A GIS approach to lithium exploration in the Barroso-Alvão area, northern Portugal

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Keywords: Lithium, GIS spatial analysis, catchment basin, spodumene, petalite, LCT pegmatite, Barroso-Alvão, Portugal

Introduction

One of the well-known examples of Portuguese Li mineralization occurrences is in the Barroso-Alvão (BA) pegmatite field, located in the northwestern part of the Iberian Peninsula, northern Portugal. This area has been recognized for its numerous (~2000) outcropping aplite-pegmatites (e.g. Lima, 2000; Martins, 2009), hundreds of them bearing Li- and Sn- mineralization. These occurrences make the BA pegmatite field one of the most prospective areas for Li in Portugal. Pegmatite swarms from the lithium-cesium-tantalum (LCT) family can form large scale ensembles, which are difficult to explore due to the relative small size of the individual bodies, and their different mineralization style and mineral content. One approach to overcome these challenges is simply the application of Geographic Information System (GIS) methodologies which can help companies defining target areas with potential for Li exploration.

Geological setting

The BA pegmatite field is located on the western occidental part of the Iberian part of the so-called Ibero-Armorican arc. The Iberian Peninsula was affected by the Variscan orogeny starting in the Devonian and continuing to the Carboniferous and early Permian time. Its structural organization results from three main deformation phases (D_1 to D_3) that occurred during the Variscan orogeny (Ribeiro, 1974). The pegmatite field is located in the Galicia Trás-os-Montes Zone (GTMZ), an essentially parautochthonous geotectonic zone using the classification proposed by Julivert et al. (1974), but very close to the southern boundary between the GTMZ and the Central Iberian Zone (CIZ). A major late-D_3 shear structure with NNE-SSW trend (regional fault Régua-Verin) occurs at the east side of the study area. Several types of granitic bodies are present in the vicinity of the pegmatite belt (Fig. 1). They differ in mineralogy (biotite + Ca-plagioclase or two-mica) and timing (deformed or undeformed) with regard to the three episodes of deformation. On the base of the pegmatite's macroscopic fabric, which was affected by post-consolidation stress, the dikes are considered to be older than the youngest unfoliated, post-D_3 biotite granites of the area (Ferreira et al., 1987).

GIS Spatial analysis and catchment basins

Applying the statistical approach by Deveaud et al. (2013) in order to study the spatial relationships between known, abandoned Sn mines and potentially mineralized aplite-pegmatite dikes, the euclidean distance was computed between the Sn mines (associated with petalite-bearing veins) and its closest pegmatites. In the reference distribution, the euclidean distance was also measured between the reference points (random points distributed all over the study area) and its closest aplite-pegmatite dike, in order to compare these data with the above mentioned ones. The resulting histograms of frequency distribution correspond to the distance between abandoned Sn mines (see dark grey bars of the histogram in Fig. 1) and reference points (see light grey bars of the histogram in Fig. 1) to the proximal aplite-pegmatite dikes with a specific strike. The spatial relationship between Sn mineralization and pegmatite dikes was already discovered at the time when the dikes were exploited for Sn. Our analysis reveals that the Sn exploitation occurred preferentially in NS to NNE-SSW and NNW-SSE to NS dikes. These orientations correspond to the orientation of late-stage, post-D_3 faults (Marques et al., 2002) which controlled the emplacement of the pegmatite dikes.

In the second step the catchment basin approach has been applied. The catchment basin approach is based on the relationship of an area of statistical representativeness with each sample, and on the assumption that the concentrations measured in the stream sediments can be considered as average reference values for this area (Spadoni, 2006). A percentile classification is used to delineate zones of high relative enrichment in each of the studied elements. All catchment basins were reclassified based on percentiles (50th, 75th, 84th, 90th, 95th and 97.5th). The background was considered as being 50th, the anomaly threshold as 84th and the anomaly as 97.5th according to Pires (1995). However Pires (1995) based the anomalies on stream sediments (SS) Li content isolines, and not on catchment basins as applied in this study. Therefore, there are many SS Li positive anomalous catchment basins that are offset from the previously defined isolines' higher values. The previous methodology did not provide appropriate interpretation for SS campaigns, resulting in missing some of the mineralized pegmatites (Fig. 2).

Final Remarks

There are essential challenges to overcome in defining strategies for exploration of hard-rock Li deposits: i) the knowledge of the assemblage of Li-bearing minerals and gangue minerals; ii) the chemical pureness of Li minerals (spodumene + quartz intergrowths which may require fine milling to liberate the spodumene); iii) the occurrence and abundance of accessory minerals such as cassiterite and columbite-tantalite group minerals that have potential economic importance as by-products. The major goal of this study was to illustrate that a simple applicable methodology can assist exploration companies in overcoming challenges when defining target areas of potential Li mineralization. The results of this study are: i) the delineation of geochemical Li and Sn anomalous catchment basins using GIS; and ii) the identification of the most common orientation of Li-petalite mineralized pegmatite dikes N0° to N30°E and N0° to N30°W.

Acknowledgements. The authors would like to thank DGAOT/FCUP, Project UID/GEO/04683/2013 of FCT, Portugal, to COMPETE POCI-01-0145-FEDER-007690 and to the ERA-MIN/0002/2014 project NewOreS.

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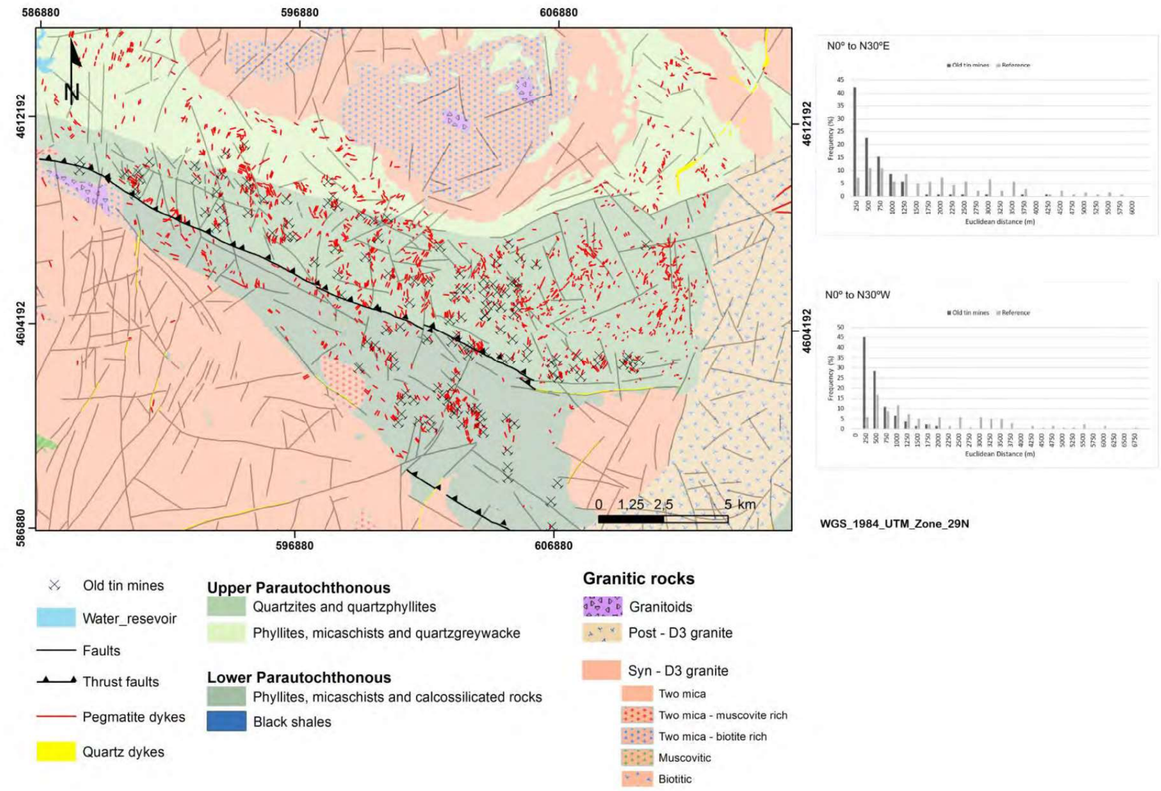

Figure 1. *Regional Geological Map of Barroso-Alvão showing the outcropping pegmatites and old tin mines, and correspondent orientation histograms.*

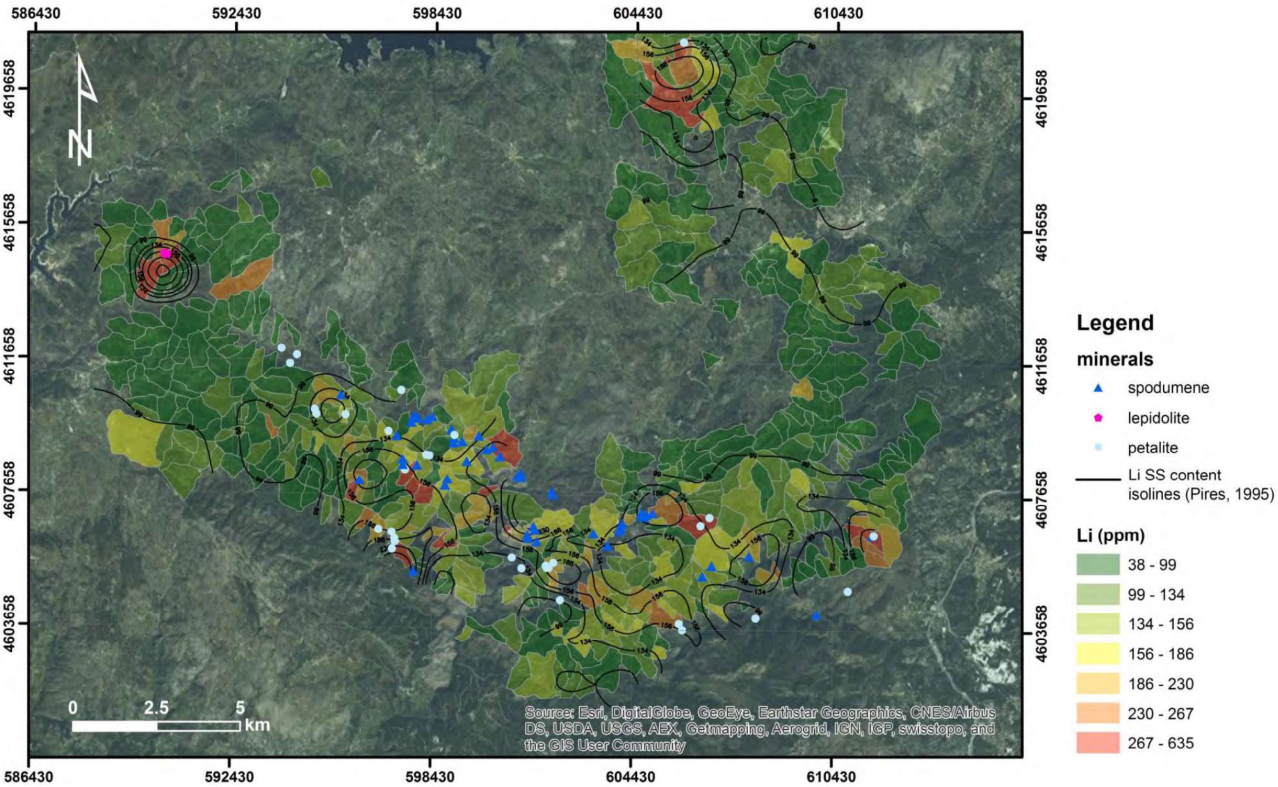

Figure 2. *Regional Geochemical SS Li content of Barroso-Alvão in isolines and catchment basins showing the outcropping mineralized pegmatite.*