Lithium Pegmatites Exploration in Eastern Portugal using Statistical and Geostatistical Analysis

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INTRODUCTION:

This study is part of a PhD project which main objective is the exploration of rare-element aplite-pegmatite dikes in the Almendra-Barca d'Alva Region (AB). The geostatistical analysis was used as a complementary tool for this work. This methodology was based on 2828 stream sediment samples, collected by Portugal Geological Survey of and the BRGM (France). These samples were analysed for several elements and a geostatistical approach was developed in order to find an association between the lithium estimates and the Li-bearing mineralization.

GEOLOGICAL SETTING:

The AB is located in the Central-Iberian Zone, in an E-W narrow metamorphic belt, bordered by the orogenic Mêda-Penedono-Lumbrales Granitic Complex (MLGC) in the South (Fig. 9). These granites are syn-F_3 Hercynian, heterogeneous, fine- to medium-grained, two-mica, peraluminous leucogranites. In the N-NW border of the region, to the east of Vilariça fault, outcrops the late- to pos-tectonic (relatively to F_3) Numão and Freixo de Numão granites.

The aplite-pegmatite dikes intruded the low-grade metasedimentary pre-Ordovician terrains of the Schist–Metagraywacke Complex (SMC), which comprise an alternation of quartzites, graywackes, schists and pelites.

In the AB area, the metamorphism shows an isograd distribution increasing to South, parallel to the MLGC contact, reaching locally the sillimanite (fib.) isograd.

Figures: 1. Spodumene; **2.** Spodumene dikes; **3.** Lepidolite; **4.** Lepidolite layering; **5.** Petalite; **6.** Petalite; **7.** Petalite dikes; **8.** Bajoca petalite-bearing open-pit mine.

Table 2: Lithium average values for whole-rock analysis .

	SMC	MLGC	post-tect. granites	Lepidolite dike	Petalite dike
Li (ppm)	100[a]	118[b]	82[c]	4960[d]	2050[e]

SMC – Schist-Metagraywacke Complex; MLGC - Mêda-Penedono-Lumbrales Granitic Complex. Data from: [a] Roda-Robles et al. (1999); [b] Bea & Ugidos (1976); [c] Oliveira et al. (1982); [d] Charoy & Noronha (1999); [e] Almeida (2003).

APLITE-PEGMATITE DIKES:

In the AB area, several hundreds of pegmatites have been identified. These pegmatites show a zonal distribution from barren to enrichment in Li, F, Sn, Rb, Nb>Ta, B, P and Be, from the granite northwards. Most of these bodies correspond to poorly evolved pegmatites. In general, pegmatites from the AB area may be grouped in three main categories:

(i) barren conformable pegmatites with quartz, K-feldspar > albite, muscovite, tourmaline ± andalusite ± garnet;

(ii) intermediate discordant pegmatites, characterized by the occurrence of Fe-Mn phosphates, montebrasite, and micas and feldspars with higher Rb and Cs contents than those of the barren pegmatites;

(iii) fertile discordant pegmatites, mainly rich in Li-minerals and/or cassiterite, that maybe classified in three different groups (Table 1).

Table 1: Main characteristics of the groups of Li-pegmatites recognized in the AB area.

TYPE	MINERALOGY		METAMORPHISM of the host rock	MORPHOLOGY and STRUCTURE	ENRICHMENT
	Main Minerals	Other important Minerals			
Spodumene (Vau)	qtz spd ab Ksp	msc mtb pet be	Biotite/chlorite limit zone	Disconformable dyke-like, without internal zonation thickness 4-15m	Li, Sn, P, Be
Petalite (Pombal & Bajoca)	qtz pet ab	msc cass ±mtb ±ecr	Sillimanite and andalusite zones	Disconformable dyke-like, without internal zonation thickness 5-30m	Li, Sn, P
Lepidolite (Ramalha & Castelhano)	qtz ab lep Ksp	msc cass mtb	Biotite and chlorite zones	Disconformable dyke-like, Sometimes with internal zonation thickness ≈ 3m	Li, Sn, P (Rb, Cs)

Qtz-quartz; Ksp-K-feldspar; msc-muscovite; ab-albite; mtb-montebrasite; spd-spodumene; pet – petalite; lep – lepidolite; cass-cassiterite; be-beryl; ecr-eucryptite

LITHIUM ESTIMATION:

Based on a major twofold division of the geology between metasediments and granitic rocks, an analysis of the continuity of the lithium values, in stream sediments, was carried out. For this purpose, experimental variograms were calculated and fitted by nested spherical models corresponding to the two mentioned units. Ordinary kriging was applied as the interpolation technique and a kriging map was generated for blocks of 400m x 400m size. A map with the lithium estimates is presented in Figure 9, along with the geology, structures and mineral occurrences, highlighting mineralization trends and new possible mineral exploration targets.
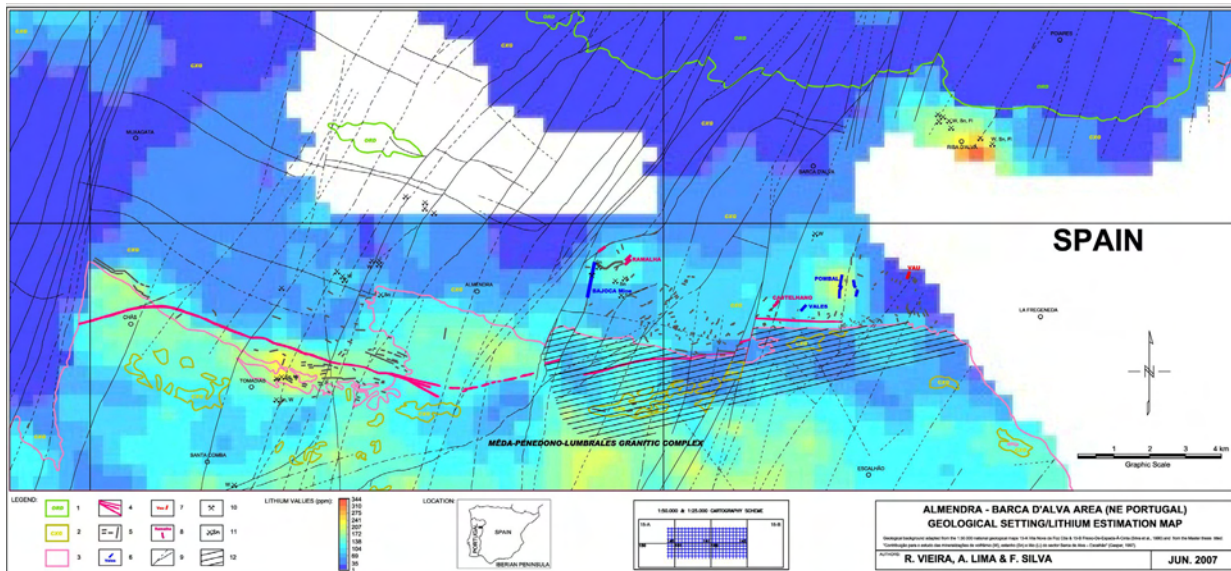

Figure 9. Lithium estimation map overlapped on the Almendra-Barca d'Alva regional geological setting. Legend: **1** – Ordovician formations; **2** – Pre-Ordovician Schist-Metagraywacke; **3** – syn-F3 Mêda-Penedono-Lumbrales Granitic Complex; **4** – porphyry granitic/riolitic; **5** – aplite-pegmatite dike; **6** – petalite-bearing dike; **7** – spodumene-bearing dike; **8** – lepidolite-bearing dike; **9** – Faults; **10** – active mines; **11** – old mines; **12 –** shear zone.

DISCUSSION & CONCLUSIONS:

1. Lithium estimation is a simple and expedite tool for analysing stream sediment data;

2. From the map shown above there is a clear contrast between the lithium content of the stream sediment collected in the granitic rocks area when compared to those collected in the metasediments area;

3. It is also evident that in the granitic complex shear zone (fig. 9) the stream sediment values of lithium are lower. This is due to the weathering and fracture system of these granitic rocks, leading to lithium depletion;

4. Although this is an effective method in the exploration of lithium-bearing mineralization, namely aplite-pegmatite dikes, there are some targets that can be masked and overlooked if there is not a previous study of the region characteristics: regional geology, geomorphology and morphology of the drainage basins. This situation is confirmed in the case of the Vau spodumene-bearing dike, were there is not a positive target on the stream sediment values due to the proximity of a 1st order river;

5. The analysis of the stream sediment data has confirmed known lithium mineralization as Riba d'Alva and Bajoca;

6. The methodology applied highlighted areas not previously known to host lithium mineralization, as those found for the petalite-bearing dike of Pombal;

7. Targets of future exploration will follow up at the Tomadias area, an example of a potential target revealed by this method.