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Phase relations in trachytes: implication for magma storage conditions in the Chaîne des Puys (French Massif Central)

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Trachytes from the Chaîne des Puys, French Massif Central, have been studied by performing phase equilibria in order to (i) constrain the storage conditions of the trachytic magmas that lead to explosive eruptions (either dome destructions as concentrated or diluted pyroclastic density currents or highly explosive events) and (ii) provide phase relationships and compositions for differentiated alkaline magmas.
Phase assemblage, proportion, and compositions have been determined on six trachytes (62-69 wt % SiO_2 and 10.5-12.0 wt % alkali) mostly coming from the actual domes dated from 9.2 to 15 Ka and aligned along a 10-km distance in the Chaîne des Puys. All samples contain ∼23-30 % of phenocrysts, mainly consisting of plagioclase (15-17 % and K-feldspars for the two SiO_2-richest samples), biotites (2-6 % except in the SiO_2-poorest sample, where it is absent), and Fe-Ti oxides (1-3 %). The three SiO_2-poorest samples also contain ∼2 % of amphibole and the SiO_2-richest one has 1 % of clinopyroxene. All samples have apatite and zircon as minor phases and sphene for the SiO_2-richest one. Glasses (melt inclusions and residual glasses) analysed in pumices resulting from highly explosive events, show trachytic to rhyolitic compositions (65-73 wt % SiO_2 and 10.5-13.0 wt % alkali). Analyses of melt inclusions (EMP by-difference method) and the biotite+K-feldspar+magnetite hygrobarometer both suggest pre-eruptive H_2O contents up to 7-8 wt %, which are so far the highest contents ever reported for alkaline liquids. The melt inclusions also contain ∼3400 ppm chlorine, ∼700 ppm fluorine, and ∼300 ppm sulphur (EMP analyses).
Phase equilibria of six representative trachytes have been performed between 200 and 400 MPa, 700-900°C, H_2O saturation, and oxygen fugacity from NNO-1 to NNO+1. The comparison between the natural and experimental products suggests magma storage conditions at pressures of 300-350 MPa, temperatures increasing from 700 to 825°C with decreasing bulk SiO_2 contents, oxygen fugacity from NNO to NNO+1, and melt H_2O contents close to saturation conditions (∼8 wt. %). The high H_2O contents of the trachytes show that wet conditions prevail during the differentiation of continental alkaline series.