CORRESPONDENCE

Pyroxene accumulation in spinifex-textured rocks

SIR – Campbell & Arndt (1982) have emphasized that in komatiitic lava flows of relatively low MgO content pyroxene rather than olivine occurs as the dominant elongate mineral in the A_2 (spinifex) unit, even though equilibrium phase relations indicate that olivine should have crystallized for many tens of degrees before pyroxene crystallization (Arndt, 1976). They attribute this anomaly to extreme supercooling of lava to below the temperature of a postulated olivine → pyroxene peritectic at approximately 1200°C, with subsequent metastable crystallization of pyroxene. As an instance of this behaviour Campbell & Arndt cite Fred's flow in Munro Township (Arndt, Naldrett & Pyke, 1977) and show that the lava would have had to be supercooled by approximately 170°C to enter the stability field of pyroxene. The flow is 120 m thick and has a chilled margin containing 16% MgO (15% normative olivine). The pyroxene–spinifex zone begins 7 m below the top of the flow, where the cooling rate would have been on the order of just 0.01–0.001 °/C h^{-1} (estimated from Jaeger, 1968, p. 511).

Experiments conducted by Walker *et al.* (1976), Grove & Walker (1977) and Donaldson (1979) quantify the effect of cooling rate in the supercooling of mafic and ultramafic magmas with respect to olivine. In order to supercool a melt with 11% normative olivine by 170 °C, a cooling rate exceeding 1000 °C h^{-1} is necessary (extrapolation of curves in Fig. 3*c* of Donaldson, 1979). Hence, although controlled cooling rate experiments on Fred's flow material are needed to test Campbell & Arndt's proposition, the existing results on other olivine-normative melts do not encourage the view that, during slow cooling (< 1 °C h^{-1}), the magma supercooled by the 170 °C needed to suppress olivine in favour of metastable pyroxene.

Other evidence against the proposal is the 5–7 m thick zone of olivine–spinifex between the top of Fred's flow and the pyroxene–spinifex zone (Arndt *et al.* 1977). Nearer the top of the flow cooling would have been faster than lower down and greater supercooling would have resulted. Yet it is olivine, not pyroxene, that forms under the faster cooling conditions.

While not disagreeing with Campbell & Arndt that A_2 spinifex zones are 'cumulates' in the sense of Irvine (1982), it seems to me that the discrepancy between the phase relations and the actual mineral constitution of Fred's flow is still not adequately explained.

Two promising ideas have emerged since the publication of Campbell & Arndt's paper. These are: (*a*) that during solidification of Fred's flow magma flowed continuously under the chilled margin and changed composition (cf. Barnes, Gorton & Naldrett, 1983), becoming cooler and more fractionated during crystallization of the pyroxene–spinifex zone as compared with that from which the overlying zones crystallized; and (*b*) that komatiite flows cool convectively rather than conductively (Huppert *et al.* 1984), resulting in much faster cooling than previously appreciated, and possibly fast enough to enter the pyroxene metastable field.

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