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Petrogenesis and mantle source of lavas from La Palma (Canary Islands): implications for plume-lithosphere interaction and apatite assimilation

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Subaerial volcanic activity at La Palma (Canary Islands) was confined to three volcanoes: (1) the extinct Taburiente shield volcano (>1.7 - 0.4 Ma), (2) the extinct Bejenado volcano (0.56 - 0.49 Ma) and (3) the presently active Cumbre Vieja rift zone (125 ka to present). We carried out major and trace element analyses of La Palma mafic lavas in order to reconstruct systematic temporal and spatial geochemical variations in magma composition during the evolution of the island and to place constraints on the mantle source beneath La Palma. Cumbre Vieja rocks are systematically more enriched in incompatible trace elements (P, Th, U, Nb, Sr, LREE) and show larger La/Yb (27.1 - 49.1) and Sm/Yb (4.6 - 7.3) ratios than the older Taburiente and Bejenado rocks (La/Yb = 19.1 - 37.2; Sm/Yb = 3.7 - 6.3). Remarkably, La/Yb and Sm/Yb ratios of CV lavas are also higher than those of most OIB wordwide. Slight concave-upward REE patterns, negative K anomalies as well as relative depletion in Rb and Ba on mantle-normalized diagrams of fractionation-corrected La Palma basalts require the presence of residual amphibole in their melting region. It is suggested that this amphibole is of metasomatic origin as a consequence of infiltrating melts, which were derived from rising plume material penetrating the lithosphere at its base during the early submarine stage of La Palma volcanism. Model calculations for the variation of trace element ratios as a function of source composition and degree of melting illustrate that the observed rare earth element ratios and the high contents of P, Sr, Th, U and LREE of Cumbre Vieja lavas cannot be derived by a single-stage melting process from amphibole-bearing garnet lherzolite, garnet pyroxenite, or a combination of both. The compositions rather require assimilation of 1 to 2% apatite by Cumbre Vieja melts during their ascent through the lithosphere. We propose that the apatite has been

metasomatically added to a lithosphere volume which did not influence the generation of Taburiente and Bejenado magmas. Our data indicate that there is no progressive geochemical evolution of La Palma magmas but a compositional break between Taburiente volcanism in the north and Cumbre Vieja volcanism in the south. This conclusion is also supported by significant differences of Nb/U ratios between Cumbre Vieja lavas (33.8 - 52.3) and those of Taburiente and Bejenado (49.7 - 87.6), the latter being clearly above the global OIB range (47 ś 10) probably due to amphibole assimilation. The combined data suggest that Cumbre Vieja and Taburiente/Bejenado represent distinct volcanic systems, rather than a progressively evolving volcano.