Cenozoic Magmatism and Dynamic Topography of Libya and Tibesti

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Dynamic topography is the surface expression of sub-lithospheric convective circulation. It is generally agreed that hot upwelling mantle produces dynamic uplift whilst cold downwelling mantle causes regional subsidence. Intraplate magmatism is often regarded as an important manifestation of convective upwelling. However, the relative importance of temperature and source composition remain controversial. One way of tackling this problem is to combine geochemical and geophysical observations. The Cenozoic Libyan and Tibesti volcanic fields have been active from ~17 Ma until the present-day and are characterized by long wavelength topographic swells. Admittance analysis of gravity and topography, together with surface wave tomographic imaging, suggest that a low density and slow shear wave velocity anomaly lies beneath the lithosphere. To investigate the relationship between these geophysical observations and basaltic geochemistry, we have assembled a database of 224 XRF and ICP-MS analyses. Inverse modeling of rare earth element distributions shows that Libyan basalts were generated by melting of a predominantly anhydrous mixed peridotitic mantle source with a potential temperature of ~1400 ºC. In contrast basalts compositions from Tibesti can be inverted with a lower potential temperature of ~1350 ºC. These combined results suggest that the existence and distribution of volcanism are caused by upwelling of warm asthenospheric mantle beneath thin (< 100 km) lithosphere. The Tibesti volcanic field is usually invoked as a hotspot location since it caps a substantial domal swell and consists of large composite volcanoes. However, our results show that the highest potential temperatures and largest melt fractions are more consistent with a present-day plume swell centred beneath the Haruj volcanic field in central Libya. This interpretation is consistent with a range of geophysical observations.