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Microdiamonds from the Thirsty Lake (Akluilâk) Dyke, Northwest Territories, Canada

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Introduction

The Thirsty Lake dyke forms part of the Akluilâk Dyke system in the central Churchill Province, NWT, Canada. The dyke, interpreted to be a metamorphosed minette (Kaminsky et al., 1998), is extremely rich in micro-diamonds, but markedly poor in macro-diamonds. A 22kg sample yielded >1700 diamonds (MacRae at al., 1995). It is of interest as a non-kimberlitic primary diamond-bearing rock. The Thirsty Lake, North and South Dykes of the Akluilâk system comprise a zone of over 15km in length. Apatite xenocrysts containing monazite inclusions have been dated at 1832 ±28Ma (MacRae et al., 1995). This age is consistent with correlation of the Akuilâk system with the Christopher Island Formation (CIF) of the Dubawnt Supergroup.

Results

Sixty micro-diamonds were studied in terms of colour, morphology and infra-red absorption characteristics. The diamonds show intense colouration, mostly in shades of olive green, yellow, burgundy, and brown. Cubo-octahedral and cubic forms are common, as well as resorbed dodecahedral shapes. Many diamonds appear to be zoned with distinct cores and rims. Carbon isotope analyses were obtained for 30 of the diamonds studied. The range in carbon isotopic composition is from -12.2 to -4.3‰, compared to a range of -16.4 to -3.3‰ reported by Kaminsky et al., (1998). The mode at -7.3‰ is shifted to 'lighter' isotopic values than the 'normal' mode of -5‰ for natural diamonds.

Fourier Transform Infra-Red (FTIR) spectroscopic studies of the diamonds revealed several unusual characteristics, most notably abnormally high nitrogen and hydrogen contents. No nitrogen-free Type II diamonds were detected, and the maximum nitrogen content of 8000 atomic ppm far exceeds that of most natural diamonds. Furthermore, the nitrogen is contained within the Type Ib-IaA aggregation series, in contrast to the Type IaA-IaB series observed in mantle-derived diamonds associated with kimberlites (e.g. Harris, 1992).

Discussion

Survival of relict unaggregated nitrogen defects in the Thirsty Lake diamonds indicates an unusually short mantle residence time and/or low temperatures of equilibration. If the diamonds are assumed to have resided in the mantle for a brief period of 1 Ma, temperatures of 860-990 C would have been required to yield the observed nitrogen aggregation states. This is in stark contrast to the average equilibration temperatures of 1050 and 1250 C for kimberlitic peridotitic and eclogitic inclusion-bearing diamonds respectively, and much longer mantle residence times (>1 Ga; Harris, 1992).

The nitrogen aggregation states of the Thirsty Lake micro-diamonds are comparable to those from ultra-high pressure (UHP) metamorphic rocks of the Kokchetav massif, Kazakhstan (De Corte et al., 1998). However, the Kokchetav diamonds are generally lower in nitrogen content (up to 4500ppm) and do not contain significant concentrations of hydrogen (see Figure 1). The Kokchetav diamonds are considered to have crystallized within the diamond stability field in the crust during an UHP metamorphic event (De Corte et al., 1998). In view of the broad similarities between the Thirsty Lake and Kokchetav diamonds, a similar genesis might be applicable for the Thirsty Lake diamonds. Nonetheless, unlike in Kazakhstan, no other petrological evidence of UHP metamorphism has been documented for the Churchill Province.

It is known from synthetic diamond growth by Chemical Vapour Deposition (CVD) methods that hydrogen species are of importance in promoting diamond nucleation. Considering the elevated hydrogen contents of the Thirsty Lake diamonds, it is possible that the high volatile content (hydrogen and nitrogen) of the diamond growth region may have promoted metastable diamond crystallisation at conditions below the experimentally determined diamond stability field. This would explain the abundance (high nucleation rate) of micro-diamonds and lack of large macrodiamonds.

Conclusion

Thirsty Lake diamonds are envisaged to have grown in a volatile-rich region of the deep crust or uppermost regions of the mantle. Subduction of oceanic crust and resultant metasomatism may have provided the required volatiles including carbon, hydrogen and nitrogen. The geological setting of the occurrence is consistent with this proposal: collision of the Slave and Superior Provinces with the Churchill Province during the 2.0Ga Thelon and 1.9Ga Trans-Hudson orogenies resulted in subduction of oceanic material. The carbon isotopic signature of the Thirsty Lake diamonds is consistent with such an origin.

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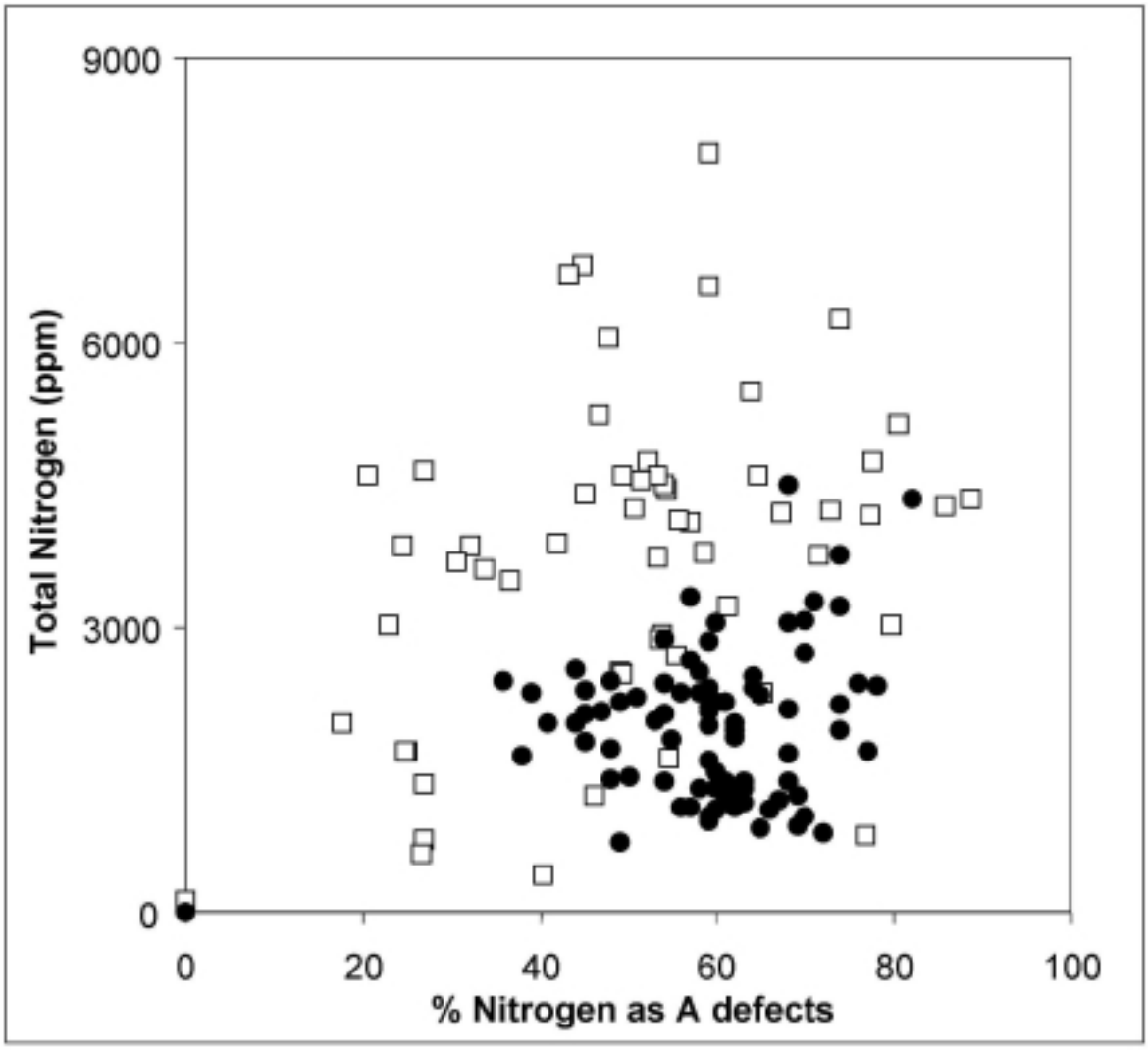

Figure 1. Plot of nitrogen content versus nitrogen aggregation state for diamonds from Thirsty Lake (open symbols) and the Kokchetav Massif (solid symbols; De Corte et al., 1998).

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