Tantalum mineralization in the Tanco pegmatite: magmatic *versus* metasomatic processes

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ABSTRACT

In the Tanco pegmatite, Manitoba, Canada, two complementary styles of Ta mineralization (one associated with primary magmatic zones, the other with late mica replacement) were investigated in order to characterize the mineralizing processes, in particular the role of late immiscible fluids. Magmatic versus metasomatic processes were investigated based on complex textures between Ta oxide minerals, and their major and trace element chemistry. We show that both styles of mineralization can form entirely from magmatic processes, and that immiscible fluids did not play an important role.

Keywords: *tantalum mineralization, Tanco pegmatite.*

INTRODUCTION

In the Tanco deposit, Manitoba, Canada, tantalum mineralization shows a complexity that reflects the complex petrogenesis of its host pegmatite. Two complementary styles of Ta mineralization were investigated in order to characterize the mineralizing processes, in particular the role of late immiscible fluids in the precipitation of Ta oxide minerals (colombite-group minerals CGM, wodginite-group minerals WGM, microlite and ferrotapiolite). The first style of mineralization is hosted by primary magmatic zones, and is particularly abundant in the aplitic albite zone. The second style is associated with the late mica replacement of central zones, known at Tanco as MQM (Mica-Quartz alteration after Microcline). The magmatic *versus* metasomatic processes were investigated based on complex textures between Ta oxides, and major and trace element chemistry of Ta oxides and associated minerals (tourmaline and micas).

RESULTS

Textural features

Tantalum oxides from the primary magmatic style of mineralization commonly show simple zoning that is interpreted as magmatic in origin. However, X-ray element distribution maps of the oxides of the replacement style revealed complex textures, as shown in Figure 1. The following general paragenetic sequence has been determined through detailed petrography: CGM + microlite (early primary), followed by intergrown CGM/WGM + microlite (late primary), and finally WGM + microlite + ferrotapiolite (replacement). Relics of primary CGM + WGM (often intergrown) were corroded during mica alteration, and microlite + ferrotapiolite (±WGM) were deposited (as replacement or overgrowth of earlier Ta phases) during the alteration event.

Chemical trends

Chemical evolution of Ta oxides (in particular CGM and WGM) in the columbite quadrilateral reveal the classical increase in the Ta/(Ta+Nb) and Mn/(Mn+Fe) ratios, usually observed in CGM of rare-element pegmatites. The Ta/(Ta+Nb) increase is consistent with the experimental data of Linnen & Keppler (1997) which shows that manganotantalite solubility is higher than manganocolumbite solubility in a melt. The Mn/(Mn+Fe) increase is controlled by the crystallization of tourmaline first, then by micas. The chemical evolution of WGM shows a reverse trend, with a distinct Mn/(Mn+Fe) decrease. This can be explained by the experimental data of Linnen & Cuney (2005) who show that the solubility of the Fe end-members of CGM in granitic melts are higher than those of the Mn end-members. If WGM behaves similarly, the Fe enrichment trends can be interpreted as being magmatic in origin. Ferrotapiolite is also interpreted as magmatic based on its equilibrium crystallisation with late manganotantalite.

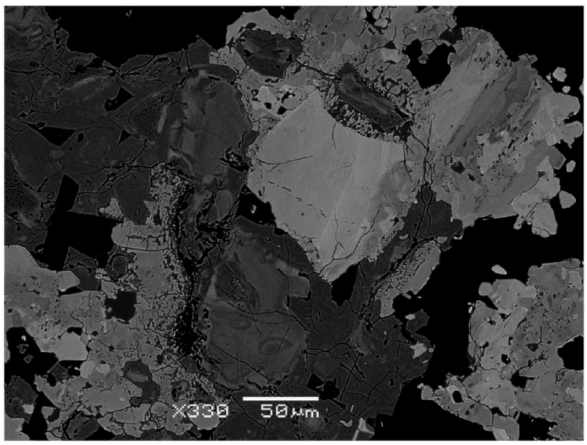

FIGURE 1. SEM image showing the complex association of manganotantalite, wodginite, microlite and ferrotapiolite. As a certain grey level can be attributed to any Ta phase, X-ray distribution maps are necessary to distinguish the different phases.

CONCLUSIONS

Both textural and chemical features indicate that Ta oxides of both mineralization styles could form from magmatic processes. This is consistent with the preliminary experimental results on Ta fluid-melt partition coefficients that indicate that Ta is not transported by fluids (Chevychelov et al. 2004). This hypothesis is reinforced by the fact that alteration micas contain high Ta contents (40-100 ppm), although these concentrations are lower than in primary micas (100-400 ppm).

Finally, a metallogenic model for Ta mineralization can be presented in the framework of currently admitted ideas for the formation of highly-fractionated pegmatites. The concept of boundary layers advocated by London (1999, 2005) can be applied to Ta mineralization. At the crystallization front of a pegmatite zone, a boundary layer develops that accumulates highly incompatible elements, such as volatiles (Li, B, P, F…) and metals (Ta, Zr…). When volatiles diffuse back to the bulk melt, Ta solubility suddenly decreases, which promotes the precipitation of Ta oxides. Some field evidence of such process will be shown (e.g. Fig. 2).

We conclude that, although late fluids may exsolve out of the melt in the late stages of pegmatite formation, they do not play an important role in Ta mineralization at Tanco.

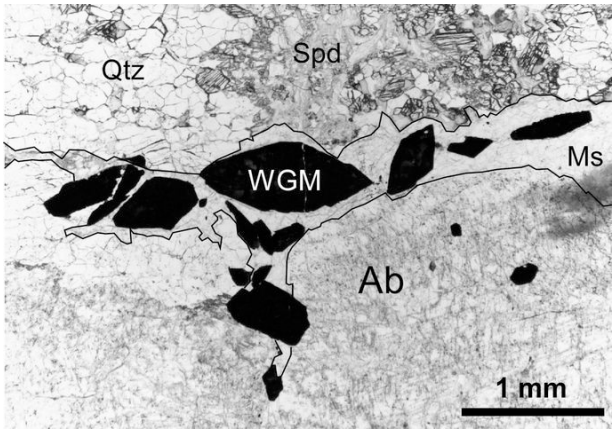

FIGURE 2. Tantalum oxides in a boundary layer of the Tanco pegmatite. A possible explanation for this texture is as follows: the fast crystallization of albite (Ab) leads to a residual melt locally enriched in incompatible elements (e.g., Li, Ta) at the interface between albite and melt. In a second stage, lithium diffuses back to the melt, resulting in the crystallization of spodumene (Spd). Since Ta diffusivity is lower than that of Li, and since Ta solubility decreases with decreasing Li concentration in the melt, the crystallization of spodumene leads to an oversaturation of Ta in the melt and to the crystallization of Ta oxides (here, wodginite: WGM) in the vicinity of albite minerals.

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