Palaeoproterozoic eclogite formation in Tanzania: a structural, geochronological, thermochronological and metamorphic study of the Usagaran and Ubende orogenic belts.

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Abstract

Eclogites and other high-P low-T rocks have been used to understand changing tectonic regimes and the processes which have shaped the Earth. Uncertainty exists over the tectonic setting of Palaeoproterozoic high-pressure rock formation with several workers proposing that deep subduction, the most commonly inferred method for modern high-pressure metamorphism, was not functioning at the time these rocks formed. Tanzania hosts two of the oldest *in-situ* eclogites in the 2.0 Ga Usagaran and 1.85 Ga Ubendian orogenic belts, with km-scale eclogite & retrograde-eclogite sheets in these locations interlayered with felsic gneisses and amphibolites. These orogenic belts form the south-eastern and south-western margins of the Tanzanian Craton. Based on detrital zircon study on stream sediments the Tanzanian Craton formed between 2850 – 2500 Ga with magmas derived from an evolved (T_{DM} crustal = 3.2 Ga) source.

Lu-Hf studies on metasedimentary rocks show the Ubende and Usagaran Belt's crustal material formed between 1850 – 2050 Ma from a more evolved magma source (T_{DM} crustal = 2.6 Ga) that also reworked some Archaean material from the Tanzanian Craton. The Ubende and Usagaran belts have similar but not identical crustal evolution histories through the Archaean and Palaeoproterozoic, but the Mesoproterozoic evolution of the Ubende diverges from the Usagaran. The Songea district, situated at the junction of these orogenic belts, has a separate crustal evolution and does not form the link between the two orogens. The youngest zircon population (1.0 – 1.2 Ga) may be derived from the Irumide Belt, and has a mixed (T_{DM} crustal = 2.1 and 1.3 Ga) magma source. Thus the belts, sometimes referred to as a continuous orogenic system, are in fact distinguishable by their crustal evolution and the timing of sedimentation and metamorphism.

Ubendian eclogites have been dated using $^{40}Ar/^{39}Ar$ at 1848±6 Ma (Boven et al., 1999). $^{40}Ar/^{39}Ar$ thermochronology on a suite of five samples coupled with U-Pb geochronology yields a new metamorphic age for the Ubende Belt. An age of ~1070 Ma is preserved in zircon within metasedimentary rocks with cooling below ~500 °C at ~1020 Ma.

Structures in the Usagaran Belt are consistent with sinistral transpression associated with collision between the Tanzanian craton and an unknown continent. The metasedimentary rocks of the eastern Usagaran rocks are inconsistent with being derived from the Tanzanian Craton, indicating the existence of an as yet unidentified continental block as part of the collisional event. Rocks from the western Usagaran are more consistent with being derived from the craton, with some input of sediment derived from local igneous activity, possibly a volcanic arc.

Two metamorphic events were recognised in the Usagaran belt. Usagaran metamorphism occurred over ~20 My between 2007 and 1991 Ma. The East African orogen affected these rocks during the Neoproterozoic, and is recorded in zircon growth in the east of the orogen at 577 ± 17 Ma. Peak eclogite–facies P-T conditions in the Usagaran Orogeny (17.2 ± 3.6 kbar, 839 ± 173 ºC) were slightly higher temperature than previously published. Lithologies intercalated with eclogite in the eclogite body experienced conditions of at least 13.4 ± 2 kbar, 920 ± 130 ºC, however there is no evidence of pelitic rocks having experienced the 17 kbar which the eclogites saw. Fe-Mg diffusion modeling on garnet-biotite shows that country-rock pelites cooled at ~1-2 °C/My, compared to 25ºC/My for eclogites between 1999 and 1991 Ma.

All of these facts are consistent with the eclogite body having formed during subduction of Palaeoproterozoic sea-floor which became intercalated with metasediments and other metaigneous rocks during exhumation. The surrounding blocks of the Isimani suite did not experience eclogite-facies metamorphism but were tectonically juxtaposed during exhumation. All this strongly supports a Palaeoproterozoic subduction-related origin for eclogites in the Usagaran Belt.

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