NITROGEN AGGREGATION AND CATHODOLUMINESCENCE CHARACTERISTICS OF DIAMONDS FROM THE POINT LAKE KIMBERLITE PIPE, SLAVE PROVINCE, NWT, CANADA.

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Introduction: The Point Lake kimberlite pipe was discovered near Lac de Gras in the Northwest Territories of Canada in 1991 (Pell, 1994). It was the first of numerous diamondiferous kimberlite pipes located by indicator mineral and geophysical surveys in the central Slave Province. Pipes in the Lac de Gras region intrude Archean metasediments and granite gneiss and in some cases cut dolerite dikes of which various Proterozoic swarms are recognized. Radiometric dating of two pipes in the Lac de Gras region have given Eocene ages. During 1992, bulk testing of 160 tonnes of drill core from the Point Lake kimberlite yielded a total of 101 carats of diamond of which approximately 25% were gem quality (Pell, 1994). In this study, a selection of macrodiamonds (+3 fraction) and ~1 mm-sized diamonds (-3 fraction) were examined. From the mm-sized stones, a representative sample was chosen for detailed infrared (IR) spectral and cathodoluminescence (CL) investigation. Some large diamonds were polished on opposing faces to reveal internal structure.

Results: In terms of external morphology, colour and resorption history, the Point Lake diamonds of both size ranges show great diversity. Diamond morphologies range from colourless octahedra through resorbed dodecahedral forms and unusual dendritic shapes to cubes. The cubes include translucent to opaque coated (i.e. overgrown) stones some of which are distinctly milky in colour due to the presence of abundant carbonate. Occasional clear diamonds have "exploded cores" containing high pressure CO_2 and carbonate. Several diamond specimens show strong surface etching and graphitization presumably arising from interaction with volcanic gases at high levels in the pipe.

The nitrogen aggregation characteristics of the Point Lake diamonds are as diverse as their physical character. Quantitative IR analyses indicate the diamonds span a large range of aggregation states from >95% (i.e. dominantly type IaB diamond) to <0.5% (i.e. pure type IaA) and a range of nitrogen concentrations from ~25 to 1600 atomic ppm with most diamonds having N contents in the 400 to 800 atomic ppm range. On a nitrogen aggregation plot for the mm-sized diamonds (Fig. 1), three broad groups can be identified based on aggregation state and platelet peak position (related to platelet size). These are (i) a high temperature group with nitrogen aggregation temperatures T(NA) > 1100°C, normal platelets (≤1370 cm-1), and a dominance of brown to pale brown colours arising from plastic deformation; (ii) a low temperature group with T(NA) < 1100°C, unusually small platelets (≥1371 cm-1), and a dominance of colourless to pale pink colours; and (iii) a group of pure IaA stones including coated diamonds and cuboid/dendritic forms. Type II (i.e. nitrogen-free) diamonds are comparatively rare. Under CL, the polished diamond plates show multistage growth histories with at least three growth stages represented in some specimens. The high T(NA) diamonds are characterized by plastically deformed cores and younger overgrowths with differences in T(NA) values between core and rim of >100°C. In the low T(NA) diamond plate B15 (Fig. 2), an oval "seed" diamond of cuboid growth form with pink CL colours and high hydrogen occurs in the growth centre, but not the geometric centre, of the specimen. It is surrounded by a zone of low nitrogen diamond with no CL response and this is overgrown by octahedral zones with more usual blue CL colour. T(NA) values vary from ~1095°C in the core region to ~1071°C in the outer rim assuming a Proterozoic mantle residence time (tMR ~2 Ga).

Discussion: The Point Lake pipe has sampled a number of different diamond populations having various formation ages and depths of origin within the lithosphere.

The plastically deformed cores to the high T(NA) diamonds presumably represent an old Archean diamond growth event. Some of the later diamond growth periods may correlate with magmatic events that affected the Slave Province during the Proterozoic. The last diamond growth event resulted in pure type IaA diamonds including coated stones. If these diamonds grew under relatively low T conditions at ~1050°C, near the top of the diamondiferous lithosphere, then their nitrogen aggregation characteristics constrain their formation age to between 10 and 200 Ma before kimberlite eruption.

References:

Pell, J. (1994) Kimberlites and diamond exploration in the central Slave Province, NWT. EGS 1994-7, NWT Geology Division, Yellowknife.

FIG. 1 POINT LAKE MM-SIZE DIAMONDS

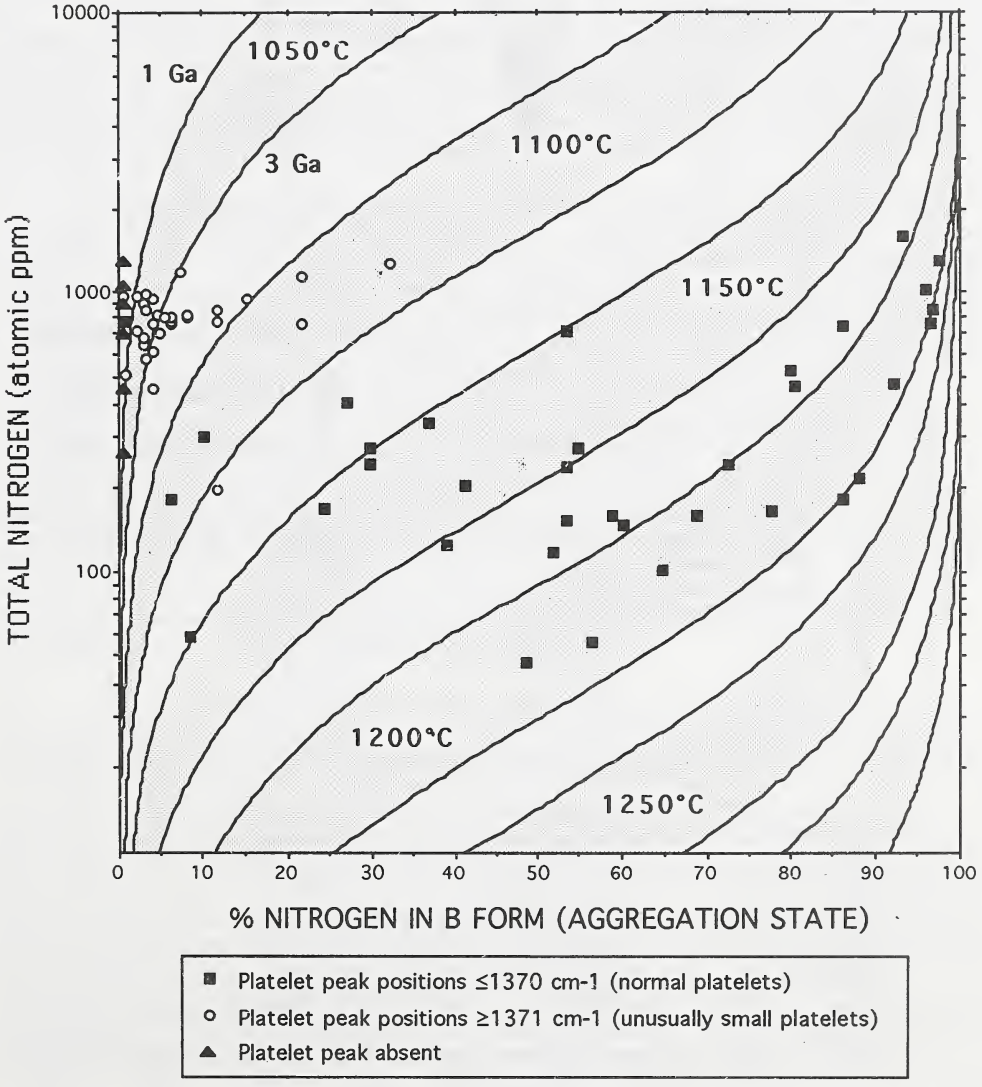

FIG. 2
POINT LAKE
PLATE B15