sition elements may carry information on the origin of the magmas. If melting of a recently metasomatized mantle could provide a satisfactory interpretation, wall rock alteration formalized with the zone refining equation fit well the present data. An important implication of this process is the rapid equilibration of high partition coefficient elements (HRE for instance) with conduit walls in contrast with low partition coefficient elements (LRE). It is found that a liquid generated in the garnet stability field of the mantle and rising through spinel lherzolites or harzburgites would result in magmas having geochemical characteristics similar to melilitites or kimberlites.

C17

Nd ISOTOPES IN KIMBERLITES AND MANTLE EVOLUTION

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Estimation of P, T, conditions of equilibration of garnet peridotite xenoliths in kimberlites indicates that kimberlitic liquids are derived from depths greater than 180 kms. No other rock, with a depth of origin greater than 180 kms, is readily available for analysis. A Nd-isotopic study of kimberlites of different ages from different continents is, therefore, important in understanding the history and evolution of the mantle. The present study is an extension of our earlier study (Basu and Tatsumoto, 1978, 1979, 1980) where we demonstrated that kimberlites are derived from a relatively undifferentiated chondritic mantle.

We have analyzed the Nd-isotopic composition of the following kimberlites and related rocks: Nine kimberlite pipes from South Africa and Lesotho; two from southern India; one from the U.S.S.R.; fifteen kimberlite pipes and related dike rocks from eastern and central U.S. and three pipes from the Shangdong Province of eastern China. The age of emplacement of these pipes ranges from 1300 m.y. to 90 m.y. before present. The initial Nd-isotopic compositions of these kimberlitic rocks expressed as ε_{Nd}^{I} with respect to a chondritic bulk earth growth curve show a range between 0 to +4, with the majority of the kimberlites being in the range 0 to +2. This result strengthens our earlier conclusions that kimberlitic liquids are derived from a relatively primeval and unique mantle reservoir with a nearly chondritic Sm/Nd ratio.

C18

THE EVOLUTION OF OLIVINE MELILITITE AND KIMBERLITE MAGMAS

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Olivine melilitites and olivine nephelinites occur in two pipe clusters in the Namaqualand-Bushmanland area of western South Africa. Disparate ages and differences in initial Sr-isotope ratios indicate that it is not possible to relate these rocks to a common parental magma. Nevertheless, it is possible to model the differences in bulk rock chemistry between the pipes in terms of processes common to magmas generated in the same tectonic environment, although it is recognised that the rocks themselves cannot be co-magmatic.

Chemical characteristics of the southern (Garies) pipes lower MgO and higher concentrations of some incompatible elements indicates that they are compositionally more "evolved" than those in the Gamoep pipe cluster to the north. Compositional variation withinthe southern pipe cluster has been dominated by fractional crystallisation of olivine, melilite, perovskite and titanomagnetite (the low pressure phase assemblage in these rocks).

Compositional variation within the northen pipe cluster reflects the imprint of polybaric fractional crystallisation which has involved both a high pressure (megacryst) phase assemblage of olivine, clinopyroxene and ilmenite and the same low-pressure phases that dominantly control the compositional variation in the southern pipes.

Substraction of the high-pressure phases from an average Gamoep (northern magma composition will produce a composition similar in "compatible" major element contents to that of an average Garies (southern) magma. This suggests that the Garies pipes could have been derived by high-pressure crystal fractionation of a more primitive magma which was similar in major element chemistry to an average Gamoep composition. However, the enrichment of incompatible trace elements such as Zr and Nb in the Garies rocks relative to those in the Gamoep pipes is far higher than would be predicted by a simple crystal fractionation model. This suggests that the primary magmas for the two pipe clusters were produced by different degrees of partial melting or that there were compositional differences between their respective source areas.

Although it is possible to model the compositional derivation of the Garies rocks from a Gamoep-type magma it would appear that the parental magma for the Gamoep pipes was itself relatively evolved, since olivine phenocrysts in the Gamoep rocks are always more Fe-rich than would be expected in an unmodified mantle-derived liquid. A consideration of the compositional data suggests that an average Gamoep type magma could be derived from a "primary" magma very similar to an average South African kimberlite by crystal fractionation of the kimberlite megacryst assemblage comprising olivine, orthopyroxene, clinopyroxene, garnet and ilmenite. Sr isotope evidence is also supportive of a genetic relationship between South African kimberlites and the olivine melilites of Namaqualand-Busmanland since both have clearly been derived from isotopically "depleted" mantle source areas.

Alkaline volcanic pipes of post-Gondwanaland age show a systematic variation in composition with their geographic position on the southern African subcontinent. Diamondiferous kimberlites, which appear to be the least evolved chemically, are confined to the central, ancient, cratonic areas. More evolved alkaline rocks (olivine melilitites and olivine nephelinites) are concentrated closer to the continental margin in the east and west of South Africa. While the most evolved alkaline rocks (the trachybasalts of the Alphard Banks) occur on the southern continental shelf. It is postulated that this chemical zonation may be related to a steepening of the geotherm from the centre of the subcontinent towards its edges.

C19

THE GEOCHEMISTRY OF SOME KIMBERLITES FROM THE TYPE AREA IN KIMBERLEY SOUTH AFRICA, IN RELATION TO MODELS OF KIMBERLITE PETROGENESIS

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When compared to the available information about more widespread and thoroughly studied rocks such as basalts, considerable uncertainty remains about the chemical composition of kimberlite magmas. This is because the frequently violent emplacement of kimberlite leads to contamination during emplacement, and further renders kimberlite susceptible to post-emplacement alteration by groundwater which can percolate through the relativity permeable tuffs and brecciated kimberlite, for which many analyses appear in the literature. Quietly intruded magmatic kimberlites which are free of crustal inclusions and impermeable groundwater after emplacement are rare. However, some such specimens are included together with altered rocks in a collection of seventy kimberlites for which full major and some trace element analyses are presented in the present work. (See Berg and Allsopp, 1972 and Barret and Berg, 1975 for brief descriptions and isotope data for some of these rocks).

Systematic appraisal of the geochemical data was combined with the petrographic assessment of freshness as described in Barret and Berg (1975). This approach was designed to characterise the geochemistry of kimberlite magma as closely as possible and to identify rocks in which the original kimberlite chemistry has been altered to such an extent that their analyses no longer represent the original kimberlite magma's composition sufficiently closely to be satisfactory for testing models for kimberlite formation. Alteration and contamination lead to increases, for example, in the concentrations of Na_2O and Al_2O_3. There are no significant differences in the concentrations of some elements like MgO between fresh magmatic and altered kimberlites, but many altered kimberlites have significantly higher concentrations of SiO_2 than fresh kimberlites. Those altered kimberlites which do have similar concentrations of SiO_2 to fresh kimberlites, nevertheless have relatively high SiO_2/MgO ratios, as have the altered kimberlites which contain higher concentrations of SiO_2. Care must be taken to distinguish between increases in the concentration of Al_2O_3 and SiO_2/MgO ratios which are due to an increase in the amounts of primary phlogopite in a sample rather than to contamination and alteration reactions.

It was found that composition such as the averages for Lesotho kimberlites given by Dawson (1962) and Gurney and Ebrahim (1973), which have been used by other investigators to represent the chemistry of kimberlite magmas, fall in the range of the altered kimberlites sutied here. An outcome of the alteration of kimberlite is to increase the amount of orthopyroxene in the norm of average compositions, which may lead to incorrect differentiation models and influence the results of high pressure phase equilibrium studies based on the chemistry of average kimberlite. Consequently it is suggested that some current models for the formation of kimberlite and related rocks may require considerable refinement.

Some implications are considered, such as the indicated partition coefficients for Cr and Ni, when the assumption is made that kimberlite is a partial melt of low degree in the mantle, and that the fresh kimberlites here described adequately represent the composition of such kimberlite magma at its source.

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