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Experimental determination of phase relationships of a chemically-zoned peralkaline silicic reservoir: the example of Green Tuff eruption at Pantelleria (Italy)

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Phase equilibrium experiments are recognized as an excellent method to determine the pre-eruptive conditions of magmas inasmuch they are extremely sensitive to small variation in major elements composition in the studied rocks. Trachytes and peralkaline rhyolites (i.e pantellerite and comendite) usually represent the felsic end-member in continental rift systems and oceanic island settings. Pantelleria island, almost entirely made up of trachyte and pantellerite, is well known in the petrological literature as being the type locality of pantellerites. In this study we present the results of phase equilibrium experiments performed on representative peralkaline rhyolite (pantellerite) and metaluminous trachytes of the Green Tuff eruptions of Pantelleria, the sole known compositionally zoned ignimbrite at this volcanic location, which varies from a crystal-poor pantellerite at the base towards a crystal-rich trachyte at the top of the eruptive sequence. Crystallization experiments were performed in the temperature range 750-950°C, pressure 1-1.5 kbar, fluid saturation conditions with XH_2O ($=H_2O/H_2O+CO_2$) between 0 and 1 and redox conditions fixed around the FMQ (Fayalite-Magnetite- Quartz) buffer.
Results show that at 900 °C pantelleritic starting compositions are well above their liquidus, regardless their water content. At T < 800°C clinopyroxene is the liquidus phase followed by amphibole and alkali feldspar. Aenigmatite and quartz crystallize at 750°C and XH_2O lower than 0.8. In contrast, the trachytic composition at 800°C is highly crystallized regardless its water content. The liquidus phase is clinopyroxene crystallizing at 950°C and XH_2O<0.8 followed by iron-rich olivine and alkali feldspar. Iron-bearing minerals record the effect of both H_2O and fO_2, showing progressive iron enrichment when XH_2O decreases. Alkali feldspar becomes the most abundant mineral phase for XH_2O<0.8 at 900°C or XH_2O<1 at 850°C both at 1 and 1.5 kbar. Experiments reproduced the mineral assemblages of the natural rocks, i.e. the pre-eruptive conditions were constrained at P $\sim$ 1 kbar, and is found that the compositional zoning in magma chamber (pantellerite to trachyte) is related to a temperature gradient (750°C-900°) within the reservoir. Moreover, our results allow demonstrating that a peralkaline liquid derivate can be produced from a metaluminous trachyte at T< 850°C after extensive alkali feldspar crystallization ($\sim$ 80 wt%).