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Lava compositions of the 2021 La Palma eruption reflect magma recharge and mixing processes in the lithosphere

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The recent Cumbre Vieja eruption on La Palma from September 19 to December 13, 2021, was the first sub-aerial eruption in the Canary Islands for half a century. Approximately 0.2 km^3 of lava was erupted semi-continuously from a composite volcanic edifice on the northwestern flank of the Cumbre Vieja. Comprehensive sampling of lavas for the 85-day duration of the eruption reveals that they are olivine- and clinopyroxene-phyric alkali basalts that display temporal changes in their bulk rock and olivine major- and trace-element geochemistry. Initial lavas were low MgO (~6 wt.%), elevated TiO_2 (~4 wt.%) tephrites with progressively more mafic compositions erupted with time to approximately day 20 of the eruption, when compositions remained relatively constant as basanite (~8 wt.% MgO; 3.7 wt.% TiO_2) until eruption termination. Parental magmas calculated from olivine-bulk rock compositions had 8.2±0.8 wt.% MgO, were oxidized (fO_2 = +1.5 to +2 FMQ) and were derived from between 2.5 to 3% partial melting of the mantle source, potentially containing a contribution from a pyroxenitic component (X_{px} = 0.31±0.12). The temporal compositional changes in lava chemistry reflects initial eruption of reactivated, chemically fractionated magmas, followed by later eruption of deep-sourced, primitive magma.

Combined with seismic data, the lavas provide a high-resolution record of the progression of the eruption. Early magma was stored at upper-lithospheric depths (25 to 35 km) up to three years prior to the eruption, confirmed from pre-cursor seismicity and the presence of partially reacted amphibole and lithic fragments in early lavas. Later parental magmas, in contrast, were sourced from ephemeral upper mantle magma chambers at greater than 30 km depth. This magmatic progression is like that inferred from the 1949 and 1971 eruptions on the Cumbre Vieja from petrological constraints. These discrete events suggest that pre-cursor events involve early seismicity, underplating and fractionation of magmas at depth, followed by reactivation, eruption, and eventual exhaustion of partial melts. In this sense, ocean islands with limited basaltic magma supply show similar phenomena to larger silicic systems where initial magma emplacement and evolution is often followed by later magma recharge which triggers volcanic activity.