

# TRACE ELEMENT ANALYSIS OF DIAMOND BY LAM ICPMS: PRELIMINARY RESULTS

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Mantle-derived diamonds provide valuable insights into mantle processes at high temperatures and pressures. During crystallisation, diamonds commonly include small silicate, oxide and sulfide inclusions and incorporate minor and trace elements such as nitrogen and boron in their crystal lattice. The study of these inclusions can yield information about the chemical, isotopic and mineralogical composition of the host rocks and nature of the fluids from which the diamonds were formed

The trace element composition of diamond may provide information on the conditions and environment of diamond crystallisation. Characterisation of these patterns also may prove useful in recognising diamonds from different sources. We have analysed 115 diamonds for trace elements using a 266nm laser microprobe, attached to an Agilent 7500 ICPMS. The diamonds come from a range of localities including Siberia, Eastern Australia (Wellington and Bingara), Brazil (Juina), Canada (Slave) and Thailand. We also have analysed fibrous diamonds from Jwaneng (Botswana) and Central Africa. The study includes both gem-quality and industrial-quality stones; the latter have higher trace element contents.

Analyses were performed in two stages; (1) using a trace element-doped oil as external standard and carbon as the internal standard to measure Mg, Al, Ca and other trace elements; (2) using Mg, Al or Ca as the internal standard to determine other elements with the NIST 612 glass as the external standard.

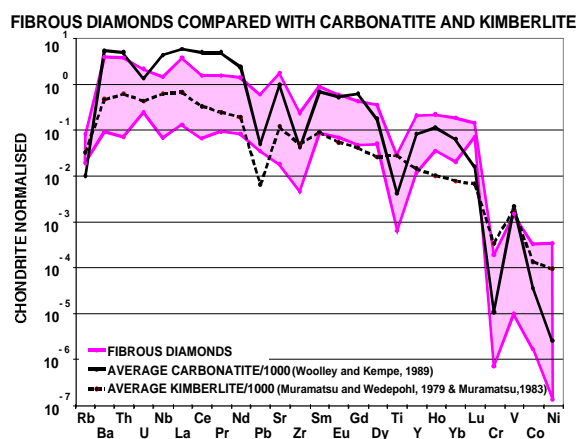
Based on their syngenetic mineral inclusions, diamonds can be grouped into two main associations, the peridotitic suite, consisting of olivine, ortho-pyroxene, clino-pyroxene and pyrope garnet, and the eclogitic suite, which includes omphacitic clino-pyroxene, garnet, rutile etc. (Meyer, 1987). Superdeep diamonds are characterised by ultra high-pressure phases such as ferropericlaase and perovskite (Kaminsky et al, 2001). Mineral inclusions were used to classify the diamonds into eclogitic, peridotitic, superdeep parageneses. The

diamonds from Eastern Australia were further classified into Group A and Group B based on their morphological features, mineral inclusions, carbon isotope signatures, nitrogen content and aggregation state and internal structure (Davies et al, 2002).

The analyses of the fibrous diamonds have been used as a basis against which the other diamonds are compared. Unlike most diamonds, these stones have grown very rapidly in the kimberlite magma itself, during its ascent to the surface, and their fibrous structure has trapped samples of the growth medium. These micro-inclusions represent syngenetic mantle fluids under high pressure (e.g. Navon et al., 1988; Navon, 1991).

The trace elements in the fibrous diamonds such as K, Na, Rb, Sr, Zr, Cs, Ba, Hf, Ta, Th,U and the LREE elements exhibit a wide range in concentrations. This depends on the concentration and distribution of the micro-inclusions between the fibres of the diamond.

The range of concentrations obtained for the JWA 115 diamond from Botswana (Table 1), compares well with



**Figure 1:** Trace element patterns in fibrous diamonds compared with those in carbonatite and kimberlite

the NAA analyses of Schrauder et al. (1996), and illustrate the heterogeneity of such fibrous stones.

The fibrous diamonds all have very similar chondrite-normalised trace element patterns with moderate LREE enrichment. No Eu anomaly is observed but Zr, Ti, Pb and Nb show pronounced negative anomalies. This pattern strongly resembles those of average carbonatite and average kimberlite but the strong negative HFSE anomalies are more similar to the carbonatite pattern.

**Table 1. Diamond Trace Elements**

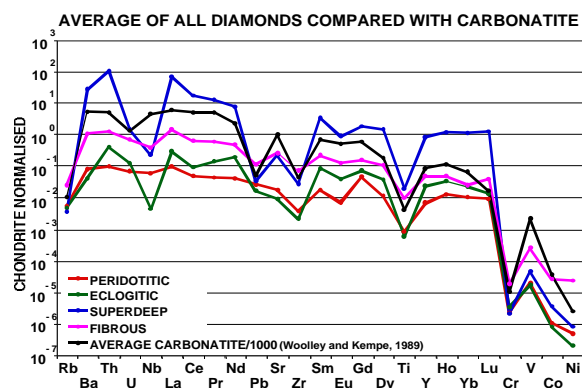
ppm	-----This study -----			Schrauder et al., 1996	
	Minimum	Maximum	Avg. (n=6)	Minimum	Maximum
Ti	6.36	12.5	9.24	-	-
Rb	0.054	0.183	0.119	0.403	0.587
Sr	1.48	12.1	5.30	1.95	2.40
Y	0.053	0.321	0.151	0.000	0.000
Zr	0.140	0.336	0.241	0.420	0.503
Nb	0.061	0.129	0.096	-	-
Ba	1.63	8.28	3.63	1.902	3.712
La	0.115	0.764	0.391	0.133	0.238
Ce	0.171	0.913	0.444	0.223	0.403
Pr	0.019	0.140	0.065	-	-
Nd	0.081	0.623	0.300	-	-
Sm	0.014	0.131	0.049	0.016	0.029
Eu	0.004	0.032	0.014	0.007	0.011
Gd	0.009	0.076	0.034	0.010	0.020
Dy	0.012	0.085	0.035	-	-
Ho	0.002	0.012	0.005	-	-
Yb	0.003	0.014	0.009	0.003	0.005
Lu	0.003	0.003	0.003	0.000	0.001
Pb	0.085	0.108	0.097	0.000	0.000
Th	0.019	0.095	0.042	0.018	0.036
U	0.002	0.015	0.006	0.010	0.010

The superdeep diamonds show negative anomalies in Zr, Nb and Ti and have the negative Pb anomaly seen in the fibrous diamonds. The diamonds from Juina show more enrichment in the LREE than the Slave superdeep diamonds, which have a flatter pattern moresimilar to that of the fibrous diamonds. The Juina diamonds show a negative Eu anomaly whereas the Slave diamonds show a positive one. The Slave diamonds also show strong positive Sr and Y anomalies.

Peridotitic diamonds worldwide show REE patterns that are generally flatter than that of the fibrous diamonds

and have no Eu anomaly. They also are depleted in Ni and Co relative to the fibrous diamonds. The greatest relative LREE enrichment is seen in diamonds from Thailand and Dalnaya (Siberia). HFSE anomalies are widely variable. The Slave diamonds show a positive Nb anomaly and negative Zr and Y anomalies whereas diamonds from Wellington and Thailand show a negative Nb anomaly. Slave, Zarnitsa (Siberia) and Wellington diamonds show negative Sr anomalies.

The eclogitic diamonds show a range in REE patterns. Although most patterns are relatively flat, the diamonds from Wellington are LREE enriched and have a small negative Eu anomaly. Diamonds from the Bingara locality have a similar REE pattern, but lack a Eu anomaly and their HFSE anomalies are much deeper than in Wellington diamonds. Slave diamonds show negative Sr, Y, Ti, Zr and Nb anomalies.



**Figure 2:** Trace elements in all diamonds compared with those from carbonatite.

The broad similarities in trace element patterns in samples analysed thus far suggest a genetic relationship to carbonatite-like fluids. However, there appear to be some consistent differences between diamonds of different paragenesis, and between diamonds of similar paragenesis from different localities. A larger body of data is required to test these conclusions and further analyses are underway.

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