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Detrital tourmaline in Archean meta-turbidites of the Beartooth Mountains, MT-WY, USA: Sources from lithologically diverse Paleoarchean-Mesoarchean crust

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Detrital tourmaline compositions provide powerful constraints on sedimentary protoliths, particularly in Archean clastic (meta)sedimentary successions where probable source terranes are no longer preserved. This feature is exemplified by the Archean Jardine Metasedimentary Sequence (JMS) of the western Beartooth Mountains, northern Wyoming Province (MT–WY, USA), a well-preserved late Mesoarchean turbidite succession deposited along an active continental margin. Primary sedimentary structures, including graded bedding, Bouma sequences, and channelized sand–mud couplets, indicate JMS deposition within a mid- to distal-submarine fan system. Stratigraphic and geochronologic constraints bracket sedimentation between >2.9 Ga (youngest detrital zircon) and <2.8 Ga (intrusion of crosscutting granitic plutons). Detrital zircon U–Pb age spectra spanning 2.9–3.6 Ga record recycling of Paleoarchean to Mesoarchean continental crust. The JMS is allochthonous and not sourced from the adjacent 2.8 Ga plutonic rocks of the main Beartooth block. Subsequent tectonothermal activity at 2.8–2.9 Ga produced medium-grade, low-pressure metamorphism (~550–600 °C, 3–4 kbar), based on the diagnostic staurolite–andalusite–biotite assemblage, consistent with crustal thickening and syntectonic magmatism during late Archean stabilization.

Tourmaline petrochronology integrates sedimentary provenance with prograde metamorphic evolution. **Detrital tourmaline cores** preserve pre-depositional geochemical signatures that constrain the lithologic character of exposed upper continental crust before ~2.9 Ga. Provenance discrimination indicates tourmaline derivation from compositionally diverse and evolved source rocks, including peraluminous and weakly fractionated granites, aluminous metapelites, Fe^{3+}-rich metapsammites, and magnesian metasediments. This diversity implies heterogeneous and differentiated Paleoarchean to Mesoarchean crustal domains. **Metamorphic tourmaline overgrowths** nucleated on detrital cores exhibit compositional asymmetry adjacent to the core along the +c and −c poles. These temperature-dependent differences record initial overgrowth crystallization at ~350 °C, as constrained by tourmaline thermometry. Progressive heating during metamorphism resulted in convergence toward a homogeneous peak-metamorphic chemical signature of the outermost tourmaline rims.

Integrating detrital zircon geochronology and tourmaline crystal-chemical evolution documents recycling of 2.9–3.6 Ga continental crust, deposition in an active-margin turbidite basin after 2.9 Ga, and prograde low-pressure metamorphism at 2.8–2.9 Ga. Thus, the JMS constitutes a high-resolution mineralogical archive linking Archean sedimentation, crustal recycling, and tectonothermal stabilization within this sector of the Wyoming Province.