5.4.25

Geochemistry and U-series isotope systematics of the Cumbre Vieja rift zone, La Palma (Canary Islands)

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New major and trace element data, and Sr, Nd, Pb, U, Th and Ra isotopes of historic and prehistoric lavas from the Cumbre Vieja rift zone on La Palma are presented. The chemistry of the lavas is highly alkaline and forms a differentiation trend from primitive basanite (mg# 52-63), via tephrite to phonolite. Along rift-axis variation of Sr-Nd-Pb isotopic compositions is limited indicating that the melts are derived from a single, relatively homogeneous mantle source. (^{230}Th)/(^{238}U) disequilibria range in most samples from 1.07 to 1.33. Most historic eruptions have fairly similar (^{230}Th)/(^{232}Th) of 1.07-1.13, whereas the 1949 A.D. samples show major variation in this parameter, 0.96-1.27. We have looked in detail at the complex 1585 A.D. eruption. The similarity in (^{230}Th)/(^{232}Th) among the 1585 A.D. samples within analytical errors suggests that 1) the mafic and evolved melts could have formed within 15,000 years from a common parental melt, and 2) that the higher (^{238}U)/(^{232}Th) ratio (0.96-0.98) of the phonolites in comparison to the associated basanites (0.83-0.86) could reflect differentiation. Elevated (^{238}U)/(^{232}Th) similar to the 1585 A.D. phonolites has also been found in evolved, titanite-bearing phonotephrite of the Nambroque eruption. Interestingly two of the prehistoric basanites from the Cumbre Vieja rift have similar (^{238}U)/(^{232}Th) to the 1585 A.D. phonolites, possibly reflecting contamination with a Th-rich phase such as titanite. Alternatively the differences in (^{238}U)/(^{232}Th) between prehistoric and historic basanites may reflect fractionation of U from Th during partial melting. Historic eruptions in the Cumbre Vieja show extensive ^{226}Ra excess (38-66%) with the exception of 1949 A.D. samples, which show little or no excess at all. The lack of ^{226}Ra excess in 1949 A.D. samples could either be due to longer residence times in the crust prior to eruption, or diffusive reaction with plagioclase-rich cumulates. Although our results clearly show that the interpretation of U-series data even in historic eruptions is not straightforward, both the U-Th and Ra-Th disequilibria data from the 1585 A.D. eruption suggest that the phonolites could have formed from basanites within short differentiation times of <15,000 years to <500 years.

5.4.31

Fractional crystallisation of a mafic pluton and the composition of the parental melt: Microanalytical study of a gabbro-norite plug

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Studies of mafic and ultramafic cumulate rocks often revolve around the wish to obtain information on the composition of the melt(s) from which the cumulate rocks crystallised. Information of the trace-element composition of the parent melt is of particular interest and can be obtained by combining in situ analysis of major and trace elements in minerals with distribution coefficients to give a equilibrium melt composition.

Spot analysis techniques have been used to unravel the crystallisation processes in a coarsegrained olivine bearing gabbro-norite plug from Tertiary East Greenland. Whole-rock analyses of the gabbro-norite and its chilled margin are identical to within analytical error, yet the gabbro-norite is coarse-grained and has large, strongly zoned pyroxene, olivine and plagioclase crystals. Electron- and ion-microprobe and LA-ICPMS analyses of clinopyroxene crystals reveal a complex zonation pattern, which can be explained in terms of an initial period dominated by inperfect fractional crystallisation, which is followed by a period dominated by fractional crystallisation, which accounts for an additional ca. 40% solidification. This transition in crystallisation process correlates with the estimated solid/liquid ratio at the stage when the growing mineral grains form an interconnected network. Calculated melt compositions in equilibrium with clinopyroxene cores from the gabbro-norite are for most elements close to the composition of the chilled margin, thus lending credit to this approach in estimating the composition of melts parental to plutonic rocks.