

Volatile and trace element partitioning for a peralkaline rhyolite volcano: Mayor Island, New Zealand

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Introduction and method

Mayor Island, New Zealand is a small isolated occurrence of a peralkaline rhyolite volcano 60km away from the calc-alkaline Taupo Volcanic Zone. During the volcano's 130,000 year sub-aerial history the erupted magma increases in peralkalinity, with the Agpaitic Index (AI) rising from ~ 1 in the very oldest lavas to ~ 1.25 in the most recent eruptions, straddling the compositional divide between comendite and pantellerite. In addition to this an $\sim 40\%$ enrichment of REE's and certain trace elements (e.g. Zr, Y, Nb) is observed. Phenocryst phases present include alkali feldspar, quartz, aenigmatite, Na-hedenbergite, aegerine and fayalitic olivine. With the slight exception of the feldspar which has a slight bimodality in Na/K ratio the major element compositions of these phases remains stable throughout the evolution of the magma.

Analysis of melt inclusions, matrix glass and phenocryst phases has allowed an estimation of (i) volatile element partitioning between melt and vapour and, (ii) non-volatile trace element partitioning between phenocrysts and melt. These data allow an assessment of the role that the phenocrysts have played in the evolving magma composition through fractional crystallisation and they give insight into the effect of degassing on magma chemistry. Trace elements were measured using the secondary ion mass spectrometer (ion microprobe) analysis and the volatile components of both inclusion and matrix glass utilised FTIR (H_2O), electron microprobe (Cl) and ion microprobe (H, F) techniques.

Results

Analyses of melt inclusions trapped in quartz phenocrysts show that the H_2O content of the magma has remained constant at 4–4.5wt% over the last 65,000Ka. In contrast to this the Cl content of the inclusions increases from ~ 2300 ppm to 3600ppm as the AI increases from 1 to 1.25. The partition coefficients for Cl between

matrix glass and inclusion are close to those found by Webster (1992) for a vapour saturated peralkaline melt. Fluorine contents remain relatively stable at about 2000ppm, with a vapour/melt partitioning coefficient of approximately 1 inferred from the inclusion/matrix glass data. Allowing for natural glass inhomogeneity and statistical counting error the partition coefficients between glass and inclusions for selected trace elements also remain at ~ 1 showing these elements to be incompatible in an excess volatile phase.

Of the phenocryst phases discussed only alkali feldspar, aenigmatite and Na-hedenbergite are present throughout the entire eruptive sequence. Ti, Rb, Sr, Zr, Ba and Eu were measured in the alkali feldspars with only Sr and Ba having a partition coefficient of greater than 1. F, Y, Zr, Nb, Ba, Ce, Eu were measured in the aenigmatite and sodium hedenbergite and were generally found to be incompatible other than Y and Ce (Na-hedenbergite) and Nb (aenigmatite) with values similar to those reported by Kovalenko *et al.* (1988).

Phenocrysts were sampled from the entire eruptive sequence and no significant difference was found in partition coefficients for aenigmatite and Na-hedenbergite despite a marked increase in the more abundant trace elements (e.g. Zr increase from ~ 1100 ppm to 1800ppm). The feldspars had a higher degree of variability in the measured elements (and also lower abundances of the measured trace elements leading to a larger counting error) but this can be attributed to the variation in Na/K ratio in the feldspar rather than the changing trace element abundances. This suggests that the increasing peralkalinity of the magma does not exert a direct control on the partition coefficients of these mineral phases.

References

- Kovalenko, V.I., Hervig, R.L. and Sheridan, M.F. (1988) *Amer. Mineral.*, **73**, 1038–45.
Webster, J.D., (1992) *Geochim. Cosmochim. Acta*, **56**, 659–78.