Micro-inclusions in monocrystalline octahedral diamonds from Diavik, Slave Craton: Clues to diamond genesis

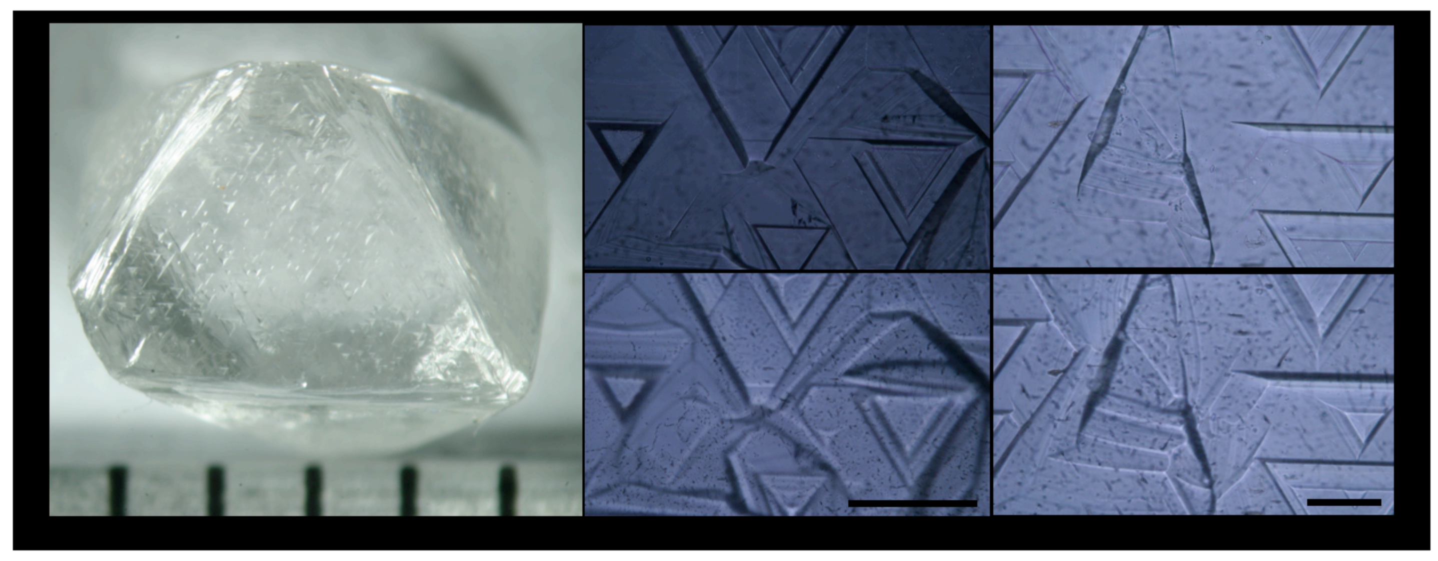
Débora P. Araújo, William L. Griffin, Suzanne Y. O'Reilly

GEMOC, Dept. Earth & Planetary Sciences, Macquarie Univ., NSW 2109, Australia

INTRODUCTION

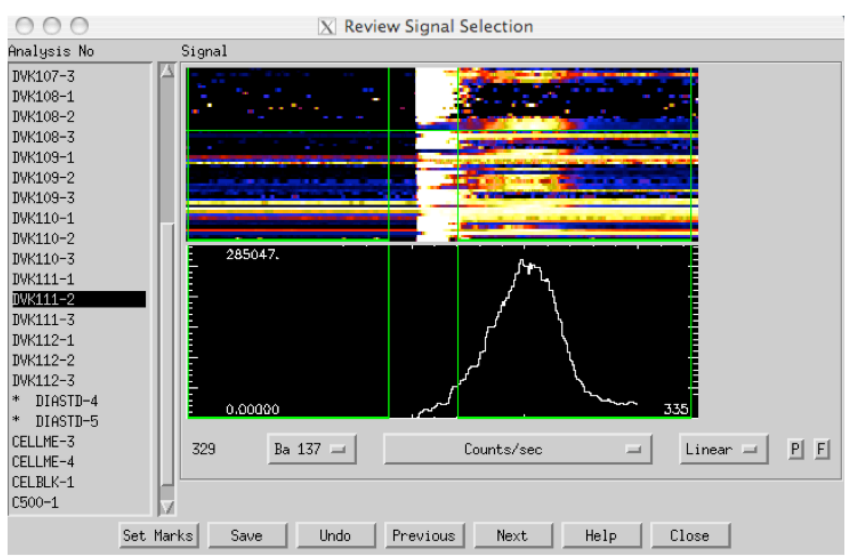
Some gem-quality octahedral diamonds from Diavik Mine, Slave Craton, have abundant shallow planar trigons over part or all their surfaces. Microscope observation of the etched surfaces revealed micro-inclusions (< 0.5 μm) concentrated in layers ~ 10-15 μm beneath the surface (scale bar in middle and right photos is 0.1 mm). Areas with higher concentration of micro-inclusions are separated by curvilinear boundaries from smaller areas where they are absent. The micro-inclusions are rounded with small single fractures extending from them, producing a tadpole-like shape.

Laser cut diamond plates of these diamonds and coated diamonds from this site are compared. The samples were analysed for N content and N aggregation state (FTIR - Thermo Scientific, Australia), trace element contents (LA-ICPMS, GEMOC, Macquarie University, Australia) and δ^{13}C composition (SHRIMP, Australian National University, Canberra, Australia).

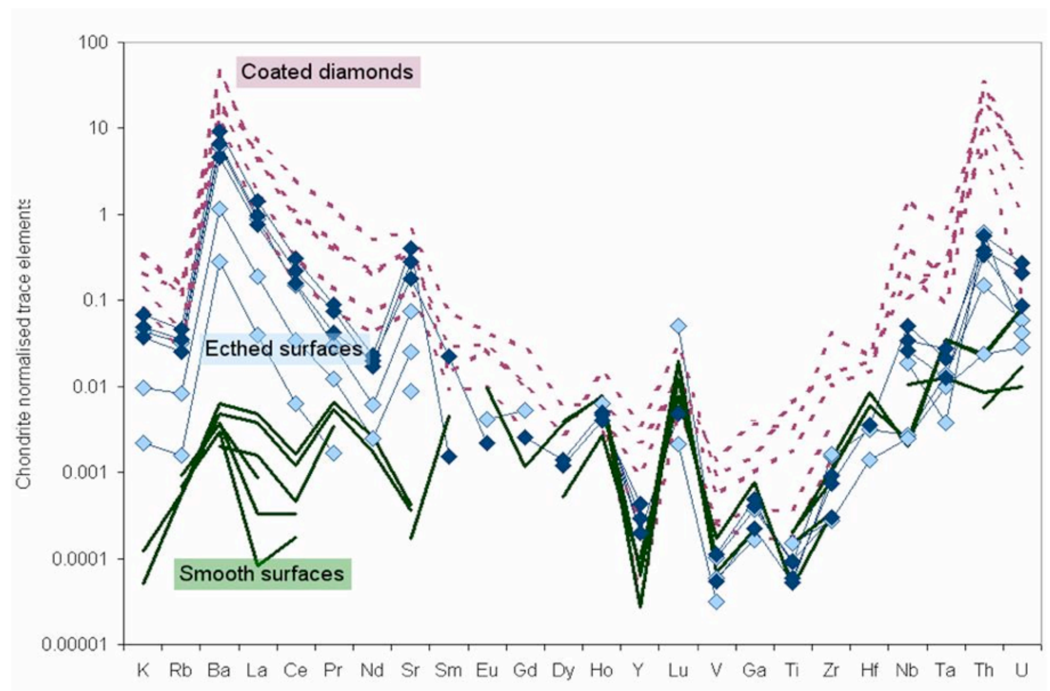


LA-ICPMS ANALYSES OF MICRO-INCLUSIONS

Time-resolved LA-ICP-MS analyses (100 µm spot size) were done on etched and non-etched surfaces. In one diamond (DVK109), ablation of the etched surfaces shows an increase in trace-element contents coinciding with the sub-surface inclusion-rich layers, which are < 40 µm thick. Absolute concentrations change depending on the analysis location, reflecting the abundance of micro-inclusions. Analyses of non-etched surfaces do not show such trace element-enriched layers.



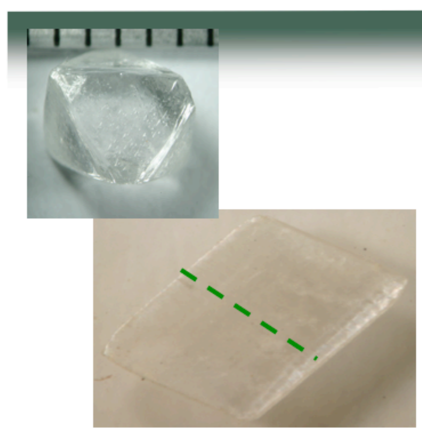
COMPOSITION OF MICRO-INCLUSIONS



The micro-inclusions have high Ba, K, LREE, Ba/La(CN) and Ba/Lu(CN)>>1 and a positive Sr(CN) anomaly relative to Sm, compared to the composition of diamond beneath non-etched surfaces. The CN trace-element patterns of the micro-inclusions are comparable to the coats of coated diamonds from the same kimberlite (Griffin et al. this conference, Abst-102).

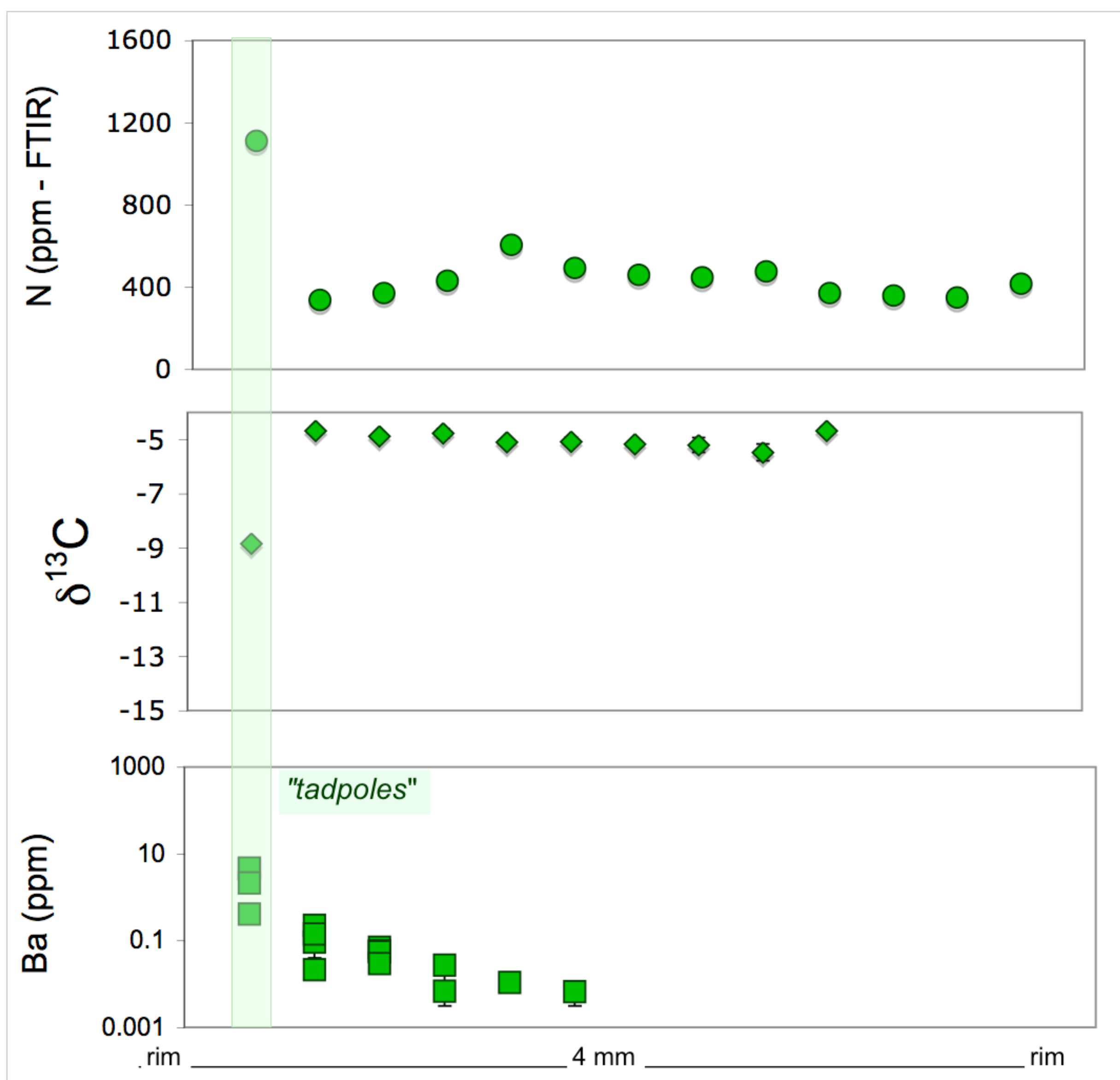
The trace-element levels are intermediate between the levels seen in the diamond coats and the diamond beneath the non-etched surfaces for elements such as LREE, Ba, Th, Nb and Sr, but are similar to the non-etched surfaces for HREE and most HFSE.

MONOCRYSTALLINE DIAMOND



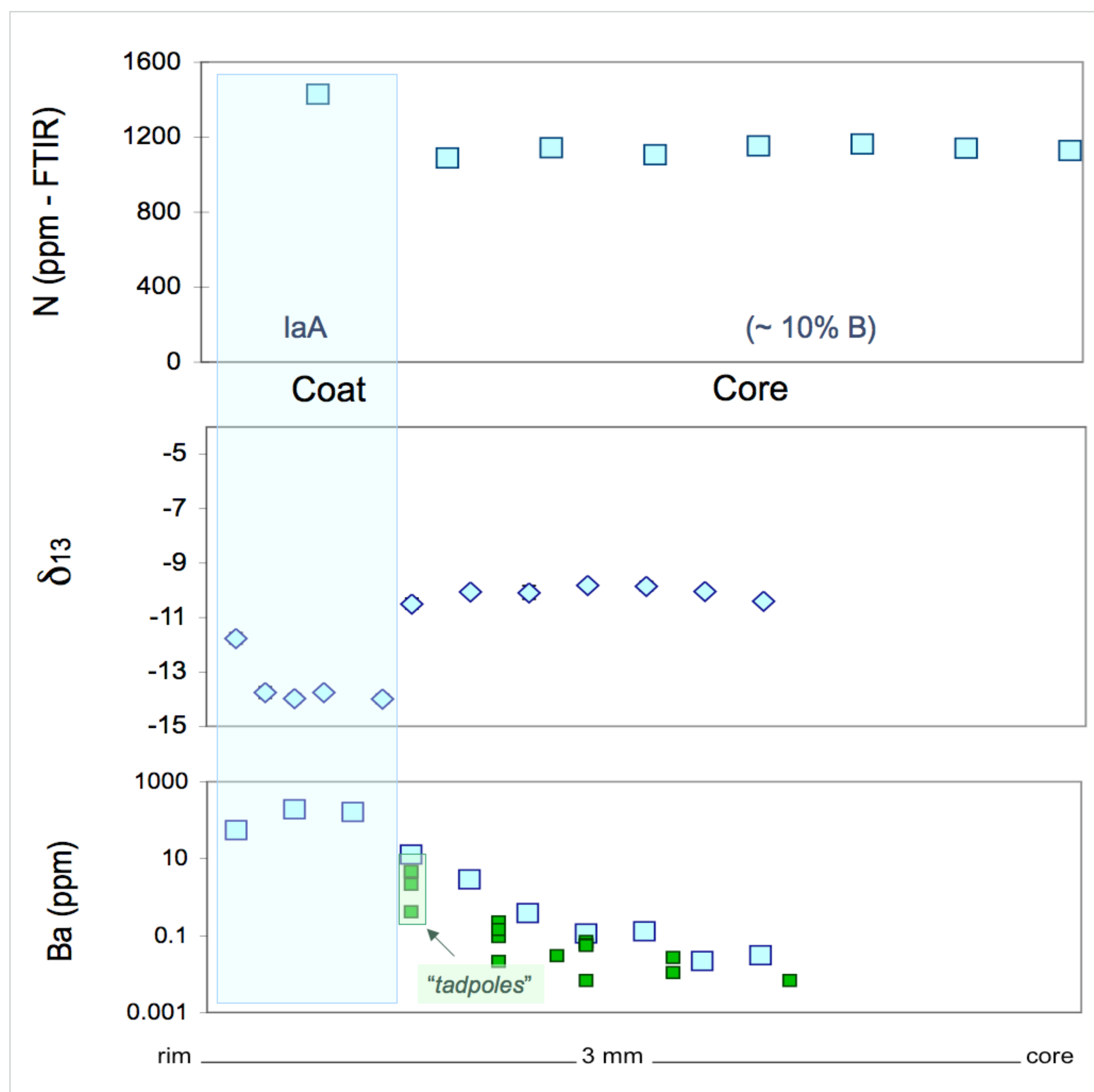
DVK109 (non-polished plate)

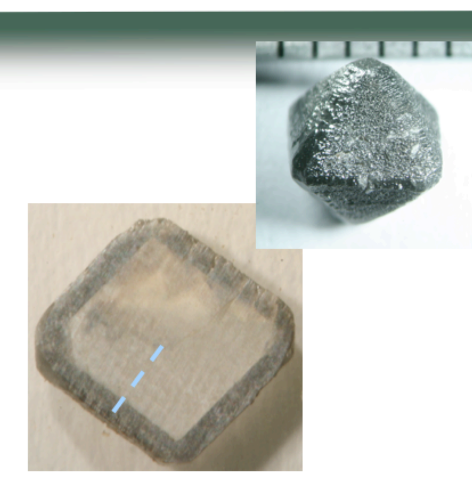
In DVK109, the enriched layer (1st analysis) has higher N (1100 ppm) and trace element contents (e.g. Ba ~ 10 ppm) and depleted δ^{13}C (-8.8‰, 1σ = 0.16) compared to the remaining of the trasverse (average 418 ppm N, 0.06 ppm Ba and -5.0‰ δ^{13}C).



The trace element contents show a decreasing trend towards the center of the diamond to levels below detection limit (<0.01). The diamond is mostly Type IaA, with 4 analyses (core to intermediate, right side) giving IaAB with up to 10% N as B centers.

COATED DIAMOND





DVK127 (non-polished plate)

In DVK127, the coat has higher N (1430 ppm) and trace element contents (average 150 ppm Ba) and depleted δ^{13}C (-13.3‰ average, 1σ = 0.17) compared to the core (average 1090 ppm N, 4.1 ppm Ba and -10.1‰ δ^{13}C). The coat is Type IaA and the core has up to 12% N as B centers.

The trace element contents in the core show a decreasing trend similar to that found in the monocrystalline diamonds with the "tadpoles" (green squares). The core also has similar N content and δ^{13}C composition to the "tadpole" layer.

DIAMOND FORMING-FLUIDS

The fluids forming coated diamonds from Diavik are related to carbonatitic/ kimberlitic melts (Griffin et al. Abst-102; Araujo et al. Abst 139). The chemical resemblance of the "tadpole" micro-inclusions to the fluids trapped in Diavik diamond coats and the outer cores of coated diamonds, and the distribution of micro-inclusions in layers, suggest that such fluids also have been present during the growth of monocrystalline diamonds.

Changes in growth mechanism due to temperature and/or oxygen fugacity variations can influence the incorporation of micro-inclusions through rapid growth (Sunagawa 1984). However, the distinct trace-element patterns of the micro-inclusion layers, the δ^{13}C composition and the N contents suggest that the layers reflect the influx of new fluids into the growth environment. The gradual increase of trace element contents towards the rim in the monocrystalline diamond and in the outercore of the coated diamond may suggest gradual influx of the fluids. The N contents and δ^{13}C compositions would following change sharply with the arrival of more fluid and when the carbon supersaturation is high to promote fast growth.

The distinctly different trace-element patterns between the diamond in the center of the monocrystalline diamonds suggests that these parts of the diamond grew from a fluid quite different from the one trapped in the microinclusions, and in the coats on coated diamonds. The occurrence of the microinclusions as layers within these diamonds suggests that these two different types of fluid coexisted within the local metasomatic environment in which the octahedral diamonds grew.

Araujo et al. 2008. 9IKC, Extended Abstracts 139. **Griffin et al. 2008**. 9th IKC, Extended Abstracts 102. **Sunagawa, I.**, 1984. In: Sunagawa I (ed) Material Science of the Earth's Interior, vol. Terra Scientific Publishing Company (TERRAPUB), Tokyo, pp 303-330