

SHORT COMMUNICATION

## The Vale de Abrutiga uranium phosphates mine, central Portugal

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### Abstract

A brief summary about the composition and origins of the U deposit is present. The mineralization is composed by secondary uranium phosphates (saleeite and meta-saleeite). The precipitation was probably the main responsible factor for U retention within the quartz veins leading to the uranium phosphate mineralization of Vale de Abrutiga.

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### 1. Introduction

In Portugal there are several generations of uranium deposits, whose origin was discussed by Coteló Neiva (2003). The Vale de Abrutiga U deposit occurs in brecciated quartz veins, in the meteoric weathered zone, at the intersection of two fault systems, close to the Variscan granite. The mineralization consists mainly of saleeite, meta-saleeite, a ferrous-substituted-saleeite and other U-phosphate phases with similar compositions to saleeite, but with different H<sub>2</sub>O content (from 5 to 9 molecules). In order to understand the formation of uranium phosphates from the U-mine, U-bearing minerals in granite and in mineralized quartz veins were studied.

### 2. Methodology

Polished thin sections of samples, of rocks collected at several depths from drill cores, were prepared to

determine the paragenetic relations and chemical composition of the U-bearing minerals and to try to understand the origin of the U-ore deposit. Its mineralogical characteristics were examined using reflected and transmitted light microscopy, back-scattered electron imaging (BSE), and scanning electron microscopy (SEM).

### 3. Results and conclusions

The granite contains texturally and chemically altered uraninite (SiO<sub>2</sub>: 0.53 wt%, FeO: 2.42 wt%, low totals: 98.89 wt%), U-bearing monazite (low totals: 94.87 wt%) and zircon (low totals: 84.69 wt%). The quartz veins contain sulphides, wolframite, zircon and monazite, which correspond to an early hydrothermal mineralization phase, indicated by their textures. Zircon in mineralized quartz veins is dissolved and vacuolated. The grains have cores chemically close to the end member [(Hf,Zr)SiO<sub>4</sub>], but rims are hydrated, have very low totals (~82 wt%), low SiO<sub>2</sub> (~14 wt%) and ZrO<sub>2</sub> (~40 wt%) contents and high UO<sub>2</sub> (~18 wt%) contents. Altered zircon grains show loss of Si, U, Th and Pb (Geisler et al., 2002), so the high U contents found in

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rims of the altered zircon are probably due to very small inclusions of uraninite, not distinguished by BES. Monazite from the mineralized quartz veins is poorer in  $U_3O_8$  (0.19 wt%) than monazite from the granite (up to 2.0 wt%), showing low totals (92.93 wt%) and with the rims of the crystals poorer in U than the respective cores, suggesting leaching of U. So, monazite, zircon, and probably uraninite, were formed during the early hydrothermal mineralization phase and were later dissolved by meteoric fluids that also dissolved uraninite, monazite and zircon in the granite. In the mineralized quartz veins the rims of chlorite crystals are richer in  $UO_2$  (0.25 wt%) than the cores (0.05 wt%). The U contents found in the chlorite are probably due to its sorption by the associated secondary Fe oxyhydroxides, with a very small size, formed by chlorite weathering, which is more intense close to the edges of the crystals. The formation of Fe oxyhydroxide provides additional surface for U complexation and increased U adsorption (Krawczyk-Bärsch et al., 2004). There are Fe oxyhydroxides with high values of U, P and both, which can be due to adsorption. The U and P released to fluids from Fe oxyhydroxides during its aging to haematite led to the precipitation of U-phosphates, when saturation was attained. Fe oxyhydroxides with MgO (up to 2.45 wt%) and/or  $P_2O_5$  (up to 7.12 wt%) and/or  $UO_2$

(up to 5.63 wt%) were also found. This can be due to nanoinclusions of U-phosphates. The precipitation was the main responsible factor for U retention within the quartz veins leading to the uranium phosphate mineralization of Vale de Abrutiga. Precipitation of Fe oxyhydroxides and later of U-phosphate minerals occurred close to the surface in the brecciated quartz veins that acted as structural traps. So it is possible to find wolframite, sulphides and uranium phosphates in the same vein.

## References

- Cotelo Neiva, J.M., 2003. Jazigos portugueses de minérios de urânio e sua gênese. In M.R.P.V. Ferreira (Ed.), *Engineering Geology and Geological Resources*, Book in honour to Prof. J. M. Cotelo Neiva. Coimbra University Press 1, pp. 15–76, (written in Portuguese).
- Geisler, T., Pidgeon, R.T., van Bronswijk, W., Kurtz, R., 2002. Transport of uranium, thorium, and lead in metamict zircon under low-temperature hydrothermal conditions. *Chem. Geol.* 191, 141–154.
- Krawczyk-Bärsch, E., Arnold, T., Reuther, H., Brandt, F., Bosbach, D., Bernhard, G., 2004. Formation of secondary Fe oxyhydroxide phases during the dissolution of chlorite—effects on uranium sorption. *Appl. Geochem.* 19, 1403–1412.