The Micro-/Macro-Diamond Relationship: A Preliminary Case Study on Diamonds From Artemisia Kimberlite (Northern Slave Craton, Canada)

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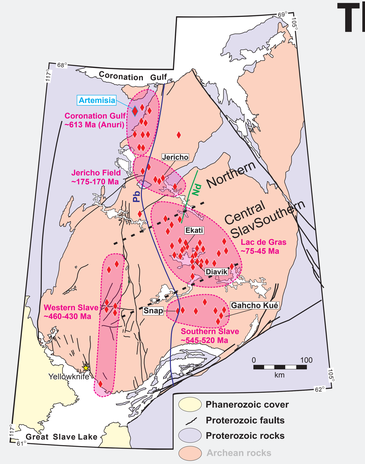

Figure 1. Map of kimberlite occurences and kimberlite fields on the Slave Craton (redrawn after Bleeker and Hall,2007). Bleeker, W., and Hall, B., 2007, The Slave Craton: Geology and metallogenicevolution, in Goodfellow, W.D., ed., Mineral Deposits of Canada: A Synthesis of Major Deposit-Types, District Metallogeny, the Evolution of GeologicalProvinces, and Exploration Methods: Geological Association of Canada, MineralDeposits Division, Special Publication No. 5, p. 849-879.

Introduction

Micro-diamond size distributions are currently a standard tool for the prediction of macro-diamond grade from relatively small exploration samples. Problems with this approach have, however, become apparent e.g. Wawa (Ontario), where high micro-diamond counts lead to significant exploration expenditures but a matching macro-diamond population could not be established.

In this ongoing project we aim to verify the complexities arising from the possible presence of multiple diamond populations in a single deposit through a detailed comparison of quantifabile diamond characteristics determined on a series of size classes from the micro- to the marco-diamond scale. We are in the process of determining the carbon isotopic ($\delta^{13}C$) and the nitrogen characersitics (nitrogen abundance and aggregation state) of a set of ~ 400 micro- (<0.5mm) and macro-diamonds (>0.5mm) from the Artemisia kimberlite, located within the Coronation diamond district of the Northern Slave Craton (Figure 1)

Methods

The carbon stable isotopic composition ($\delta^{13}C$) of a first batch of micro-diamonds was analysed by secondary ion mass spectrometry (SIMS) at the University of Edinbrugh (EIMF). Analytical precision is about ±0.2‰ (1 sigma). For diamonds with a mass>0.5mg, $\delta^{13}C$ can be determined through conventional sealed tube combustion technique and subsequent gas-flow mass spectrometry established at the University of Alberta. Analytical precision is about ± 0.05‰ (1 sigma). The convention analysis of macro-diamonds has just begun.

Nitrogen abundance (atomic ppm) and aggregation states (relative precentage of the highly aggregated B-centre) for micro- and macro-diamonds were determined through FTIR spectroscopy. Spectral deconvolution was achieved through software developed by D. Fisher (DTC Research Labs, Maidenhead, UK). The detection limit for nitrogen is 5-10at.ppm, analytical precision is about 10% relative for concentration and aggregation state determinations.

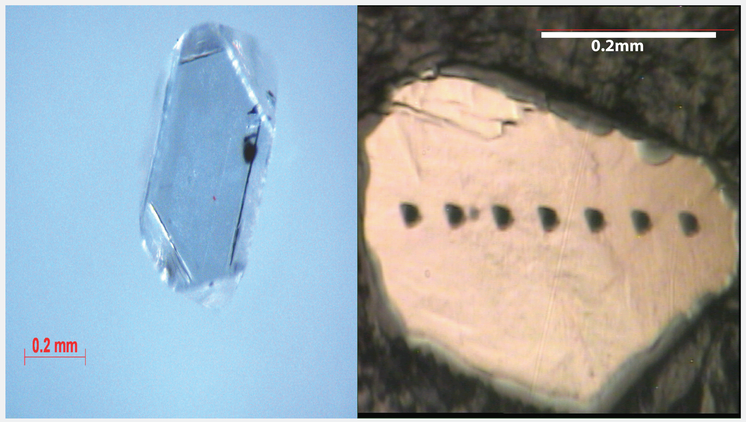

Figure 2. Sample Art-30 prior to (left) and after SIMS analysis (right). The dark spots represent individual analyses

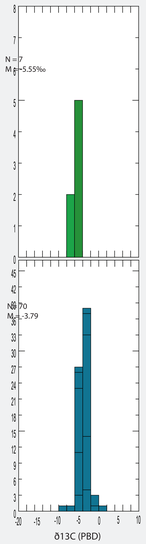

Figure 3. Carbon stable isotopic compositions of micro- (blue) and macro-diamonds (green) sample populations from the Artemisia kimberlite

Results

The micro-diamond sample set (N=70) displays a range in $\delta^{13}C$ from +1.6‰ to -9.2‰, with a mean value of -3.8‰ (Figure 3). Preliminary results for macro-diamond samples (N=7) indicate a range in $\delta^{13}C$ between -4.3‰ and -6.7‰, with a mean value of -5.6‰ (Figure 3).

Nitrogen abundances for micro-diamonds (N=18) were determined to range between 11 and 644 at.ppm, with a mean value of 175at.ppm. For the macro-diamond samples (N=45) a range from 18 to 1840 at.ppm with a mean value of 276 at.ppm was established. Aggregation states range from 10 to 100 %B for the microdiamonds and 2 to 100% for the macro-diamonds.

Discussion

At Artemisia, the compositional range in $\delta^{13}C$ appears to be broader in the micro-diamond sample set. The mean values are also shifted, from -3.3‰ for the micro-diamonds to -5.6‰ for the macro-diamond samples

Slight variations in mean $\delta^{13}C$ can also be observed when comparing a number of sieve classes (Figure 5). The micro-diamond sample set can be divided into 5 classes, and from finest to coarsest the mean shifts from -3.7‰(0.212mm sieve) to -4.1‰ (0.450mm sieve). At this time, the analyzed macro-diamond samples all belong to one sieve size (0.600mm), with an associated mean $\delta^{13}C$ value of -5.6‰. If significant, these vairations in carbon isotopic composition can be attributed to distinct diamond sources or diamond forming fluids.

Nitrogen abundances and aggregation states in both macro- and micro-diamond populations display a wide range in values and at this stage apparent differences are not statistically significant.

in view of the small number of macro-diamonds currently analyzed, the range and mean value of $\delta^{13}C$ for this size class are poorly constrained. Variations among different size classes of micro-diamonds overlap within the 2 sigma range $\delta^{13}C$ analyses via SIMS. Before more analyses are completed it cannot be concluded whether geochemical variability exists between the micro- and macro-diamonds from Artemisia

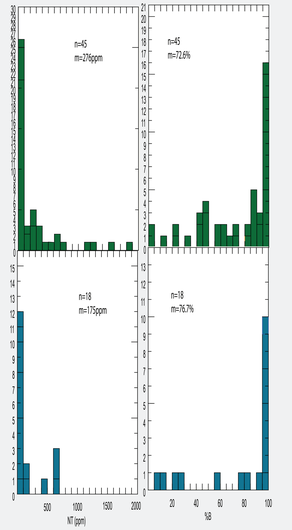

Figure 4. Nitrogen abundance and aggregation state of micro- (blue) and macro-diamonds (green) from the Artemisia kimberlite

Acknowledgements

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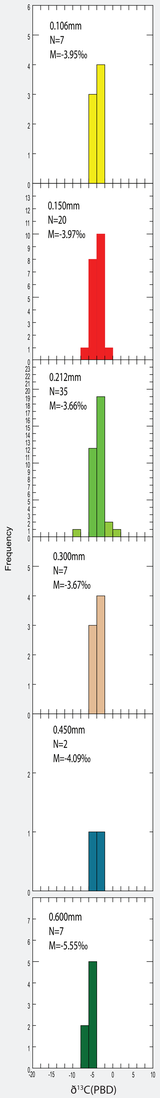

Figure 5. Histograms of carbon stable isotopic compositions of analysed diamonds from the Artemisia kimberlite. Plots are sorted by size class.