Magma generation in the Main Ethiopian Rift (MER) and Afar

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Magmatic activity in the Ethiopian volcanic province has been attributed to the activity of a mantle plume located beneath the Afar triangle ~30 Ma years ago, when large volumes of flood basalts erupted in this area. The current location of the plume and its relationship with the recent volcanism in the MER and Afar is a subject of debate.

In the present study we assess the geochemical characteristics of basaltic lavas from seven volcanic centres within the rift-valley (Ayelu, Hertali, Dofan, Fantale, Kone, Bosetti and Gedemsa from NE to SW) in order to locate the present position of the plume and to constrain source characteristics, melting depths and magma generation processes.

Trace element patterns indicate the presence of amphibole during the genesis of all samples. According to the pressure stability of amphibole this translates to a melt generation or reequilibration depth of 80 km maximum. The minimal melting depth is constrained by the crustal thickness, which decreases from 38 km in the MER to 24 km in Afar.

La/Yb ratios decline with increasing latitude of the sampling location. Low La/Yb ratios in Afar can be explained by higher degrees of melting, i.e. a reduced melt generation depth, which corresponds to the observed thin crust, whereas higher La/Yb values measured in the MER basalts result from higher melting depths and mirror the increased crustal thickness.

Basalts from Afar and the Afar-MER transition zone display εNd values above +4.8 and $^{87}Sr/^{86}Sr$ ratios between 0.70354 and 0.70383. Samples from the MER plot below εNd +4.8, their $^{87}Sr/^{86}Sr$ values range from 0.70384 to 0.70430. Assuming a plume related origin, two enriched mantle end-members similar to EM I and EM II can be identified in the MER samples, constraining the present location of the plume. Low $^{206}Pb/^{204}Pb$ ratios (19.317 to 18.484) support this finding and rule out the involvement of a HIMU component. In Afar, an additional MORB-like component is present.

To summarize, the sampled quaternary basaltic lavas were derived from a heterogenous EM-like plume-source and subsequently modified by reequilibration within the lithospheric mantle beneath the Ethiopian rift. Incipient sea-floor spreading can be inferred from a MORB component in Afar. The MER lavas however are most probably the surface expression of ongoing mantle plume activity.

Reproducibility of apatite fission-track length inversion modeling

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Although apatite fission-track length data have long been used to derive thermal history information, there are no agreed-upon conventions for calibration of length measurements. In an effort to document variability among analysts and determine what features a length calibration protocol should include, an experiment was conducted in which eleven analysts measured approximately fifty track lengths on one or both of two grain mounts, one with unannealed induced tracks in F-apatite and another with a single large-etch-figure population featuring a breoad distribution of spontaneous track lengths. Variation in the measured length distributions among analysts was considerably in excess of statistical expectation, probably reflecting differences in microscope technique.

Two thermal history scenarios were tested with inversion modeling: cooling-only, and a reheating history indicated by other data from the field area. When cooling-only inversions assumed a standard literature value for initial track length, results varied markedly. However, when track lengths were normalized using each analyst's unannealed mount measurement, histories became much more consistent, although differences remained in the amount of time spent at high temperatuers (~100°C), due in part to differential sampling of long- and short-length populations. Accounting for track angle using *c*-axis projection further enhanced congruence for various thermal history features, such as the onset time of fast cooling. The second scenario was primarily evaluated in terms of the predicted peak reheating temperature. Under both initial-length assumptions, predictions showed considerable variation when lengths were used without accounting for track angle, but again inversions that utilized c-axis projection were much more congruent.

Taken in sum, these results indicate that fission-track length calibration should account not only for absolute length measurement but also the relative tendencies among analysts for measuring different length populations. However, even with the minimal length calibration steps of measuring an unannealed induced population and accounting for initial length variation as a function of etch figure diameter, reproducibility of many thermal history features was good, and improved when track angle data were utilized as well.