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Zircon constraints on crustal evolution of the Tanzania Craton 3.9 to 4.0 Ga ago

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The preserved and documented rock and mineral record from the Eoarchean remains scarce on the African continent, limiting our understanding of early crust formation. In this context, we present a comprehensive dataset for >3.8 Ga zircons recovered from Archean quartzites in the central part of the Tanzania Craton. Uranium-Pb ages, trace metal and O-Hf isotopic compositions provide insights into zircon source rock melt compositions, crystallization temperatures, crust-mantle differentiation, and redox conditions. This allows evaluation of crust formation models for the Early Earth. Well-preserved REE (and Ti) compositions in oscillatory-zoned >3.8 Ga zircons imply crystallization from TTG-like melts at temperatures of 832 ± 34 °C. Estimates of oxygen fugacity derived from zircon REE systematics (-3.4 to +1.8 DFMQ) match both modern and Archean mantle values. Zircon O isotopic compositions overlap the mantle range and initial Hf isotopic ratios are uniformly near-chondritic. These signatures offer no support for the involvement of strongly depleted mantle and evolved continental crust as source reservoirs or reworking after prolonged periods of crustal residence. Likewise, models involving partial melting of hydrated (ultra)mafic precursor materials (e.g., volcanic-tectonic burial), assimilation of surface-derived material (e.g., subduction), or hydrothermal activity (e.g., impact-related or involving meteoric water in a subaerial setting) are not supported. Instead, we propose a model where TTG melts formed through underplating and injection of (basaltic or) picritic melts, followed by hybridization with residual mid-(proto?) continental crust in an intraplate setting. Near-contemporaneous formation of incoming melts and pre-existing crust is implied by the near-chondritic zircon Hf isotope compositions.