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NEW STUDIES OF URANIUM DEPOSITS RELATED TO GRANITES IN ARGENTINA

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INTRODUCTION

At present, the National Atomic Energy Commission of Argentina (CNEA), in cooperation with the National University of Cordoba (UNC), is carrying out the project "Geochemical and Mineralogical Characterization of Uranium and Thorium Deposits"in the framework of the IAEA Coordinated Research Project (CRP), which is "Geochemical and Mineralogical Characterization of Uranium and Thorium Deposits". This paper briefly describes the specific objectives and activities in progress of this research project which has been underway since 2015 [1].

This project aims to focus their studies to characterize the Devonian to Lower Carboniferous magmatic and hydrothermal systems related to granitoids of Pampean Ranges and relate these processes to uranium metallogeny.
Therefore, several metallogenetic studies have been carried out in order to improve the geological, structural, geochemical and mineralogical characterization of uranium deposits related to granites to define: felsic igneous rocks that have played the most relevant role as uranium sources; successive fractionation in the different magmatic complexes; relations between magmatic uranium enrichment and hydrothermal deposits; alteration and uranium mobility.

DESCRIPTION AND RESULTS

The scientific scope of this paper is specifically covers four mineralizations where granite-related (endogranitic) have been described: Sala Grande, Don Alberto and Los Riojanos enclosed in the Achala Batholith and La Estela located in Cerro Áspero –Alpa Corral Batholith [2] [3].

Petrographic data were obtained from observations of polished thin sections using conventional transmitted and reflected light microscopy. Appropriate unaltered mineral areas suitable for laser ablation analysis were selected using a CAMECA SX100 electron microprobe (EMP). Major and trace elements (U, Pb, Th, Ca,Si, Al, Ti, Fe, Mn, V, Na, Nb, La and Y) were obtained by the EMP method, while Rare Earth Element (REE) and a series of trace element contents of uranium oxides were determined using laser ablation inductively coupled plasma mass spectrometry (LAICPMS). These studies were carried out at the facilities of the Nancy University [4][5].

Don Alberto, Sala Grande and Los Riojanos sites are located in the peraluminous S-type Achala batholith (ca. 2500 km2), which belong to the Cordoba Pampean Ranges. This is composed by several magmatic suites and numerous facies, where two-mica monzogranites are by far the most largely exposed lithologies and muscovite leuco-monzogranite is the most evolved rock that occurs as marginal plutons or facies [6][7].

In Don Alberto site uranium mineralization is hosted in dark gray, coarse grained biotitic gneiss, weakly foliated, intruded by a porphyritic two mica granite. Microtexture is predominantly granoblastic, with few biotite-sillimanite rich domains. It shows polygonal aggregates of quartz, plagioclase and cordierite (pinnite replacing cordierite). Accessories minerals are apatite, zircon and opaque minerals (uraninite, ilmenite and rutile).

The cordierite shows two textural varieties: idioblastic poiquilitic and xenoblastic highly poiquilitic with biotite, zircon, apatite and euhedral uraninite crystals inclusions. The uraninite shows concentric radioactive

disintegration halos of yellowish and brown tones and marked radial fracture.
Uranium oxides from the two samples analysed of Don Alberto are present as euhedral uraninite grains with significant Th content (about 1 wt % ThO_2) which indicates a high temperature origin. They have between 2.7 and 3.8 wt% PbO corresponding to chemical ages comprised between 255 and 325 Ma. Their Yttrium content is not significantly enriched (0.07 to 1 wt% Y_2O_3), but the highest value correspond to an altered U-oxide (characterized by the lowest UO_2: 86.2 wt% and PbO: 0.1 wt% contents, and the highest SiO_2: 7.58 wt% and CaO: 3.18 wt% contents, compared to the other analytical points).

The global fractionation of the REE patterns and the high REE contents of the U-oxides from the two samples of Don Alberto are identical. Only one analysis has slightly lower REE contents. These patterns are similar to those found for magmatic uraninite at Rössing deposit in Namibia, but with lower total REE contents [8]. The other trace element patterns of these U-oxides are also similar, with significant enrichment in W, Zr and Mn and more limited enrichments in B, As, W, except two samples which are not enriched in Mo, W and Ti. They are boh very poor in Nb.

In Sala Grande site uraniferous mineralization is located in the subhorizontal contact between the biotitic (± sillimanitic) gneiss and the intrusive granitic surface. The metamorphic rock lies as a roof pendant affected by contact metamorphic process developing a compact hornfels rock in hornblende facies [9].

The intrusive facies in this site is a porphiryc, two micas coarse grained, granite. Microtexture shows a spaced foliation; cleavage domains consist mainly of biotite-sillimanite and microlithons composed by quartz, relict andalusite, cordierite and scarce plagioclase. Second andalusite blastesis is poiquilitic with inclusions of biotite, apatite and fibrolite. It presents hex-shaped uraninite inclusions with marked radiohalos that may be partially altered to oxidized uranium minerals, probably corresponding to uranophane. Other accessory minerals are: monazite, zircon, fluorite and manganese rich ilmenite.

Uranium oxides from Sala Grande are similar to the ones of Don Alberto, with a ThO_2 content of about 1% indicating high temperature uraninite. Their REE patterns are also identical to the non-altered uranium-oxides from the Don Alberto mineralization, suggesting a similar origin for the two occurrences. The trace elements pattern is also very similar to those of Don Alberto, indication similar environment and formation processes.

In Los Riojanos, main lithologies in this site are an equigranular reddish fine grained muscovite leucogranite and fine grained porphyric granite. The first facies has monzogranitic modal composition with albitic plagioclase (An05-An10) and shows intergrowth of quartz and antiperthite textures. Biotite has been totally muscovitized, being the last one relatively abundant. Accessory minerals are apatite, zircon, monacite and rutile. The porphyric granite is monzogranitic but this composition may by locally modified by post magmatic hydrothermal processes. The accessory minerals are apatite, zircon, rutile, titanomagnetite, fluorite and tourmaline.

The main uranium mineralization is hosted in a cataclastic belt affecting the equigranular granite. This cataclasites are formed by a recrystallized fine grain granitic matrix and also low temperature hydrothermal quartz [10].
The sample corresponds to a drill core of 44 meters deep. The uranium is located in a 0.5 mm vein, associated with pyrite and quartz. This vein present “in mortar” texture formed by crushed and recrystallized quartz. Both, the vein and small cavities are filling with pyrite and sooty pitchblende.
Uranium oxides from Los Riojanos have no detectable Th-content; significant yttrium (0.47 to 1.01 wt % Y_2O_3) and calcium (3.49 to 4.46 wt% CaO) with low to moderate silica contents (1.7 to 3.21 wt %), indicating a low temperature hydrothermal origin.

La Estela mine, with estimated resources of 1500 tU at 0.07%U, is located in calc-alkaline high K Cerro Áspero –Alpa Corral batholith (ca. 440 km2) which belongs to Comechingones Range [11]. The main internal facies is represented by coarse-grained biotite monzogranites. The border facies is made of two mica or muscovite leucogranites, whose compositions range from monzogranites to alkali-feldespatic granites [12]. In this deposit, fluorite is spatially associated with pitchblende and other hexavalent uranium minerals (uranophane, metaautunite). This granite has primary magmatic foliation which would control the movement of younger hydrothermal system generating intense E-W brecciation of surrounding granitic rocks. The breccia is polyepisodic showing fractures filled with black fluorite (antozonite) associated with pitchblende and pyrite [13].

Uranium mineralization has a completely different composition compared to Don Alberto and Sala Grande ones. La Estela deposit does not have detectable Th and yttrium contents, and shows relatively high Si (14.82 and 15.47 wt% SiO_2) and Ca concentrations (6.91 and 6.67 wt% Ca) corresponding to a coffinite type composition. Their REE patterns are similar to deposits associated to granites, but with an important Ce positive anomaly and a very high abundance in total REE. Their trace element patterns are characterized by a very high abundance of elements associated with hydrothermal granite related deposits such as B, As, Mo, W, Mn, as well as less mobile elements as Ti, Nb and Zr.

DISCUSION AND CONCLUSION

The interpretation of different REE and other elements patterns [14] allowed improving the metallogenic knowledge of uranium deposits related to granites which would aid in turn to adjust the exploration guides to be applied.

Finally, it can be pointed out that granites play an important role both as uranium source and hosting diverse types of uranium mineralization. Besides, it is thought that, at the existing level of knowledge, there are prospects to develop new uranium resources related to granites in Argentina.

This contribution is a summary of several studies that were conducted by the National Atomic Energy Commission (Argentina), the University of Nancy (France), the International Atomic Energy Agency and the National University of Cordoba. The authors are grateful to many institutions for allowing the information to be assessed and presented here.

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