

## Diamond forming fluids from Snap Lake – a comprehensive study.

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### Introduction

Sub-micrometer inclusions in fibrous diamonds carry high-density fluids (HDFs) from which the diamonds have precipitated. The trapped material remains shielded from any changing conditions during further diamond growth or later mantle metasomatism. Thus, the analysis of diamond microinclusions is a major tool for the direct study of mantle fluids. The trapped HDFs are rich in volatile species along with solutes varying between three end-members: (a) a silicic end-member rich in water, Si, Al, and K; (b) a carbonatitic end-member rich in carbonate, Mg, Ca and K and (c) a saline end-member rich in water, Cl and K (Schrauder and Navon, 1994; Izraeli et al., 2001). The fluids are characterized by steep REE patterns, enrichment in LILE and relative depletion in HFSE (Schrauder et al., 1996; Zedgenizov et al., 2007; Weiss et al., in press).

We explored the major and trace element composition and the radiogenic isotopic ratios, of the HDFs trapped within micro-inclusions in six fibrous diamonds from Snap Lake, (NWT-Canada) and conducted a FIB/TEM study of the diamonds.

### Results and discussion

Using FIB, five foils were cut out of three diamonds, allowing TEM analysis of 21 microinclusions. The inclusions carry crystals, quenched amorphous material together and voids that were probably filled with a fluid prior to the inclusion rupture (Fig 1). The main crystalline phases in the inclusions are mica, carbonate

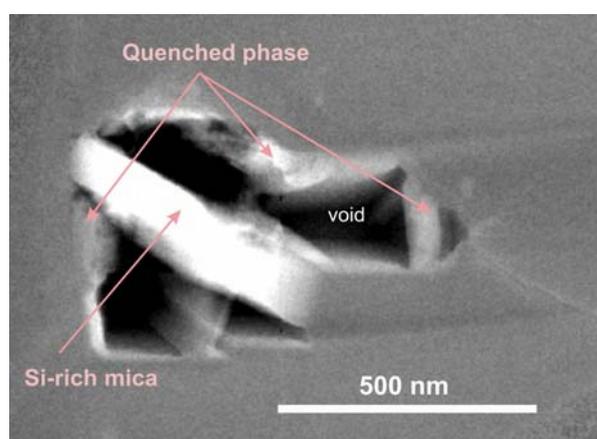


Figure 1: A mica bearing micro-inclusion were and apatite; both Ba-Sr-Ca and Fe-Mg carbonates were detected. Non crystalline material was typically rich in SiO<sub>2</sub>. In some cases minute KCl quenched products were found in the inclusions and a rare Ba-sulfide phase was found in one of the inclusions. The mica composition in most cases had excess Si similar to the high silica mica identified within carbonatitic-silicic diamond microinclusions from Diavik (Klein-BenDavid et al., 2006).

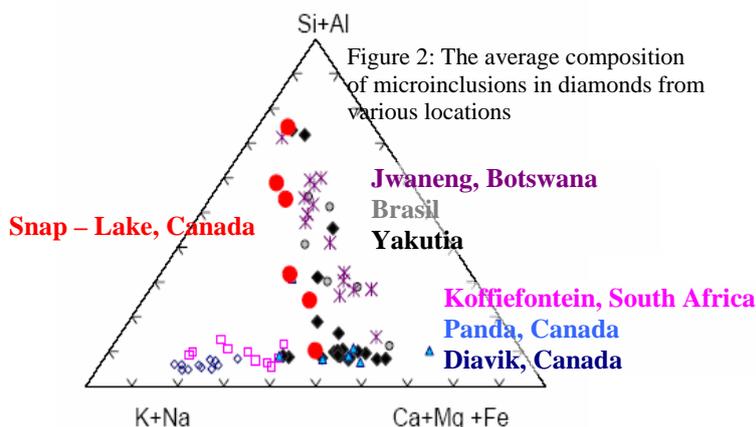


Figure 2: The average composition of microinclusions in diamonds from various locations

Individual micro-inclusions were analyzed using EPMA. The diamonds plot on a compositional array defined by Botswana diamonds (Schrauder and Navon, 1994) covering the complete compositional range between the silicic and carbonatitic endmembers. Nevertheless, the high alkali content of the diamonds distinguishes this suite from HDFs in diamonds from Botswana, Brazil, Guinea and Russia (Fig 2).

Figure 3 presents the composition of individual microinclusions in the Snap Lake diamonds. Most diamonds show a negative correlation between the MgO and SiO<sub>2</sub> in the fluid. In contrast, diamond SLC-47, the most carbonatitic in this group, has widely varying MgO (13-22 wt%) at relatively constant SiO<sub>2</sub>. The composition and behavior of the fluids in this diamond is similar to the **high-Mg carbonatitic** group observed in diamonds from Yakutia and Guinea (Logvinova et al., 2008; Klein-BenDavid et al., in revision; Weiss et al, 2008). This group is intermediate between the low-Mg HDFs and kimberlites

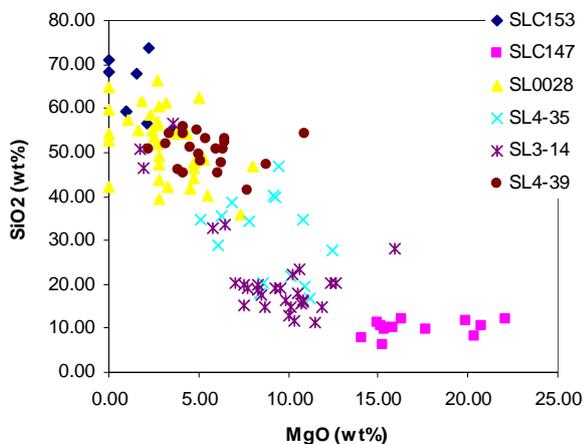


Figure 3: the SiO<sub>2</sub> vs. MgO content of all analyzed microinclusions for each diamond.

Diamond SL0028 spans a relatively wide compositional range with respect to the other Snap lake diamonds, with SiO<sub>2</sub> varying between 36 and 66 wt% (volatile free basis; Fig 3). The diamond is compositionally zoned with higher silica and alumina content in the inner zone and higher TiO<sub>2</sub>, CaO, Na<sub>2</sub>O, P<sub>2</sub>O<sub>5</sub> and Cl content towards the rim (Fig 4). FeO, MgO and K<sub>2</sub>O show no clear zoning. Unfortunately we were not yet able to examine the trace element and

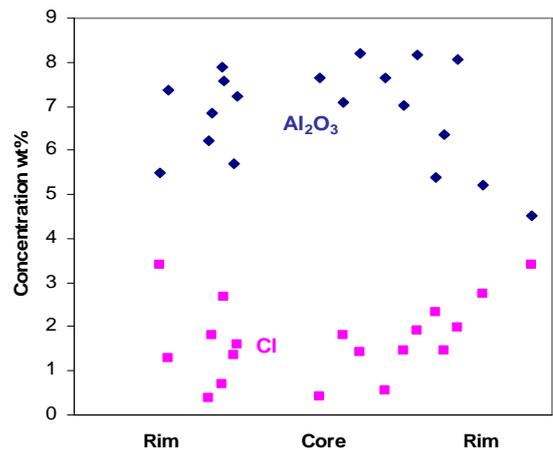


Figure 4: compositional zoning in diamond SL0028

isotopic variation across this diamond.

The trace element composition of the trapped fluids was analyzed in four of the diamonds. All diamonds show steep REE patterns characteristic of diamond forming fluids (Schrauder et al., 1996). On a primitive mantle normalized trace element diagram the fluids show enrichment in Pb and depletion in HFSE. There is a negative correlation between the Th/U ratio and the silica content of the fluids. Two diamonds display a positive Sr anomaly, while others show none. Diamond fluids from Africa show significant depletion in Sr (Schrauder et al., 1996; Klein-BenDavid et al., 2008; McNeill et al., 2008, Weiss et al., 2008). Similar enrichment in Sr was observed in carbonatitic globules within CPX (van Achterbergh et al., 2004). Dalton and Presnall (1998a, b) have shown that low fraction melts of carbonated peridotite evolve from carbonatitic to kimberlitic compositions. Thus the parental fluids for the formation of the Snap-Lake HDFs may be more carbonatitic in composition; whereas higher fraction melts (i.e. kimberlites) are characterized by a negative Sr anomaly and may be more closely related to the African fluids.

The <sup>87</sup>Sr/<sup>86</sup>Sr ratio was measured for three of the diamonds. They are significantly more radiogenic than kimberlites and carbonatites (<sup>87</sup>Sr/<sup>86</sup>Sr up to 0.7085). Their Sr isotopic composition is also more radiogenic than the values reported for fibrous diamonds in Zaire (Akagi and Masuda, 1988). However these

compositions are within the range of fibrous diamond from Botswana and Congo (Klein-BenDavid et al., 2008; McNeill et al., 2008). The Sr isotopic composition of the three Snap Lake diamonds analyzed so far is positively correlated with their silica content. Thus, although the fluids share many common features (e.g. enrichment in alkalis, increased Sr content) and form continuous arrays on oxide vs. silica diagrams, there must be at least 2 isotopically distinct sources involved in forming the variation of Sr isotope.

The continuous compositional spectrum of the Snap Lake diamond-forming fluids and their general similarity in trace element patterns indicates that one of the fluids contains little in the way of solutes but has a significantly different Sr isotopic composition. The Nd isotopic composition was measured for one diamond (SL0028) and has a composition that indicates long-term LREE enrichment ( $\epsilon_{Nd} = -16.2$ ). This value translates to a CHUR model age of 1650 Ma and implies an ancient enrichment event in the lithospheric mantle that subsequently donated solute to the formation of the diamond fluids. The Pb isotopic composition was measured for the same diamond and is significantly enriched relative to the NHRL for both  $^{207}\text{Pb}/^{204}\text{Pb}$  and  $^{208}\text{Pb}/^{204}\text{Pb}$ , also consistent with a long-term U/Pb and Th/Pb enrichment of its fluid source. These features are similar to the observed for diamonds from Botswana (Klein-BenDavid et al., 2008)

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