African 30 Ma and younger volcanism and its relationship to the Plume Generation Zone

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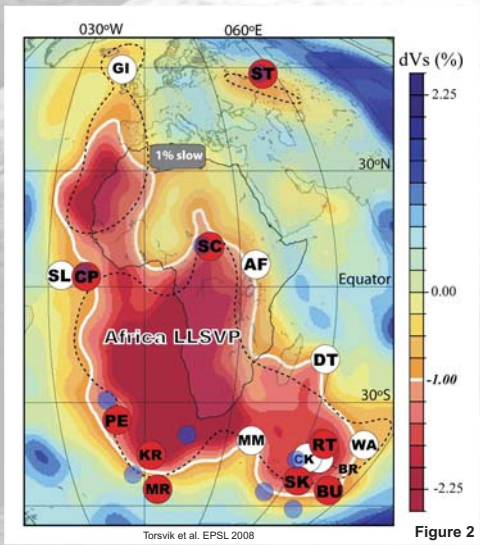
Introduction

African 30 Ma and younger volcanic activity has been most continuous on the spreading centers that almost surround the continent and abundant in numerous hotspot volcanoes on the ocean floor. Here we present a compilation of 30 Ma and younger hotspot activity for the African and Antarctic plates and propose this volcanic activity is directly linked to the Plume Generation Zone at the Core - Mantle boundary.

African basins and swells

Burke and Gunnell (2008) presented a compilation of African basins and swells that began to form at ca. 30 Ma. A modified version of this compilation is presented in Figure 1 and now includes also Point Libre and recent/active volcanism on the Antarctic plate (Prince Edward and Marion islands, Crozet islands, Heard and McDonald islands and Kerguelen). Hotspot volcanoes on the African continent are found mainly on the crests of swells. Some however are close to sea level, in areas where uplift has been balanced by denudation due to heavy rainfall. Several hotspots within and on the margins of the Sahara, one of the driest places on the planet, are also not on high ground. Wet conditions prevailed there however until 2.8 Ma, explaining their occurrence. None of the hotspots occur on cratonic crust.



Torsvik et al. EPSL 2008

Figure 2

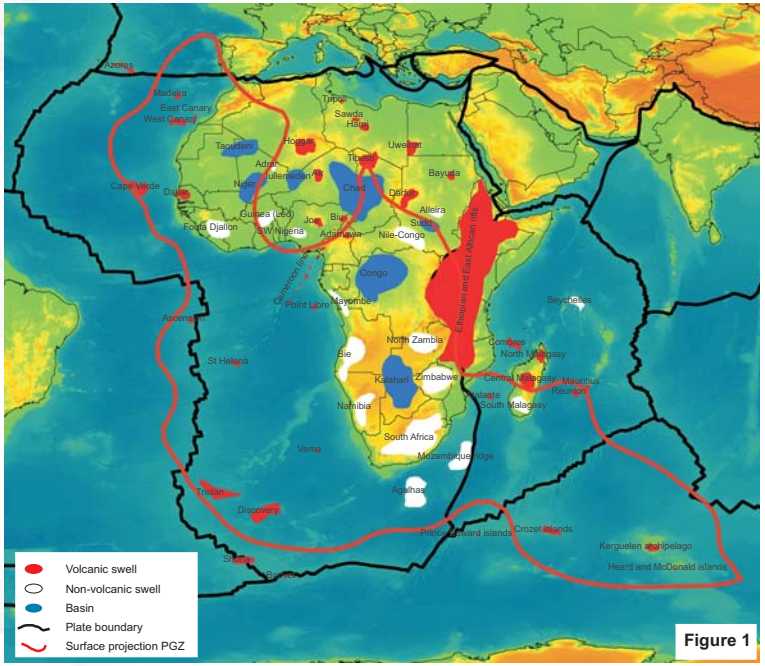


Figure 1

Plume Generation Zone (PGZ)

Torsvik et al.(2006) reported a clear correlation between downward projected Large Igneous Province eruption sites of the past 200 Myr and the margins of Large Low Shear wave Velocity Provinces at the base of the mantle. The persistence of the LLSVPs over 200 Myr is consistent with independent seismological evidence that they are compositionally distinct and not just thermal anomalies. This concept, now based on an improved reference frame (Torsvik et al. 2008), has recently been proven to be compatible with most reconstructed Large Igneous Provinces for the last 300 Myr (Figure 2).

Figure 3 displays the distance between the location of the volcanic swells and the projection of the 1% slow contour at the surface (red line in Fig. 1). The volcanic swells are distributed symmetrically around this contour, with approx. 90% of them less than 900 km away. We therefore conclude that African hotspot volcanoes of the last ~30 Ma as well as recent/active volcanic activity in the adjacent Antarctic plate are directly related to the Plume Generation Zone. Because movement of the African plate has been slow during the last 30 Ma there is no need to reconstruct the position of the swells, although this would probably help to reduce the spread in the histogram.

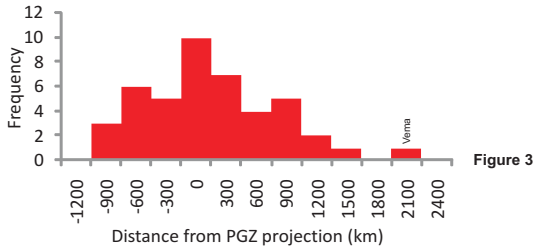


Figure 3

Plumes below a moving African plate

Plumes formed in the PGZ lay beneath the African lithosphere before the plate slowed down. Their tops were smeared out and they showed no surface display. When the plate slowed down they penetrated the lithosphere and were assimilated into the new plate-wide shallow mantle convection.

The Afar plume is distinctive. It appears to have found the newly forming Red Sea, Gulf of Aden and Ethiopian rifts by 'upside down drainage'.

The non-volcanic swells of the last ~30 Myr (Figure 4) lie almost exclusively within, or very close to the surface projection of the 1% slow contour and so do the sedimentary basins of the last 30 Myr. The only exception to this rule are the Seychelles (see also poster by M.Ganerød et al. In this session).

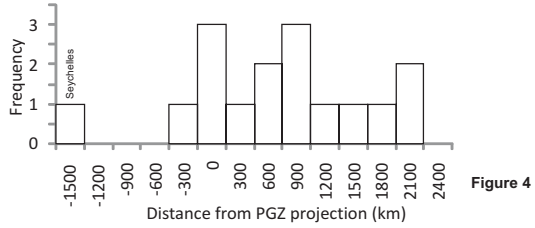


Figure 4

Summary

The correlation observed between hotspot volcanism at the surface and the position of the PGZ at depth strongly suggests that African volcanism of the last 30 Myr is triggered at mantle depths, by a common mechanism. How this mechanism works is however still a fundamental, open question.

References

Torsvik, Smethurst, Burke and Steinberger, 2006. Large igneous provinces generated from the margins of the large low-velocity provinces in the deep mantle. GJI, V167, pp. 1447 - 1460.

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Burke and Gunnell, 2008. The African Erosion Surface: A Continental-Scale synthesis of Geomorphology, Tectonics, and Environmental Change over the past 180 million years. Geological Society of America Memoir 201.