Liquidus temperatures of komatiites and the effect of cooling rate on element partitioning between olivine and komatiitic melt

PAOLO A. SOSSI[12]* AND HUGH ST. C. O'NEILL[1]

[1]RSES, ANU, 2601, Canberra, ACT, Australia
[2]IPGP, 75238 Paris cedex 05, Paris, France (* sossi@ipgp.fr)

Olivine is the first phase to crystallise from primitive basaltic or ultramafic magmas on decompression and cooling. The uppermost zones (A1, A2) of komatiite flows contain randomly-oriented 'spinifex' olivines, indicative of rapid cooling and growth [1]. Fe-Mg partitioning between olivine and assumed komatiitic liquid typically shows departures from experimentally determined relations [2], extending towards higher $K_D^{Fe\text{-}Mg}$. If such high values are a disequilibrium effect it would lead to erroneous calculation of parental magma composition, and thus eruption temperature.

In order to investigate this possibility, we have performed experiments on two komatiite compositions, the classic Barberton Aluminium Undepleted Komatiite (AUK) sample 49J, (32% MgO) and Munro AUK sample 422/95 (23% MgO). Fixed-temperature experiments to constrain phase equilibria at atmospheric pressure, between 1360°C and 1600°C at FMQ-1.7 and FMQ+1.1 on 49J reveal a liquidus temperature (T_{liq}) of 1605±4°C, ~ 50ºC lower than a previous estimate [3]. $K_D^{Fe\text{-}Mg}$ ranges between 0.320 and 0.295 at FMQ-1.7, with a slight negative dependence on temperature.

To replicate the conditions that prevail during the quenching of komatiites in the upper chill zones, experiments with a constant cooling rate were performed at FMQ-1.7 on 422/95 (T_{liq} = 1450°C) at 0, 0.5, 1.5, 2.5, 6.5 and 16°C/min. Olivine morphology changes from euhedral to tabular at low cooling rates, hopper at intermediate, and skeletal and chain structures at high rates. Concurrently, the $K_D^{Fe\text{-}Mg}$ increases monotonically from an equilibrium value of 0.305 to 0.376 at 16°C/min, reflecting the inability of unwanted cations to diffuse away from the growing olivine, and confirming that the high $K_D^{Fe\text{-}Mg}$ in the spinifex olivine is due to rapid cooling.

[1] Donaldson, C.H., 1976, *CMP*, **57**, 187-213. [2] Toplis, M.J. 2005. *CMP*, **149**, 22-39. [3] Green, D.H., et al. 1975, *Geology*, **3**, 11-14.