Superplume control of East Africa Rift volcanism: Helium isotope evidence from alkaline magmatism of Tanzania

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We present new helium isotope data on mafic crystals of lava/tephra samples from both Older and Younger Extrusives of Rungwe Volcanic Province (RVP) in southern Tanzania – the southernmost expression of Cenozoic volcanism along the East Africa Rift System (EARS). All samples are alkalic in composition and include alkali basalts, basanites, nephelinites and a picrite and trachy-basalt. We compare these samples with peridotite xenoliths from 5 localities on or close to the Archean craton in northern Tanzania.

Regarding the He results: (1) The highest measured ^{3}He/^{4}He ratios (~ 15 R_A) far exceed the canonical range of 8 ± 1 R_A, diagnostic of MORB-source mantle. Indeed, a total of 17 (out of 31) RVP samples have OL/CPX ^{3}He/^{4}He > MORB. High ^{3}He/^{4}He ratios are found in volcanoes of the Younger Extrusives (Ngozi, Rungwe and Kiejo) and in the Kiwira Series (Older Extrusives), and thus are widespread in time and space. (2) Remaining RVP samples fall within the range normally associated with MORB: this He component is sampled in all 6 Rungwe volcanic series. (3) All of the northern Tanzania peridotite xenoliths fall within or overlap the SCLM range (6.1 ± 0.9 R_A).

The range of ^{3}He/^{4}He ratios at RVP reveal a heterogeneous mantle source including a deep (plume) component. In contrast, the peridotite xenoliths sample shallow lithospheric mantle. We view the African Superplume – a huge low velocity anomaly originating near the core-mantle boundary – as the ultimate source of high ^{3}He/^{4}He. Alkaline volcanism at RVP samples this component implying the superplume is a continental-scale feature. It provides dynamic support for topographic swells throughout the EARS and heat/mass to drive continuing magmatism.

Erosion in the Arctic: Enhanced carbon sequestration associated with high latitude warmth?

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Soils at high latitudes contain ~40% of the total carbon stock in organic matter on land (~500x10^{15} gC). This region experienced large climatic fluctuations over glacial-interglacial cycles and throughout the Cenozoic, while is extremely sensitive to changes in climate predicted over the coming century. If these changes force transfer of this C back to the atmosphere, or transfer to lithospheric storage, they may induce feedbacks in the Earth System. Here we question whether erosion of this soil organic matter results in a significant transfer of particulate organic carbon (POC) by Arctic Rivers to the ocean. We have sampled the Mackenzie River, Canada, and its major tributaries shortly after freshet (ice break up floods) in June 2009, using a depth-sample approach to collect the full range of erosion products in river suspended and bed sediment. The ^{14}C-content (fraction modern, F_{mod}) and the stable carbon isotopes ($\delta^{13}C_{org}$, ‰) provide the first systematic assessment of POC source in this river. They demonstrate mixing of ^{14}C-enriched (F_{mod}>0.84) and depleted (F_{mod}<0.10) POC, consistent with input of fossil POC from bedrock and modern POC from vegetation and soils. However, $\delta^{13}C_{org}$ requires a third component with a ^{14}C-age of ~12ka (F_{mod}~0.22). This is consistent with soils formed following the retreat of ice after the Last Glacial Maximum. We estimate that the Mackenzie River is likely to have exported ~15-20x10^{15} gC of post-LGM soils to the Arctic Ocean as POC during the Holocene. This is a result of the prevailing climate, promoting high soil carbon stocks and very high erosion rates during the freshet. We propose that the erosion and transfer of soil-derived POC to the ocean by Arctic Rivers may sequester CO_2 while high-latitudes are ice-free, providing a negative feedback to climate over glacial-interglacial cycles.