ISOTOPIC COMPOSITION OF STRONTIUM IN INDIAN KIMBERLITES

D.K. Paul (Geological Survey of India, Calcutta 16, India)

Samples analysed:

Concentrations of rubidium, strontium and isotopic compositions of strontium are reported for twenty three kimberlites from India. The samples are from six diatremes occurring in two petrographic provinces and have been collected from surface, underground mine and bore hole core.

Analytical method:

Concentrations of Rb and Sr have been determined by isotope dilution. The procedure for separation and purification of Rb and Sr and mass spectrometry is similar to that described by Burwell (1975). Blank levels varied from 12 to 25 ng for Sr. Measured $^{87}Sr/^{86}Sr$ ratios have been normalized to a $^{86}Sr/^{88}Sr$ ratio of 0.1194. The mean value for Eimer and Amend standard Sr obtained during the course of the work is 0.7081.

Results:

Abundances of Rb, Sr and the $^{87}Sr/^{86}Sr$ ratios are presented in Table 1. The initial $^{87}Sr/^{86}Sr$ ratios from the Majhgawan pipe (Central India) range from 0.7030 to 0.7064 corresponding values in three pipes from south India vary from 0.7027 to 0.7102.

Discussion:

The kimberlites of the present study exhibit large variations in Sr isotope ratios, but the spread is within the range established earlier for kimberlites (Mitchell and Crocket, 1971; Berg and Allsopp, 1972; Barrett and Berg, 1975). General geological and petrographical description of the Indian kimberlites have been given by Paul et al., (1975 a). Based on the criteria of Berg and Allsopp (1972), the south Indian occurrences would be classified as 'fresh' and those from central India as 'altered'. From Table 1, it is observed that the $^{87}Sr/^{86}$ Sr ratios are not related to the degree of alteration. Leaching experiments on three whole rock kimberlites with dil. H_3PO_4 showed no significant difference in the Sr isotopic composition of the leached solution and residue. The Indian kimberlites have been emplaced through Precambrian granites and gneisses, estimated to be 40 - 45 km thick. One sample of basement granite from Wajrakarur (south India) gave a $^{87}Sr/^{86}Sr$ ratio of 0.7101 and a strontium content of 668 ppm. A significant amount of contamination of crustal rocks of this composition would be required to obtain the Sr isotope ratios of kimberlites (Table 1). There is no evidence for such assimilation.

The mineralogy of kimberlites and associated nodules indicate their deep-seated nature. Some of the Indian kimberlites are,however, enriched in ^{87}Sr compared to the normal mantle region. Two explanations can be offered to explain this : (a) disequilibrium partial melting in the source region where no isotopic equilibration was attained between the melt and the residue, and (b) equilibrium melting of a heterogeneous source.In the first hypothesis, the isotopic composition of Sr in the initial melt would be mainly controlled by phlogopite on account of its high Rb/Sr and $^{87}Sr/^{86}Sr$ ratios (Sun and Hanson,1975), leading to higher $^{87}Sr/^{86}Sr$ ratios in the melt compared with the parent. When other minerals e.g. olivine, orthopyroxene contribute to the melt, the $^{87}Sr/^{86}Sr$ ratios will tend to decrease. This agrees with the REE

distribution patterns (Paul et al. 1975 b) in that kimberlites are derived by small amounts of partial melting in a peridotitic mantle. Accordingly, isotopic composition of Sr would depend on the extant of melting. Alternatively, the isotopic characters of kimberlites may be inherited from the source region which had undergone enrichment of LIL elements in small sub-systems with variable Rb/Sr ratios. Indeed, Brooks et al., (1976) showed that subcontinental mantle has Sr isotope ratios from 0.703 to 0.710, a range encompassed by the kimberlites. In this case, variable isotopic composition of kimberlites would be a necessary consequence of melting in the heterogeneous source region.

References:

Barrett D.R. and Berg G.W. (1975). Physics and Chemistry of the Earth, 9,619 - 636.

Berg G.W. and Allsopp, H.L. (1972). Earth Planet. Sci. Lett., 6, 27 - 30.

Brooks C., James D.E. and Hart S.R. (1976). Science, 193, 1086 - 1094.

Burwell A.D.M. (1975) . Earth Planet Sci. Lett., 29, 69 - 78.

Mitchell R.H. and Crocket J.H. (1971). Contrib. Mineral. Petrol., 30, 277 - 290.

Paul, D.K. Rex D.C. and Harris P.G. (1975 a). Bull. Geol. Amer., 86, 364 - 366.

Paul D.K., Potts P.J., Gibson I.L. and Harris P.G. (1975 b). Earth Planet. Sci. Lett., 25, 151 - 158.

Sun S.S. and Hanson G.N. (1975). Geology, 3, 296 - 302.

TABLE 1: Rb,Sr and $^{87}Sr/^{86}Sr$ ratios of Indian Kimberlites.

Sample No.	Rb ppm	Sr ppm	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$ measured	$^{87}Sr/^{86}Sr$ @ initial
Central India					
MG 21	20.3	1206.6	0.049	0.7036	0.7030
MG 50	43.1	1513.4	0.083	0.7044	0.7033
MG 11	15.8	87.8	0.052	0.7045	0.7038
MG 40	37.3	1343.2	0.080	0.7048	0.7038
MG 6	36.3	1207.7	0.087	0.7050	0.7038
MG 25	39.3	1343.9	0.085	0.7051	0.7040
UG 11A	81.1	1558.1	0.151	0.7066	0.7045
UG 136	97.6	1577.8	0.179	0.7069	0.7043
UG 84	60.0	1316.0	0.132	0.7073	0.7064
HV 4/4	99.1	1824.6	0.157	0.7063	0.7041
HV 4/7	63.6	1047.6	0.176	0.7074	0.7050
HV 4/1	29.8	605.6	0.143	0.7086	0.7067
HV 4/6	37.0	628.0	0.171	0.7093	0.7068
South India					
WK 1/1	6.3	760.5	0.024	0.7044	0.7044

Table 1 contd.

Sample No.	Rb ppm	Sr ppm	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$ measured	$^{87}Sr/^{86}Sr$ initial
WK 2/7	146.1	858.6	0.493	0.7102	0.7060
WK 2/6	174.5	936.3	0.540	0.7106	0.7043
WK 2/9	206.6	1089.3	0.550	0.7121	0.7057
WK 2/5	185.0	774.7	0.692	0.7142	0.7061
LM 3/5	4.5	560.4	0.024	0.7094	0.7091
LM 3/4	125.9	863.7	0.422	0.7160	0.7102
LM 4/6	120.8	666.3	0.525	0.7102	0.7027
LM 4/7	108.9	508.7	0.620	0.7132	0.7046
LM 4/9	153.6	642.4	0.699	0.7141	0.7043
WK granite	38.1	667.9	0.165	0.7101	

@ assumed age for samples with prefix WK is 840 Ma; for others assumed age is 1000 Ma (Paul et al., 1975 a)