Geophysical Research Abstracts, Vol. 7, 08262, 2005
SRef-ID: 1607-7962/gra/EGU05-A-08262

Magmatic processes beneath Lucky Strike segment, Azores region, 37ºN on Mid-Atlantic Ridge

P. Ferreira (1), B. Murton (2) and C. Boulter (2)

(1) INETI, Alfragide, Portugal, (2) Southampton Oceanography Centre, Southampton, UK (pedro.ferreira@ineti.pt / Fax: +351 21 471 89 41 / Phone: +351 21 470 54 37)

Introduction

It is well known that mid-ocean ridge basalts (MORB) are dominated by incompatible-element depleted normal tholeiite (N-MORB). However, the identification of less depleted, and even incompatible-element enriched basalts (E-MORB), resembling those from ocean islands, is becoming more frequent with the increased number of mid-ocean ridge segments sampled. These observations suggest that the upper mantle beneath ocean ridges is heterogeneous. However, the origin, size, and history of the enriched heterogeneities in the dominantly N-MORB mantle generally remain enigmatic, but along the northern Mid-Atlantic Ridge, such enrichment can be ascribed to mantle plume influence. The Lucky Strike segment is the third segment south of the Azores platform and the geochemical composition of the lavas must clearly show such enrichment characteristics due to the proximity of the Azores mantle hot spot.

While most Mid-ocean ridges erupt basalts from a common source, at least at local scale, and this eruption is of low vesicularity, some large central volcanoes on the Mid-Atlantic Ridge have a history of explosive eruption and very heterogeneous lavas. A type example of this sort of volcano is the Lucky Strike segment located at 37.17ºN. The dramatic increase in vesicularity of the lavas over a relatively small water-depth change, and the large variation in composition, begs the question of what causes such changes? Are they the result of mantle heterogeneity, metassomatism, or assimilation processes related to melting of hydrothermally altered crust at shallow levels in the volcano?

Results

New major and trace element, and Nd-Sr isotopic, data on samples from the Lucky Strike segment are presented. All samples studied are enriched mid-ocean ridge basalts (E-MORB), but different degrees of enrichment are identified. Considering the relationship among various incompatible trace elements, Lucky Strike basalts have been subdivided into three distinct compositional groups: In Group 1, the lavas have the highest La/Sm, La/Yb, Nb/Zr, Nb/Y, Zr/Y, K_2O/P_2O_5, K_2O/TiO_2, $^{87}Sr/^{86}Sr$ and the lowest $^{143}Nd/^{144}Nd$ ratios, are spatially restricted to the central part of the axial volcano, are highly vesicular, and are plagioclase phyric. These lavas have a degree of enrichment between those of E-MORB and OIB. Group 3 lavas have the smallest La/Sm, La/Yb, Nb/Zr, Nb/Y, Zr/Y, K_2O/P_2O_5, K_2O/TiO_2, $^{87}Sr/^{86}Sr$ and the highest $^{143}Nd/^{144}Nd$ ratios, were collected throughout the Lucky Strike segment (from 37º12,0' to 37º27,3' in latitude), are almost aphyric to plagioclase microphyric, and present REE and multi-element patterns typical of E-MORB. Group 2 lavas have chemical characteristics intermediate between those of groups 1 and 3 in terms of trace and isotope compositions, producing continuous, and regular trends in different element ratios that link the lavas from the previous two groups. Thus, these lavas have the maximum dispersion in the different element or element ratios, and present an enrichment degree between those of group 1 and 3 lavas.

Discussion

Extensive low-pressure crystal fractionation (olivine + clinopyroxene + plagioclase), reaching a maximum of 50%, is the main differentiation process controlling the chemical evolution among the magmas precursors of lavas from group 3. Also extensive, accumulation processes, essentially involving plagioclase and clinopyroxene, have exerted the main control on the major and compatible trace element concentrations in the magmatic precursors of group 1 basalts. Incompatible trace element abundances in these group 1 basalt progenitors were little influenced by accumulation. Modelling based on incompatible trace element ratios, together with the Sr and Nd isotopic data, exclude the possibility of different degrees of partial melting, from an homogeneous mantle, as the explanation for the existence of different chemical signatures in the basalts from groups 1 and 3. This suggests derivation of these two magma types from distinct enriched parental magmas. Good fits of calculated mixing lines to the chemical data, demonstrate that mixing is probably an important process for the Lucky Strike tholeiites, involving an N-MORB type source end-member and an enriched one, similar to that assumed to generate the group 1 basalts.

Variable extents of melting of a heterogeneous mantle, having small and dispersed non-uniform domains of an highly enriched component in the ambient, already enriched, mantle source can be invoked to explain the geochemical variability among the Lucky Strike segment lavas. Melting itself is an efficient mixing process if the mantle in the melting region is heterogeneous and if the size of the enriched domains is small and their distribution is not uniform (Niu, 1996).

References:

Niu, Y., Waggoner, D. G., Sinton, J. M. & Mahoney, J. J. (1996). Mantle source heterogeneity and melting processes beneath seafloor spreading centers: the East Pacific Rise, 18˚–19˚S. *Journal of Geophysical Research* **101**, 27711–27733.

Acknowledgements: This work was supported by a PhD Scholarship (SFRH / BD / 7231 / 2001) awarded by the Portuguese Foundation for Science and Technology (FCT) to P. Ferreira.