

Use of $\delta^{18}\text{O}$ for Fluid Tracing and Quartz-Cassiterite Thermometry of Sn Deposits Surrounding the Mole Granite, NSW

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The world-class Mole Granite in northeastern New South Wales (NSW) is surrounded by over 1200 deposits that display a strong metal zonation including W-, Sn-, Pb \pm Zn \pm Cu and Au \pm Bi dominated deposits. Formation of these zoned deposits is thought to be driven by a thermal gradient resulting from the mixing of late magmatic fluids of the Mole Granite and meteoric fluids; however, exact fluid compositions and mechanisms of ore formation over the entire system are poorly constrained.

We have measured the oxygen isotope compositions of cassiterite-quartz pairs from four deposits (Great Britain, Lower Targona, Upper Taronga and Wallaroo) and cassiterite from three other deposits (Yankee, Emmaville, and McDonald's) of the Mole Granite system using the SHRIMP SI in order to obtain temperature estimates of Sn mineralization, and characterize the composition of mineralizing fluids.

Previous $\delta^{18}\text{O}$ (SMOW) cassiterite analyses on bulk separates from the Mole Granite system identified two fluid compositions at ca. -6.2‰ and ca. $+2.2\text{‰}$, representing variable input from magmatic ($\delta^{18}\text{O} \approx +10$ per mil) and meteoric ($\delta^{18}\text{O} \approx -15\text{‰}$) fluids. In contrast, measured $\delta^{18}\text{O}$ cassiterite values in this study generally show a larger range with Yankee, Emmaville, Great Britain, Lower Taronga, and Upper Taronga varying between $\delta^{18}\text{O} \approx 0$ to $+6\text{‰}$, whilst Wallaroo is distinct with $\delta^{18}\text{O} \approx -6\text{‰}$. Quartz from Great Britain, Lower Taronga and Upper Taronga range from $\delta^{18}\text{O} \approx +10$ to $+12\text{‰}$, whereas Wallaroo is significantly lighter with a weighted average of -2.2 ± 2.0 . These results clearly differentiate Wallaroo as the results of a separate mineralizing event, which is confirmed by recent U-Pb cassiterite geochronology and trace element analysis, indicating that it formed ~ 10 m.y. later.

Cathodoluminescence imaging (CL) of cassiterite commonly reveals complex internal zoning related to chemical heterogeneities. Our in-situ analyses revealed intragrain $\delta^{18}\text{O}$ variability within cassiterite up to $\sim 5\text{‰}$, corresponding to zones recognized in CL imaging. In conjunction with the greater $\delta^{18}\text{O}$ variability identified from a wider range of deposits, this study indicates that cassiterite has crystallized over a larger range of fluid composition than previously thought.

Fractionation of oxygen isotopes between cogenetic quartz and cassiterite is strongly temperature dependent. Calculated crystallization temperatures vary between 270° – 500°C , slightly broader than previously published results of nearby deposits (240° – 410°C). Crystallization temperatures generally decrease with distance from the Mole Granite, the assumed heat source.