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THE EVOLUTION OF KIMBERLITE INDICATOR MINERAL INTERPRETATION ON THE CHIDLIAK PROJECT, BAFFIN ISLAND, NUNAVUT.

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INTRODUCTION

The 858,888 ha Chidliak diamond project (Chidliak) is located on Hall Peninsula at the southern end of Baffin Island, Nunavut, Canada. Kimberlite indicator minerals (KIMs) were first discovered in the region in 2005 by conventional sampling of glacial till deposits at a nominal 15 km grid spacing. This project was jointly funded by Peregrine Diamonds Ltd. and BHP Billiton. Five samples from this survey contained confirmed KIMs. Since 2005, over 3000 glacial sediment samples have been collected at Chidliak at grid spacing ranging from 500 to 2500 m. From these samples, the chemical compositions of 10,715 indicator minerals have been studied. Initial, traditional KIM interpretation revealed promising garnet mineral chemistry with significant numbers of eclogitic and high Cr_2O_3, low CaO (G10) pyrope garnets (Figure 1). The presence of numerous diamond-facies G10D pyropes (see Figure 1) emphasized the likelihood that diamond-bearing kimberlites would be discovered at Chidliak. In addition, chrome diopside thermobarometry delineated a cold, cratonic geotherm that enters the diamond stability field at ~ 900°C (Pell et al., this conference). The first three diamondiferous kimberlites were discovered at Chidliak in August-September 2008, in areas of high-count KIM recoveries. A total of 59 kimberlites has been discovered to date (Pell et al., this conference).

DIAMOND-ASSOCIATED KIMBERLITIC MINERAL COMPOSITIONS AT CHIDLIAK

KIM compositions available to the exploration team at the start of the 2009 field season comprised industry-standard electron microprobe data for 181 chromite, 441 Cr-diopside, 836 ilmenite and 3359 garnet grains derived from 426 KIM-positive sediment samples. Garnets were classified according to the scheme of Grütter et al. (2004, see Figure 1).

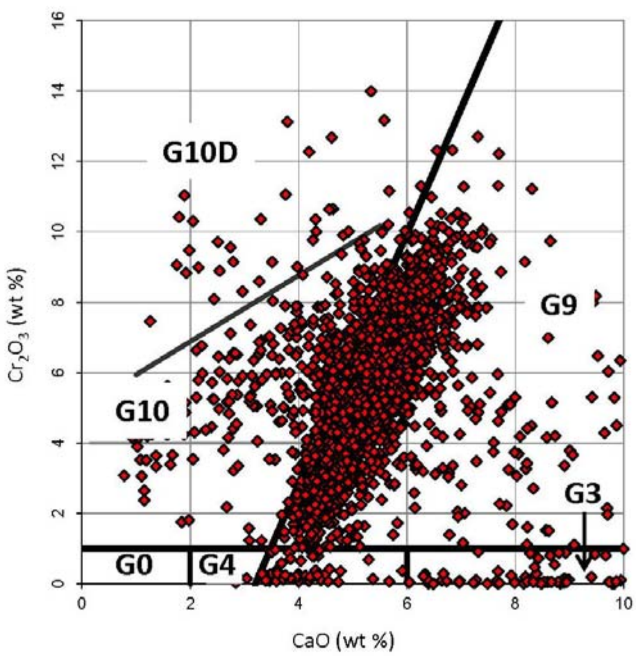


Figure 1: Cr2O3-CaO compositions of garnets recovered from Chidliak sediment samples in 2005 to 2008, with fields from Grütter et al. (2004).

The distribution of 74 G10D, 63 G3D and 29 G4D garnets was used to prioritize prospecting areas and geophysical targets for discovery of diamond-bearing kimberlites. In order to leverage the substantial additional information available for 3193 G9 and other garnet types, the project team also employed and slightly modified the Mn-in-pyrope-thermometry techniques of Grütter and Tuer (2009). Cr-pyropes were categorized as graphite-facies (T <900°C), shallow diamond-facies (900°C< T <1100°C) and deep diamond-facies (T >1100°C), or as high Titanium (G1 and G11 garnets with TiO2 >0.6 wt%) (Figure 2). Areas with higher diamond-facies tenor were accordingly also prioritized, as they were considered to have higher diamond potential. For example, the high proportion of diamond-facies garnets (blue and red colours) in the northern dispersion in Figure 3 was considered more prospective for diamond-bearing source(s) than the southern glacial dispersion train which is overwhelmingly dominated by graphite-facies garnets (yellow).

The discovery of thirteen new kimberlites during the 2009 field season, and assessment of their KIM and diamond content, stimulated further evolution of the interpreted relationships between KIM garnet compositions and the diamond content of Chidliak kimberlites. Summary results presented in Table 1 show that the abundance of diamond-facies eclogitic-websteritic garnets constitutes an important gauge of diamond mineralization. The garnet classification scheme implemented readily separates the important G3D (diamond-facies eclogite) and G4D (diamond-facies websterite-eclogite) garnet categories from compositionally similar G1 (megacryst) garnets (Figure 4).

Based on Table 1, a low tenor of diamond-facies Cr-pyrope garnets (and correspondingly high tenor of graphite-facies Cr-pyrope garnets) should not be interpreted as indicating poor diamond potential at the Chidliak project. This outcome strongly contrasts with examples from the Daldyn-Alakit, Archangelsk and Sarfartoq kimberlite provinces, in which kimberlite diamond content has been correlated with the tenor of diamond-facies Cr-pyrope garnets (Malkovets et al., 2007; Grütter and Tuer, 2009).

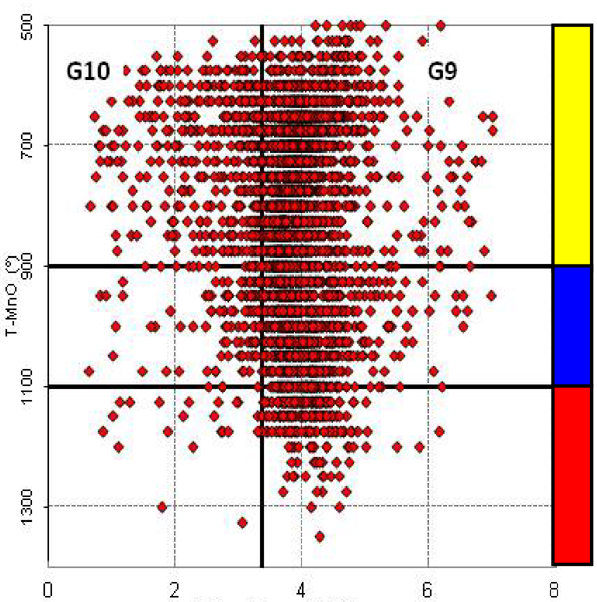


Figure 2: Mn temperature vs. Ca intercept of Cr-pyropes in Chidliak sediment samples. T-Mn <900ºC = graphite-facies (yellow in following figures), T-Mn 900 to 1100ºC = shallow diamond-facies (blue), T-Mn >1100ºC = deep diamond-facies (red)

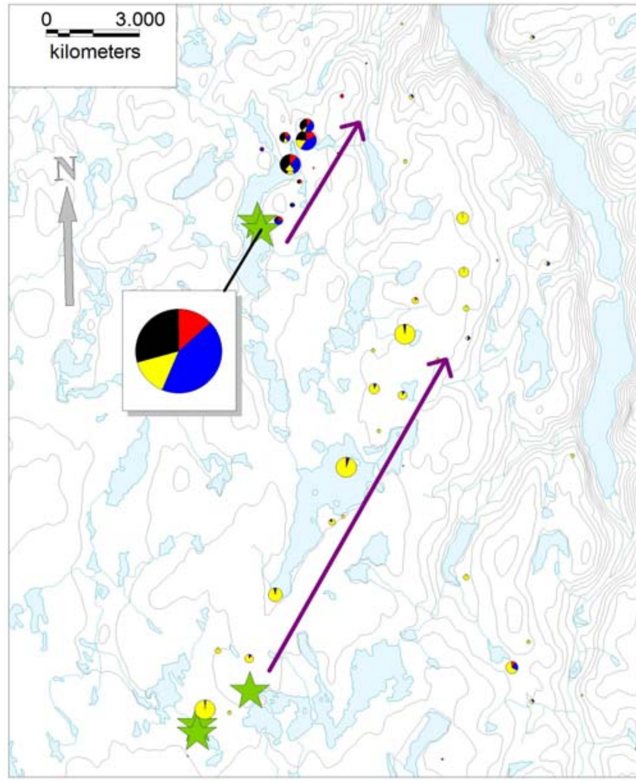
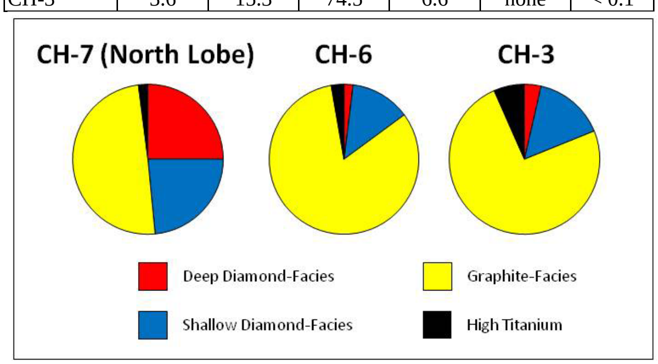


Figure 3: Map of garnet temperature/depth range (colours) and garnet abundances (size of circles) in Chidiak sediment samples. Inset shows garnets from the indicated kimberlite (pie not to scale); see Table 1 for colour legend. Arrows indicate interpreted ice flow direction.

Table 1: Mantle tenor of garnets (in %) and grade of selected kimberlites; tenor expressed as pie diagrams.

Kimberlite Name	Deep Diam. Facies	Shallow Diam. Facies	Graph. Facies	High TiO2	Diam. Ecl. Facies	Grade (ct/t)
CH-6 A	2.0	12.9	82.4	2.7	71.6*	6.8
CH-7 N	30.2	23.5	42.7	3.6	90.1*	1.04
CH-3	3.6	15.3	74.5	6.6	none	< 0.1



*100 x (G3D+G4D)/(G3+G4+G3D+G4D)

It was also recognized that any kimberlite with significant amounts of KIMs was likely to have significant diamond content, and that the source of high garnet counts in sediment samples, regardless of composition, was worth pursuing.

SOURCE FINGERPRINTING AND RESOLUTION OF MINERAL DISPERSION TRAINS

After the 2009 exploration program it was recognized that, on the southern half of the Chidliak project, KIMs were spread over a large area and did not form distinct trains (Figure 5). It was considered unlikely that such a mineral dispersion was related to a single source and it became apparent that a more detailed and innovative interpretation of indicator mineral chemistry was required to discriminate separate sources.

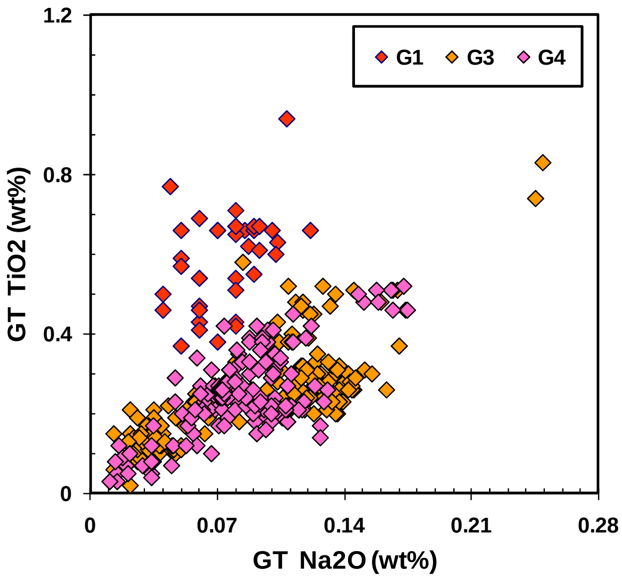


Figure 4: TiO2-Na2O compositions of G1, G3 and G4 garnets recovered from the CH-6 kimberlite. Garnet classification follows Grütter et al. (2004).

The mantle tenor of the garnets in the CH-6 kimberlite (Table 1) is similar to that of garnets recovered from local sediment samples, identifying a train sourced from the CH-6 kimberlite and vectoring to the northeast (Figure 6). The same is true for the northern train in Figure 3. The southern train, with much higher proportions of graphite-facies pyropes, must have a different source(s).

The Chidliak kimberlites sampled the peridotitic mantle lithosphere over significantly variable depth, and that garnet thermometry can be used to "fingerprint" the mantle sampling profile of individual kimberlites. Comparing the "fingerprint" of minerals in known kimberlites to those in the exploration sediment samples resolved mineral trains from known kimberlites and sources yet to be discovered.

Locally, the garnet "fingerprint" in the sediment samples at Chidliak contrasts with those of garnets in nearby kimberlites – a strong indication that there are sources remaining to be found. The northeast-southwest trending mineral dispersion in Figure 7 has high proportions of graphite-facies garnets - much higher than in kimberlites discovered in the area to date.

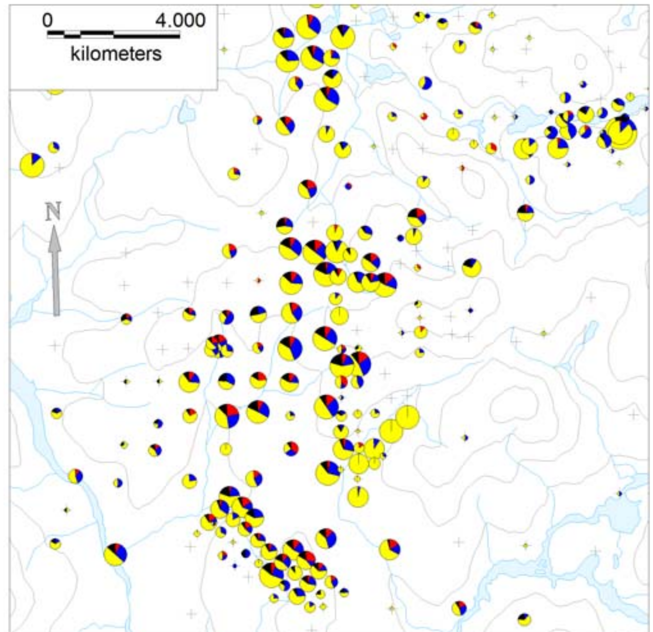


Figure 5: Mantle tenor classes (see Table 1 for colour legend) and abundance (size of pie charts) of garnets in the southern mineral anomaly on the Chidliak project.

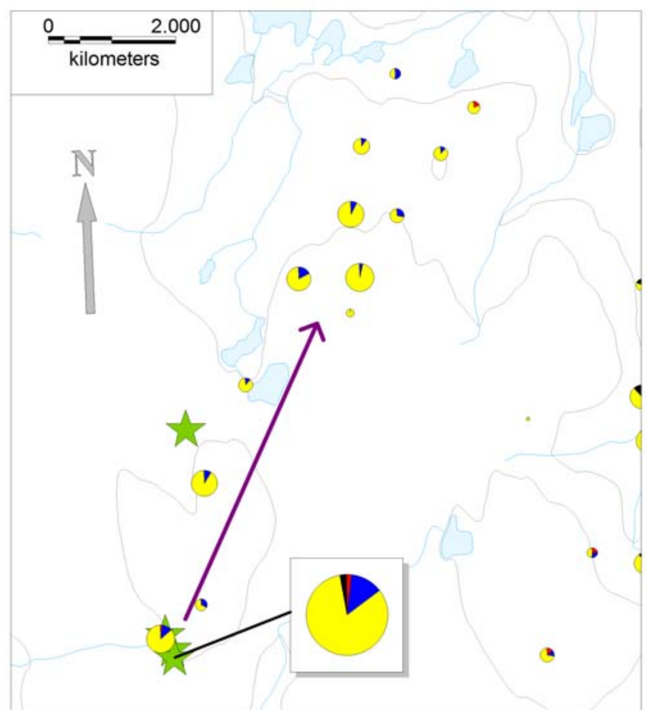


Figure 6: Mantle tenor classes (see Table 1 for colour legend) and abundance (size of pie charts) of garnets in the area of the CH-6 kimberlite. Inset shows garnets from the CH-6 kimberlite (pie not to scale). Green star = kimberlite. Arrow indicates interpreted ice flow direction.

ILMENITE AS A FINGERPRINTING TOOL

Ilmenite has also been a useful tool in resolving individual mineral trains. Kimberlitic ilmenites are chosen using the criteria in Wyatt et al., 2004. When the kimberlitic ilmenites are plotted in Cr_2O_3-MgO space, four distinct ilmenite populations emerge: IL-1 (>1.2 wt% Cr_2O_3, >12.4 wt% MgO), IL-2 (>1.2 wt% Cr_2O_3, <12.4 wt% MgO), IL-3 (0.5<wt% Cr_2O_3<1.2), and IL-4 (<0.5 wt% Cr2O3) (Figure 8).

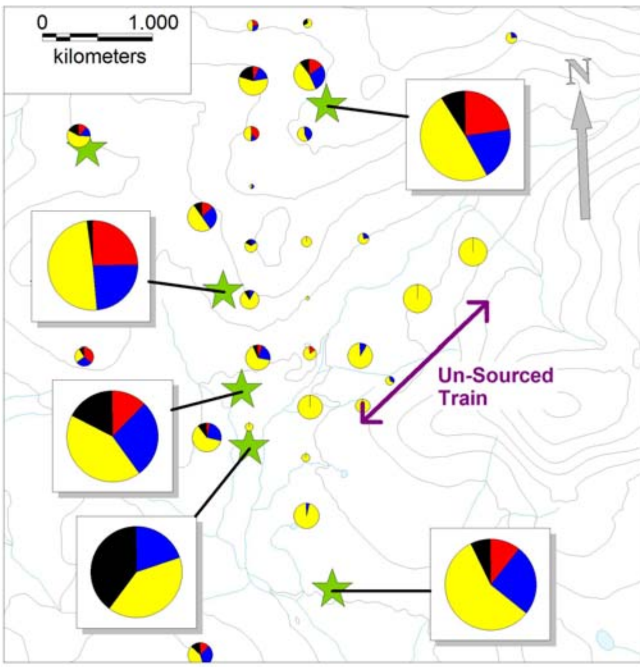


Figure 7: Mantle tenor classes (see Table 1 for colour legend) and abundance (size of pie charts) of garnets in a small area of the Chidliak property. Insets show garnets from indicated kimberlites (pies not to scale). Green star = kimberlite.

Ratios of the four ilmenite populations vary between kimberlites. Within zones of abundant indicator minerals, the variation of the ilmenite population ratios from sediment samples enables the resolution of individual trains. Two kimberlites in Figure 9 have low IL-3:IL-1 ratios, as do the ilmenites recovered from nearby sediment samples, while a kimberlite immediately to the north has a high IL-3:IL-1 ratio (also reflected in the nearby sediment).

IMPLICATIONS FOR ICE FLOW DIRECTION

To date, the glacial history of Hall Peninsula has not been studied in detail. Regional ice flow directions are believed to be dominated by the Hall Ice Divide, with the primary ice flow direction parallel to the ice divide and then emanating to the north and south away from it (Dyke and Prest, 1987).

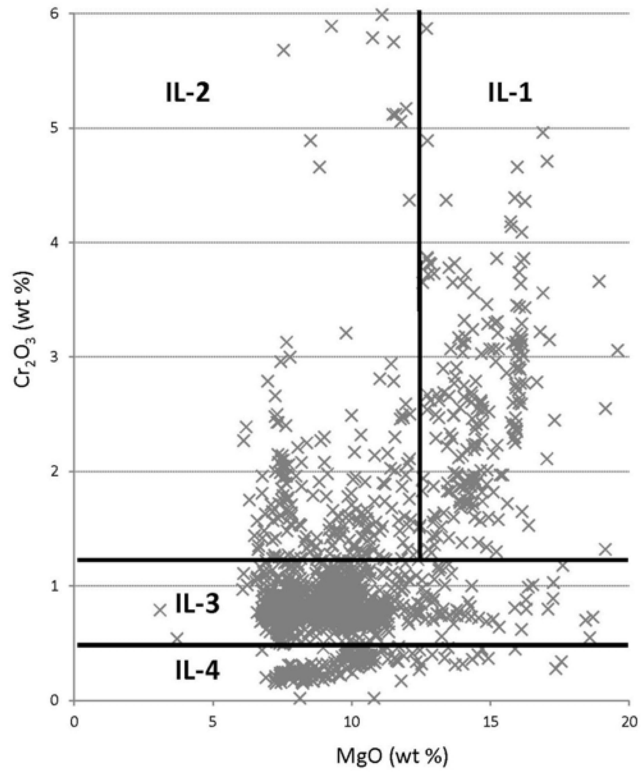


Figure 8: Cr2O3-MgO compositions of ilmenites from Chidliak sediment samples.

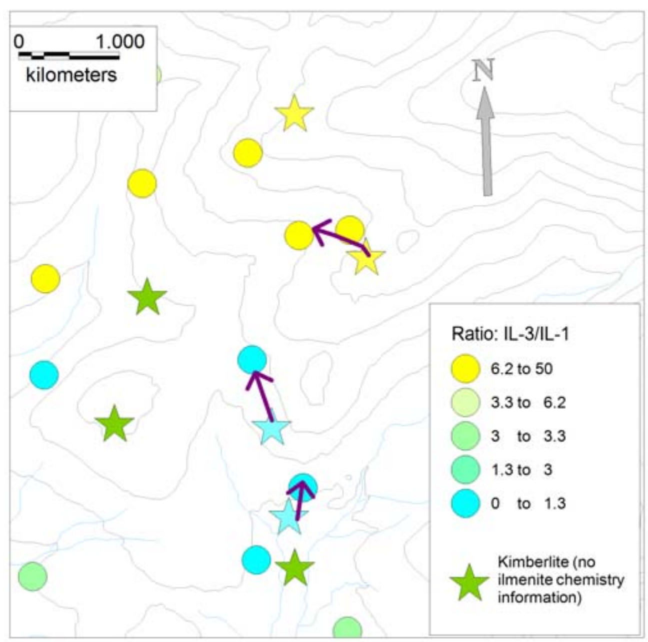


Figure 9: Ilmenite population ratios in kimberlites (stars) and sediment samples (circles) in a selected area of the Chidliak property. Arrows indicate interpreted ice flow direction.

Comparing the mineral chemistry fingerprints from kimberlites with that of till has made it possible to trace the trains from individual sources across the terrain, determining the local ice flow direction.

Travel distances for KIMs across the property are variable, but can locally be quite short (on the order of a few kilometres). Within the area of the southern "cloud" of indicator minerals, sediment appears to have traveled in several different directions, affected more by local topography than by larger-scale glacial flow (Figure 7; Figure 9). This implies that, locally, later stage glaciation, rather than the earlier, regional ice flow, had a greater effect on mineral dispersion (Figure 10).

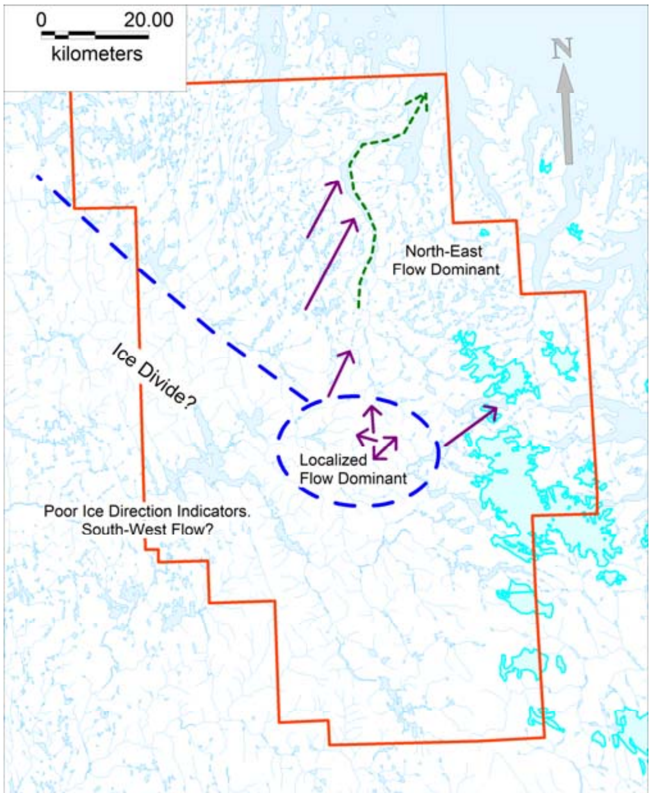


Figure 10 - Glacial flow domains on the Chidliak project (orange boundary). Solid arrows indicate ice flow directions interpreted from mineral dispersion. Stippled arrow indicates generalized northward dispersion of garnets from southern indicator anomaly.

SUMMARY/CONCLUSIONS

The use of indicator mineral chemistry at Chidliak has evolved from a conventional "G10-centered" approach. Garnet thermometry and ilmenite chemistry have been found to be useful in identifying individual sources in an area where there is a "cloud" of indicator minerals. Ratios and concentrations of garnet and ilmenite populations were used to distinguish minerals from known kimberlites relative to undiscovered sources. Mineral trains determined to have come from known kimberlites were used to refine the understanding of the ice directions on Hall Peninsula. Local ice flow directions appear to have locally had more influence on kimberlite indicator mineral dispersion than regional ice flow. There are strong indications in the KIM data that the Chidliak project hosts additional undiscovered kimberlites.

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