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Generating HIMU-like domains through the metasomatic enrichment of continental lithospheric mantle (East African Rift System)

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Magma generation during continental rift development requires a contribution from sources that are not located within the ambient asthenosphere. Elevated mantle potential temperature and unusual isotopic signatures have typically pointed to contributions from upwelling mantle plumes. However, the isotopic diversity of rift magmas suggests that the continental lithospheric mantle must also play a role in magma generation processes. The Turkana Depression, located within the East African Rift System, has an extensive temporal record of mafic rift magmatism. Lavas from this region exhibit a wide diversity of compositions but can broadly be divided into samples that exhibit the influence of a “C”-like mantle plume (Afar Plume) and samples that exhibit the influence of a HIMU-like end member. Prior work suggests that such compositions reflect either two mantle plumes or a single, zoned mantle plume. Here we propose an alternative hypothesis whereby the HIMU-like end member is generated in situ through radioactive ingrowth within the continental lithospheric mantle. We investigate the potential for lithospheric mantle metasomes to evolve HIMU-like isotopic ratios by utilizing a two-stage chromatographic metasomatism model. This model simulates the formation and melting of metasomatic cumulates within the Turkana lithosphere during two critical stages of lithosphere modification: the Pan-African Orogeny (~700 Ma) and Mesozoic Central African Rift (~145 Ma). The first model stage utilizes representative island arc basalt compositions for the metasomatizing agent to generate metasomes during Pan-African stabilization of the lithosphere at 700 Ma. The second model stage, during Mesozoic rifting (~145 Ma), simulates destabilization and melting of the stage-one metasomes and re-enriches the lithosphere to generate new metasomes. When these Mesozoic metasomes are melted and mixed with melts from Turkana convecting upper mantle, their trace element and isotopic characteristics are consistent with the observed Turkana lavas that are characterized by the influence of a HIMU-like end member. Our findings suggest that the HIMU-like signature found in lavas throughout East Africa reflect the influence of continental lithospheric mantle and not necessarily a complex mantle plume.