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# Pan-African tin mineralization events in the Damara orogenic belt, Namibia, SW Africa: Constraints of cassiterite U-Pb dating and trace elements fingerprinting

Rongqing Zhang*, Weidong Sun, Bernd Lehmann, Gregory Symons, Reimar Seltmann, Christian Schmidt, Congying Li

*CAS Key Laboratory of Mineralogy and Metallogeny, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou, China, Guangdong, Email: zhangrq1986@gmail.com

The Pan-African Damara orogenic belt, Namibia, SW Africa hosts numerous tin deposits making it be one of the important tin provinces in the world. Tin mineralization is mainly associated with the rare metal pegmatites. Minor vein-type and skarn-type tin deposits are related to the granites. From south to north, this province can be divided into four belts, i.e. the Sandamap-Erongo-Arandis belt, Neineis (Nainais)-Kohero belt, Cape Cross-Uis belt, Brandberg West-Goantagab belt. Due to the disturbances of the zircon U–Pb, whole rock/mineral Rb–Sr and K–Ar isotopic systems by late-stage hydrothermal alterations, the timing of the pegmatites and tin deposits is poorly constrained.

Cassiterite ($SnO_2$) is a common ore mineral in rare metal granites/pegmatites and tin deposits, and is also an associated mineral in some tungsten and VMS deposits. It belongs to the rutile group ($M^{4+}O_2$), which in principle should have high U and low common Pb contents in its crystal structure. Cassiterite U–Pb ages directly date tin mineralization process. In this study, we selected cassiterite samples from four representative tin deposits for U–Pb dating, i.e. tin pegmatites in Uis, Arandis, Neineis, and tin quartz vein and skarn from Goantagab. Meanwhile, combined with cathodeluminescence (CL) and trace elements analysis are used to fingerprint the growth environment of the cassiterite in the magmatic-hydrothermal system. Cassiterite grains from the pegmatite of magmatic origin have high Nb and Ta contents, and dark CL images, whereas hydrothermal cassiterite grains from the quartz vein and skarn have low Nb and Ta contents but bright CL images showing clear zonation. Cassiterites from quartz vein and oxidized ore in the skarn from Goantagab tin deposit yield Tera-Wasserburg U–Pb age of 518.4 ± 7.7 Ma (2 σ, n = 35, MSWD = 0.84) and concordia U–Pb age of 509.9 ± 2.7 Ma (2 σ, n = 33, MSWD = 5.0), respectively. Two cassiterite samples from Uis Sn pegmatite give Tera-Wasserburg U–Pb ages of 513.0 ± 6.9 Ma (2 σ, n = 38, MSWD = 0.74) and 503.8 ± 5.9 Ma (2 σ, n = 27, MSWD = 0.78). Two cassiterite samples from Neineis and Arandis pegmatites yield Tera-Wasserburg U–Pb ages of 524.2 ± 3.5 Ma (2 σ, n = 40, MSWD = 5.0) and 500.9 ± 8.7 Ma (2 σ, n = 22, MSWD = 0.22). Our U–Pb dating results indicate that the Pan-Africa tin mineralization event in the Damara orogenic belt occurred at 501-524 Ma, which is related to a post-tectonic system.