later leucogranite sheets (e.g. Tangtse and Muglib granites), and extensive dyke-sill networks (Weinberg & Searle, 1988, Searle et al., 1998, Phillips, 2004; Phillips et al., 2004; Weinberg & Mark, 2008).

   During magmatic processes, Li^{+} is known to replace Mg^{2+} and Fe^{2+} in Amphibole (Ure and Berrow, 1982) which indicates a possibility for lithium to have accumulated in amphibolites of Pangong Metamorphic Complex in Ladakh.

4. Lithium rich pegmatites occur immediately adjacent to or in sillimanite grade metamorphic rocks which are found in pellites of Pangong Metamorphic Complex in Ladakh as well. There is a probability of having lithium rich pegmatites.

5. The pegmatites genetically associated with gneiss are rich in lithium. Along Upshi-Litse-Himiya transect, Ladakh Granitoids deform to give migmatites and gneissic structures, at some places, they have tourmaline bearing leucogranites and 3 to 4 m thick pegmatites intruding them.

6. Pangong Tso is a long and narrow lake in the neighborhood of the famous Chushul Mountains with mirror-calm water which is cold, clear, and extremely salty and holds sufficient quantity of lime to form a calcareous deposit, cementing the pebbles together in patches of concrete on its bank. It shows a possibility of salt lake bed deposit as believed that there is a large amount of minerals in the basin of the lake, which is resulted from the melting of the snow.

   Tso-morari, a huge mountain lake in Southeast Ladakh, in the Rupshu Changthang plains and Tso Kar both contain mineral deposits.

7. Fluorite mineralization in Chumathang's fluorite bearing pegmatites is in the form of quartz-fluorite veins cutting across granitoids and shale-sandstone-grit unit of the Indus Flysch. Textural studies indicate that fluorite crystals have replaced the earlier formed quartz and feldspar or the marginal zone of pegmatites. Lithium may also be found in these fluorite bearing pegmatites.

8. Puga valley, Chang Tang is a mountain plateau between Tso Moriri and Tso Kar (Salt Valley) of altitude 4300m. It is a geothermal belt with tectonic faults to the ascent of hydrothermal fluids (hot water and mineral deposits and sulphur fumaroles). A three foot thick deposit of borates covers an area of two square miles.

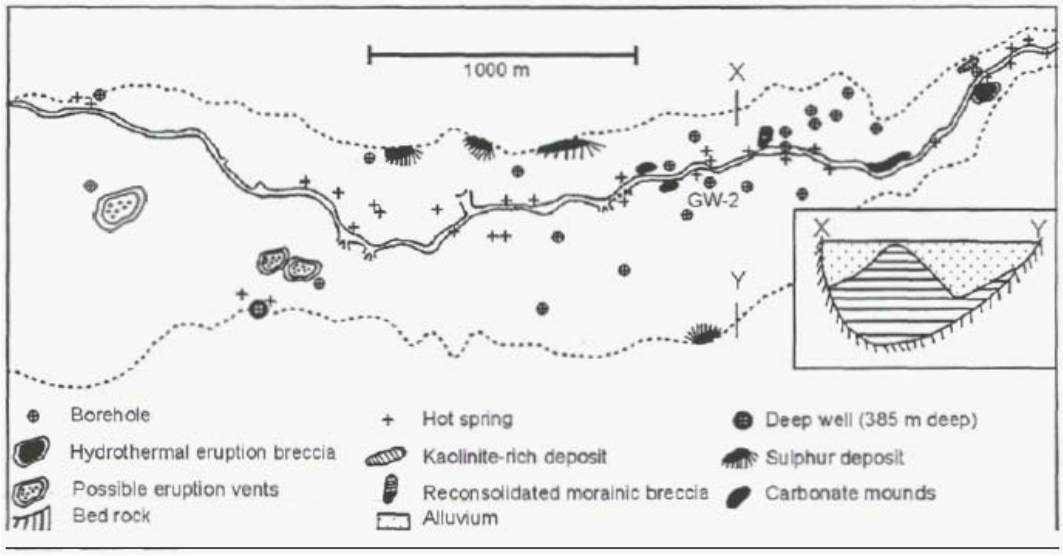


Figure B. shows the presence of carbonate mounds. Lithium mineralized springs are associated with carbonated fluids. Minerals found in hydrothermal fluids of Puga Valley are Borax, Kaolinite, Sulphur, Epidote and Stibnite. The presence of Kaolinite ($Al_2Si_2O_5(OH)_4$), a silicate mineral, gives indications of lithium.

Conclusions

1. Lithium deposits in Ladakh can be inferred to be present in the form of pegmatite veins and dykes, mineralized springs and salt lakes as studied in Afghanistan's deposits.
2. Extensive field studies are required to establish the ground truth of the inferences.
3. Further, geochemical studies will be required to determine the grades of lithium if present.

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