THE CARBON AND NITROGEN ISOTOPE CHARACTERISTICS OF ARGYLE AND ELLENDALE DIAMONDS.

van Heerden,[1,2] L.A., Boyd,[1,3] S.R,. Pillinger,[1] C.T.

1. Department of Earth Sciences, The Open University. Walton Hall, Milton Keynes, MK7 6AA, England.
2. Present address: Department of Geological Sciences, The University of Cape Town, Private Bag, Rondebosch 7700, South Africa.
3. Present address: Institute de Physic du Globe, Laboratoire de Geochemie des Isotopes Stables. Universite de Paris 7, 2 Place Jussieu, 75251 Paris, Cedex 05, France.

Carbon stable isotope ratios of diamond are frequently invoked in attempts to elucidate diamond genesis. In particular, the existence of a marked ^{13}C depletion in many diamonds is often cited as direct evidence for subducted, crust-derived volatile material being directly involved in the formation of some diamonds. The causes of carbon isotope variability within the mantle are however still poorly constrained and this is largely due to the lack of independent information with which to compare C isotope data. Nitrogen is a common trace constituent of diamonds and as it consists of two stable isotopes, it provides an additional geochemical parameter that may be studied in conjunction with C. This paper reports the first comprehensive study of the C and N stable isotope variation within a suite of well characterised diamonds from a geographically restricted area.

The diamonds used in this study come from the Argyle, Ellendale 4 and Ellendale 9 lamproites. Whole inclusion-free diamonds and fragments of stones from which the inclusions had been broken, were cleaned and described and had their infra-red absorption spectrum collected. Microgram sized chips from each diamond were then combusted in the extraction system described by Boyd *et al*., (1988). Nitrogen stable isotope ratios were measured in the mass spectrometer described by Wright *et al*., (1988) and carbon stable isotope ratios were measured in the SIRA24 dynamic mass spectrometer in routine use at the Open University. Stable isotope ratios are expressed in the conventional δ notation as per mille (‰) deviations from an internationally accepted standard. In the case of carbon, $\delta^{13}C$ is expressed relative to PDB, and for nitrogen, $\delta^{15}N$ values are relative to air.

There are large variations in the stable isotopic compositions of both carbon and nitrogen in diamonds from the Argyle and Ellendale lamproites (Table 1). The distribution of $\delta^{13}C$ values from Argyle and Ellendale 4 are unimodal but there is a bimodal $\delta^{13}C$ distribution for Ellendale 9 diamonds (Figure 1) with one of the Ellendale 9 modes corresponding to the Argyle diamonds and the other mode corresponding to the Ellendale 4 diamonds. Ellendale 9 diamonds also have a $\delta^{15}N$ distribution that is transitional between that of the Argyle and Ellendale 4 $\delta^{15}N$ distributions (Figure 2).

	$\delta^{13}C$			$\delta^{15}N$		
	Argyle	Ellendale 4	Ellendale 9	Argyle	Ellendale 4	Ellendale 9
n	112	21	68	101	20	66
min.	-14.9	-6.24	-22.14	-4.64	-10.43	-9.34
max.	-4.51	-1.96	0.01	13.60	3.6	13.15
median	-10.06	-4.73	-6.08	5.50	-1.02	-0.89
mean	-9.88	-4.57	-7.94	5.83	-2.34	0.10
std.error	0.20	0.25	0.51	0.40	0.98	0.58
variance	4.35	1.32	17.93	15.96	19.15	22.23
std. dev.	2.09	1.15	4.23	3.994	4.376	4.715

Table 1: Statistical description of the $\delta^{13}C$ and $\delta^{15}N$ values of Argyle and Ellendale diamonds.

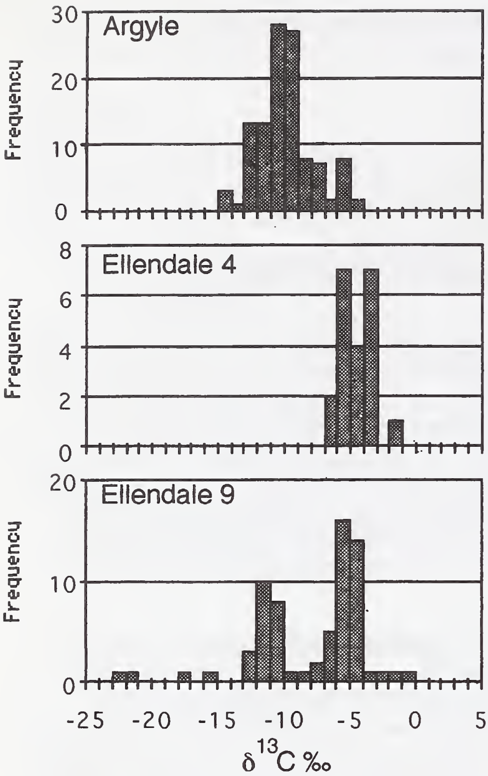

Figure 2: Histograms showing the $\delta^{13}C$ distribution of Argyle and Ellendale diamonds.

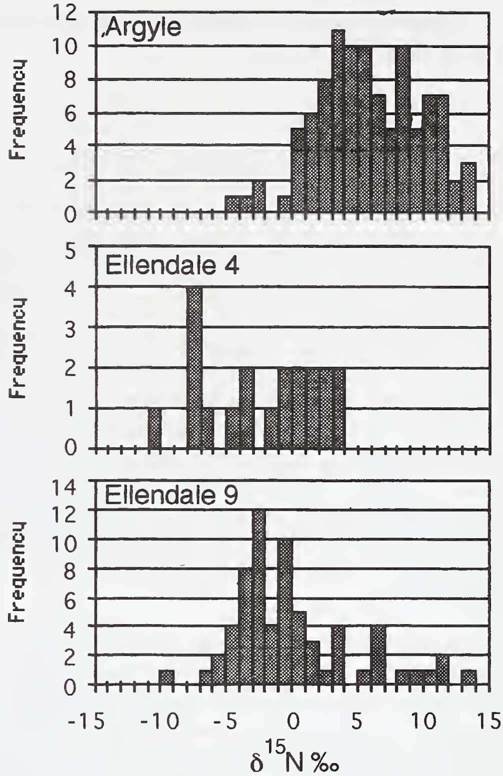

Figure 3: Histograms showing the $\delta^{15}N$ distribution of Argyle and Ellendale diamonds.

There are no consistent relationships between the stable isotope ratios of these diamonds and their colour, morphology, state of nitrogen aggregation or nitrogen content. The $\delta^{13}C$ and $\delta^{15}N$ values however show a covariation and this may be related to diamond paragenesis (Figure 3). Eclogitic paragenesis diamonds are characterised by having a more negative mean $\delta^{13}C$ value than lherzolitic paragenesis diamonds, but there are no statistically significant differences in the mean $\delta^{15}N$ values of eclogitic and lherzolitic paragenesis diamonds from these Western Australian (W.A.) lamproites. Eclogitic paragenesis diamonds however define a group with a positive slope on Figure 3 whereas lherzolitic diamonds define a negative slope. There are no $\delta^{15}N$ data from harzburgitic paragenesis W.A. diamonds available for comparison, although van Heerden *et al.*, (1995) suggest that the nitrogen stable isotope ratios of harzburgitic diamonds are expected to differ from those of both eclogitic and lherzolitic diamonds.

The C and N stable isotope data are interpreted as evidence for the recycling of crust-derived organic material, oceanic basalt and peridotite and sediments back into the diamond source region. Eclogitic and lherzolitic diamonds both show evidence of this subducted component. Harzburgitic diamonds from elsewhere (for example Finsch) which have less variable $\delta^{13}C$ and $\delta^{15}N$ values are thought to be more characteristic of pristine or "primary" mantle material.

A compilation of all the nitrogen stable isotope data available for diamonds has a mean $\delta^{15}N$ value of 0‰ ± 6‰ (Van Heerden, 1994). It is suggested that this $\delta^{15}N$ value is characteristic of well mixed, sub-continental lithospheric upper mantle, in the same way that $\delta^{13}C \approx -5‰$ is accepted as the characteristic mantle carbon isotope signature.

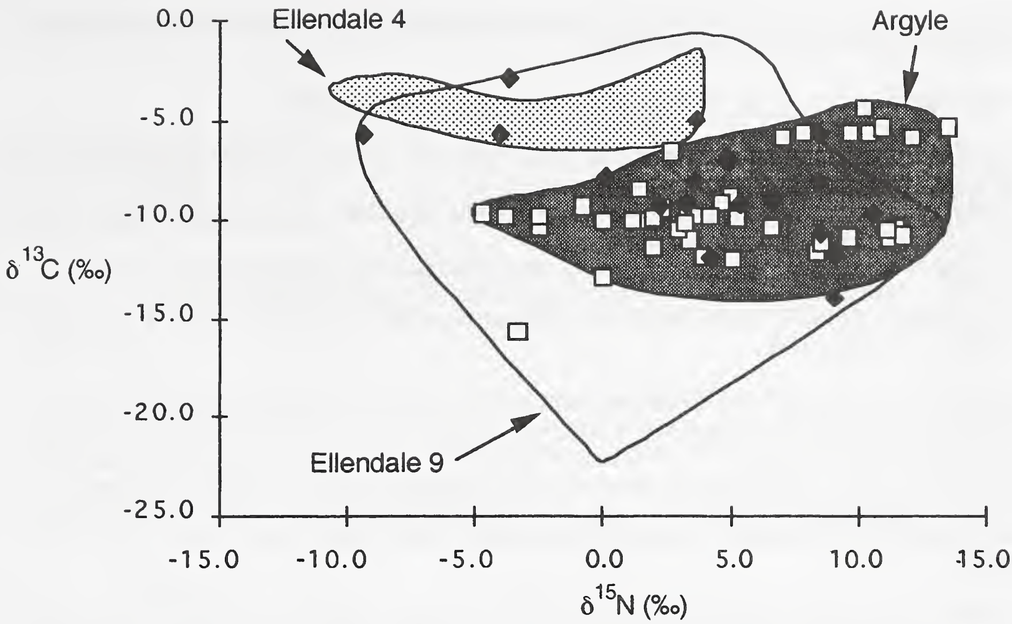

Figure 3: $\delta^{15}N - \delta^{13}C$ covariation for W.A. diamonds. Fields for individual lamproites are shown. Filled symbols are individual lherzolitic diamonds. Eclogitic diamonds are are shown by open symbols.

The large variation in C and N stable isotope ratios within diamonds, and the causes of their covariation clearly warrant further investigation.

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