LEAD AND STRONTIUM ISOTOPES IN INCLUSIONS IN DIAMONDS AND IN MANTLE-DERIVED XENOLITHS FROM SOUTHERN AFRICA

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Batches of approximately one gram of diamonds with sulphide inclusions from three South African diamond mines were burned and the inclusions (and volatilised lead) recovered for analysis. The procedure was similar to that described by Welke et al.(1974), with however a reduced analytical blank for lead (1-1.6 nanogram). The samples were from the Premier mine (Transvaal), Finsch mine (Cape Province) and "Kimberley Pool", a plant which works kimberlite from the De Beers, Wesselton, Dutoitspan and Bultfontein pipes in Kimberley, Cape Province. The Finsch pipe and those in Kimberley are post-Karroo in age, whereas the Premier pipe is Precambrian (about 1250 m.y., Barrett and Allsopp, 1973). The results are listed in Table 1. Fig. 1 shows the results in the 207/204 vs. 206/204 diagram, in comparison with the lead isotopic compositions (initial) of the respective host kimberlites. Isotopic disequilibrium between the diamond inclusions and the host kimberlites is evident in each case, but is especially striking in the samples from Finsch and from the Kimberley Pool. Given the very primitive lead isotopic composition of the inclusions in these diamonds, it is inconceivable that they would have crystallised from liquids with the isotopic composition of the Finsch and Kimberley-Pool kimberlites. Observations of this kind have not yet been made on diamonds with other kinds of inclusions; nevertheless a xenocryst nature is indicated for some diamonds by the present data.

Lead and strontium isotope ratios of separated clinopyroxenes from three xenolith suites from cretaceous kimberlite occurrences are shown in Figs. 2, 3 and 4 and discussed below.

(1) Roberts Victor (Orange Free State). This pipe is 127 m.y. old (Allsopp and Barrett, 1975). It contains a large variety of eclogitic xenoliths, some of them banded, in which diamonds occasionally occur. These eclogites are considered products of fractional crystallisation (C.Hatton, personal communication). The spread in lead (Fig. 2) and strontium isotope ratios is very large. The lead data confirms the findings of Manton and Tatsumoto (1971) in that the slope of the data in the 207/204 vs. 206/204 diagram defines a deep Precambrian age (2500 m.y., excepting sample HRV 67). Apart from the evidence of this old age, the observation that rock units in the subcontinental mantle can retain very primitive lead isotopic compositions is important.

(2) Matsoku (Lesotho). This pipe is post-Karroo in age and is located in North-Eastern Lesotho. It contains a large variety of peridotitic xenoliths, recently described by Gurney, Harte and Cox (1975). On the basis of bulk chemistry (chiefly Mg/Fe ratio) these authors distinguish between residual mantle-material ("common peridotites") and products of fractional crystallisation ("cumulates") in this suite. Some xenoliths contain "veins" of fine-grained peridotite. Samples of three common peridotites, three cumulates and two vein rocks were analysed. The $^{87}Sr/^{86}Sr$ ratios are all between .703 and .704. The lead isotope ratios are plotted in Fig. 3. A fairly strong heterogeneity exists within the group of common peridotites, whereas the cumulates and vein rocks show relatively good homogeneity within their group. This data provides strong support for the abovementioned interpretations of rocks from this suite.

(3) Kimberley (Cape Province). The four pipes which make up the Kimberley Pool have yielded a large variety of xenoliths and xenocrysts. Six samples of separated diopsides from porphyroclastic and granular lherzolites from the De Beers and Bultfontein mines showed a large spread in lead and strontium isotope ratios (lead: see Fig. 4; strontium: .704-.713; Kramers, 1977), suggesting that they form part of a Precambrian rock province. Four clinopyroxene megacrysts from the four pipes on the other hand have lead isotope ratios very similar to each other (Fig. 4), as well as much more uniform $^{87}Sr/^{86}Sr$ ratios between .703 and .704. This data suggests that these megacrysts were produced in a more recent homogenisation event, possibly involving a magma chamber.

The data, considered together, allows the suggestion that the diamonds analysed might originally have been rock-forming minerals in a deep-Precambrian rock suite such as the one sampled by the Roberts Victor kimberlite. Furthermore the data shows that the occurrence of magmatic events which lead to fractional crystallisation in the subcontinental mantle need not obliterate older isotopic heterogeneity in their vicinity.

Table 1: Diamonds with sulphide inclusions.

Sample	206/204	207/204	208/204	206/204*	207/204*	208/204*
Premier	16.98±.01	15.49±.01	36.99±.03	16.93	15.49	36.98
Finsch	14.48±.06	14.93±.06	35.05±.14	13.72	14.81	34.20
Kimberley	15.16±.17	14.93±.12	35.05±.30	age correction insignificant.		

*age correction. Premier: minimum (1250 m.y.; pipe age)
Finsch: maximum (2500 m.y.; "model age")

References

H.L. Allsopp and D.R. Barrett (1975): Rb-Sr age determinations on South African kimberlite pipes. Physics and Chemistry of the Earth, 9 (Pergamon Press), pp 605-615.

D.R. Barrett and H.L. Allsopp (1973): rubidium-strontium age determinations on South African kimberlite pipes. First International Kimberlite Conference, extended abstract volume (University of Cape Town), pp 23-25.

J.J. Gurney, B. Harte and K.G. Cox (1975): Mantle xenoliths in the Matsoku kimberlite pipe. Physics and Chemistry of the Earth, 9 (Pergamon Press), pp 507-532.

J.D. Kramers (1977): Lead and strontium isotopes in cretaceous kimberlites and mantle-derived xenoliths from Southern Africa. Earth and Planetary Science Letters, 34, pp 419-431.

W.I. Manton and M. Tatsumoto (1971): Some Pb and Sr isotopic measurements on eclogites from the Roberts Victor mine, South Africa. Earth and Planetary Science Letters, 10, pp 217-226.

H.J. Welke, H.L. Allsopp and J.W. Harris (1974): Measurements of K, Rb, U, Sr and Pb in diamonds containing inclusions. Nature, 252 No. 5478, pp 35-37.

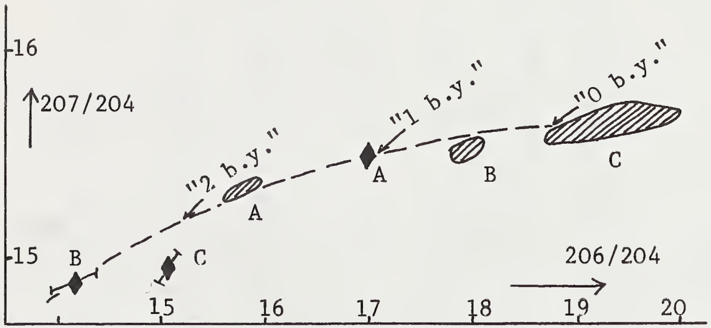

Fig. 1: Lead isotopes in diamond inclusions and host kimberlites. ♦ : inclusions in diamonds; :host kimberlites, initial ratios. A: Premier, B: Finsch, C: Kimberley Pool. (Premier kimberlite: Kramers, unpubl.; Finsch, Kimberley kimberlites: Kramers, 1977).

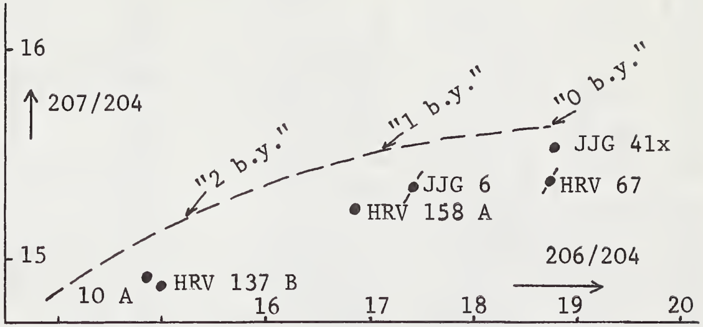

Fig. 2: Lead isotopes in separated clinopyroxenes from Roberts Victor eclogites. JJG 41x: Kramers (1977); other samples this work. Slope (excepting HRV 67) defines age of 2.5 b.y..

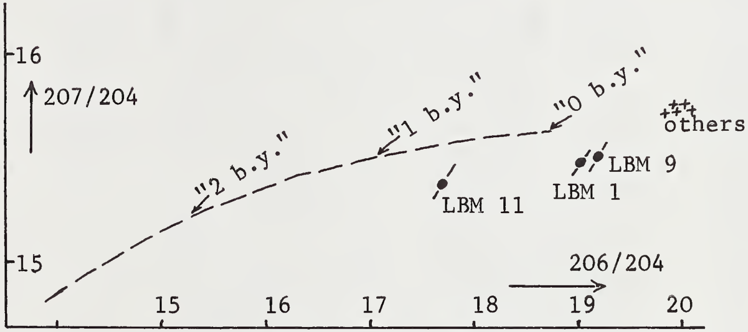

Fig. 3: Lead isotopes in separated clinopyroxenes from Matsoku peridotites. : "common peridotites"; + : "cumulates" (Kramers, 1977) and vein rocks (LBM 90 and 38B, this work)

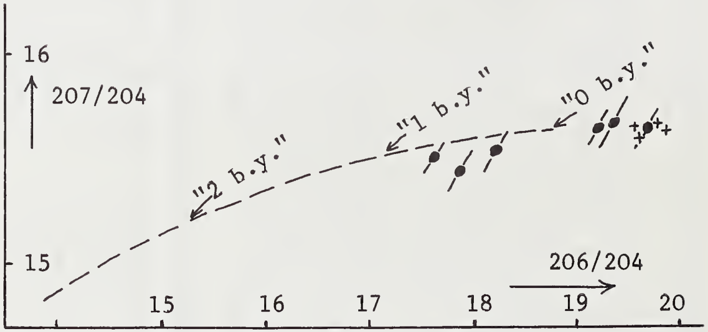

Fig. 4: Lead isotopes in separated clinopyroxenes from Kimberley peridotites (, Kramers, 1977) and in clinopyroxene megacrysts (+ , this work) from the four pipes of the Kimberley Pool.

NB: Growthcurve and "model ages" drawn in purely for orientation purposes.