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Melt supply and magmatic evolution at a large central MOR volcano located in the Lucky Strike Segment

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New major and trace element, volatile (H_2O and CO_2) and Sr-Nd-Pb isotopic, data on samples from the Lucky Strike segment are presented. All studied samples are enriched mid-ocean ridge basalts (E-MORB), but different degrees of enrichment are identified. Based on the relationship among several incompatible element and isotopic ratios, Lucky Strike basalts have been subdivided into three distinct compositional groups: In Group 1, the basalts have the highest more-to-less incompatible element ratios (e.g. La/Sm, Nb/Zr, Ba/Y) and have the most Sr-Nd-Pb radiogenic values. They are spatially restricted to the central part of the axial volcano, are highly vesicular, and plagioclase phyric. These basalts have a degree of enrichment between those of E-MORB and OIB. Group 3 basalts have the lowest more-to-less incompatible element ratios and the lowest Sr-Nd-Pb radiogenic values. In spite of this, the basalts present REE and multi-element patterns typical of E-MORB. They were collected throughout the Lucky Strike segment (from 37º12,0' to 37º27,3' in latitude), are almost aphyric and exhibit low vesicularity. Group 2 basalts have chemical characteristics intermediate between those of Groups 1 and 3. This subdivision is readily recognized in the volatiles data. Group 1 glasses have higher dissolved H_2O concentrations (and estimated pre-eruptive CO_2 concentrations), relative to those of Group 3, but have lower H_2O/Ce ratios (108-197 and 251-343 for Groups 1 and 3, respectively) that are well below the average defined for this MAR region (253$\pm$33).

Extensive low-pressure crystal fractionation is the main differentiation process controlling the chemical evolution among the magma precursors of lavas from Group 3. Also, extensive accumulation processes, essentially involving plagioclase and clinopyroxene, determined the major, and compatible trace element, concentrations in the magmatic precursors of Group 1 basalts. Good fits of calculated mixing lines to the chemical data, demonstrate that mixing, between Group 1 and 3 magmas, was probably an important process for generating Group 2 Lucky Strike tholeiites. The interpretation of the obtained chemical data (namely the distinct isotopic signatures) suggests that magmas from Group 1 and 3 were generated from distinct mantle sources.

Taking into account the sample spatial distribution, the basalt textural characteristics, the bathymetric (shallow depths at segment centre), and the gravity data (negative "bull's eyes" RMBA anomalies at segment midpoint), together with the geochemical data interpretation, a genetic volcanic model is generated. The enriched, more fertile, mantle heterogeneities (Group 1), related to Azores mantle plume material, in the Lucky Strike sub-oceanic mantle, are delivered to the centre of the segment by highly focused, sub-lithospheric processes. Forming wetter domains, they start to melt first, deeper in the mantle (in the garnet stability field), melting more, but generating lower melt fractions, than the ambient mantle (Group 3). Group 1 vesiculating melts, having their density reduced, will be aggregated in a high-level axial magma chamber (AMC). The limit of neutral buoyancy of these magmas is never reached, thus the magmas are delivered vertically to the segment centre. Further magmas, formed from melting of the ambient mantle, will be aggregated in the AMC, which is predicted to be of RTF type. Thus, initial mixing of Group 1 and 3 melts and, lastly, only differentiation of Group 3 melts will produce Group 2 and 3 basalts, respectively. The disruption of pressure equilibrium of the magmatic system as a result of the ridge extensional stress regime, and the subsequent magnitude of internal overpressure in the magma reservoir will control the magma delivery along the Lucky Strike segment.