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U Series Isotopic Variability in Galapagos Lavas, Evidence of a Mildly Buoyant Plume

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Evaluation of trace element composition and Sr, Nd and Pb isotopes of Galapagos lavas indicates that magma mixing between plume and asthenospheric melts has been the main process responsible for the geochemical variation observed in the archipelago[1, 2, 3]. The correlation between isotopes and trace element ratios (such as Nb/La, Nb/Zr, Ba/La, K/Rb and Ba/Ce) indicates that magma mixing controls most of the trace element variations in the basalts. The extent of melting represented by the extreme components of the mixing seems to be inversely proportional to the fertility of the sources. The correlation between He isotopes and Ti/Ti*, K/Rb and Nb/La ratios suggests that the mantle plume has positive anomalies of Nb and Ti and negative anomalies of K. The decrease of these anomalies toward the eastern islands where the trace element pattern are flatter and the isotopic ratios become more depleted, indicates that the increase in the proportion of a MORB component in the mixture tend to erase these anomalies. In contrast, positive anomalies of Sr and negative anomalies of Th and U are higher in lavas from the eastern islands. The origin of the Nb, Ti, Sr, K, Th and U anomalies in the Galapagos lavas is still a matter of debate. The high (^{230}Th/^{238}U) disequilibrium found in Galapagos (ranging from 1.04 to 1.26 for tholeiites and from 1.15 to 1.475 for alkalic lavas), indicates that the Galapagos basalts originated completely or partially in the garnet stability field. The positive correlation between (^{230}Th/^{232}Th) and (^{238}U/^{232}Th), with ^{230}Th excesses decreasing toward higher (^{230}Th/^{232}Th) ratios, can be accounted for by mixing of magmas generated by low extents of melting from a fertile source with magmas produced by relatively large extents of melting from a depleted source. The correlations between (^{230}Th/^{232}Th) and Sr, Nd and Pb isotopes confirm that the Th isotopic ratios are mainly source-controlled and are the result of magma mixing between the plume and asthenospheric melts. This mixing model illustrates that the mixture carries a garnet signature in the most incompatible elements (such as U, Th) even though the variation of the MREE to HREE does not reveal any indication of melting in the garnet stability field. Dynamic melting[4] and equilibrium porous flow[5] models constrain mantle upwelling velocities for the Galapagos plume (Fernandina) to ~ 7 cm/y and maximum porosities of 1.3%, indicating that the Galapagos plume is mildly buoyant; result that is consistent with a 3D numerical model of the Galapagos plume-Galapagos Spreading Center interaction[6]. Evidence for very slow mantle upwelling and low porosity for Pinta (1 to 2 cm/y and 0.5%) and Floreana (0.5 to 1 cm/y and 0.2%) supports the hypothesis that the lateral transport of the plume across the 90^{o} 50$'$ transform fault produced additional slow upwelling and further small extent of melting.

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