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Titanite petrochronological constraints on the thermo-metamorphic history of Neoproterozoic migmatitic rocks from southeastern Nigeria Basement complex

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A detailed understanding of the timing and nature of tectono-thermal events is essential for unravelling the evolution of orogenic terranes. This study enhances the geochronological framework of the southeastern Nigeria Basement Complex by integrating U–Pb geochronology and geochemical analyses of titanites from migmatitic rocks southwest of the Obudu Plateau. Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) was used to analyse U–Pb isotopes and trace elements in titanites to constrain the temporal evolution of tectono-thermal events during the Pan-African orogeny.

Two titanite types were identified: metamorphic and igneous. The metamorphic titanite, dated at 626 ± 4.9 Ma, exhibits LREE enrichment, flat MREE-HREE patterns, and positive Eu anomalies. Zr-in-titanite thermometry yields temperatures of ~619-771 °C, ~1 GPa (~34 km depth). These and other features of this class reflect peak metamorphism, with garnet sequestering HREEs and plagioclase consumption influencing the Eu anomaly. This phase marks the peak collisional stage of the Pan-African orogeny, characterized by crustal thickening and burial.

The igneous titanite, dated at 559 ± 3.2 Ma, displays LREE depletion, negative Eu anomalies, and flat MREE patterns, with Zr-in-titanite temperatures of 809–846 °C at 0.5 GPa (~17 km depth). These features indicate plagioclase fractionation during magma evolution and limited garnet stability. The reconstructed *P–T–t* path exhibits a clockwise trajectory reflecting initial prograde metamorphism, peak conditions (~626 ± 4.9 Ma, ~1 GPa, ~800–850 °C), partial melting, and subsequent cooling and exhumation (~559 ± 3.2 Ma, ~0.5 GPa, ~17 km crustal thickness). The estimated decompression rate (~0.008 GPa/million years) and unroofing rate (~0.23 mm/year) suggest significant crustal thinning over ~70 million years during the late stages of the orogeny. Similar timescales (30–80 Myr) have been reported for other Pan-African belts, including the Arabian-Nubian Shield and the Damara Belt of Namibia. These findings provide critical constraints on the *P–T–t* evolution of the southeastern Nigeria Basement Complex within the framework of the development of the Trans Saharan orogenic belt.