Behaviour of trace metals during magma degassing: evidence from melt inclusions in the 2000 eruption products of Miyake-jima

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Miyake-jima volcano has been discharging on average 40,000 ton SO2 per day (1) since the summer of 2000, representing the highest emission rate world-wide. Sulphur isotope data indicate that the sulphur is most likely of magmatic origin (2), which points to the presence of a sizeable magma reservoir beneath the volcanic edifice. Because of the high degassing rate and the occurrence of large melt inclusions in its eruption products, this volcano provides a good opportunity for a study of the behaviour of trace metals during volcanic degassing. Juvenile pyroclastic fragments of the June 27 (submarine) and August 18 (subaerial near the summit) eruptions were used for this study.

Bulk rock composition. The compositions show a typical arc pattern with enrichment of LILE (Rb, K, Ba, Pb, Sr, Th, U) and low HFSE (Nb, Ta, Zr). The contents of Ni (5-15 ppm) and Cr (15-30 pm) are very low, which suggests a considerable evolution of the magma since in equilibrium with the mantle. In contrast, concentrations of chalcophile elements are high compared to average arc magmas: Cu (140 compared to 80 ppm), Zn (120 ppm compared to 70 ppm), although sulphide phases are very scarce. During this study, only two sulphide grains (approximately 7 micometers) were identified and both of them in subaerial samples. They are Cu-bearing with highly irregular shape.

Melt inclusions. Melt inclusions (5-300 micrometers) commonly consist of brown glass. Most are rounded to oblong and oriented parallel to phenocryst rims. The compositions of the melt inclusions are similar in the subaerial and submarine samples, despite differences in whole rock composition, and are very similar to the whole-rock composition of the submarine sample. Sulphur in the inclusions is present in equal amounts of sulphate and sulphide and the estimated oxidation state of the melt is NNO+0.4, similar to many arc magmas. Our results are consistent with earlier results (3) Groundmass glass is enriched in FeO (total), TiO2, K2O, P2O5 and Cl and depleted in MgO and S compared to melt inclusions (Fig. 1).

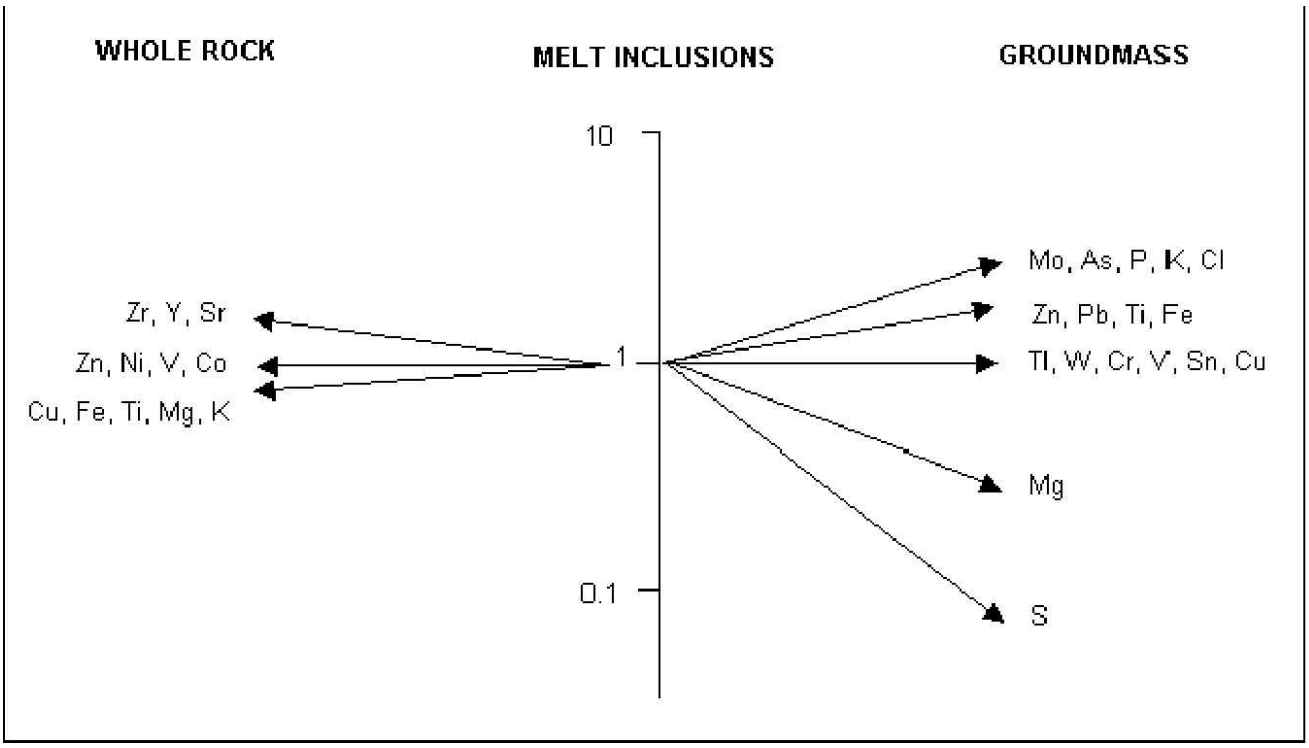
Discussion

A sharp decrease in sulphur content from 900 ppm in melt inclusions to 70 ppm in groundmass glass indicates rapid degassing from the shallow magma chamber. However, parallel decreases in concentrations are not observed for chalcophile and volatile metals, such as Cu, Zn, As, Sb, and Pb. Despite their chalcophile character these elements did not partition in the sulphur-rich vapour present at Miyake-jima.

The retention of trace metals may be possibly related to the preservation of Cl in the magma as many metals are considered to be transported as volatile chloride complexes (4). Indeed, Cl contents increase from 900 to 1600 ppm in groundmass glass and K/Cl ratios of melt inclusions and groundmass glass are very similar, suggesting little or no chlorine loss from the magma. This is also consistent with low HCl/SO2 ratios (approximately 0.06) in the degassing plume (5).No matter the cause for the retention of trace metals in the magma, our data show that magmas may be enriched in chalcophile metals even after significant devolatilization. This may have important implications for genetic models of porphyry copper mineralization, as some authors have suggested that these type of mineralizations cannot form in active volcanic environments because degassing would strip the magma of metals. Our study defies that assumption.

References

1. Kazahaya, K. et al., 2001, Japan EPS Meeting, V0-P010
2. Ohba, T., Hirabayashi, J., and Nogami, K., 2001, Japan EPS Meeting, V0-030
3. Yasuda, A., S. Nakada, and T. Fujii, 2001, Bull. Volc. Soc. Japan, 46, 165-173.
4. Symond, R.B. et al. (1987) Geochim. Cosmochim. Acta, 51: 2083-2101.
5. Mori, T., Sumino, H., and Notsu, K., 2001, Japan EPS Meeting, V0-029


WHOLE ROCK
MELT INCLUSIONS
GROUNDMASS
10
1
0.1
Zr, Y, Sr
Zn, Ni, V, Co
Cu, Fe, Ti, Mg, K
Mo, As, P, K, Cl
Zn, Pb, Ti, Fe
Tl, W, Cr, V, Sn, Cu
Mg
S