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Application of microCT scanning in the recovery of endo-skarn associated scheelite from the Riviera Deposit, South Africa

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ABSTRACT

The granite-hosted Riviera W-Mo-REE deposit is an approximately 40 million ton low grade (~0.2% WO_3) endo-skarn resource and contains disseminated scheelite as the principle ore. Scheelite is strongly zoned and has a molybdenum-rich core and depleted rim. Separation of the high-demand low-molybdenum scheelite does not appear possible. The high density contrast between scheelite (ρ = 6.1) and gangue (ρ = 2.7) allows separation by gravity on tables, wet or dry spirals and heavy medium liquids. In the present laboratory study the latter method was used as a pre-concentration stage and yielded at best a ~50% scheelite recovery of the −1 mm size fraction. The generally fine grain size of the liberated grains and considerable loss to the −45 µm fraction is a function of the friable nature of scheelite and possible overgrinding. The influence of this mineralogical characteristic on scheelite recovery will have to be accommodated in the beneficiation in particular the comminution stage, of the deposit in the future. As a complimentary study MicroCT scanning was applied as a relatively new analytical tool to evaluate the beneficiation results obtained. The method studied both sinks and floats of the various size fractions and allowed quantification of scheelite grain size distribution and calculation of ore grade of the coarse fractions. MicroCT images displayed the textural relationships between the ore and gangue minerals and the degree of scheelite liberation. This analytical tool proved useful in the present study and the results indicate that it can be applied to similar ore beneficiation studies.

1. Introduction

The Riviera W-Mo-REE deposit is located in the Piketberg area of the Western Cape Province and is hosted by late stage granites of the Neoproterozoic-Cambrian Cape Granite Suite (Rozendaal et al., 1994, 1999). The tabular-shaped ore body has an unclassified mineral resource of 46 million tons @ 0.216% WO_3, 0.025% Mo using a 15 m thickness cutoff and extending to a vertical depth below surface of 220 m. Within this ore body, a high grade portion was delineated with unclassified mineral resources of: 7 million tons @ 0.279% WO_3, 0.02% Mo. Rare earth element concentration in the deposit is highly anomalous, but resources have not been calculated. The style of mineralization is that of an endoskarn closely associated with pervasively hydrothermally altered, early quartz monzonite porphyry (QMP), biotite monzogranite (BMG) and late-stage aphanitic granite-monzogranite (AGM), (Rozendaal and Scheepers, 1995; Rozendaal and Boshoff, 2011; Rozendaal and Theart, 2013). Scheelite ($CaWO_4$) is the only tungsten-bearing mineral and molybdenite (MoS_2) reflects the molybdenum grade. Rare earth elements are mainly hosted by allanite a member of the epidote group.

Scheelite is most abundant in the zones of endoskarn and the bordering skarnified granite. Together they define a favourable zone present as a cupola in the roof of the Riviera pluton (Fig. 1). Although abundant quartz veins traverse the Riviera pluton not all of them contain scheelite. Grain size of scheelite is highly variable but generally medium- to coarse-grained (50–600 µm) and shape anhedral to euhedral. It has two distinct and one less prominent cleavage direction and as a result is friable despite a Moh hardness of 4.5–5. Specific gravity of scheelite varies between 5.9 and 6.1.

All the scheelite grains observed display strong zonal crystal growth, the result of variation in crystal chemistry (Fig. 2). In general two distinct generations of scheelite have been identified. The yellow fluorescent-type with high molybdenum (1000–4000 ppm) is the earlier phase and shows overgrowths of late stage blue fluorescent scheelite which is relatively depleted in molybdenum (1–100 ppm; Pieterse et al., 2014).

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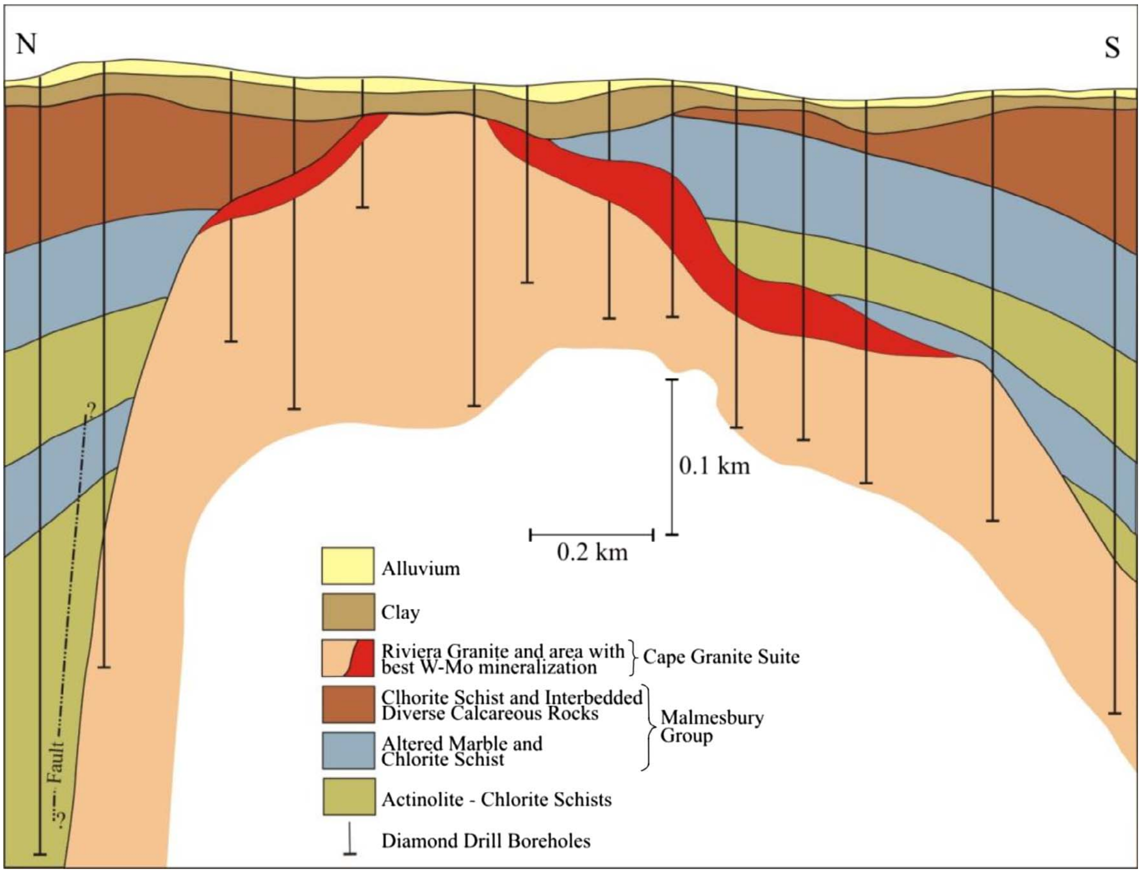

Fig. 1. Schematic vertical cross-section of the Riviera pluton showing the W-Mo-REE mineralized zone located on the contact between the granite host and Malmesbury Group meta-volcanosedimentary wall rocks.

2. Aims

The specific gravity of scheelite varies between 5.9 and 6.1 and contrasts sharply with the gangue mineralogy which consists of quartz, feldspar and hydrated alteration products ($\rho < 2.9$) as well as the silicate mineralogy of the skarn zones (garnet $\rho \sim 4.0$, clinopyroxene $\rho = 3.5–4.0$, titanite, zoisite and epidote). Ore minerals are present in minor to trace concentrations and consist of pyrite, pyrrhotite, molybdonite, allanite, chalcopyrite and sphalerite ($\rho = 4–4.5$). This density contrast between ore and gangue minerals allows the separation and beneficiation of these phases by gravity either on tables, wet or dry spirals or by means of high density liquids. As a result it was suggested that scheelite beneficiation of the Riviera deposit should be considered by means of conventional heavy medium separation as a pre-concentration stage. This report presents the results of an orientation study that used split core from a diamond drill hole that intersected a representative mineralized section of the Riviera ore zone. As a second aim of the project the microCT scanner was introduced to test its application and capabilities as an additional/alternative analytical tool in the minerals industry and beneficiation of granite-hosted scheelite in particular. The use of microCT in the geosciences is growing steadily and has been reviewed recently by Cnudde and Boone (2013). The general use of microCT for analysis of ore minerals including particle size analysis was discussed in Kyle and Ketcham (2015). The use of

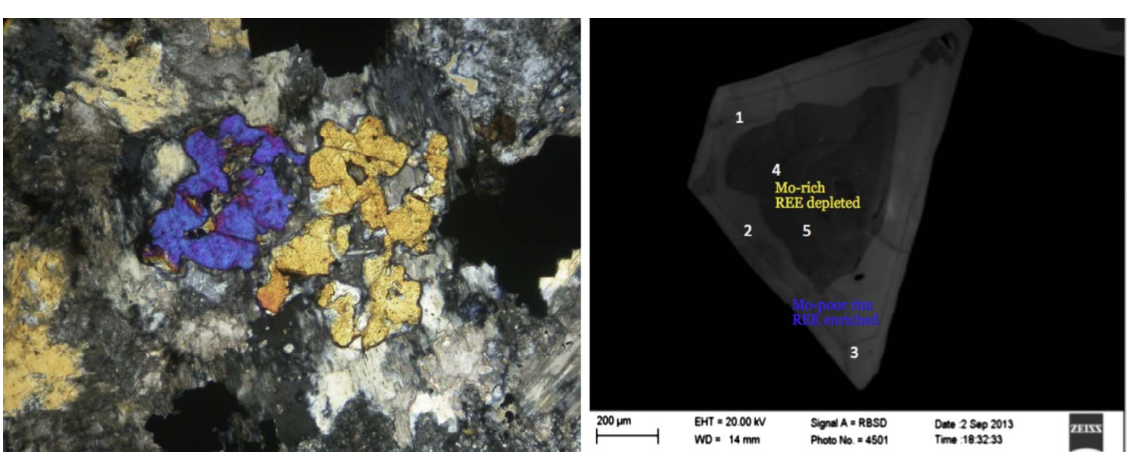

Fig. 2. a) Anhedral scheelite hosted by hydrothermally altered monzogranite indicated by sericitization of the feldspars (XPL). b) Scanning electron microscope image of euhedral scheelite showing oscillatory zoning with a molybdenum-rich core and depleted rim.