Supplemental Document 4 – MELTS Modeling Details

Transcrustal Magmatic Systems: Evidence from Andesites of the Southern Taupo Volcanic Zone

Journal of the Geological Society

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MELTS Modeling Procedures, Justification, and Outcome

Simulations of crystallization in an MgO-rich TVZ basalt, the Waimarino basalt, using MELTS_Excel (Gualda and Ghiorso 2015) may provide some constraints on our question of a pressure differential causing the observed pyroxene signatures. Graham and Hackett (1987) modeled Type 5 andesites of the TVZ (Ohakune is considered a Type 5 andesite) from Waimarino basalt via the crystallization of olivine, clinopyroxene, plagioclase, and chrome spinel. Conway *et al.* (2018) indicate that Ohakune and Pukeonake magmas lie along a mixing trend between Ruapehu dacites and Waimarino basalt compositions. Thus, the Waimarino basalt is implicated as at least a part of the petrogenesis of high-Mg# andesites. It can therefore be utilized in models as a basis for testing hypotheses regarding the pressure-dependence of the Hi-Al and Lo-Al groups.

We ran cooling crystallization simulations (i.e., decrease temp from liquidus (~1300°C) to 800°C) at varying constant-pressure scenarios (2.0 kbar, 5.3 kbar, and 8.0 kbar) on Waimarino basalt TVZ-11 (Gamble *et al*. 1990; see Table D1 below) with 3.0 wt. % H_2O. Runs at lower H_2O contents did not saturate olivine and were not considered because of this. Models were constrained in fO_2 at the NNO buffer. The 5.3 kbar depth was based on thermobarometry results from this study and others, discussed in the main text; the 2.0 and 8.0 kbar scenarios were chosen as other plausible pressures of crystallization in an arc magmatic system. MELTS calculated the composition of modeled melts, and crystals derived from such melts.

These simulations showed, at an Mg# equivalent to the average of Ohakune clinopyroxenes & at 2.0 kbar, Jd in pyroxene is 0.0088. At 5.3 kbar the modeled pyroxenes have a Jd of 0.0120,

and at 8.0 kbar show 0.0152. The 5.3 kbar and 8.0 kbar results are both within the range of Jd that we observe in natural Ohakune samples. This is summarized in Table D2 below.

Table D1

Oxide	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI
Wt. %	52.26	0.47	12.70	9.28	0.16	13.17	9.61	1.64	0.43	0.05	0.7

The non-normalized major element oxide composition (in weight percent) of Waimarino basalt TVZ-11 used as input for modeling, taken from Gamble *et al.* 1990.

Table D2

Group	Temperature (°C)	Mg#	Jadeite
Lo-Al (Observed)	1033*	83**	0.0115 (average)
Hi-Al (Observed)	1025*	82**	0.0148 (average)
2.0 kbar (MELTS)	1095	81	0.0088
5.3 kbar (MELTS)	1035	80	0.0120
8.0 kbar (MELTS)	1159	79	0.0152

*Constrained by thermobarometry; see main text. Temperatures of MELTS runs are reported from the output.

** Average values calculated from observed data

Table summarizing observed pyroxenes, and modeled clinopyroxenes from MELTS_Excel simulations.

References

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