

nococrysts" within the basalt. This matching of liquidus and xenocryst phases in chemical composition and in paragenesis can only be achieved experimentally over a very small P, T range. In particular, the possible temperature of precipitation is rather closely fixed by the observed degree of solid solution between co-existing pyroxenes and the load pressure at precipitation may be deduced from the relative roles of pyroxene or olivine as liquidus phases and by the Na₂O content of the clinopyroxene. It is considered that the "xenocrysts" are not of accidental origin but are cognate, high-pressure phenocrysts precipitated from the host olivine basalt at depths of around 50–55 kms, (load pressure 14–16 kb) and a temperature close to 1200 °C. These conditions of precipitation require that the basalt liquidus was depressed about 130 °C below the dry liquidus – this is consistent with the presence of approximately 2% water within the magma at the depth of precipitation of the crystals.

The inferred high pressure phenocrysts have lower 100 Mg/(Mg+Fe⁺⁺) values than that inferred for parental mantle material or those values present in lherzolite or garnet peridotite xenoliths (100 Mg/(Mg+Fe⁺⁺) ~88–92). Thus the composition of the Auckland Id. olivine basalt is not considered to be that of a direct partial melt from mantle peridotite but rather to be a liquid produced from some more primitive parent magma by fractional crystallization at depths ≥ 50 km. While it is not possible to unequivocally deduce the nature of this parent magma, the Auckland Id. olivine basalt magma provides natural evidence of a process of fractional crystallization operating at about 50 km depth and "quenched" by the rapid eruption of both liquid and precipitating phases. This fractionation trend is dominated by pyroxene separation and in particular, by orthopyroxene. Although olivine accompanies the near-liquidus pyroxenes in the experiments, it is volumetrically a minor percentage of the precipitated material i.e. the precipitated material would be olivine-poor pyroxenite and not peridotite mineralogy. In chemical composition, the estimated crystal extract at

14–16 kb is very similar to that deduced for the olivine basalt and alkali olivine basalt by GREEN and RINGWOOD (1967a). The calculated fractionation trend at 14–16 kb, ~1200 °C, deduced for the Auckland Id. olivine basalt predicts more hypersthene-normative, tholeiitic compositions as parental to the observed host basalt and predicts nepheline-normative alkali olivine basalts as lower temperature derivative liquids from the host basalt. The data support and extend the conclusions of GREEN and RINGWOOD (1964, 1967a) on the dominant role of orthopyroxene and orthopyroxene+clinopyroxene crystallization at 13–18 kb in producing a spectrum of basaltic liquids from olivine tholeiite to basanite. It has been demonstrated that it is possible to characterize in a rather unequivocal manner, the P, T conditions and water content of some magmas within the upper mantle, prior to rapid extrusion.

Acknowledgements

We thank Dr J. B. Wright for originally bringing the Auckland Id. basalt and its xenocrysts to our attention. The technical assistance of Mr E. H. Pedersen in the preparation of microprobe mounts is gratefully acknowledged.

References

- BULTITUDE, R. J. and D. H. GREEN (1968) *Earth Planet. Sci. Letters* **3**, 325.
 DAVIS, B. T. C. and F. R. BOYD (1966) *J. Geophys. Res.* **71**, 3567.
 GREEN, D. H. and A. E. RINGWOOD (1964) *Nature* **201**, 1276.
 GREEN, D. H. and A. E. RINGWOOD (1967a) *Contr. Mineral. Petrol.* **15**, 103.
 GREEN, D. H. and A. E. RINGWOOD (1967b) *Geochim. Cosmochim. Acta* **31**, 767.
 KUSHIRO, I. (1968) Upper Mantle Committee Symposium, Abstr. Proc. XXIII Internat. Geol. Congr. Prague. 11.
 LINDSLEY, D. H. (in press).
 MACDONALD, G. A. and T. KATSURA (1964) *J. Petrol.* **5**, 82.
 O'HARA, M. J. (1968) *Earth Sci. Rev.* **4**, 69–133.
 POLDERVAART, A. (1964) *Geol. Soc. Am. Bull.* **75**, 229.
 ROSS, C. S., M. D. FOSTER and A. T. MYERS (1954) *Am. Mineralogist* **39**, 693.
 TILLEY, C. E. and I. D. MUIR (1964) *Geol. Foren. Stockholm Forh.* **85**, 434.
 YODER, H. S. and C. E. TILLEY (1962) *J. Petrol.* **3**, 342.