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Tracking the Onset of Plume Volcanism in the Southern East African Rift

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The extent to which magma is required to facilitate rifting of cold, strong continental lithosphere is a matter of ongoing debate. In the southern portion of the East African Rift (EAR) the surficial scarcity of magmatism suggests that it might not be a prerequisite to early stages of continental rifting. Our research on the magmatism of Rungwe Volcanic Province is motivated by the goals of SEGMENT, a multidisciplinary research project studying the roles of tectonic segmentation and magmatism in the early stages of continental rifting. We have carried out chemical and Sr-Nd-Hf-Pb isotope analyses of primary magmas from Rungwe to establish source characteristics, timing, and evaluate processes that contribute to melting and melt extraction, on the lone volcanic province in the southern EAR.

At least two chemically and isotopically distinct sources contribute to the mafic alkaline melts at Rungwe, with eruptions that span ~20Ma to recent in age based on Ar-Ar dating. Source one influences the majority of melt events throughout the full span of time and produces melt with an isotopic affinity to bulk earth ratios in Sr-Nd-Hf, and EMI Pb-isotopes, termed component "V" [1]. Trace element patterns of these samples are sub-parallel, suggesting varied melt fractions of the same source. The second component is termed "high-He," since these units have a primordial $^{3}He/^{4}He$ ratio of 12-15 R/R_a [2]. The high-He component contains less radiogenic Nd-Hf, more radiogenic Sr, and Pb outside the range of most OIB. The two high-He units are among the youngest events based on preliminary Ar-Ar results. Compared to component V, the high field strength elements are more depleted with respect to similarly incompatible elements in the high-He melts.

A new melt thermobarometry model yields potential temperatures near ambient mantle and depths consistent with recent tomographic modelling [3]. The depth estimates suggest Rungwe melts are not of lithospheric origin as has been previously concluded [4]. Despite apparent lithospheric thinning of 15% due to extension and thermal erosion since ~9Ma [5], we find that recent melts originate from the deepest depths. Model temperatures are within the range of ambient mantle, none of our current data support elevated mantle temperatures in the southern EAR [6]. Rather than elevated temperatures, we conclude that these melts require compositionally fluxed melting that instead accomplishes melting by lowering the solidus temperature through the inclusion of volatiles.

Our chemical and isotopic data serve to better define the high-He component, and dating constrains its full emergence to two recent eruptions. The high-He melts originate deeper than all others inspected, supporting the claim in [2] of a deep seeded-plume. Component V melts appear to be influenced by carbonatite, but it is unclear if this difference implies a unique asthenospheric origin or a mixture of lithospheric components. Mesozoic carbonatites in the Rungwe region may signify a carbonated metasomatic overprint in the lithosphere. If Nb/Ta ratios and Hf-Pb isotope compositions like these carbonatites persist in the lithosphere, component V could be the product of interaction between the high-He component and lithosphere. We expect to deconvolve and quantify the degree of influence each of these components has on Rungwe melts through time with the completed dataset to present a model for melting during tectonic extension in the Southern EAR.

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