PETROCHEMISTRY OF KIMBERLITIC ROCKS AND ASSOCIATED XENOLITHS OF SOUTH-EASTERN AUSTRALIA

John Ferguson (Bureau of Mineral Resources,
J.W. Sheraton P.O. Box 378, Canberra City, A.C.T. 2601, Australia)

Fourteen widely-separated areas of kimberlitic rocks have recently been discovered in south-eastern Australia in the States of South Australia, Tasmania, Victoria, and New South Wales (Fig. 1). (Locality details, structural relations and ages are given by Stracke et al., this volume). One of the occurrences exhibits an intimate spatial association with carbonatite.

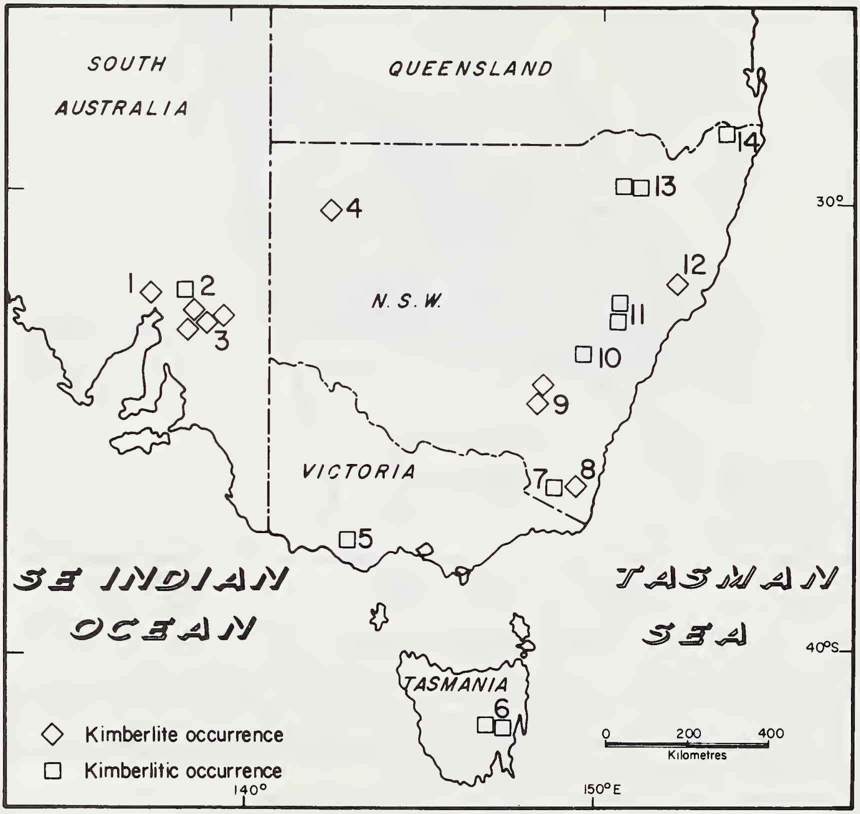

Fig. 1 Localities of kimberlite and kimberlitic occurrences in south-eastern Australia.

Areas: 1 = Pt. Augusta; 2 = Walloway; 3 = Terowie; 4 = White Cliffs; 5 = Bullenmerri; 6 = Oatlands; 7 = Delegate; 8 = Bombala; 9 = Jugiong; 10 = Abercrombie; 11 = Nulla Mountain; 12 = Gloucester; 13 = Bingara; 14 = Mt. Brown.

Analyses were carried out on mineral concentrates comprising one or more of the minerals clinopyroxene, garnet, and ilmenite, and were obtained from seven of the kimberlitic occurrences. Lherzolite nodules were obtained from two areas, and eclogite nodules from four areas. The garnet compositions are given in terms of the cluster group classification of Dawson and Stephens (1975) for garnets from kimberlites and associated xenoliths. By far the greatest proportion of garnets, including those from nodules and concentrates, fall into cluster 9. Cluster group 5 garnets also occur, but are confined to concentrates. Cluster group 3 garnets are found in concentrates and in some eclogites. With only minor exceptions, all cluster group 9 garnets from south-eastern Australian kimberlitic occurrences fall into the lherzolite field as defined by Boyd (1970) in terms of the ternary parameters Ca-Mg-(Fe^{2+} + Mn), and Cr-Fe^{3+} - Al. Similarly, they also fall within field II, as defined by Sobolev (1977), for the Russian occurrences of garnets from peridotite xenoliths. Over half the concentrate clinopyroxenes are chrome diopsides with Mg/Mg + Fe^{2+} ratios between 0.89 and 0.93, and Ca/Ca + Mg ratios of 0.45 to 0.50. Diopsides from lherzolite inclusions are virtually identical in composition to the concentrates from the same intrusions, which, together with similarities in garnet compositions suggest that the latter represent xenocrysts derived by fragmentation of similar nodular material. Ilmenite concentrates were recovered from five areas: in terms of the molecular proportions of ilmenite-geikielite-hematite those from two areas fall into the kimberlitic field; the remainder are Fe-enriched having chemical similarities to those found in alnöite (Frick, 1973; Mitchell, 1977).

The investigated kimberlitic rocks of south-eastern Australia may be divided into two chemically distinct groups, which define divergent trends within the CMAS tetrahedron. The South Australian kimberlites, notably those from the Walloway area, form part of the typical trend shown by kimberlites and related alkaline ultramafic rocks of southern Africa (Ferguson et al., 1975; McIver and Ferguson, this volume), and fall towards the more evolved end of this trend. Kimberlitic rocks of this type are considered to have been formed by small degrees of partial melting of phlogopite-bearing garnet lherzolite at depths exceeding 125 km. Olivine and orthopyroxene were the main fractionating phases during the early stages of kimberlite evolution, whereas the more evolved rocks may be explained on the basis of olivine-dominated fractionation; garnet and clinopyroxene do not appear to have been significant fractionating phases. The kimberlitic rocks of the Jugiong and Delegate areas have close chemical affinities with olivine nephelinites and related rocks, and appear to be unrelated to the 'normal' kimberlitic trend. Consideration of phase relationships in the CMAS tetrahedron (after O'Hara, 1968) indicate equilibration pressures of about 20 kb, and the observed chemical variation may be explained on the basis of relatively minor olivine and possibly orthopyroxene fractionation. T-P conditions of 1240 $\pm$ 20°C and 22 $\pm$ 1 kb for these nodules are indicated by temperature estimates based on compositions of coexisting minerals in lherzolite and eclogite nodules (Mori, 1977; Råheim and Green, 1974), together with the occurrence of a unique garnet-spinel lherzolite inclusion containing an equilibrium assemblage falling on the quasi-univariant boundary between the spinel and garnet lherzolite fields (Ferguson et al., 1977). This is well supported by the data obtained for the host rocks. The very high geothermal gradient implied by these estimates suggests that kimberlitic magma could have been generated by small degrees of partial melting of garnet lherzolite at depths of about 70 km, and at temperatures of about 1300°C.

The abnormally high geothermal gradient present when the olivine nephelinite magmas of the Jugiong area were generated intersects the diamond/graphite inversion curve at much greater pressures and temperatures than those indicated by the nodules, so that it is highly unlikely that diamondiferous kimberlites of Cainozoic age occur in this part of New South Wales.

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