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Optimization of the tantalum ore production by control the milling process

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Abstract - Tantalum is a strategic metal with multiple applications in the new technologies. Tantalum deposits are scarce in EU. Thus, more efficient extracting processes are necessary to contribute to major European independency on these critical raw materials. Tantalum occurs mainly in pegmatites and leucogranite deposits and its placers. Europe does not produce tantalum; however, several deposits are susceptible of being exploited if technologies of processing are improved. This work is part of the Optimore Project which aims to develop modelling and control technologies, using advanced sensing and advanced industrial control by using artificial intelligence techniques, for the more efficient and flexible tantalum and tungsten processing from crushing to separation process. In this paper, a preliminary study of characterization of tantalum ores from leucogranite and alluvial deposits is presented to be used as a base for design the milling experiments to optimize the tantalum recovering during the processing. In the ore deposits tantalum appears in solid solution with niobium in complex oxides, which forms low grade aggregates which need to be processed by means of a separation process. Tantalum ores characterised here belong to alluvial placers of pegmatitic origin located in the Bolivian Amazon Craton and to leocogranites of Penuota, in Spain. Ta bearing minerals of the Bolivian placers are mainly from the columbite group minerals. In Penouta microlite is abundant and often it has a zoning characterised by a Nb-rich core followed by a Ta-rich rim of several cm in thickness.

***Keywords*:** Tantalum, Ore processing, Milling, Mineralogical characterization, Columbite-tantalite, Microlite

1. Introduction

New technologies, leading to the miniaturisation of electronic devices, had resulted in increased use of tantalum. Tantalum-based capacitors, in particular, were on the rise and were increasingly used in automotive electronics, mobile phones, personal computers and wireless devices (Mackay and Simandl, 2014).

Tantalum is mainly supplied by Australia, Democratic Republic of Congo (DRC) and Brazil. Over 50% of the world's tantalum supply comes from Africa particularly the DRC. The tantalum market has important ethical aspects that should be take into account for a sustainable mining ; further 23% originates from the conflict area in the DRC (Greve, 2013) and, in addition, here child labour is being used in this mining activity (Smith et al., 2012). Also, new sources of supply may be developed to diversify geographic sources of supply for strategic reasons (Mackay and Simandl. 2014), although since 2014 it is considered as critical metal by the European Union (Web-2).

The use of models and parameter adjustment processes increases the optimization of ore raw materials processing, while the use of artificial intelligence techniques allows us a better process control.

Recently many systems of automatic chemical and morphological analysis of particles have emerged (Pirrie etal., 2009; Sylvester, 2012). This automated mineralogy characterization is an advanced Scanning electron microscopy system (SEM) that combines the functions of the energy dispersive X-ray spectrometry (EDX) for the chemical analysis and the digital image analysis of back-scattered electron (BSE) micrographs. These techniques can be applied for mineral characterization in all the steps of the mining studies, from the raw material characterization to the processing. In the present project they will facilitate the design of on-line systems of control during the mineral processing of the tantalum ore.

The present work is part of the Optimore project (Web-1) which aims to optimize the crushing, milling and separation ore processing technologies for Tungsten and Tantalum mineral processing, by means of improved fast and flexible fine tuning production process control based on new software models, advanced sensing and deeper process physical study increasing yield in 7-12% on the current best production processes, increasing energy saving on a 5% compared to the best available techniques. The development of specific tools for the processing of tantalum will contribute to optimize the production with lower costs for their production.

2. Materials and methods

Tantalum in Europe occurs mainly in leoucogranites located the west part of the continent. The materials used in the present project are the rare-element enriched granites of St Austell, Cornwall and the Penouta leucogranites, located in Galicia, Spain.

In addition, a tantalum rich ore was used to facilitate the study. Placer deposits formed from rare-elemet pegmatites from the Bolivian Amazonian Craton, located in the border with Brazil, were selected by their high concentration in Nb-Ta bearing minerals.

Materials were characterized by Scanning electron microscopy and microprobe. Scanning electron microscopy with energy-dispersive spectral analysis (SEM–EDS) was used in the back-scattered electron mode (BSE). Electron microprobe analyses (EMPA) were performed in the Centres Cientifics i Tecnològics de la Universitat de Barcelona using a JEOL JXA-8230 electron microprobe.

3. Mineralogy and chemistry of tantalum bearing minerals

Tantalum occurs in great variety of oxide minerals. The most common are columbite-tantalite, $(Fe,Mn)(Nb,Ta)_2O_6$, and microlite, $(REE, U, Y, Ca,Na)2(Ta,Nb)_2O_6(O,OH,F))$, which belong to the pyrochlore group minerals. Also tantalum can be in the structure of cassiterite, SnO_2, in substitution of Sn, being in some cases an ore of Tantalum

In columbite tantalite and microlite niobium and tantalum constitute a solid solution, with their relative ratios distributed in different ways, giving place to uniform or zoned minerals. The structural characterization of these minerals is very important to design the milling operations during the processing in order to obtain the desired degree of Ta_2O_5 richness of the concentrate.

In the case of pegmatitic ore from Bolivian alluvial deposits most grains of the Nb-Ta bearing minerals belong to the columbite group. Columbite-tantalite occurs as subhedral tabular dark brown crystals up to 1 cm in size. Half of the crystals are homogeneous and the other are zoned. Zoning commonly is oscillatory, with multiple light, Ta-rich, and dark, Nb-rich, bands. Irregular patchy zoning is also present (Fig. 1). This appearance is usual for tantalum minerals in pegmatitic occurrences (eg. Alfonso et al. 1995; Tindle and Breaks 2000).

Microlite, fersmite, and other Nb-Ta bearing minerals only occur as late replacements of columbite-tantalite crystals distributed following fractures or in the rims. These phases are of few microns in size, difficult to separate from the rest of the grain. The composition of these phases can be rich in Ta, or in other cases, in Ti; in addition they can contain high contents in Uranium, and occasionally in Thorium. These are considered as damaging elements for placing tantalum on the market.

In leucogranites the Na-Ta bearing minerals are scarce; preliminar chemical analyses of the Penouta leucogranite show concentrations of no higher than 150 ppm of Ta. Chemical composition and textures of Ta bearing minerals of these leucogranites contrast with the obtained from the Bolivian deposit. In the Penouta leocogranites microlite is an important Ta bearing phase that often has a zoned texture with a Nb-rich core and a Ta-rich rim, of several microns (Fig. 1). The composition of a typical grain is shown in Fig 2.

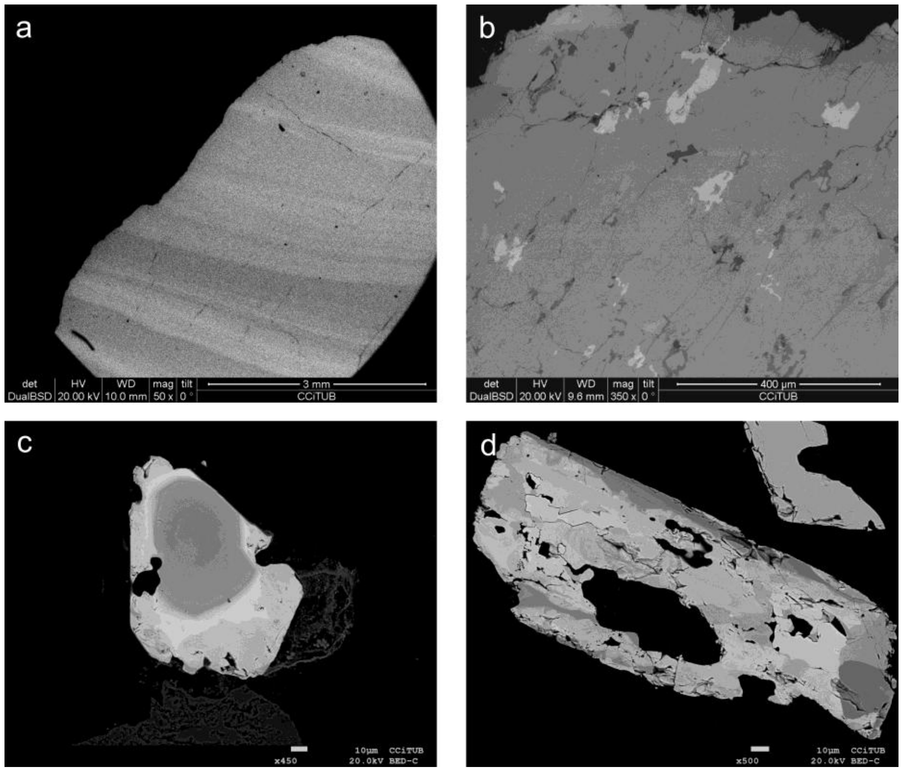

Fig. 1. Backscattered SEM images of Ta-rich minerals: a) typical zoned crystal from the alluvial Bolivian deposit; b) Homogeneous columbite crystal from the same place with inclusions of microlite (bright); c) microlite from the Penouta leucogranite with a Nb-rich core (dark) and a Ta-rich rim (bright),; d) columbite-tantalite from Penouta.

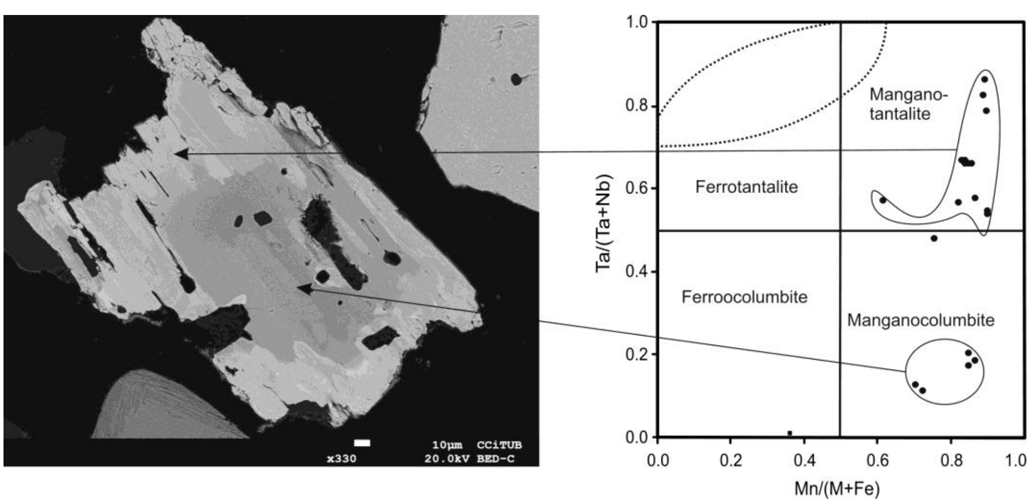

Fig. 2. Composition of a representative zoned microlite from the Penouta leucogranite. Left, backscattered SEM image); right, Ta/(Ta+Nb) versus (Mn/(Mn+Fe) ratio of the microprobe analyses.

4. Conclusions

Tantalum deposits in Europe have low ore concentrations and with the present methods of processing they are not economically viable their exploitation.

The mineralogical characterization of the tantalum ore is necessary to determine the grade that could be provided during the ore processing. Nb and Ta occur as solid solution in different oxide minerals. In some cases as in the Penouta leucogranite, the Nb-rich and the Ta-rich zones of the mineral particle can be separated with a conventional degree of milling, obtaining a high degree of T_2O_5 content in the concentrate. In other cases, these metals are completely mixed or distributed in very narrow zones, preventing it separation by physical methods.

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References

Alfonso P, Corbella M, Melgarejo JC (1995) Nb-Ta- minerals from the Cap de Creus pegmatite field, eastern Pyrenees: distribution and geochemical trends. Mineral Petrol 55: 53-69

Greve, N. (2013). Tungsten, tantalum, rare earths emerging “critical” global metals. Mining Weekly, 3 July.

Mackay, A.R., Simandl, G.J. (2014). Geology, market and supply chain of niobium and tantalum—a review. Miner. Deposita 49, 1025-1047.

Pirrie,D., Power, M.R., Rollinson, G.K., Wiltshire, P.E.J.,Newberry, J.., Campbell, H.E. (2009). Automated SEM-EDS (QEMSCAN®) Mineral Analysis in Forensic Soil Investigations: Testing Instrumental Reproducibility. Criminal and Environmental soil Forensics, 411-430.

Smith, E.K., Cazier, J.A., Fox, J., Kitunda, J.M. (2012) The effect of child labour in Africa on consumers of the cell phone industry. Int. J. Information Systems and Change Management, 6, 147-159.

Sylvester, P. (2012). Use of the Mineral Liberation Analyzer (MLA) for mineralogical Studies of sediments and sedimentary rocks. In Quantitative Mineralogy and Microanalysis of Sediments and Sedimentary Rocks (P. Sylvester, ed.). Mineralogical Association of Canada Short Course Series V. 42, 1-16.

Tindle AG, Breaks FW (2000) Columbite-tantalite mineral chemistry from rare element granitic pegmatites: Separation Lake area,NWOntario, Canada. Min Petrol 70: 165-198.

Web sites:

Web-1: http://optim-ore.eu/ consulted 1 Apr. 2015.

Web-2: http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/report-b_en.pdf. Consulted 10 Jan 2015