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Elevated CO_2 concentrations and volatile-trace element ratios suggest carbon-rich fluid flux melting under Lanzarote, Canary Islands

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The 1730-1736 CE Timanfaya eruption provides an opportunity to investigate magmatic volatile systematics in the context of mantle heterogeneity. Mafic magma, often nodule-bearing, evolved from basanite at the beginning of the eruption through alkali basalt to tholeiite at the end. Volatile concentrations were measured in olivine-hosted melt inclusions of the Timanfaya and the 1824 CE eruptions on Lanzarote. The inclusion glass exhibits remarkably high volatile concentrations, with up to 2 wt.% H_2O, 4600 ppm CO_2, 3900 ppm S, 1300 ppm Cl and 1800 ppm F. Ratios of volatiles to similarly incompatible non-volatile trace elements, such S/Dy, CO_2/Nb and H_2O/Ce, are highly variable and far from proposed values for the primitive mantle. The variable volatile to trace element ratios most likely reflect the combination of mantle heterogeneity, carbonated flux melting and differential degassing. Vapor bubbles are ubiquitous in Lanzarote melt inclusions, a few of which were imaged in 3D using Raman spectrometry. Multiphase inclusions contain silicate melt + solid carbonate + CO_2 fluid in the bubble, which was formed either during heterogeneous entrapment of a pre-existing CO_2 phase within the parental melt and/or from an immiscible carbonate liquid that unmixed within the melt inclusion during ascent and partially crystallized. As an example, a single inclusion reveals the presence of solid carbonates occupying more than half of the bubble volume. The restored primitive melt CO_2 concentration reaches weight percent levels when the contribution from all three phases is taken into account. The elevated CO_2 concentrations and the variability of volatile-trace element ratios strongly suggest carbon-rich fluid flux melting of a heterogeneous mantle source, giving rise to the exceptionally volatile-rich character of the primary magmas beneath the Canary Islands.