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Evidence That Most Peridotitic and Eclogitic Diamonds from Kimberley Pool (RSA) Crystallised from the Same Carbon Source

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Introduction Kimberley Pool is a group of five historical kimberlites, Kimberley, De Beers, Dutoispan, Bultfontein and Wesselton, the three latter being presently mined. Previous studies have shown that the five kimberlites have emplacement ages within experimental errors between 83 and 92Ma (Allsopp and Barrett, 1975) and that the diamonds are originating from the same mantle region (Harris et al., 1984). Also harzburgitic diamonds have been dated at about 3.2Ga. Before closure of DeBeers a new extensive suite of inclusion-bearing diamonds was obtained. Over 547 diamonds containing at least one inclusion were recovered (Phillips and Harris, 1995). From this sample set, 186 samples (43 eclogitic and 143 peridotitic) were selected. Based on the type or chemical composition of the inclusion, 116 peridotitic diamonds were further classified into harzburgitic (subcalcic), (83), lherzolitic (calcic), (13) and moderately subcalcic (20), parageneses. These samples have been used to characterise the nitrogen and carbon isotopic compositions together with nitrogen contents. Here we mostly focus on the significance of the measured $\delta^{13}C$-values.

Results Carbon stable isotopic compositions vary greatly from one paragenesis to the other. $\delta^{13}C$-values of harzburgitc diamonds vary from -6.82 to -0.93‰, with a mean value of -4.66‰ and a positive skewness. $\delta^{13}C$-values for moderately subcalcic diamonds vary from -6.90 to -3.90‰ and an extreme value down to -26.38‰ displayed by a zoned sample. The mean $\delta^{13}C$-value is -6.22‰. Lherzolitic diamonds show $\delta^{13}C$-values from -5.97 to -4.22‰ and a mean value of -5.13‰. Eclogitic diamonds have $\delta^{13}C$-values contained within a -15.38 to -3.06‰ interval, with a mean value of -5.70‰, and show a clear negative skewness. With the exception of the zoned sample mentioned above, among the duplicate $\delta^{13}C$-analyses available (Tables 1 to 4), Kimberley Pool diamonds show very little $\delta^{13}C$-variability.

Diamonds of different parageneses have different $\delta^{13}C$-ranges, mean $\delta^{13}C$-values, etc... and these results could be interpreted according to a model involving several, distinct carbon sources. However, it is of major importance to emphasise that the MAIN $\delta^{13}C$ mode for every diamond parageneses (harzburgitic, lherzolitic, moderately sub-calcic and eclogitic) is the same (at about -5.0‰) within the order of 0.1‰ which is the accuracy of the determination. This fact implies that most peridotitic and eclogitic diamonds from Kimberley Pool crystallised from the same carbon source. The evidence brought from the carbon isotopes is strengthened when nitrogen isotopes are considered, as the eclogitic and peridotitic parageneses overlap a nearly identical field in a $\delta^{13}C$-$\delta^{15}N$ space. Although covering a large $\delta^{15}N$-range, from ? -12 to +8‰, the fact that $\delta^{15}N$-values are centered around -5‰, implies that the main carbon source identified above is mantle-derived.

The present data argues against a formation of eclogitic diamonds and peridotitic diamonds from two (or more) distinct carbon source. Moreover, systematic $\delta^{13}C$-$\delta^{15}N$-N covariations rule out any mixing relationship involving a lower (or higher) $\delta^{13}C$ component to account for the large δ15N range (-12 to +8‰). If the large $\delta^{15}N$-range is produced by a mixing process, the second carbon source would need to be characterised by a $\delta^{13}C$-value close to -6‰.

The present results have also implications on models calling for a primordial heterogeneity of mantle carbon to account for diamond $\delta^{13}C$-values. The fact that eclogitic and peridotitic diamonds have a main $\delta^{13}C$-mode identical within experimental error suggests that the carbon provided below the Kimberley area is rather well homogenised and not heterogeneous on very small scale.

Peridotitic diamonds formed in the Archean (Richardson et al., 1984). Eclogitic diamonds from Kimberley Pool have not been dated, however, studies on eclogitic diamonds from other localities gave Proterozoic ages.

(1) Assuming that Kimberley Pool eclogitic diamonds formed in the Proterozoic and given that most eclogitic and peridotitic diamonds have the same $\delta^{13}C$-mode, implies that the carbon isotopic composition would have to remain constant over long geological periods or (2) in contrast with other studies, eclogitic diamonds would also be about 3.2Ga old too.