Diverse crust-forming mechanisms on early Earth from the Hadean–Eoarchean (4.0– 3.6 Ga) zircon record of the Tanzanian Craton

Author links open overlay panelFrancisco
E. Apen [a b], Blair Schoene [b], Yusto Joseph [c], Ronald J. Massawe [c], John M. Cottle [d],
Michael R. Ackerson [e] https://doi.org/10.1016/j.epsl.2026.119923

Abstract

Integrated U-Pb geochronology, trace element, and Hf isotope geochemistry of detrital zircon from Eoarchean–Paleoarchean quartzites from the central Tanzanian Craton document derivation from Eoarchean and Hadean crust. Concordant U–Pb ages predominantly range from 3900 to 3600 Ma, with prominent age populations at 3900 Ma, 3770 Ma, and 3700 Ma; two samples also contain rare ca. 4050 Ma grains. Ti-inzircon thermometry yields apparent crystallization temperatures between 580 °C and 840 °C (assuming SiO_2 and TiO_2 activities of unity), consistent with magmatic temperatures from the granitic water-saturated solidus up to temperatures experienced by intermediatecomposition magmas. Trace element systematics (U-Yb-Y-Hf-Nb) show similarities to zircon from continental arc-ocean island settings but show some marked differences from other known similar age zircon localities (e.g., Jack Hills and Acasta Gneiss Complex). Zircon Hf isotopic compositions are dominated by chondritic sources over the 400 Myr span of magmatism sampled by the Tanzanian quartzites, contrasting with the more unradiogenic Hf signatures from other cratons of this age. A panoptic view of elemental and isotopic signatures recorded across different Hadean–Eoarchean zircon records provides support for diverse crust-forming processes on early Earth.

Origin and age of the polymetallic (AuCuPb) mineralisation in the Mesoproterozoic Mpanda Mineral Field of the Paleoproterozoic Ubendian Belt, SW Tanzania

Author links open overlay panelEmmanuel O. Kazimoto [a], Mary C. Moshi [a], Obeid S. Lemna [a], Remigius L. Gama [a], Octavian Minja [b], Yusto Joseph [b], Miriam Christina Reiss [c], Volker Schenk [d] https://doi.org/10.1016/j.jafrearsci.2026.106136

Abstract

Our geochemical-mineralogical study decodes the genesis of the polymetallic (Au-Cu-Pb) vein deposits in the Mesoproterozoic Mpanda Mineral Field (MMF), which is hosted in the Archean to Paleoproterozoic Katuma Block of the Ubendian Belt in Tanzania. The host rocks of the ore veins have been pervasively altered by hydrothermal fluids resulting in greenschist-facies alteration halos, reaching several tens of metres into the granulitefacies country rocks. Fresh vein rocks display open-space filling textures including subhedral minerals, vugs and encrustations and are composed of coarse-grained quartz, K-feldspar, siderite, barite, galena, pyrite and chalcopyrite. Gold occurs in contact with pyrite and chalcopyrite, whereas chalcopyrite and galena is associated with secondary aikinite, wittichenite and emplectite. Secondary covellite and digenite replace chalcopyrite. Secondary hematite, quartz, azurite, malachite and copper silicate minerals represent weathering products. Lead isotope compositions of primary vein sulphides are thorogenic, pointing to an upper crustal source for the ore-forming fluids. In vein siderite, $\delta^{13}C$ values range from −7.5 to −6.5 ‰ V-PDB and $\delta^{18}O$ values from 7.3 to 9.5 ‰ V-SMOW, in agreement with metamorphic or magmatic rocks as sources for the ore-forming fluids. Isotopic fractionation between siderite and quartz of the veins points to high temperature hydrothermal conditions of 390 to 500 °C, in agreement with the greenschist-facies minerals formed in the alteration haloes of the veins. The hydrothermal alteration in the halos adjoining the ore veins has been dated directly with hydrothermally recrystallised monazite grains at ca. 1170 Ma. Petrological studies in the Wakole Block, which adjoins the Katuma Block with its MMF to the West, identified a high-grade Kibaran metamorphic event at ca. 1170 Ma that was induced by orogenic crustal thickening and occurred

coeval with the hydrothermal alteration near the veins. Thus, we propose that during the Kibaran orogeny metamorphic dehydration occurred in a subducting metasedimentary Wakole wedge beneath the Katuma Block. The liberated fluids ascended through this overlying block, where the polymetallic veins of the MMF precipitated, mainly along NNW–SSE and E–W striking and NE-dipping Paleoproterozoic fault zones, which became reactivated at ca. 1170 Ma during the Mesoproterozoic Kibaran orogeny.