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Magmatic vs. hydrothermal origins for zircon associated with tantalum mineralization in the Tanco pegmatite, Manitoba, Canada

Marieke Van Lichtervelde,[1,2,*] Frank Melcher,[1] and Richard Wirth[3]

[1]Bundesanstalt für Geowissenschaften und Rohstoffe, Stilleweg 2, D-30655 Hannover, Germany
[2]Institut für Mineralogie, Universität Hannover, Callinstrasse 3, D-30167 Hannover, Germany
[3]GeoForschungsZentrum Potsdam, Department 4, Telegrafenberg, D-14482 Potsdam, Germany

Abstract

Complex textures in zircon associated with Ta oxides have been used to assess the processes at the origin of zircon crystallization and associated Ta mineralization in pegmatites, in particular the role of magmatic vs. hydrothermal processes. The Tanco pegmatite is used as an example because its zircon is devoid of post-magmatic alteration and its petrogenesis is well constrained. Zircon in primary units is metamict with high U-Pb-Th contents. By contrast, in secondary assemblages affected by late-magmatic micaceous alteration, zircon is devoid of radiogenic elements, but it may contain abundant Ta_2O_5 (up to 4.7 wt%). The incorporation of Ta into zircon may occur through coupled substitution mechanisms involving other minor elements such as P, Al, Mn, or Li. The presence of Ta accounts for the distorted structures in the Ta-rich zircon, as revealed in high-resolution TEM images. Four zircon types occur sequentially in single zircon crystals, which permits a new model for zircon growth and evolution in rare element pegmatites to be advanced: (1) zircon (Z1) is Ta-rich and crystallized possibly before discrete Ta phases; (2) Z1 was overgrown by regularly zoned zircon Z2 and Z3, which show lower Ta and extreme Zr/Hf fractionation (HfO_2 up to 38.9 wt%), suggesting crystallization from a highly fractionated melt, possibly at the onset of Ta mineralization; and (3) close to the solidus, the aqueous fluid at the origin of micaceous alteration corroded the distorted structure of Z1, and a low-Ta zircon (Z4) replaced Z1 by dissolution-reprecipitation, whereas Z2 and Z3 resisted this alteration. Tantalum was no longer stable in the zircon structure and crystallized as Ta-oxide inclusions in the reequilibrated zircon (Z4).

Keywords: Zircon, tantalum mineralization, hydrothermal alteration, pegmatite, Tanco