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EXPLORATION AND DISCOVERY OF THE CHIDLIAK KIMBERLITE PROVINCE, BAFFIN ISLAND, NUNAVUT: CANADA'S NEWEST DIAMOND DISTRICT

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INTRODUCTION

The southern half of Baffin Island, in the Canadian Arctic, was targeted for greenfields diamond exploration by BHP Billiton and Peregrine Diamonds Ltd. in 2005. The area was selected for exploration because the regional geology was poorly known and the area was thought to be relatively under-explored. Further, 1.85 Ga to 2.92 Ga aged zircons recovered from basement ortho- and paragneisses in the area suggested that at least a portion of the region was underlain by Archean-aged basement. Reconnaissance glacial till samples collected during the summer of 2005 produced kimberlite indicator minerals (KIMs) in what is now known as the Chidliak project area, situated on the Hall Peninsula of southern Baffin Island (Figure 1).

The first kimberlite was discovered in the project area in 2008; Chidliak now hosts 59 kimberlites and 3 kimberlites are present in the adjacent Qilaq project area. The Chidliak/Qilaq kimberlite province now stretches approximately 70 kilometres in a north-south direction and 40 kilometres east-west. Seven kimberlites have been identified to date that demonstrate characteristics consistent with economic potential in Arctic settings: coarse diamond distributions and the presence of gem quality diamonds. Exploration in 2012 will include further evaluation of these kimberlites as well as exploration for new kimberlites with economic potential, which unsourced high-interest mineral trains within glacial sediments suggest should be present.

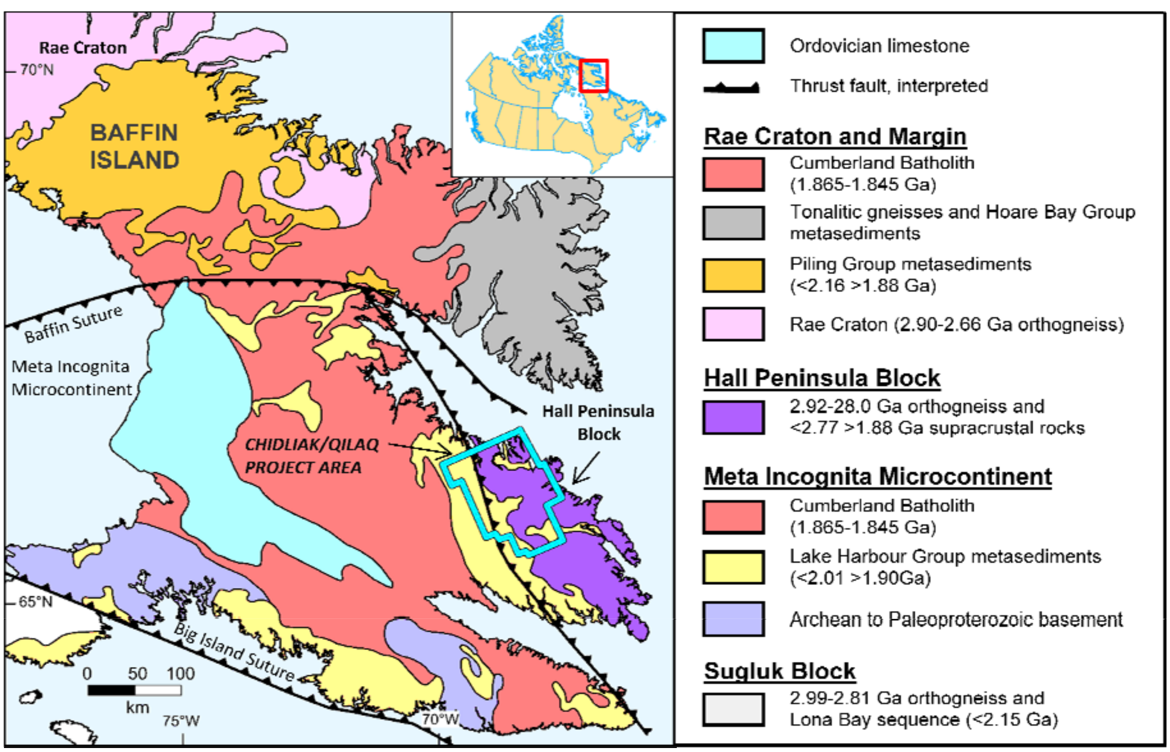


Figure 1. Simplified geological summary map of southern Baffin Island showing major tectonostratigraphic assemblages and bounding crustal structures (after St-Onge et. al., 2006 and Whalen et. al., 2010) with the location of the Chidliak/Qilaq project area.

GEOLOGICAL SETTING

The geology of the Hall Peninsula is poorly understood as it has only been mapped at reconnaissance scale (Blackadar, 1967). Based on this early work and a reconnaissance geochronological study (Scott, 1996), the peninsula has been divided into three major crustal entities (Scott, 1996, 1999; St-Onge, et. al., 2006), which, from west to east, are the Cumberland Batholith, an intermediate belt of Paleoproterozoic metasediments and an eastern gneissic terrain now termed the Hall Peninsula Block (Whalen et. al., 2010). The Cumberland Batholith comprises mainly granulite facies intracrustal (I-type) granitoids that are ~1.865–1.845 Ga in age (Whalen et al., 2011). The intermediate Paleoproterozoic supracrustal belt is a metamorphosed continental margin shelf succession that has been correlated with the Lake Harbour Group strata on MetaIncognita Peninsula (St-Onge, et. al., 2006). The Hall Peninsula block (Whalen et al., 2010) comprises Archean orthogneissic and supracrustals rocks of ~2.92–2.80 Ga and possibly, younger clastic rocks that have been tectonically reworked to some degree (Scott, 1999). All of the kimberlites discovered at Chidliak are hosted by rocks of the Hall Peninsula block (Figure 1).

It has been speculated that the Hall Peninsula block may be: 1) part of the Nain/North Atlantic Craton; 2) reworked Archean gneisses of the Nagssugtoqidian Orogen of west Greenland; or, 3) one of several microcontinents that were accreted during a two-phase, three-way collision of the Superior, Rae and North Atlantic cratons that occurred between 1.865 and 1.79 Ga (Scott, 1996; Snyder, 2010). Modern geological mapping and geochronological studies will be necessary to resolve this quandary.

The Quaternary geology of the peninsula is also complex and poorly understood. The area was inundated with ice during the last glacial maximum by the Laurentide Ice Sheet, and remnants of this ice persist at Chidliak to the present day.

EXPLORATION HISTORY

Kimberlite Indicator Mineral Sampling

After the initial anomalous samples were recovered from the Chidliak project area in 2005, follow-up KIM sampling was conducted in 2006 and 2007. The mineral chemistry of KIMs recovered from sediment sampling and the presence of fragile surface textures on the KIMs suggested that diamond-bearing kimberlites could be present in the region.

To date, over 10,000 KIMs have been recovered and analyzed from samples of glacial sediments collected in the Chidliak project area and the chemistry of over 15,000 minerals recovered from the kimberlites have been studied. Initially, traditional KIM interpretation techniques were applied, revealing promising mineral chemistry with significant numbers of G10 pyropes and sodic low-Cr garnets. Preliminary chrome diopside thermobarometry studies (Figure 2) suggested a cool geotherm (Holmes et. al., 2009). As sample density within the project area increased, it became evident that traditional interpretation techniques were not sufficient to resolve individual mineral dispersion trains, rate their prospectivity, or to link them to their source kimberlites.

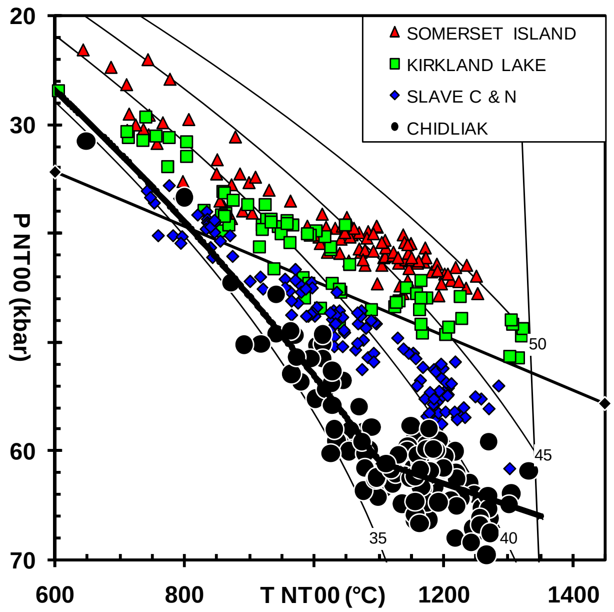


Figure 2: Nimis-Taylor (2000) thermobarometry results for Chidliak CPX in comparison to other Canadian localities. Very deep mantle sampling is indicated, on a partly-inflected (interpreted) geotherm.

Starting in 2009, the Chidliak project implemented newer KIM classification and interpretation techniques similar to those described in Grütter et. al., (2004) and Grütter and Tuer (2009), with substantial emphasis on Mn-thermometry of pyrope garnets. Application of the same techniques on indicator minerals derived from known kimberlites revealed that the integrated approach served to "fingerprint" specific sources and their glacial dispersion in a surprising array of directions (see Neilson et. al., this volume). The KIM distribution is consistent with more traditional picroilmenite "fingerprinting" techniques which can only be applied to the ilmenite-bearing kimberlites. Particular attention was paid to diamond-facies eclogitic garnets as their occurrence has, to date, proved to be a reliable indicator of high-potential kimberlite source(s) at Chidliak. Ongoing interpretation relates to areas with high till sample density and very high background KIM counts, and in the just-completed 2011 exploration season resulted in discovery of four new high-potential kimberlites.

Geophysics

Starting in 2008, a systematic program to collect high-definition helicopter-borne magnetic and frequency domain electromagnetic (EM) data has been undertaken, over KIMpriority areas of the Chidliak and Qilaq projects. To date, a total of 4245 km^2 of Fugro DIGHEM V and Resolve EM data have been collected. Typically, the airborne geophysical anomalies are screened with detailed ground magnetic and EM surveys, and prospecting, and then they are nominated for drill testing, particularly where there is heavy mineral KIM support.

Three types of ground geophysical surveys have been used across the property including ground magnetics, horizontal loop EM surveys, and more recently, capacitively-coupled resistivity (OhmMapper) surveys. OhmMapper was introduced in 2011 to replace the antiquated HLEM technique, and it has been successful in identifying kimberlite body geometry, and in differentiating between lake-bottom sediments and basement features.

Kimberlite Discovery

The first kimberlite (CH-1) was discovered in July 2008 when a kimberlite outcrop was found by prospecting an airborne geophysical anomaly in an area of high-interest KIMs. An initial 289 kilogram sample collected from CH-1 showed the body contained diamonds with a coarse size distribution. The CH-2 and CH-3 kimberlites were also discovered in 2008 by prospecting. In 2009, 13 kimberlites were discovered, six by prospecting and seven by drilling. In 2010, 36 kimberlites were discovered: 34 at Chidliak and 2 at Qilaq. Eleven of these were discovered by core drilling, eight by reverse circulation drilling and 17 by prospecting. In 2011, an additional 9 kimberlites were discovered at Chidliak and 1 at Qilaq, 6 by core drilling and 4 by reverse circulation drilling.

KIMBERLITE GEOLOGY

Surface Expression, Body Morphology and Infill

The Chidliak kimberlites are varied in surface expression. Some are covered by a thin veneer of till with little or no surface expression or are associated with vegetation anomalies. Twenty-two of the 59 kimberlites discovered to date have kimberlite outcrop, subcrop or overlying areas with abundant kimberlite float which, in some cases, occur within significant sub-circular, steep-sided topographic depressions. Only seven of the kimberlites occur under lakes. The plan view sizes of the kimberlites range from less than one to over five hectares.

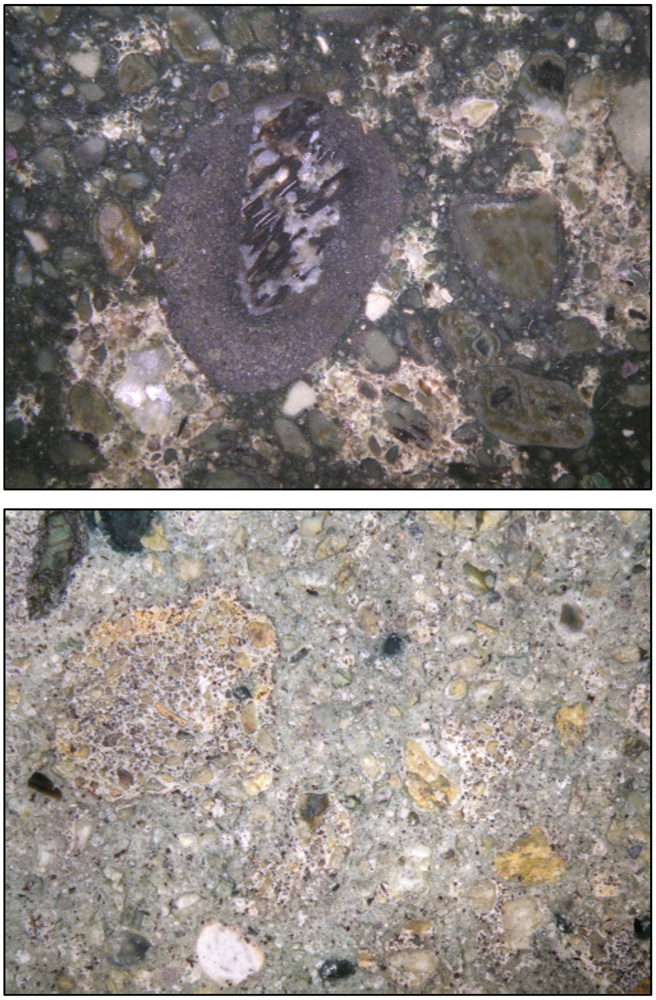
The kimberlites include both sheet-like and larger pipe-like bodies. The rocks forming the bodies contain olivine macrocrysts and phenocrysts as well as varying amounts of mantle-derived xenocrysts (chromian and sodic garnets and chrome diopside +/- picroilmenite and spinel as determined from heavy mineral concentrates). Some bodies contain a variety of fairly fresh mantle xenoliths including garnet lherzolites, garnet harzburgites, websterites and eclogites ranging up to 35 cm. Primary groundmass minerals (or their pseudomorphs) include spinel, perovskite, monticellite, phlogopite, apatite, carbonate and serpentine. These petrographic features indicate that they are kimberlites sensu stricto (Woolley, et. al., 1996) that can be classified as Group I (Skinner, 1986; Smith, 1983) type.

The observed country rocks are basement gneisses. The sheet-like bodies are mainly steeply dipping and composed of typical hypabyssal kimberlite (HK), which may contain basement xenoliths. The pipe-like bodies are different in that all or parts of them contain sedimentary xenoliths and magmaclasts. The sedimentary xenoliths are dominated by carbonates derived from a now-eroded overlying varied Paleozoic stratigraphy. The magmaclasts are typically mixed with melt-free olivines which together are interpreted as extrusive pyroclasts (Figure 3). The overall low abundance and types of xenoliths indicate pipe excavation occurred prior to pipe infilling. The Chidliak bodies are volcanic pipes with varied morphology and infill that can be illustrated by the three bodies CH-31, CH-7 and CH-6 discussed below.

The CH-31 pipe is one of the larger bodies with an estimated plan view area of 4 hectares and an irregular outline. The pipe-infill is internally variable with respect to xenolith abundance, size and type (e.g. ratio of basement to carbonate). Pyroclasts are present throughout the body. There are different types of pyroclasts formed from separate eruptions of contrasting batches of magma. In most areas, the contrasting pyroclasts are mixed and the occasional broken example has been noted. Carbonate xenoliths are common and include single blocks over 12 metres in core length. Well developed layering or sharp, internal contacts are rarely observed. These features suggest either pyroclastic recycling and/or reworking of original unlithified pyroclastic kimberlite (PK). No coherent kimberlite (CK) is observed within the CH-31 pipe, but HK sheets and stringers were encountered external to the pipe.

The surface area of CH-7 is estimated to be one hectare in size comprising two distinct lobes, both with apparent elliptical outlines. The smaller northern lobe is an inclined, plunging body with massive, basement gneiss xenolith-poor macrocrystal CK which resembles HK and may be intrusive. The southern lobe is an asymmetrical, steeply plunging pipe containing different types of kimberlite in three main distinct units all of which contain both carbonate and basement xenoliths, which are generally less than 20 cm in size. The upper two units are PKs which contain contrasting types of pyroclasts (Figure 3). There is no evidence for pyroclast mixing or reworking. The deepest unit is CK with a carbonate-rich groundmass. Various features such as the unit geometry, occurrence of carbonate xenoliths and, near the top of this unit, incipient or diffuse magmaclasts (Figure 4) suggest that the CK is an extrusive pipe-infill unit (Scott Smith, 2011a). The contacts between units are sharp and steeply dipping and the three units appear to be nested crater infilled with one phase of coherent and two phases of pyroclastic kimberlite.

Figure 3: Close ups of polished slabs from CH-7. Top – Upper PK unit which is composed of clast supported melt-free serpentinized olivines and ovoid melt-bearing pyroclasts, the largest containing a basement xenolith. Bottom – Lower PK unit composed of pale coloured clast supported amoeboid melt-pyroclasts and melt-free olivines. FOV = 15 mm.



The CH-6 kimberlite is a steep sided, slightly southwest plunging, kidney-shaped to elliptical body with a surface area estimated at 0.9 ha. The pipe infill can broadly be divided into two textural types which are distinguished megascopically by the presence or paucity of carbonate xenoliths. The kimberlite lacking carbonate xenoliths is homogeneous with olivine and groundmass characteristics that resemble HK but with no evidence of intrusive emplacement. The kimberlite containing carbonate xenoliths is an inhomogeneous, apparently coherent kimberlite. It contains incipient or diffuse magmaclasts, variable and finer-grained groundmass, broken olivine and garnet macrocrysts and has a grain-supported texture. The uppermost parts display features approaching those of PK. This rock type does not resemble HK and these features are characteristic of extrusive, clastogenic CK (Scott Smith, 2011b). Boundaries between the varying textural types are complicated and difficult to trace through the body. In parts the CK and HK appear intercalated suggesting that the HK-like units are effusive.

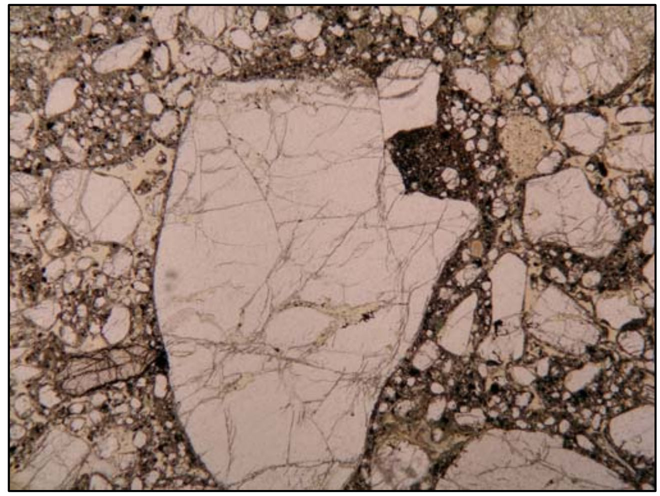


Figure 4: Photomicrograph of CH-7 south lobe coherent kimberlite, with an angular and embayed olivine macrocryst with asymmetric insipient magmaclastic selvage in the south lobe coherent kimberlite. FOV = 7 mm.

Geophysical Expression and Emplacement Ages

Perovskite U-Pb dating of twenty-five kimberlite bodies so far indicates magmatism spanned ~18 Ma from 156 to 138 Ma (Heaman et. al., this conference); during this time period, numerous magnetic reversals are recorded.

In ground magnetic data, many of the Chidliak kimberlites manifest as strong remnantly magnetized 0.5 to 2.0 ha bodies, with vectors consistent with the 145 Ma ± 10 Ma paleopoles. In many cases, the kimberlites have associated very weak and shallow conductivity responses, which are detectable in the highest-frequency quadrature airborne EM data. Exceptions to the rule can be attributed to rock type, pyroclastic kimberlites have neutral to weak magnetic signatures, appear to be more conductive, and are much larger than their CK counterparts.

The Diamonds

To date, 44 of the 62 kimberlites at Chidliak and Qilaq have been tested for diamonds using caustic fusion analysis. Results are pending for one of the 2011 discoveries at each of Chidliak and Qilaq and from additional samples taken from previous discoveries. Sixteen of the kimberlites are low interest and have not been tested for diamonds. Initial exploration samples submitted for caustic fusion analyses are typically in the range of 200 kg per kimberlite phase in order to get sufficient stones for size frequency distribution plots. Occasionally, more than one 200 kg sample from a single kimberlite is submitted. Diamonds in the commercial size range (>0.85mm square mesh) have been recovered in initial exploration samples from 18 of the kimberlites tested. Four stones in excess of half a carat were recovered from these exploration samples: a 0.62 ct diamond from CH-6; 0.64 and 0.51 ct stones from CH-7, and, a 1.15 ct diamond from CH-31. In 2008, a 2.28 tonne sample, collected from the surface at CH-1 and treated by caustic fusion, yielded 34 diamonds larger than 0.85 mm weighing a total of 3.55 carats, including a 2.01 carat clear octahedral gem. Mini-bulk samples of between 15 and 50 tonnes have been collected from 4 of the kimberlites, CH-1, 6, 7 & 28, and processed through a dense media separation ("DMS") plant (Table 1), confirming the presence of commercial-sized stones at Chidliak.

Table 1: Mini-bulk sample results summary

Kimberlite	Total Sample Weight (tonnes)	Total Number of Diamonds	Carats >0.85mm	Carats/Tonne >0.85mm	# Stones >0.5 carats	Largest Stone (carats)
CH-1	49.60	305	22.87	0.46	5	1.35
CH-6	13.95	523	40.04	2.87	9	1.29
CH-7*	47.19	502	49.07	1.04	15	6.53
CH-28	32.54	Results Pending				

*Sample taken from CH-7 North Lobe

SUMMARY/CONCLUSIONS

The Chidliak kimberlites occur as both pipes and steeply dipping sheets that were emplaced between 156 and 138 Ma into Paleozoic carbonate strata overlying basement gneisses. The Paleozoic succession is now completely eroded from the area and the only evidence of this cover is the xenoliths preserved in the kimberlites.

Pipes in the Chidliak province are filled with a variety of textural types ranging from coherent to primary pyroclastic and possibly to reworked pyroclastic kimberlite. The general emplacement processes are interpreted to be comparable to those found at Fort a la Corne, Saskatchewan or at the Victor pipe in the Attawapiskat province, Ontario. The timing of kimberlite magmatism roughly corresponds with that of some of the younger intrusions in the Attawapiskat province (Heaman et. al., this volume), which were also intruded into a Paleozoic sequence. Unlike at Chidliak, some of the Paleozoics are still preserved in the Attawapiskat region and the Chidliak bodies may be deeper analogues of Victor-type pyroclastic kimberlites.

Exploration will continue to establish the potential of this, Canada's newest, diamond district.

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