Mechanism for fractionation of Ta-Nb, Sn and W in granite-related metallogenic systems based on observations from the Karagwe-Ankole Belt of Central Africa

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Tantalum , niobium, tin and tungsten mineralization occurs worldwide in close proximity to fractionated peraluminous leucogranites. These granite-related ore deposits show a diversity of mineralization modes, ranging from plutonic-hosted breccia and hydrothermal vein-stockwork systems to (peri)batholitic greisens, skarns, pegmatites and hydrothermal veins. In the Mesoproterozoic Karagwe-Ankole orogenic belt (KAB) of Central-Africa numerous early-Neoproterozoic Nb-Ta-Sn-W rare-metal deposits formed as primary mineralization in hydrothermal quartz veins, magmatic lithium-cesium-tantalum family pegmatites and associated intra-pegmatitic greisens (Fig. 1). These deposits are on a belt-scale spatially and temporally related to ilmenite-series, peraluminous, S-type leucogranites, which are generally defined in the KAB as the Kibara Sn granite generation with an intrusion age of ~986 ± 10 Ma (SHRIMP U-Pb on zircon; Tack et al., 2010).

This study reviews the petro- and metallogenesis of Nb-Ta-Sn-W granite-related ore deposits, as they occur in the Rwandese part of the KAB, and provides a general overview of the geochemical mechanisms behind the formation of pegmatite- and quartz vein-hosted deposits and the distribution and enrichment of the ore elements Nb, Ta, Sn and W in the different metallogenic subsystems (i.e. granites, pegmatites and veins). Moreover, the observed close spatiotemporally association between leucogranites, pegmatites and quartz veins is assessed in terms of a direct genetic link between the mineralization and the felsic magmatism. Based on this review and element distribution calculations, an integrated orthomagmatic metallogenic model for Nb-Ta-Sn-W mineralization in the KAB is demonstrated. Rayleigh-type fractional crystallization acted as the main mechanism by which pegmatitic magmas differentiate from a parental leucogranitic melt and by which incompatible elements Nb, Ta, Sn and W initially are enriched. However, early aqueous fluid immiscibility has been identified to occur during differentiation of this B-rich, F-poor melt system, which greatly effects W depletion in the melt by preferential partitioning of W into the mobile fluid phase. Sn retains dominantly in the melt phase and becomes, by high degrees of fractional crystallization, enriched in late-stage magmatic fluids. Element-specific melt-fluid-crystal fractionation together with element-specific and lithological-controlled precipitation conditions are the key enrichment processes and are all responsible for the decoupling of Nb-Ta, Sn and W and their subsequent precipitation in pegmatite, hydrothermal quartz vein and greisen deposits. This formation model for the KAB system can form a major tool in the exploration for granite-related ore deposits in general.

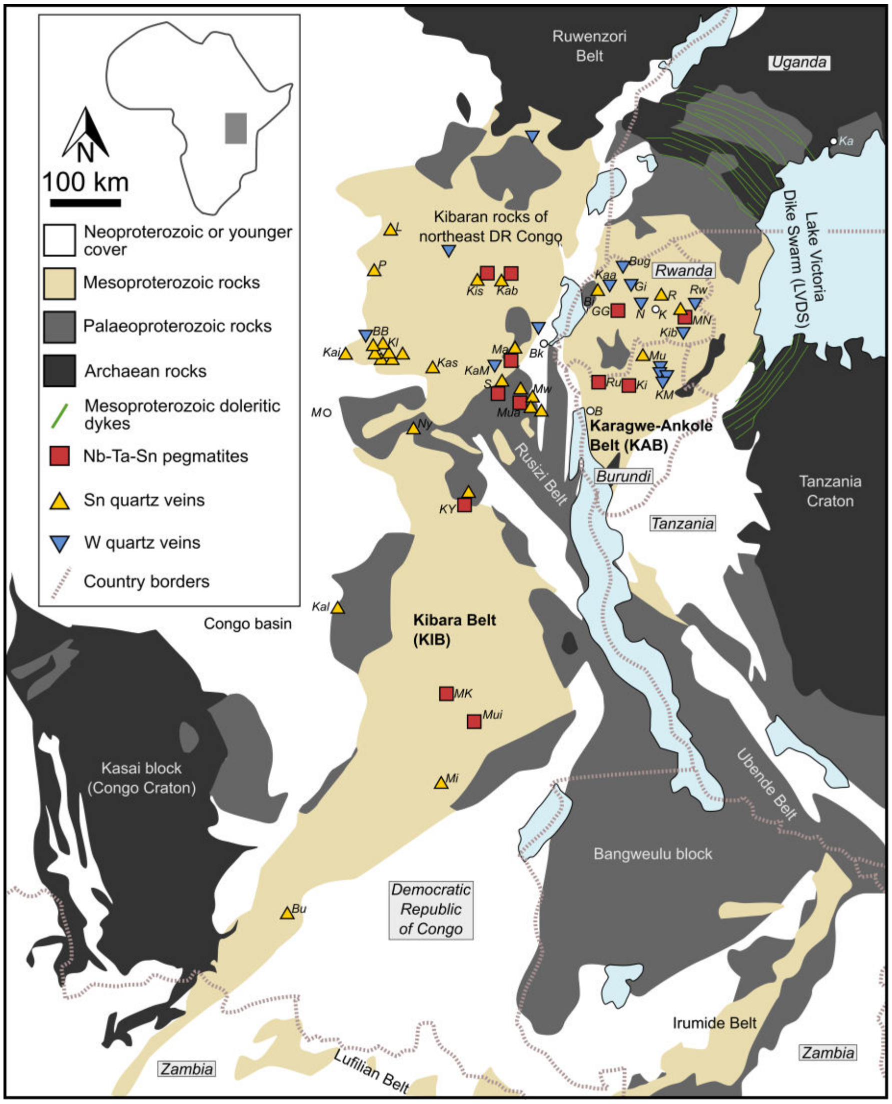

Figure 1. Conceptual outline of the geographical and geological setting of the major rare-metal deposits of the Karagwe-Ankole (KAB) and neighboring Kibara (KIB) belts in Central African Great Lakes region. B: Bujumbura, BB: Bengo-Biri, Bi: Bisesero, Bk: Bukavu, Bu: Busanga, Bug: Bugarama, GG: Gatumba-Gitarama pegmatite field, Gi: Gifurwe K: Kigali, Ka: Kampala, Kaa: Kabaya, Kab: Kabunga, Kai: Kailo, Kal: Kalanda, Kas: Kasese, Kl: Kalima, Ki: Kivuvu, Kib: Kibungo, KaM: Kamituga-Mobale, KM: Kirundo-Muyinga, KY: Kabambare – Yungwe, L: Lowa, Kis: Kiseke, Ma: Matale, Mi: Mitwaba, MK: Manono-Kitotolo, MN: Musha-Ntunga, Mu: Mulehe, Mua: Muana, Mui: Muika, Mw: Mwenga, N: Nyakabingo, Ny: Nyangulube P: Punia, R: Rutongo, Ru: Ruhembe, Rw: Rwinkwavu, S: Sasa. After Hulsbosch (in press).

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