

The Mineralizing Fluids Evolution of the Kibaran Tin Granite With Columbite-tantalite: A Comprehensive Study in Kalehe, South-Kivu (Dr Congo)

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The growing demand for critical minerals, driven by renewable energy and energy storage needs, highlights the significance of tin, a key component in electric vehicles and electronics. In the DR Congo, tin deposits are located within the Mesoproterozoic Kibaran formations, which also host tungsten, columbite-tantalite, gold, and lithium resources. Field investigations, petrographic, and SEM-EDS analyses have revealed that mica schist is graphite-rich, biotite-granites contain sphalerite, titanomagnetite, manganese, zinc, and quartz veins contain stannochromite. Additionally, aplite pegmatite and greisen are columbite-tantalite rich, phosphate pegmatite contains various colored tourmalines, and muscovite-granite showcases rare-earth elements, tin, and manganese. Fluid inclusions in quartz from muscovite-granite, aplitic pegmatite, greisen, and quartz veins were analyzed using Raman spectroscopy, revealing CO₂, CH₄, SO₂, CO, O₂, NH₃ gases, and H₂O. Granite and mineralized quartz veins contain abundant multi-phase + solid fluid inclusions with one to eight phases, with various forms (hexagonal, acicular, cubic, rhombic, rectangular, and anhedral) identified in Raman as hydrated phosphates, carbonates, sulfates, and halide minerals. The fluid inclusion homogenization temperatures (Th), salinities and pressures ranged between: 250–303°C and 3–16 wt% NaCl in the barren quartz veins; 194–296°C, 5–27 wt% NaCl, and 100–240 bars in greisen; 119–209°C, 3–25 wt% NaCl, 40–90 bars in pegmatite; 117–328°C, 9–28 wt% NaCl, 45–88 bars in mineralized quartz veins; and 128–550°C with 2.7–64 wt% NaCl in granite. Fluid modification mechanisms observed by the correlation of Th and salinity have shown that the mineralizing fluids evolved from granite, pegmatite, greisen to quartz veins, demonstrating magmatic-hydrothermal processes combined with meteoric water. In quartz veins, tin precipitation occurred through boiling and dilution, while greisen and pegmatite deposits formed via fluid mixing and boiling. Further fluid inclusion studies and geochemistry are ongoing to enhance understanding of the origin and evolution of these complex mineralizing fluids.