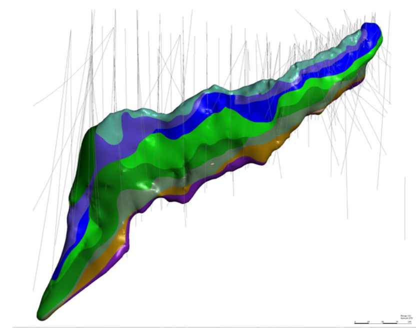
12[TH] INTERNATIONAL
KIMBERLITE
CONFERENCE

30 YEARS OF DIAMONDS IN CANADA
8–12 July 2024 • Yellowknife

12 IKC FIELD TRIP GUIDE



Northwest Territories Diamond Mines

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FT 01

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FT01 – Northwest Territories Diamond Mines Field Trip Guide

Overview of Canadian Kimberlites

Hundreds of kimberlites have been found across Canada during the ’30 Years of Diamonds in Canada’. Before 1985 only about 50 kimberlites were known. In 1988-1989 approximately one hundred kimberlites were discovered south of the 60th parallel at Attawapiskat, Ontario including the Victor Mine (2008-2023) and at Fort à la Corne, Saskatchewan, including advanced evaluation on two pipes.

In 1991 the historic announcement by BHP and Dia Met Minerals of a new kimberlite discovery containing diamonds in the Northwest Territories led to the largest staking rush in Canadian history. Hundreds more kimberlites were found, many north of the 60th parallel, with the current total at 1,077, as shown in **Figure 1** (map and data courtesy of De Beers Group).

Since Canada’s first diamond mine (Ekati) commenced production in 1998, Canada has joined the ranks of the great diamond producing countries by becoming the third largest producer of diamonds by value after Botswana and Russia. Three mines remain in operation: Ekati (Burgundy Diamond Mines), Diavik (Rio Tinto) and Gahcho Kué (De Beers / Mountain Province Diamonds).

Figure 2 summarises kimberlite pipe shapes, pipe infills and geological setting across Canada reconstructed to the time of emplacement. This shows that contrasting types of pipe infill correlate with the competency of the country rock into which they were emplaced. FPKs occur in mainly sedimentary rock (localities A, B and F) and the pipe shape reflects the degree of lithification or competency of the sediments. Where poorly consolidated shale overlies competent basement more common RFPK is observed (locality C). Kimberlites emplaced into only basement occur as KPK and HK (localities D, E).

A schematic representation of the detailed geology of the three main types of kimberlite pipes in Figure 2 is presented in **Figure 3**. The FPKs comprise light green commonly fresh olivine occurring either as discrete olivine pyrocrysts or within the fluidal commonly amoeboid-shaped magmaclasts (or FPK-type melt-bearing pyroclasts). The groundmass in the magmaclasts is composed of isotropic serpentine (dark grey) and/or cryptocrystalline carbonate (stippled white). The interclast cement is composed of serpentine and less common carbonate (purple background). Clast-supported textures, normal grading, low proportions of country rock xenoliths and an overall paucity of fine constituents are typical indicating widespread subaerial sorting during pyroclastic eruptions.

The RFPKs in the centre pipe of Figure 3 are composed of variable mixtures of commonly fresh, frequently angular, olivine pyrocrysts (green), xenoliths of the overlying poorly consolidated shale, minor xenoliths of basement (red), minor magmaclasts and wood (brown) set in a matrix of mixed disaggregated shale (paler grey). Bedding and matrix-supported textures are common. Pipe infill resedimentation processes appear to be more commonly subaerial than subaqueous.

The KPKs form pipe-infill overlying an irregular root zone of HK (dark blue) with relatively common HK sheets (paler blue lines) occurring in the vicinity. The HK is composed of olivines (green) set in a fine-grained but well-crystallised groundmass (dark blue). Sub-rounded and partly-digested basement xenoliths are in low abundance (pale grey). In contrast, the KPK contains totally pseudomorphed olivine (darker green) and abundant, angular, fresh basement xenoliths (red). Most of these constituents have thin, extremely fine-grained groundmass selvages (orange) and are termed magmaclasts. The inter-magmaclast matrix (brown) is dominated by serpentine which is commonly weathered to brown clay minerals. There is a gradational textural transition between the HK and KPK (yellow) with increasing xenolith abundance and size, olivine replacement and decreasing degree of crystallinity and xenolith reaction. These rock types are massive with no sorting or bedding indicating they have formed by subsurface magmatic processes.

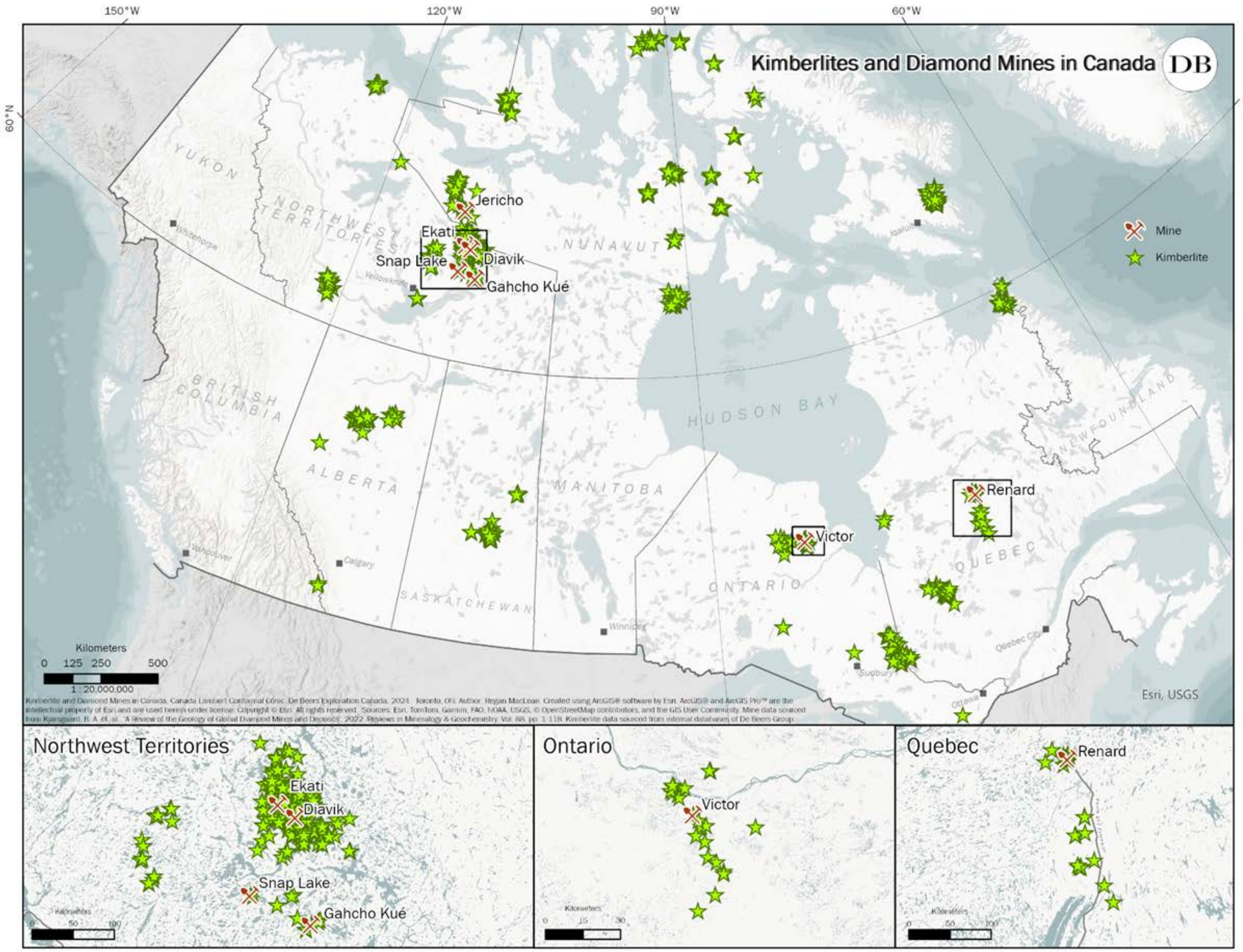

Figure 1: Map showing the location of known kimberlite occurrences across Canada, courtesy of De Beers Group.

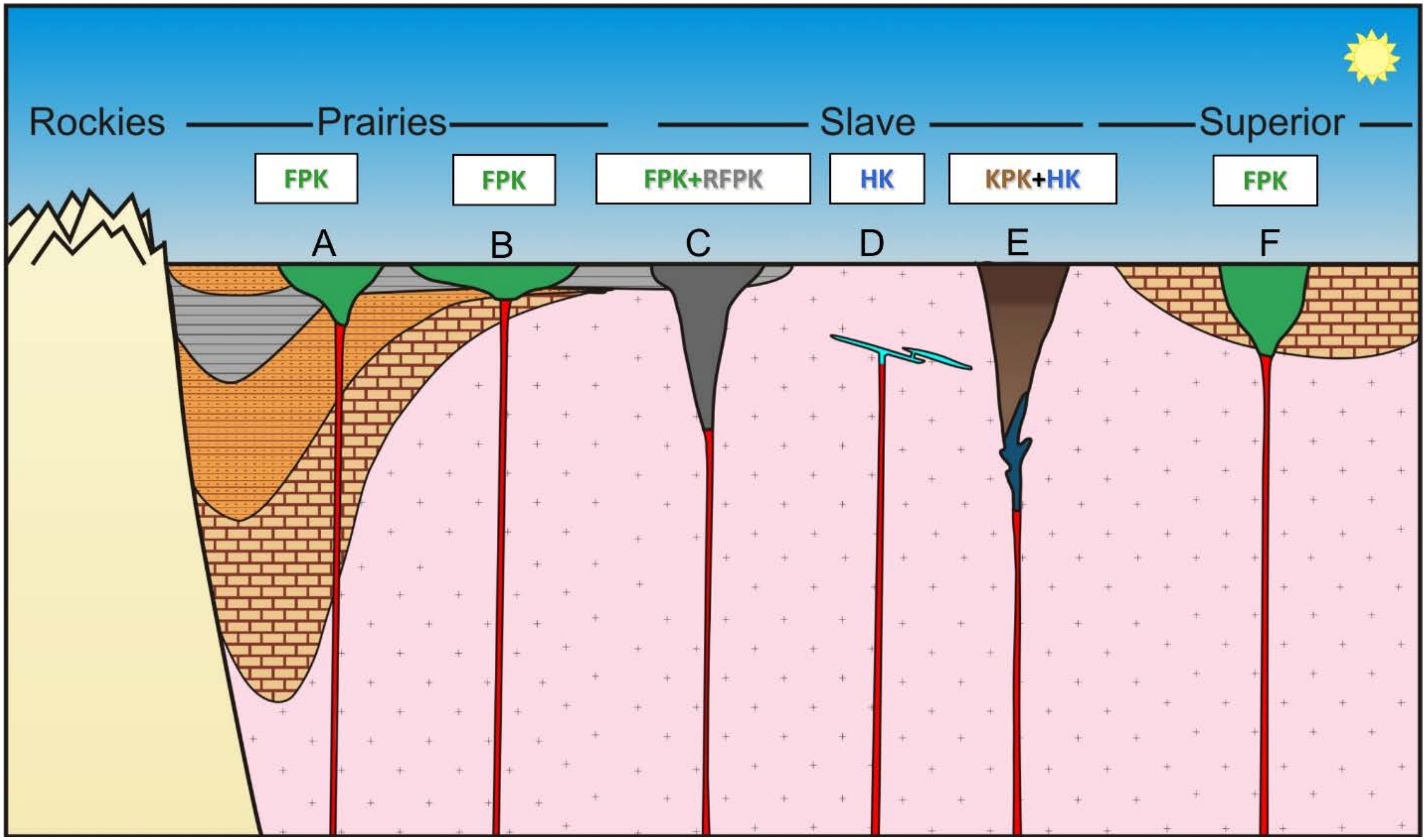

Figure 2: A schematic section across Canada summarising kimberlite pipe shapes, pipe infills and geological setting reconstructed to the time of emplacement based on approximately two thousand 1989-1999 drillcores (after Field and Scott Smith 1999 and Scott Smith 2006. Image credit: Scott-Smith Petrology Inc**.). Country rocks:** pink - basement, light brown - lithified Paleozoic carbonates, orange - partly consolidated Cretaceous siltstone, and pale grey - poorly consolidated Cretaceous shale. **Kimberlite Pipe Infill Types:** FPK - Fort à la Corne-type Pyroclastic Kimberlite, RFPK - Resedimented FPK, KPK - Kimberlite-type Pyroclastic Kimberlite and HK – Hypabyssal Kimberlite (after Scott Smith et al. 2013, 2018). **Localities: A** - Buffalo Head Hills, ~80-88 Ma., discovered in 1997; **B** - Fort à la Corne ~100 Ma., discovered in 1989; **C** - Lac de Gras, ~55 Ma., discovered in 1991; **D** - Snap Lake, ~530 Ma., discovered in 1997; **E** - Gahcho Kué, ~540 Ma., discovered in 1995; and **F** - Victor, ~170 Ma., discovered in 1988.

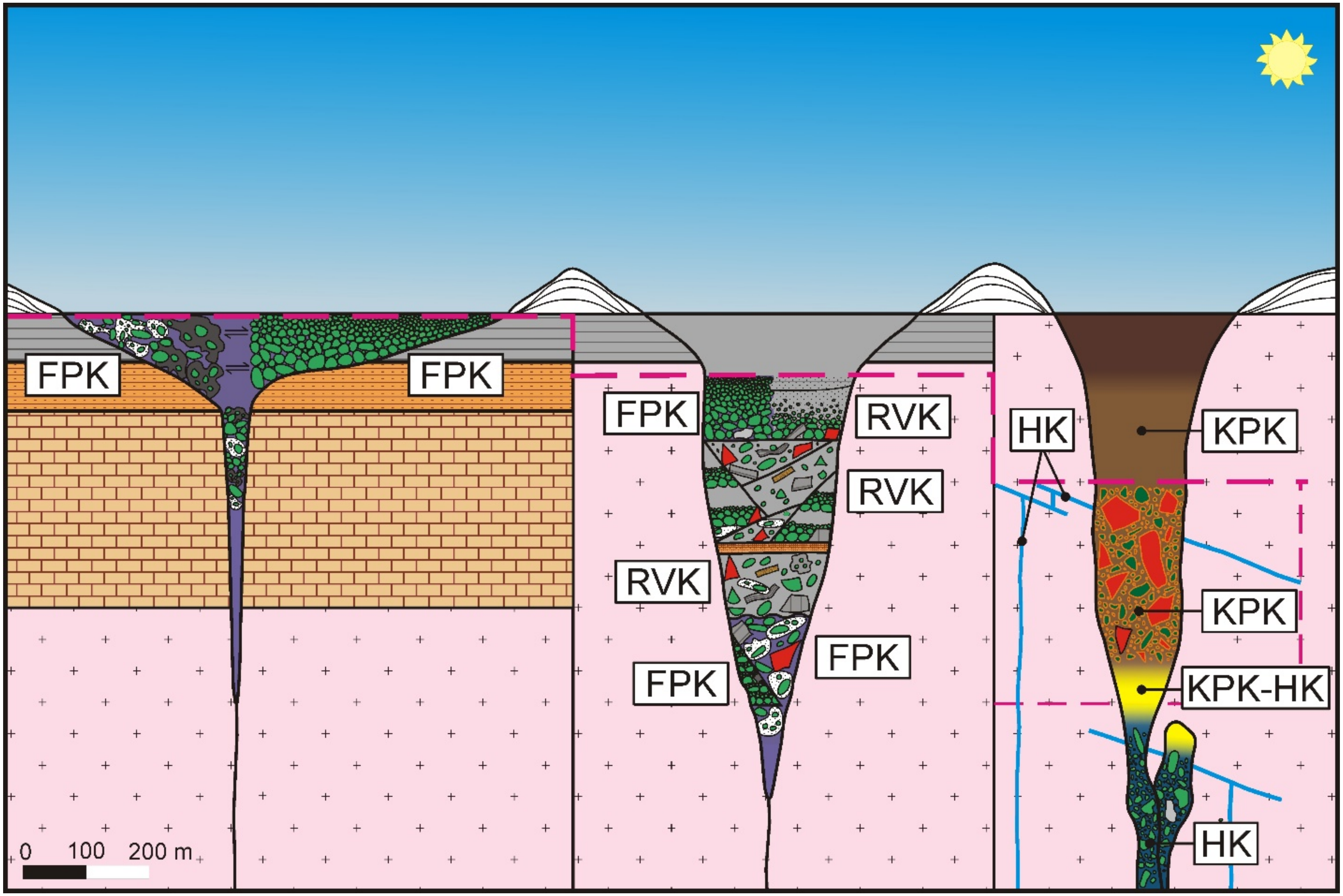

Figure 3: Schematic representation of the detailed geology of the three main types of kimberlite pipes in Figure 2 reconstructed to the time of emplacement (after Scott Smith 2008; Image credit: Scott-Smith Petrology Inc.). **Country rocks:** as Figure 2. **Kimberlite Pipe Infill Types**: as Figure 2; RVK = RFPK. Localities from Figure 2: Left hand pipe – B, centre pipe – C and right hand pipe – D and E in Figure 2. Pink dashed line = present surface.

References

Field M. and Scott Smith B.H. 1999. Contrasting geology and near-surface emplacement of kimberlite pipes in Southern Africa and Canada. The J.B. Dawson Volume, Proceedings of the Seventh International Kimberlite Conference, Vol. 1, p. 214-237.

Scott Smith B.H. 2006. Canadian kimberlites: geological characteristics relevant to emplacement. Long Abstract for 2006 Kimberlite Emplacement Workshop, September, Saskatoon, Saskatchewan, 5 pp.

Scott Smith B.H. 2008. Canadian kimberlites: geological characteristics relevant to emplacement. Proceedings of the 2006 Kimberlite Emplacement Workshop, Saskatoon, Canada. Journal of Volcanology and Geothermal Research, 174, p. 9-19.

Scott Smith B.H., Nowicki T.E., Russell J.K., Webb K.J., Mitchell R.H., Hetman C.M., Harder M., Skinner E.M.W. and Robey J.V., 2013. Kimberlite Terminology and Classification. Proceedings of the 10th International Kimberlite Conference. Special Issue of the Journal of the Geological Society of India, Volume 2, 1-17. Springer India.

Scott Smith B.H., Nowicki T.E., Russell J.K., Webb K.J., Mitchell R.H., Hetman C.M., Skinner E.M.W. and Robey J.V., 2018. A Glossary of Kimberlite and Related Terms. Published by Scott-Smith Petrology Inc., North Vancouver, Canada. 3 Parts, 259pp. www.scottsmithpetrology.com

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Diavik Diamond Mine Field Trip Guide, Wed. July 3rd, 2024

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Introduction

Diavik Diamond Mine (Diavik) is located in the Slave Geological Province approximately 300 km NE of Yellowknife and is situated on East Island on Lac de Gras. It is located in the remote Canadian sub-arctic tundra, approximately 200 km south of the Arctic circle and is accessible year-round by air and overland by winter road, typically from early February to late March.

Diavik is 100% owned by Diavik Diamond Mines (2012) Inc. (DDMI), a Yellowknife-based Canadian subsidiary of Rio Tinto plc in London, U.K. DDMI is the operator and manager of the Diavik diamond mine and surrounding exploration/ development properties. Diavik commenced operations in 2003 and to date has produced approximately 144 million carats of diamonds. Commercial production is planned to conclude in 2026.

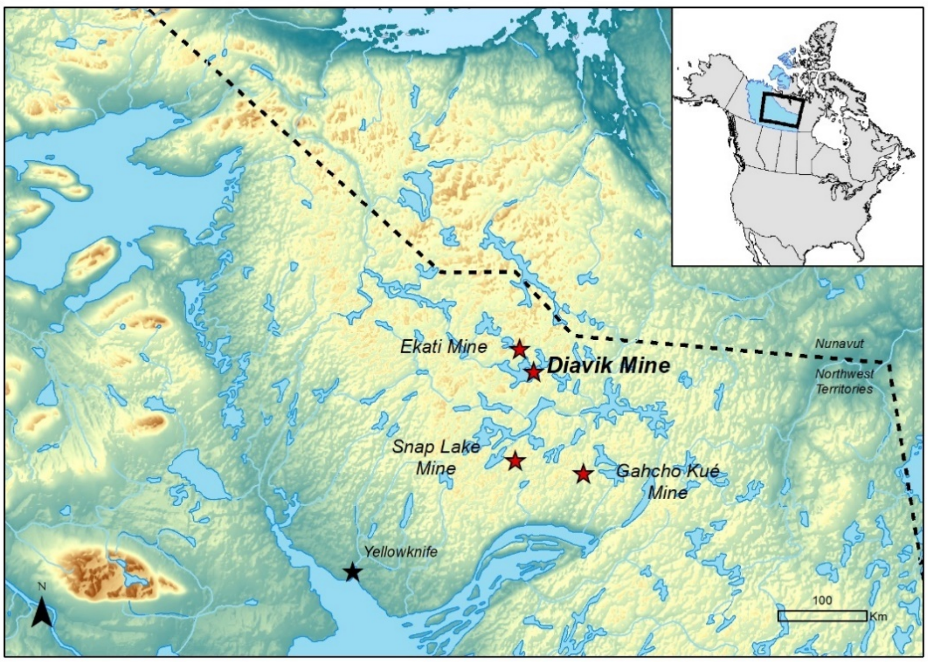


Figure 1: Location of the Diavik Diamond Mine

This field guide aims to provide a brief outline of the discovery and development of Diavik and a discussion of the geology, geochronology.

Exploration History

Aber Resources Ltd. staked mineral claims over what is now the Diavik Diamond Mine in November 1991 as part of the staking rush after the discovery of the Point Lake kimberlite. A combination of kimberlite indicator mineral sampling from glacial tills and airborne geophysics were used to identify potential kimberlite targets, which were then prioritized from further indicator mineral samples and detailed geophysics. High priority targets were then drilled, with prospective kimberlite pipes discovered by the Diavik Joint Venture under Lac de Gras just to the east of East Island.

The initial economically viable pipe to be discovered was A21 in April 1994, followed by A154N and A154S in May 1994 and A418 in May 1995. A pre-feasibility study was conducted between January 1996 and September 1997, and an initial resourced estimate was completed in 1998 for A154S, A154N, A418 and A21.

Figure 2: Aerial view showing Diavik Diamond Mine site and associated infrastructure.

Mineral Tenure

The mineral tenure package associated with the Diavik Diamond in 153 leases covering approximately 133,638 Ha, and is shown along with the location of known kimberlite in **Figure 3** below.

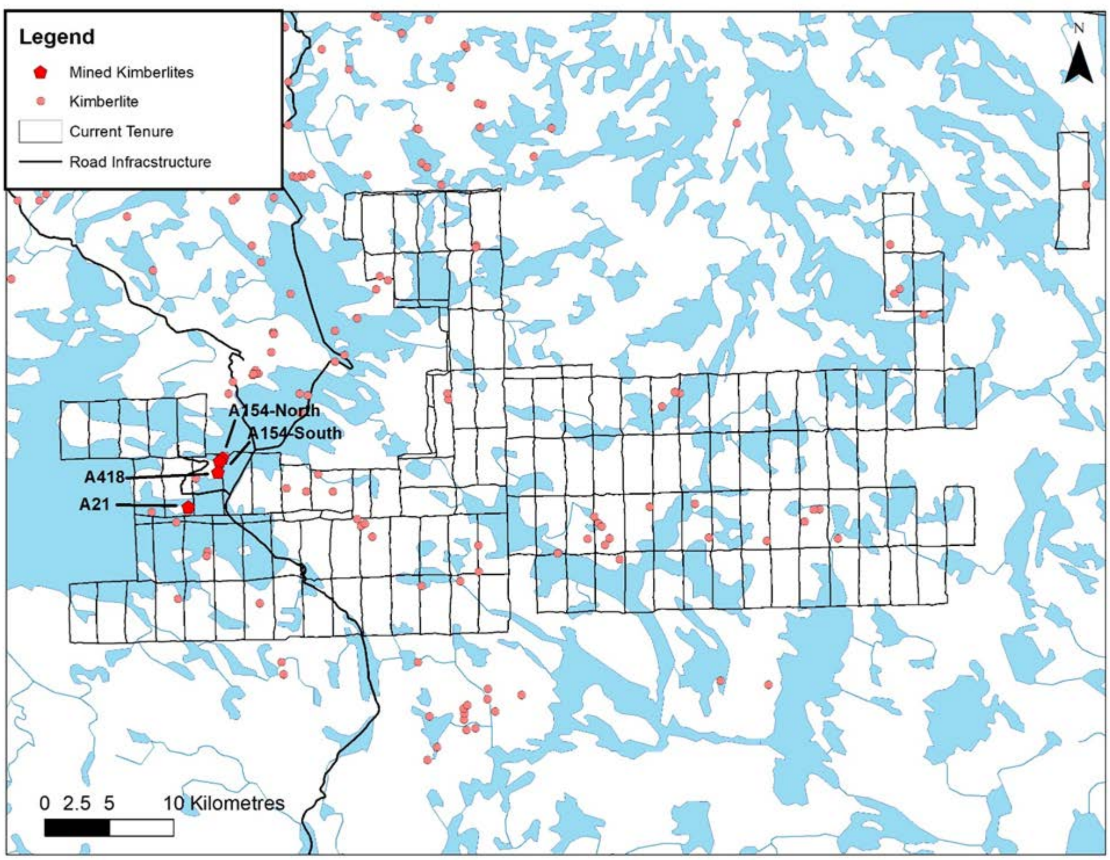


Figure 3: Diavik mineral tenure and the distribution of known kimberlites at the Diavik Diamond Mine.

Mining History

The construction of the Diavik Diamond Mine began in 2001 with the construction of a water retention dike to allow for the dewatering and stripping needed for the open pit mining of A154N and A154S (**Figure 4, 5**). Initial mining and trial processing occurred in November 2002 with commercial production achieved in January 2003. The open pit resources of A154N and A514S were depleted by 2008 and 2010 respectively. Underground production from A154N and A154S commenced in February and August 2010 respectively.

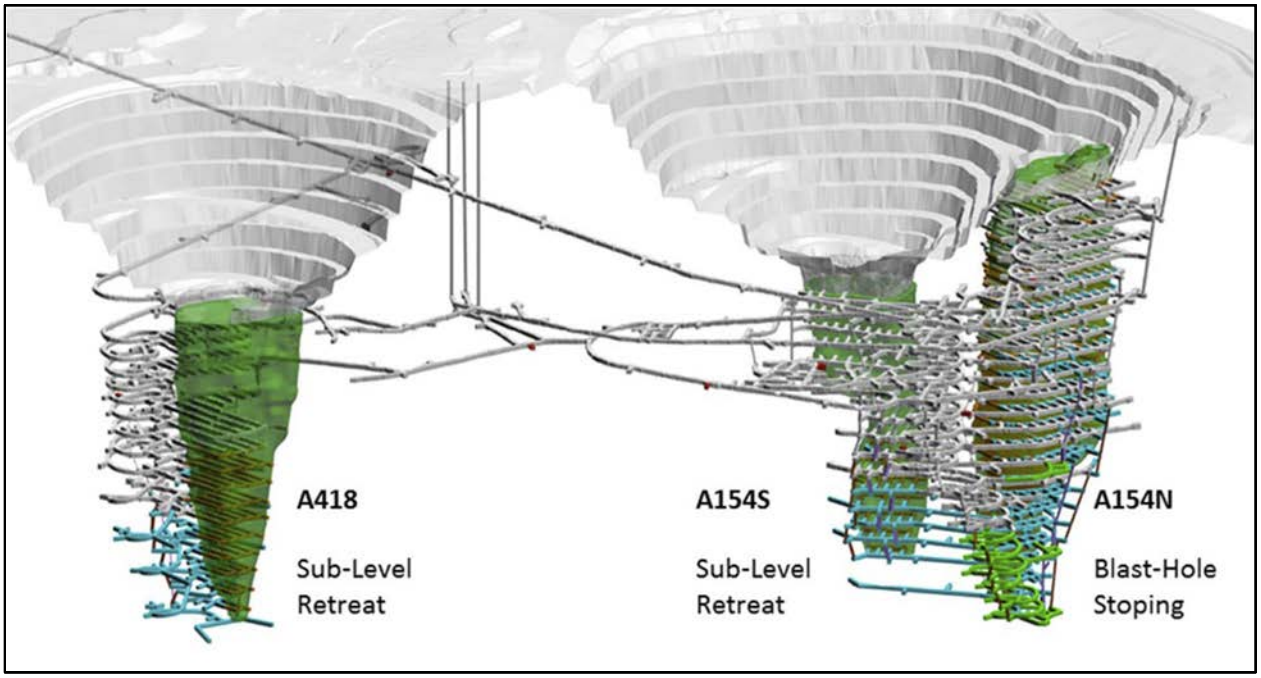


Figure 4: Diavik underground mining at A418 and A154

The construction of a water retention dyke for the open pit mining of A418 commenced in 2005, and mining operations started in May 2008. A418 completed open pit operations and transitioned to underground operations in September 2012.

Open pit developed for A21 commenced in 2015 with the construction of a water retention dike and open pit mining operations commenced in 2018. Rio Tinto has approved the investment in underground mining of the A21 pipe, with commercial production to begin in 2024.

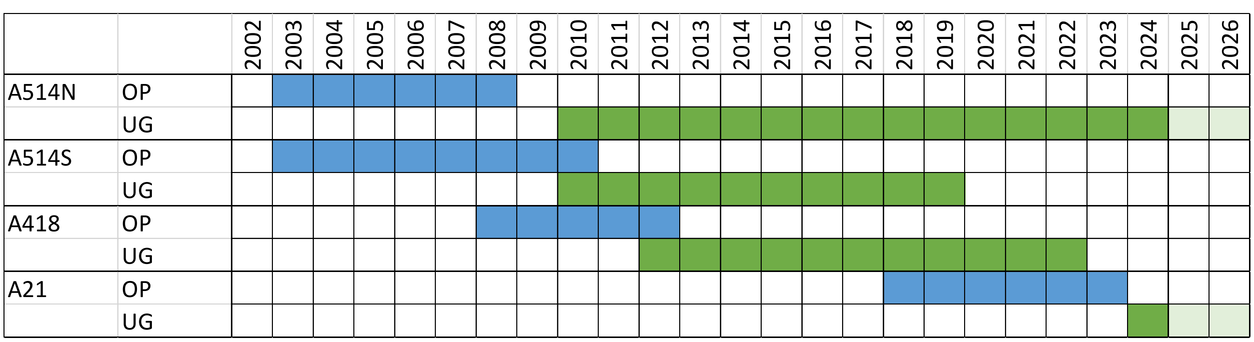


Figure 5: Summary of mining operations at the Diavik Diamond Mine

Geology Overview

The Diavik Diamond mine is located in the Archean Slave Geological Province, the bedrock geology in the surrounding area is dominated by granitoids and metasediments from the Yellowknife Supergroup both of which are cut by later Proterozoic mafic dykes (Stubley and Irwin 2019). Bedrock in the area is variably covered by Quaternary deposits, typically under 5 m thick, and large eskers systems are present in the region running approximately EW (Ward et al. 2014).

Quaternary Geology

The advance and subsequent retreat of the Laurentide ice sheet has had a significant impact on both the landscape and diamond exploration in the NW and is responsible for the glacial tills, eskers and other glacial features that currently dominate the landscape. Broadly speaking the region is discontinuously overlying by till ranging from thin veneers, to over 20 m in buried bedrock valleys, with large esker systems running approximately EW (Ward et al. 2014).

Regional Geology

The Slave Geological Province is a composite Archean greenstone-granite terrain overlying older sialic basement and juvenile basement rocks that formed via tectonic accretion of the pre-3 Ga Central Slave Basement Complex with the Neoarchean juvenile Hackett River Arc (**Figure 5**). Their contact is inferred to dip eastward and is covered by a thick sequence of Neoarchean metaturbites (<2.66 Ga), which are preserved in the central Contwoyto terrane. Post accretion and turbidite deposition, the Slave Geological Province was deformed and intruded by ca. 2.64 to 2.595 Ga syn-tectonic granodiorites and tonalites, and then intruded and overlapped with 2.605 to 2.58 Ga post-tectonic granites. Numerous Proterozoic dyke swarms cut the Slave Geological Province.

The Slave Geological Province is bounded east of Great Slave Lake northwards to the Arctic coast by the 2.02 to 1.91 Ga Thelon Tectonic Zone, and to the west by the 1.91 to 1.84 Ga Wopmay Orogen. To the south it is bound by the 1.99 to 1.91 Ga Taltson Magmatic Zone and the 1.98 to 1.93 Great Slave Lake Shear Zone. To the north, parts of the Slave Geological Province are locally overlain by Proterozoic cover sequences in the Kilohigok basin, which formed during crustal flexure due to the Wopmay Orogen. The Slave Craton extends further northward towards Victoria Island, where it is overlain by Proterozoic and Phanerozoic cover sequences. The northeastern portion of the Slave Geological Province is bound by the Bathurst Fault, and the southeastern portion is bound by the McDonald Fault.

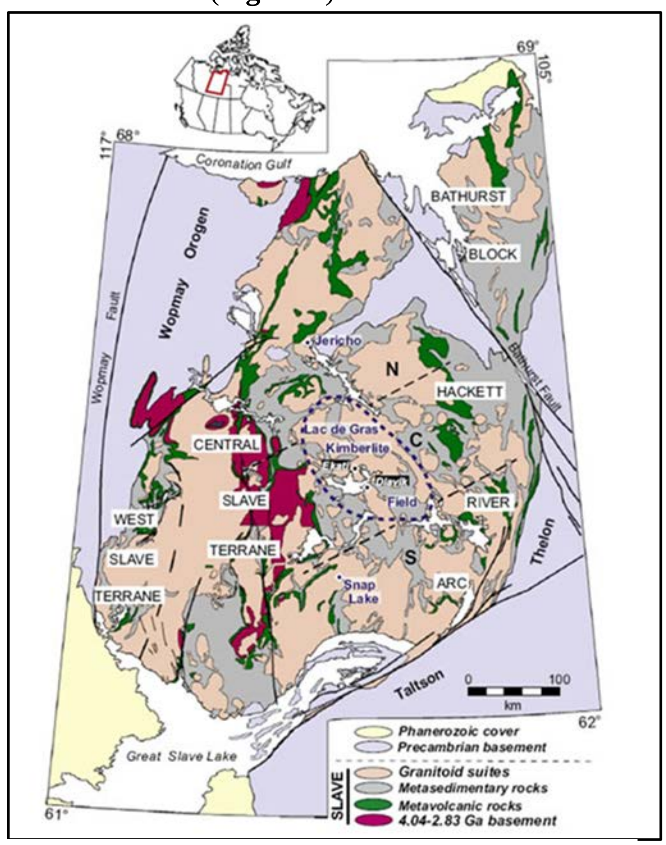


Figure 5: General Geology of the Slave Geological Province (Reproduced from Tappe et al. 2013, modified from Bleeker 2003)

Property Geology

The local geology surrounding the Diavik mining operations has been subdivide in to three main Archean units, a two-mica prohpryitic granite / granodiorite (which hosts A154N, A154S and A418), a biotite +/- hornblende tonalite / quartz diorite and a greywacke / mudstone metaturbidite (Stubley 1998, **Figure 6**). Phanerozoic strata are not currently present in the region, but are preserved as xenoliths in kimberlite, and the area is thought to have once been overlain by a 50 to 200 m thick succession of Cretaceous marine shales, terrigenous arenite and organic peat (Moss 2009).

There are three observed diabase dyke swarms present in the Diavik project area, the Malley dykes, the Lac De Gras dykes and the Mackenzie dykes which range in thickness from approximately 10 to 50 m. Refer to **Table 1** below for more detailed information (Stubley 1998). The Malley, MacKay and Lac De Gras dykes have been associated with kimberlite bodies (Wilkinson et at. 2001).

Table 1: Diabase dykes in the Diavik project area

Name	Age (Ga)	Orientation	Width (m)
Malley	2.23	45°	14885
Lac De Gras	2.020 - 2.030	10°	20-40
Mackenzie	1.27	NNW radiating	20-50

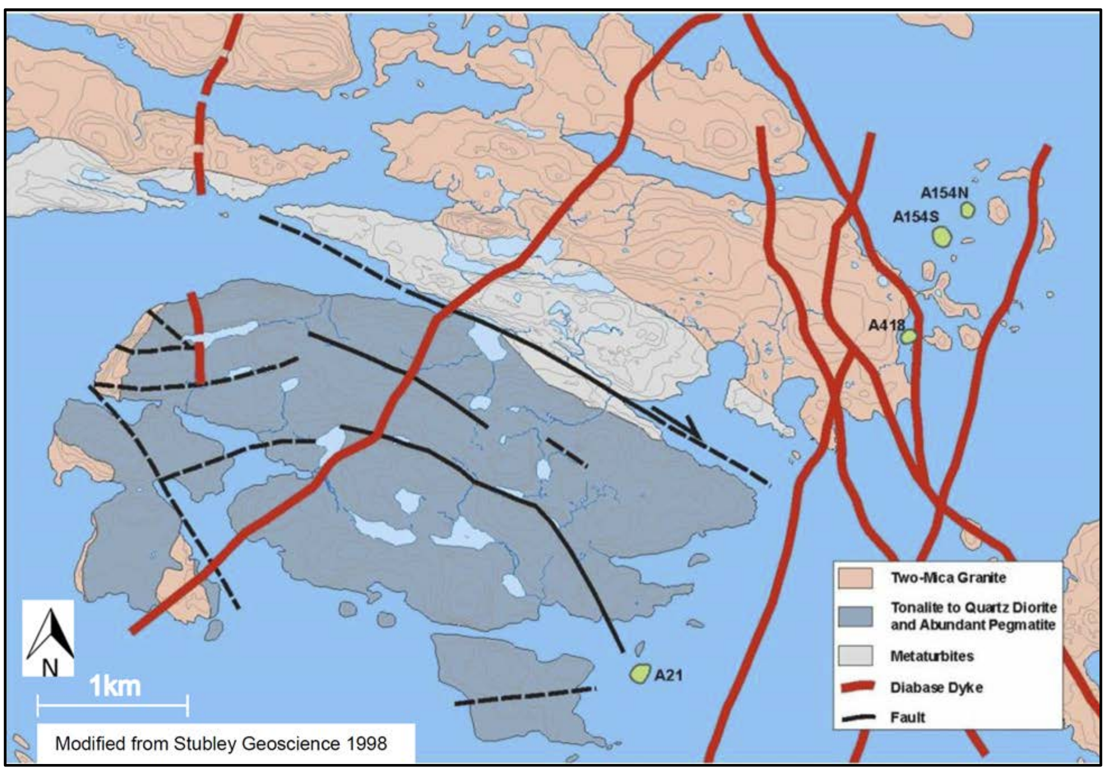


Figure 6: East Island local geology and kimberlite locations, modified after Stubley 1998

Overview of Diavik Kimberlites

To date, 71 kimberlites have been discovered on the Diavik mine leases. Four of these kimberlites, A154 South, A154 North, A418 and A21 have been or are currently being mined. They are below the water level of Lac de Gras and are relatively small, steep-sided carrot shaped bodies with surface circular surface expressions under 200 m in diameter but are of high grade with high value diamonds. These kimberlites are roughly aligned on an 030° bearing, with a narrow kimberlite filled fault of similar orientation extending NNE from A154 South (Bryan and Bonner 2003).

The Diavik kimberlites are composed of three main facies, which are variably diluted by country rock. Their general geology is presented below in **Figure 7**.

- Coherent (CK) - formed by the crystallization of kimberlite magma, as opposed to explosive emplacement
- Pyroclastic (PK) – interpreted as an explosive air-fall deposit, possibly sub-aqueous
- Volcaniclastic (VK) – formed from a combination of pyroclastic depositions and the re-sedimentation of pyroclastic kimberlite along with host material from the volcanic edifice flowing back in the open crater post eruption. This unit has a mud-rich subdivision which is sometimes referred to as resedimented volcaniclastic kimberlite (RVK).

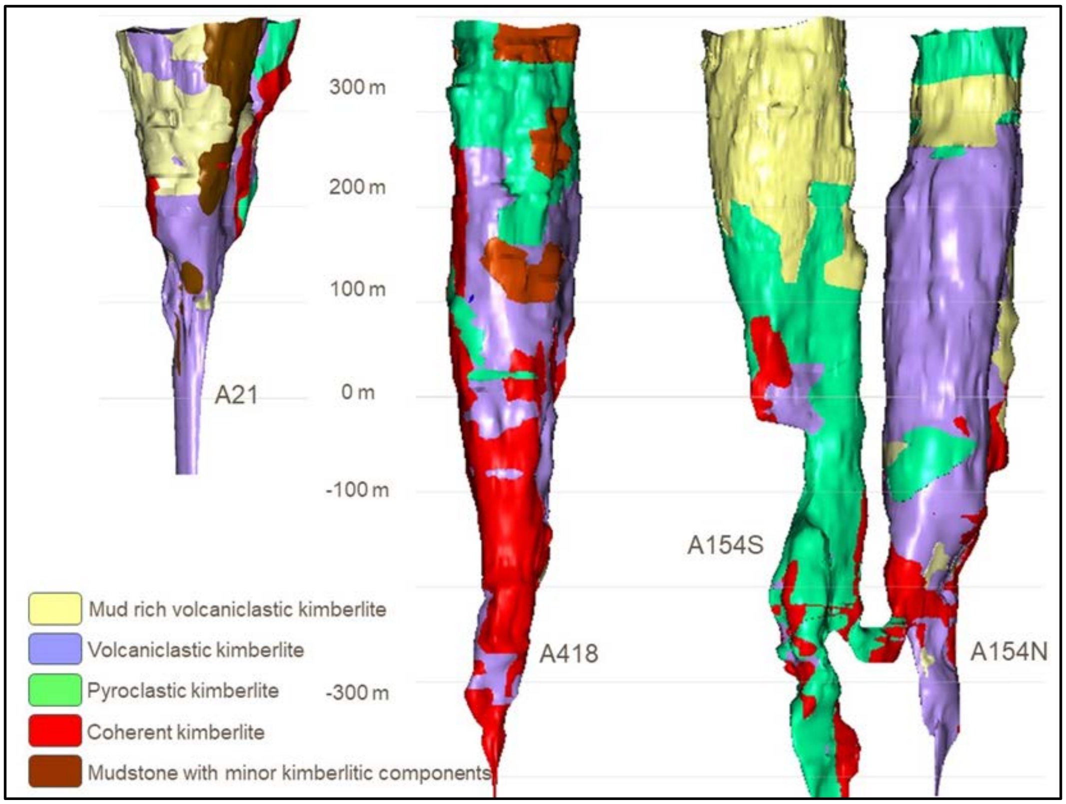


Figure 7: General geology of the Diavik kimberlites. (taken from 2017 43-101)

The Diavik kimberlites are further subdivided in to four to seven sub-units based on dilution, grain size, magnetic susceptibility, textural and alteration characteristics for resource modeling purposes. These criteria can be indicative of diamond grade as well as geotechnical information relevant to mining and milling operations.

The Diavik kimberlites contain abundant kimberlitic mud and Cretaceous mudstone clasts, and often have hypabyssal kimberlite along their margins. Country rock dilution is generally low, excepting mudstone, which can be locally dominant, particularly in the A21 and A418.

A six-stage eruption model for the Diavik kimberlites has been proposed (Moss 2009), consisting of 1) initial pipe excavation during eruption, 2) the collapses of the pyroclastic column resulted in poorly sorted volcaniclastic infilling, 3) re-deposition of tephra from crater into the crater, 4) continued sedimentation of olivine-rich and shale rich sands, 5) sedimentation of mud-rich finer grained kimberlite into the crater and 6) crater infill from the eruption of adjacent kimberlites.

Kimberlite Geology

This following section outline the subdivisions of A154N, A154S, A418 and A21 as provided by the Diavik Diamond mine.

A154N

The A154N kimberlite has been divided into 7 units, shown in **Figure 8**.

Graded Macrocrystic Volcaniclastic Kimberlite (GradedK)

This close-packed, crystal (olivine)-rich volcaniclastic kimberlite comprises the upper 40 meters of the pipe. The unit is unique in that it grades continually to larger average grain size with depth (from <0.5 mm to >3.0 mm). Country rock fragments and mantle nodules within the unit also increase in size downward. The matrix supporting the minerals and other fragments is dominated by serpentine, with subordinate carbonate and clay. The "megagrading" nature of this rock represents the strongest evidence of bedding within the unit, although larger crystals and country rock fragments tend to be oriented sub-horizontally. The origin of this unit is uncertain; however, the exceptional large-scale grading would preclude a debris flow origin. The unit most likely represents a tephra-fall deposit with no reworking. There is evidence in the northern part of the pipe, that a second (younger) graded bed used to overlie the GradedK unit but has since been eroded.

Mud-rich Volcaniclastic Kimberlite (MRK)

Variably massive to bedded, mud-rich volcaniclastic kimberlite composed of several poorly defined sub-units, which have been grouped together. Bedded intersections may contain very fine crossbedding (<10mm beds) or repeated graded beds on a scale of up to 30 cm. Locally, in the southern portions of the pipe overlying the GMC unit (see below), repeated graded beds occur which have been strongly serpentinised and contain a large proportion (up to 50%) of mudstone clasts. Bedded intersections may contain spherical mud (accretionary) lapilli like those commonly identified in the A418 kimberlite. Bedding is typically horizontal, although locally it may be as steep as 70 degrees. Massive MRK of varying hardness (most commonly soft - easily broken with a single hammer blow) and average grain size is a major component. The interpretation of the MRK is that it represents a combination of base surge and debris flow deposits.

Green Mudchip-Rich Macrocrystic Volcaniclastic Kimberlite (GMC)

In the southern half of the pipe, the bottom portion of the MRK unit is dominated by this green, close-packed, medium grained GMC. The rock is competent (2 -3 hammer blows required to fracture), and although it is interpreted as a sub-unit of MRK, serpentine represents the most common matrix component. The GMC is characterised by the presence of mudstone xenoliths, commonly grouped together and oriented sub-horizontally. Orientation of mudstone fragments is the only evidence for bedding within this otherwise massive unit. This unit is interpreted as a large debris flow, composed almost entirely of kimberlitic material.

Magnetic Lapilli-rich Macrocrystic Volcaniclastic Kimberlite (MK)

This green-black, close-packed, crystal-rich rock is volumetrically very important in A154N. It is characterised by its extremely competent nature compared with any other unit in the pipe (many blows with a hammer and chisel required to fracture). The macrocrysts present commonly contain rims of kimberlitic material, like the pelletal lapilli which are characteristic of typical kimberlitic diatreme facies rock. These lapilli are interpreted as cored lapilli. Country rock fragments are almost exclusively represented by bleached granitic and biotite schist fragments. Cretaceous mudstones are very rare, essentially absent below approximately 240 masl. The most important characteristic of this unit is its variable but significant magnetic signature. Based on the relative magnetism of the rock, three sub-units of the MK have been identified: MK1, MK2, and MK3, representing magnetic susceptibilities of <1, between 1 and 2, and >2, respectively. The extreme competence of the MK rocks implies that fractures within the rock will provide continuous and locally open conduits for the conduction of ground water and lake water from above Origin of the MK units is uncertain. Although abundant lapilli make the rock appear superficially like diatreme facies kimberlite, the lack of abundant country rock xenoliths, local evidence of a fabric to the rock, and the high density of macrocrysts precludes such a classification. The unit is therefore a volcaniclastic kimberlite, most likely pyroclastic in origin. Previous evidence of bedding in the unit may have been obliterated by subsequent volcanic activity (i.e., the eruption and deposition of the overlying units), by the magnetite-forming event, or by a combination of factors.

Black Macrocrystic Volcaniclastic Kimberlite (BMVK)

This unit is a black, massive, close- to loose-packed, macrocrystic volcaniclastic kimberlite. The rock is quite competent, being difficult to fracture with a hammer and chisel. The black colour of the rock may be due to the presence of significant mud in the matrix, however, the hard nature of the rock suggests that muds are likely not a major matrix component. If this is the case, then kimberlitic clays or ash may comprise most of the aphanitic matrix. Country rock xenoliths include small, rounded mudstones and distinctive, bleached granitic fragments, some of which are locally replaced by carbonate. Mantle nodules are typically rare.

Volcaniclastic Kimberlite Breccia (VKB)

Presently constrained to the north-eastern portion of the kimberlite, the VKB is characterised by the presence of many granite and biotite schist fragments, commonly comprising more than the 15 volume % required to designate a kimberlite as a breccia. Country rock fragments can commonly be greater than 1m and may locally be several meters (and potentially even larger). Macrocrysts within the kimberlite range from close- to loose-packed and the matrix is of varying mud content.

Hypabyssal Kimberlite (HK)

Tends to be massive, extremely hard, dominated by fresh olivine macro- to megacrysts, supported by slightly magnetic, grey coloured aphanitic matrix. Megacrystic indicators, especially ilmenites, are not uncommon. Multiple discrete kimberlite dykes crosscut the pipe infill and are typically emplaced along the margins of the pipe. These dykes are classified as macrocrystic monticellite carbonate coherent kimberlite. Like A154S, the dykes intrude as fingers, sheets and irregular intrusions, are in sharp contact with adjacent lithologies, and occur in greater abundance below 50 masl.

A154S

The A154s pipe has been subdivided into 5 subunits, shown in **Figure 8**.

Resedimented Volcaniclastic Kimberlite (RVK)

Overlying and surrounding the uppermost exposure of PK above 350 masl is a mud-rich volcaniclastic kimberlite (RVK). Distinct characteristics of RVK include a) ubiquitous 10 cm fragments to large (1 to 3 m's) blocks of poorly- to un-consolidated mud with minor to absent kimberlite components; b) autoliths comprising clasts and blocks (1 cm to > 2 m's) of variably bedded volcaniclastic kimberlite, in some cases containing abundant accretionary lapilli; c) frayed and intact pieces of 'mummified' wood (i.e. unpetrified); d) chaotic to diffuse crude layering and heterogeneous component distribution at a meter-scale throughout the deposit; and e) matrix dominantly composed of mud with minor amounts of ash-sized melt-bearing pyroclasts and olivine pyrocrysts. The contact between PK and RVK is gradational, however, few contacts are observed. Rafts (up to 20 m long), boulders and clasts of massive mud with or without minor kimberlite components are present throughout RVK.

Massive to Weakly Bedded Pyroclastic Kimberlite (PK)

The volumetrically dominant infill of A154S is a deposit of massive pyroclastic kimberlite (PK) that occurs from 350 masl to -250 masl. Distinct macroscopic characteristics of PK include: a) the presence of melt-bearing pyroclasts with thin and partial selvages; b) magnetite and antigorite pseudomorphs of olivine pyrocrysts, c) clasts and blocks from 1 cm to several m's in size comprising variably-bedded volcaniclastic kimberlite (i.e. autoliths), d) minor small fragments (<1 cm) to large blocks (2 to 5 m's) of poorly- to un-consolidated mud with minor to absent kimberlite components, e) both subtle gradation and sharp variation from dark black colour and highly competent (95 to 161 MPa triaxial compressive strength) nature in the pipe interior to a green-brown colour and more friable nature near the pipe margins, despite identical componentry, f) evenly-distributed, rounded and highly bleached granite and metasediment country rock xenoliths, g) hexagonal cooling joints and predominantly peridotite xenoliths and xenocrysts relative to minor amounts of eclogite.

Lapilli and Olivine-rich Kimberlite Breccia (PKx)

Massive, coarse-grained olivine pyroclastic kimberlite which is macroscopically distinct because of a) consistently massive rock fabric; b) evenly-distributed equant black mudstone clasts (0.5–4 cm); c) yellow-green-brown to grey green in colour. Olivine comprises 45-65% of the rock; max olivine size is 12 mm, with rare grains up to 15mm. Olivine is fresh to highly serpentinized and black/green in colour. Clasts of volcaniclastic kimberlite (i.e., autoliths) are ubiquitous, up to 2 m in size, and are typically mud-rich, well-bedded to diffusely bedded, rich in unconsolidated and irregular-shaped (i.e., fluidal) mudclasts. Melt-bearing pyroclasts are also common, comprising 8-12% of the rock. This unit has very low country rock xenolith abundance (<2-4%, rarely 6 to 8%) including dominantly granodiorite and metasediment basement xenoliths; minor equant black mudstone xenoliths; bleach-white to blue-green alteration of metasediment and granodiorite country rock xenoliths. It is macroscopically distinct from PK due to consistently massive fabric, coarser olivine, equant black mud clasts, lower proportion of fine grained/mud-rich intervals, and consistently fresh olivine.

Serpentine-altered Volcaniclastic Kimberlite Breccia (VK)

From -250 masl to the base of the existing A154S model are several small domains of volcaniclastic kimberlite within the PK. VK is distinct from PK and RVK because of clearly defined bedding, with individual beds ranging from 1 cm to 10 cm in thickness, some of which are well-sorted. The components, organization, and inter-clast matrix mud of VK resemble that observed in cm- to meter-scale clasts in PK. There is also a notably higher proportion of matrix mud and distinctly higher proportion of large (>1 m) country rock xenoliths (5 to 10%) in VK when compared to PK. VK is in sharp contact with surrounding PK and is not observed in direct contact with the host granite.

Hypabyssal Kimberlite (HK)

Multiple coherent kimberlite dykes and irregular intrusions, mineralogically classified as macrocrystic monticellite carbonate kimberlite crosscut the pipe infill. The coherent kimberlite occurs as fingers, sheets, and irregular intrusions along the pipe margin and into the pipe interior, and locally diffusely transition into discrete (dis-aggregated) pieces of coherent kimberlite set in a pyroclastic kimberlite matrix. This unit is composed of 40 to 55 % olivine crystals (0.03 to 12 mm in size) in a groundmass containing (in order of decreasing abundance) serpentine, carbonate, spinel, perovskite and monticellite. Distinct characteristics of HK at A154S include some olivine-absent thin intrusions into pyroclastic deposits.

A21

The A21 kimberlite has been subdivided into 8 subunits, shown in **Figure 9**.

Mud Dominated Kimberlite Breccia (MUKB)

Massive to chaotically bedded mud and mudstone xenolith-rich volcaniclastic kimberlite. This rock type is macroscopically distinct because of a) high matrix mud component (40-65%); b) abundant small (<0.5cm) grey/tan/red mudstone and black mudstone clasts, and c) dominantly massive rock fabric. MUKB comprises fine grained, completely serpentinized and/or remnant fresh olivine grains (up to 4mm in size; 5 to 20% of rock), and minor amounts of kimberlite indicator minerals, set in a very fine grained, dark brown matrix. Small wood fragments are observed throughout this unit, as well as isolated coarse clasts of country rock (e.g.granite, metasedimentary rocks), and isolated megacrysts (up to 3.5cm) of chrome diopside, ilmenite and garnet.

Bedded Mud-rich Macrocrystic Kimberlite Breccia (BKB)

Well-to diffusely bedded, mud-rich macrocrystic volcaniclastic kimberlite. This rock type is macroscopically distinct from MUKB and MKB due to a) a high proportion of kimberlitic components; b) bedding and/or clast and particle sorting at 1 cm to 3 m scales; and c) high proportion of elongate and irregular-shaped black mudstone clasts and blocks. BKB comprises angular to sub-rounded, poorly-to well-sorted olivine macrocrysts (0.05 to 12 mm in size; 15 to 55% of rock), black mudstone clasts (0.5 to 3 cm in size; 10-20% of rock), granite clasts (0.5 to 4 cm in size; <1% of rock), garnet peridotite xenoliths (1 per box; up to 3 cm in size), and very few distinct melt-bearing pyroclasts (<<1 cm) in a matrix (15 to 50% of rock) which varies from very fine grained olivine crystal fragments to dark brown mud. Bedding thickness varies from 0.2 to 1 m, and bedding angles relative to the core axis in vertical holes range from 50˚ to 70˚. The thickest beds (~1 to 3 m) are typically internally massive, while the thinner beds are moderately-to well-sorted. Mud-rich sub-intervals are present in BKB but are typically <3 m in length. Isolated accretionary clasts are present. Black mudstone clasts are either angular to sub-rounded or form elongate lenses and are heterogeneously distributed within the unit.

Coarse Macrocryst-rich Kimberlite Breccia (MKB)

A massive volcaniclastic kimberlite which is macroscopically distinct because of a) poorly-sorted, massive rock fabric; b) coarse (upto~15mm) olivine population; c) variably-sized clasts of volcaniclastic kimberlite (i.e., autoliths; 2 – 40 cm), unique among deposits in A21. MKB comprises apparently coarse olivine crystals (up to 15 mm in diameter 30 to 50 vol%), common mantle xenoliths and xenocrysts (2Per/row > 2 cm), minor country rock xenoliths (3 to 5%; small fresh granite clasts), and common mud-rich kimberlite autoliths (5 to 30% of rock) in a poorly- to chaotically bedded volcaniclastic kimberlite. Limited observations to date in hard copy drill core photos (A21LDC-03; 143 to 167 m) suggest A21-KIMB3 (MKB) is volumetrically minor and restricted to the north side of A21 between 9280L and 9250L.

Pyroclastic Kimberlite (PK)

A massive pyroclastic kimberlite which is macroscopically distinct because of a) abundant melt-bearing pyroclasts and a high abundance of ilmenite and chrome diopside relative to garnet. PK comprises mostly altered olivine crystals (0.03 to 10 mm in diameter; 30 to 50 vol%), black, rounded to sub-rounded, cored and un-cored melt-bearing pyroclasts (0.5 to 12 mm in size), and minor mantle xenocrysts (kelyphitized garnet, ilmenite, chrome diopside) homogeneously distributed in a very fine grained dark brown to grey matrix. Notably there is a high abundance of ilmenite and chrome diopside relative to garnet (approximately 3 to 2). Minor amounts of granite and metasedimentary rock xenoliths are present in addition to the equant black shale clasts (<1cm), and minor amounts of autoliths of volcaniclastic kimberlite (0.5 to 4 cm in size).

Massive mud with minor kimberlite components (MUDX)

MUDX is distinct from the other mud-dominated model codes because of a) the presence of minor (<1 to 5%) modal abundances of olivine; b) very minor kimberlite indicator minerals (e.g., garnet, ilmenite, chrome diopsides; <<1%); c) a massive (un-laminated) fabric; and d) poorly consolidated and lithified nature.

MUD

MUD is distinct due to the absence of any kimberlitic components, and is poorly- to un-consolidated (i.e., unlithified).

MUDSTONE

Finely laminated to massive mudstone and siltstone with no kimberlite components.

Hypabyssal Kimberlite (HK)

Multiple coherent kimberlite dykes and irregular intrusions mineralogically classified as macrocrystic monticellite carbonate kimberlite are present. The coherent kimberlite occurs as irregular intrusions along the pipe margin and into the pipe interior, and locally diffusely transition into discrete (dis-aggregated) pieces of coherent kimberlite set in a pyroclastic kimberlite matrix.

A418

The A418 pipe has been subdivide into 6 units, shown in **Figure 9**.

Finely Bedded and Mud-rich, Lapilli-bearing Kimberlite (FBLK)

Fine to medium grained well bedded variably olivine- and interclast matrix mud-rich sparsely macrocrystic to macrocrystic volcaniclastic (likely resedimented) spinel monticellite kimberlite. The presence of alternating thinly bedded/laminated olivine-rich and mud-rich intervals is distinctive. The relative proportion of olivine-rich to mud-rich intervals varies. Accretionary clasts are present and locally define bedding. There are few clasts above 9 cm in size. The interclast matric is very fine-grained mud and serpentine. Indicator minerals are commonly broken and there are fewer pyrope garnets than VBMK.

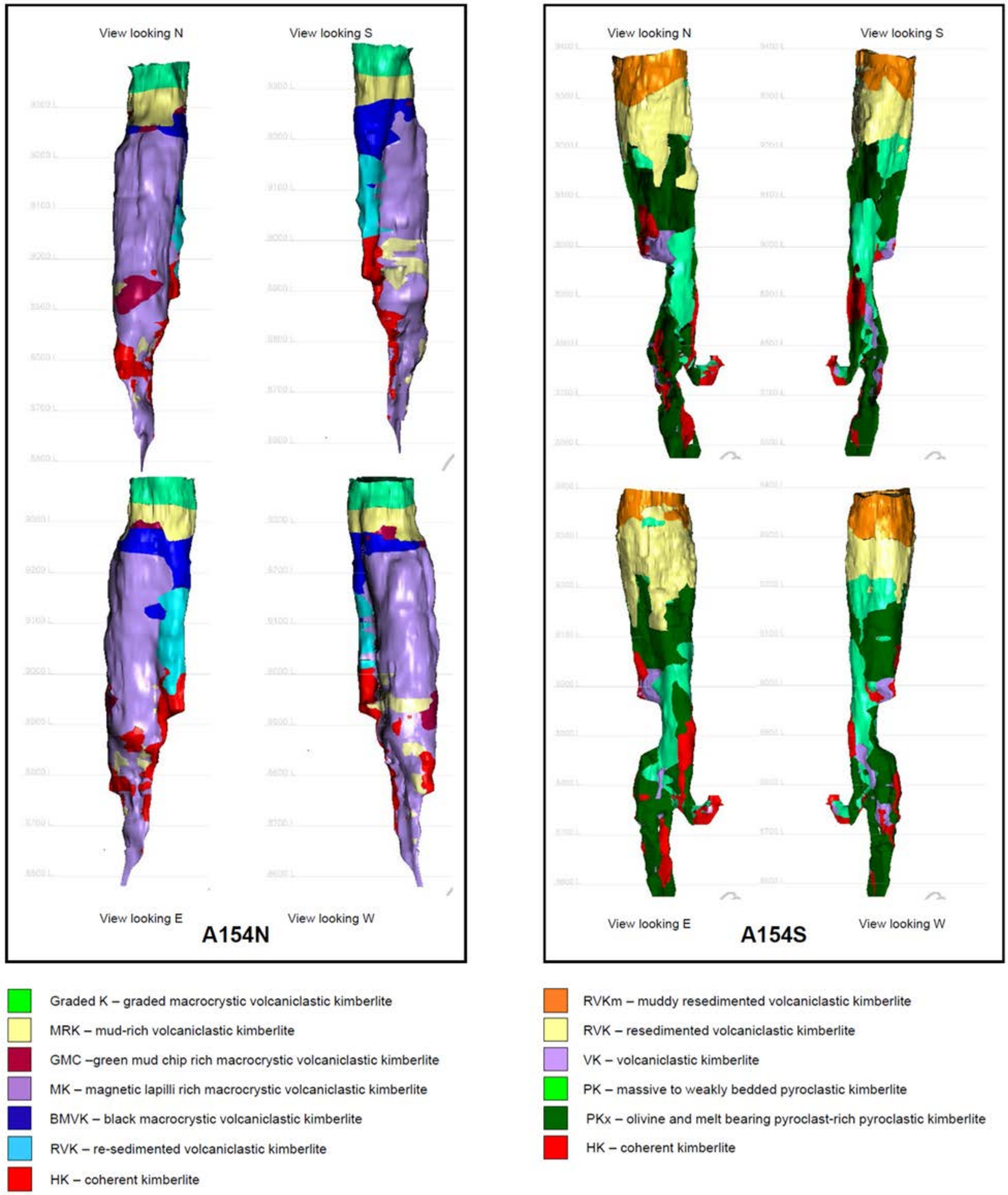


Figure 8: 3D geology of A154N and A154S (Diavik Diamond Mines, 2024)

Macrocryst-rich Kimberlite Breccia (MFKB)

A fine to medium grained unit with a downward-tapering geometry, gradational contacts with adjacent units and sharp contacts with a rind of MUD. Distinctive features of MFKB are: 1) ubiquitous mudstone clasts with fluidal or wispy morphologies (10-20%; 1-500 mm in size); 2) the highest abundances of mantle indicator mineral grains of any domain at Diavik; 3) crystal and clast-rich, close-packed fabric comprising dominantly olivine (20-50%, broken to unbroken, fresh to altered, <0.5 to 20 mm), melt-bearing pyroclasts (<10%, olivine grains with thin to thick coats of coherent kimberlite) and minor accretionary lapilli (< 5%, 1 to 5 mm); 4) minor included clasts of volcaniclastic kimberlite (4-100 mm, sub-rounded to fluidal, often containing accretionary lapilli); and 5) very low proportion of basement country rock clasts (e.g. granite + dolerite + metasediment <1 %; 5 to 500 mm, angular to sub-rounded). This unit is moderately hard and competent but disaggregates easily in contact with water.

Variably Bedded, Mixed Mud/Macrocryst-rich Kimberlite Breccia (VBMK)

A fine to medium grained occurrence of stratified volcaniclastic kimberlite observed at the outer margins of A418. This unit is distinct from other bedded units in the pipe because of a) the gradual increase in mud content from the middle to the edges of the pipe and has with abundant accretionary lapilli. VBMK has broadly similar componentry to what is observed in the massive pyroclastic domains in A418. Bedding observed in underground faces is steeply-dipping (45° to 75º; radially inwards towards the MFKB), with meter to multi-meter scale faulting and soft-sediment horizontal to sub-vertical displacements. This unit is generally soft with high interclast mud component, variable olivine abundance and is highly altered. It has gradational contacts with the FBLK unit and could possibly be a mud rich wall remnant. It contains sub-angular mud clasts and fresh country rock xenoliths.

Massive mud with minor kimberlite components (MUDX)

Several domains of mud-rich volcaniclastic kimberlite are present, each with distinct attributes. This unit comprises diffusely to chaotically bedded, mud-rich volcaniclastic kimberlite. Distinctive macroscopic features include variations in olivine abundance, variable but overall high interclast matrix mud content, variable but overall higher percentage of blocky mud clasts and country rock clasts, and generally highly altered and friable rock. MUDX is black and grey in colour and is macroscopically distinct due to the paucity of kimberlite indicator minerals, a generally massive and homogeneous to chaotic appearance, abundant clasts of volcaniclastic kimberlite (i.e., autoliths), which are themselves massive and mud-rich, broken and completely serpentinized olivine, and high proportions of inter-clast mud matrix (40 – 60 %).

Intrusive Coherent/Pyroclastic Kimberlite (ICPK)

The most volumetrically significant coherent kimberlite intrusion at A418 is a fine- to medium-grained, massive, macrocrystic, coherent perovskite spinel phlogopite kimberlite and varies from a thin (<0.20 m) intrusion to a zone more than 10 m wide over 250 vertical meters along and outside the pipe margin. There are minor occurrences ICPK in the pipe's interior and outside of the pipe margins as thin (<1 m) sheets and dykes. It is dominantly coherent but is locally disrupted into abundant large (>1 cm) melt-bearing pyroclasts. Distinctive macroscopic features include a generally massive and homogeneous appearance, and the presence of common granite xenoliths and clasts of mud-rich volcaniclastic kimberlite. It has a high magmaclast content and abundant VK autoliths.

Hypabyssal Kimberlite (HK)

The most common variety of coherent kimberlite is classified as macrocrystic monticellite carbonate coherent kimberlite. This is identical to CK occurrences at A154N and A154S. HK intrusions crosscut the pipe's interior and occur locally on the northern and eastern pipe margins. Like A154N, the dykes intrude as fingers, sheets and irregular intrusions, and are observed in greater abundance below -100 masl. This unit has sharp contacts with the surrounding units and is very competent.

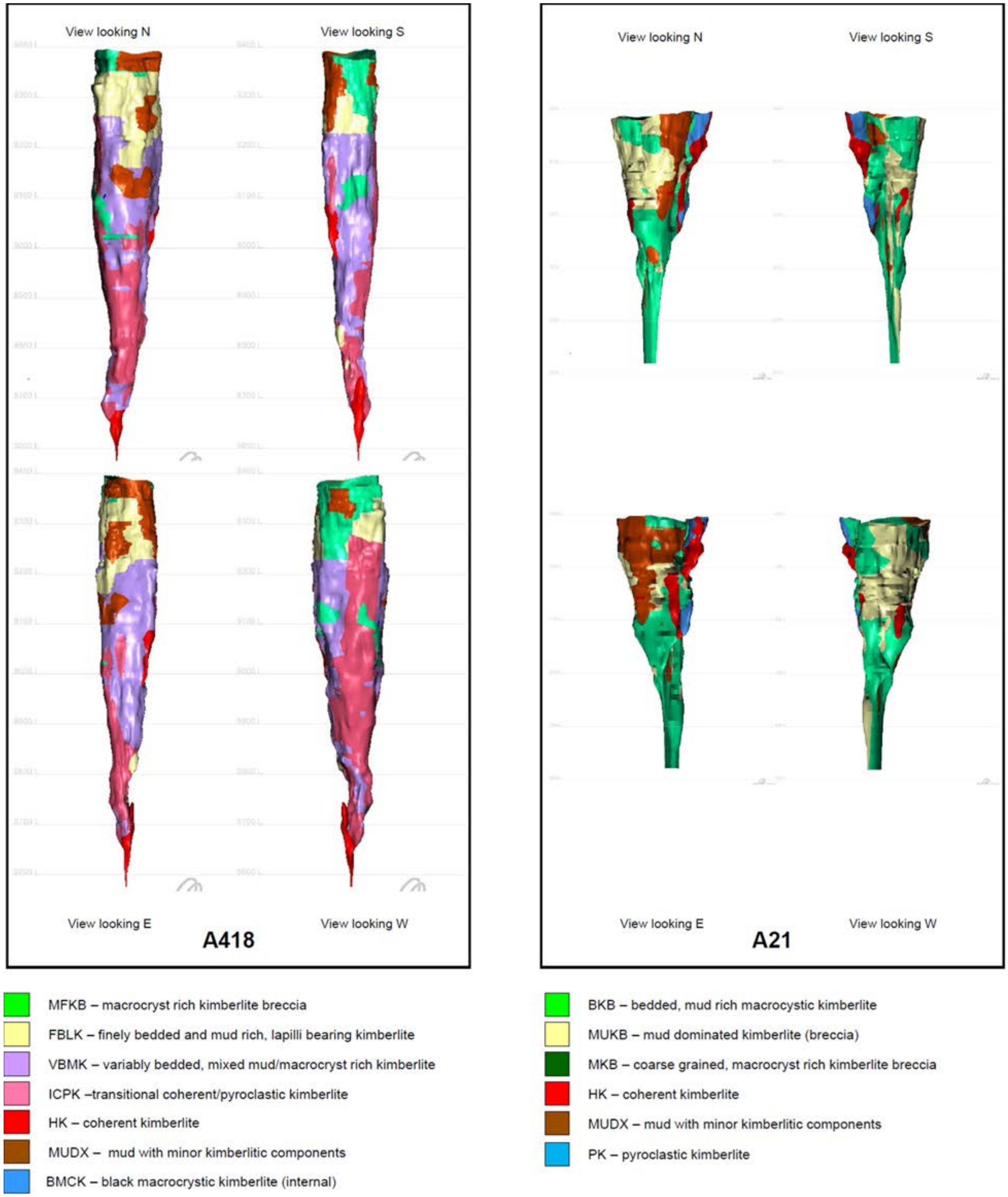


Figure 9: 3D geology of A418 and A23 (Diavik Diamond Mines, 2024)

Geochronology

Age dates are publicly available for 6 Diavik kimberlite, refer to **Table 2** below. The mined kimberlites, A154N, A514S, A21 and A418 are Eocene in age, ranging from approximately 55.7 to 56 Ma, a very similar age range to the mined kimberlites at Ekati. The C13 kimberlite, which is located approximately 20 km SE of Diavik is late Cretaceous in age.

Table 2: Published ages of Diavik kimberlites

Kimberlite	**Age (Ma)**	**Error (Ma)**	**Dating Method**	**Reference**
A154-North	56	0.7	Rb-Sr phlogopite isochron	*Graham et al. 1999*
A154-South	54.8	0.3	Rb-Sr phlogopite isochron	*Graham et al. 1999, also 55.5 +/-0.5 by Rb-Sr phlogopite (Amelin, 1996)*
A21	55.7	2.1	Rb-Sr phlogopite isochron	*Graham et al. 1999*
A418	55.2	0.3	Rb-Sr phlogopite isochron	*Graham et al. 1999*
A841 (aka Piranha)	55.8	1.6	Rb-Sr phlogopite	*Creaser et al. 2004*
C13	73.7	3.2	U-Pb perovskite	*Heaman et al. 2003*

Acknowledgements

This compilation is based on the previous 8 IKC Diavik field trip guide by Bryan and Bonner (2003) and information provided by, and unpublished reports from DDMI. It also benefited from review and contributions from Kari Pollok (DDMI).

References

Amelin, Y. 1996. Report on Rb-Sr and U-Pb study of kimberlite samples VR44444A through VR44465A., Unpublished technical report for Kennecott Canada Inc.

Armstrong, J.P. and Kjarsgaard, B.A. 2003. Geology Setting of Kimberlites in the Archean Slave Craton; in VIIIth International Kimberlite Conference, Salve Province and Northern Alberta Field Trip Guidebook, B.A. Kjarsgaard (ed.); p. 31-38.

Bryan, D. and Bonner, R. 2003. The Diavik Diamond Mine, Lac de Gras, Northwest Territories, Canada; in VIIIth International Kimberlite Conference, Slave Province and Northern Alberta Field Trip Guidebook, B.A. Kjasrgaard (ed.); p. 61-65.

Creaser, R.A, Herman, G., Carlson, J., Crawford, B., 2004. Macrocrystal phlogopite Rb-Sr dates for the Ekati property kimberlites, Slave Province, Canada: evidence for multiple intrusive episodes in the Paleocene and Eocene; Lithos, Volume 76, Issue 1-4, pp. 399-414.

Diavik Diamond Mines Inc., 2024, various communications and internal documents.

Elliott, B, 2024. Compilation of Known Kimberlites in the Northwest Territories, Canada, NWT Open Report 2024-002.

Graham, I., Burgess, J., Bryan, D., Ravenscroft, P., Thomas, E., Doyle, B., Hopkins, R., & Armstrong, K. 1999. The Diavik kimberlites - Lac de Gras, Northwest Territories, Canada. In Proceedings of the 7th

International Kimberlite Conference, Cape Town, Western Cape, South Africa. Vol. 7(1998), pp. 259-261. https://doi.org/10.29173/ikc2702

Heaman, L., Kjarsgaard, B., Creaser, R.A., 2003. The timing of kimberlite magmatism in North America: implications for global kimberlite genesis and diamond exploration; Lithos, Volume 71, Issues 2-4, pp. 153-184. https://doi.org/10.1016/j.lithos.2003.07.005

Kjarsgaard, B. A. K., Wilkinson, L. & Armstrong, J. (2002). Geology, Lac de Gras kimberlite field, central Slave Province, Northwest Territories - Nunavut. Geological Survey of Canada, Open File, 3238. https://doi.org/10.4095/213473

Moss, 2009. Volcanology of the A154N kimberlite at Diavik: implications for eruption dynamics. Ph.D. thesis, University of British Columbia, Vancouver, B.C., Canada.

Nowicki, T.E., Calson, J.A., Crawford B.B., Lockhart, G.D., Oshust, P.A. and Dyck, D.R., 2003. Field Guide to the Ekati Diamond Mine. In VIIIth International Kimberlite Conference, Slave Province and Northern Alberta Field Trip Guidebook, B.A. Kjasrgaard (ed.); p. 39-59.

Stern, R. A., & Bleeker, W. (1998). Age of the world's oldest rocks refined using Canada's SHRIMP: The Acasta Gneiss Complex, Northwest Territories, Canada. Geoscience Canada, 25, 27–31.

Stubley, M.P. 1998. Bedrock Geology of East Island Area, Lac de Gras. Unpublished internal report for Diavik Diamond Mines Inc.

Stubley, M.P. and Irwin, D., 2019. Bedrock Geology of the Slave Craton, Northwest Territories and Nunavut; Northwest Territories Geological Survey, NWT Open File 2019-01.

Ward, B., Dredge, L., and Kerr D., 2014. Surficial geology, Lac de Gras, Northwest Territories, NTS 76-D; Geological Survey of Canada, Canadian Geoscience Map 184 (preliminary, Surficial Data Model v. 2.0 conversion of Map 1870A), scale 1:125 000. https://doi:10.4095/293964

Yip, C.G. and Pollock, K.S. 2017. Diavik Diamond Mine Northwest Territories, Canada N, NI 43-101 Technical Report.

GAHCHO KUÉ MINE

4-7-2024 | IKC FIELD TRIP GUIDE

DE BEERS GROUP

MOUNTAIN
PROVINCE DIAMONDS

WELCOME FROM THE MINE GENERAL MANAGER

In the spirit of respect and partnership, we acknowledge that Gahcho Kué mine is located on the traditional territories of many peoples, including the Yellowknives Dene First Nation, Tłı̨chǫ Government, Łútsel K'é Dene First Nation, Deninu Kų́ę́ First Nation, North Slave Métis Alliance and the NWT Métis Nation.

***

It is my pleasure to welcome you to Gahcho Kué Mine, a joint venture between De Beers Group and Mountain Province Diamonds.

We're proud to sponsor the 12th International Kimberlite Conference and host this field trip to the mine.

As you know, the kimberlite we mine here at Gahcho Kué is special. Not only does it host diamonds carried up from deep within the Earth over 500 million years ago, but they offer a window to our planet's past and help us learn more about how it was formed and the hidden processes that take place deep underground.

More than that, kimberlite also offers opportunity for the communities close by. They bring jobs and income, training, business opportunities and community investments that are so important to helping develop and drive the economy of the Northwest Territories.

Gahcho Kué has a life of mine to 2031, and we take our commitments to maximizing benefits for the territory very seriously.

In May, Gahcho Kué marked a special milestone - CAD$2 billion spent with NWT and Indigenous contractor partners. The mine provides jobs to more than 245 NWT residents and in 2023 alone we invested $1.7 million in more than 90 different programs throughout the territory.

Please be safe and we hope you enjoy your visit to the mine.

Kevin Gostlin
General Manager

GAHCHO KUÉ MINE

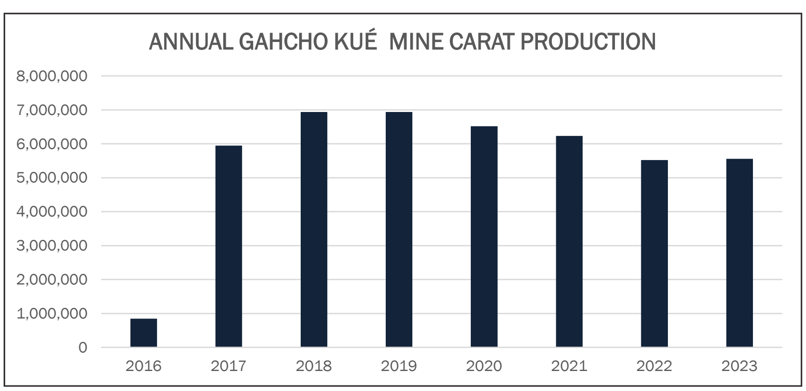
2024 FACT SHEET

AWARD-WINNING CANADIAN DIAMOND MINE

Gahcho Kué mine is a remote fly-in/fly-out operation at Kennady Lake, located 280 km northeast of Yellowknife, Northwest Territories. The mine is a joint venture between De Beers Group (51%) and Mountain Province Diamonds (49%) with De Beers as the operator. The property was discovered in 1995 and officially opened in September 2016. Commercial production was achieved in March 2017 and the life of mine is to 2031.

Since the mine opened Gahcho Kué has received numerous safety and operational awards, including:

- 2023 NWT Literacy Award: Outstanding Support for Literacy Development NWT Business Award
- 2023 & 2022 NWT MAX Award for Environmental, Social & Governance
- 2022 TSM Community Engagement Excellence Award from the Mining Association of Canada (MAC)
- 2020 national John T. Ryan Award for Select Mines (Safety)
- 2019 & 2016 Workplace Health & Safety Award - Yellowknife Chamber of Mines
- 2019 Overall Surface Winner - 14th biennial National Western Region Mine Rescue Competition
- 2024, 2019, 2018 & 2017 Overall Surface Winner - NWT/NU Mine Rescue Competition
- 2017 Surface Smoke Winner - 13th biennial National Western Region Mine Rescue Competition
- 2017 Hatch-CIM Mining & Metals Project Development Safety Award
- 2017 Viola R. MacMillan Award from the Prospectors & Developers Association of Canada (PDAC)
- Gold at the 11th annual Project Management Institute (2016) awards gala in Montreal




$704m
SPENT WITH INDIGENOUS BUSINESSES FROM 2015-2023
64%
PROPORTION SPENT WITH NWT BUSINESSES IN 2023
44.5m
CARATS RECOVERED SINCE START OF OPERATIONS
$4.2m
ROYALTIES PAID TO GNWT TO DATE
663
FULL-TIME EQUIVALENT JOBS AT GAHCHO KUÉ MINE
$48.5m
CONTRIBUTIONS TO NWT COMMUNITIES 2015-2023
21%
PERCENTAGE OF NWT INDIGENOUS EMPLOYEES AT THE MINE
17%
FEMALE EMPLOYMENT AT GAHCHO KUÉ MINE

GAHCHO KUÉ MINE

2024 FACT SHEET

1995
GAHCHO KUÉ DISCOVERED
Mountain Province Diamonds discovers the first kimberlite deposit, known as 5034. De Beers joined the joint venture in 1997.

2013
ENVIRONMENTAL ASSESSMENT
Mine receives approval from the Environmental Impact Review Board

2014
CONSTRUCTION BEGINS
Two-year construction starts in winter 2014-15

2016
OFFICIAL OPENING
The opening ceremony takes place September 20, 2016

2017
DIAMOND PRODUCTION
Commercial production begins in March.

2018-2019
NEW DISCOVERY
Team discovers NEX and Wilson kimberlites as part of exploration activities to extend life of mine

2020
NATIONAL AWARD
CIM names mine a winner of the national John T. Ryan Award for mine safety.

2024
MILESTONE SPEND
In May, Gahcho Kué surpasses CAD$2bn spent with NWT & Indigenous business since 2015.

2023 QUICK FACTS
- 5.6m carats recovered
- 37m tonnes mined
- $331m spent to operate the mine
- 663 total FTE jobs
- Safety performance improved by 43% from 2022
- $1.73m in corporate social investment

Major Mining Equipment
- 3 x 29 m3 Komatsu PC5500 Shovels
- 17 x 215 t Komatsu 830E Haul Trucks
- 1 x 17 m3 Komatsu WA1200 Wheel Loader
- 2 x 12 m3 Komatsu PC2000 Excavator
- 7 x 90t Komatsu HD785 Haul Trucks
- 2 x 3.4 m3 Komatsu PC1250 Excavator
- 4 x Atlas Copco PV271 Drills

IMPACT BENEFIT AGREEMENTS
De Beers has signed six benefit agreements with Indigenous communities. These agreements outline the impacts of the project, the commitment and responsibilities of each party, and how Indigenous groups will share in the benefits of the mine.

- North Slave Métis Alliance (July 2013)
- Tłı̨chǫ Government (January 2014)
- Yellowknives Dene First Nation (February 2014)
- Łútsel K'e and Kache Dene First Nation (July 2014)
- NWT Métis Nation (December 2014)
- Deninu Kųę́ First Nation (December 2014)

WHAT'S IN A NAME?
Gahcho Kué means "place of the big rabbits or hares" in the local Chipewyan language.

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The geology of the Gahcho Kué Kimberlite cluster, NWT, Canada

Stephan Kurszlaukis*~ and **Jennifer Pell***ǂ

*De Beers Canada, ~independent, ǂ in memoriam

Location and history

The Gahcho Kué kimberlite cluster is located on the southern Slave Craton, about 280km ENE of Yellowknife in the Canadian Northwest Territories (Fig. 1). The first kimberlite body, 5034, was discovered by Canamera Geological Ltd. in 1995. A joint venture between De Beers Group, Mountain Province Mining and Camphor Ventures Canada continued exploration and discovered and evaluated additional kimberlites leading to the opening of the Gahcho Kué Mine in 2016. The mine is a joint venture between De Beers Canada Inc. (51%) and Mountain Province Diamonds Inc. (49%). Gahcho Kué is an open pit operation, mining three kimberlite pipes in sequence: 5034, Hearne, and Tuzo.

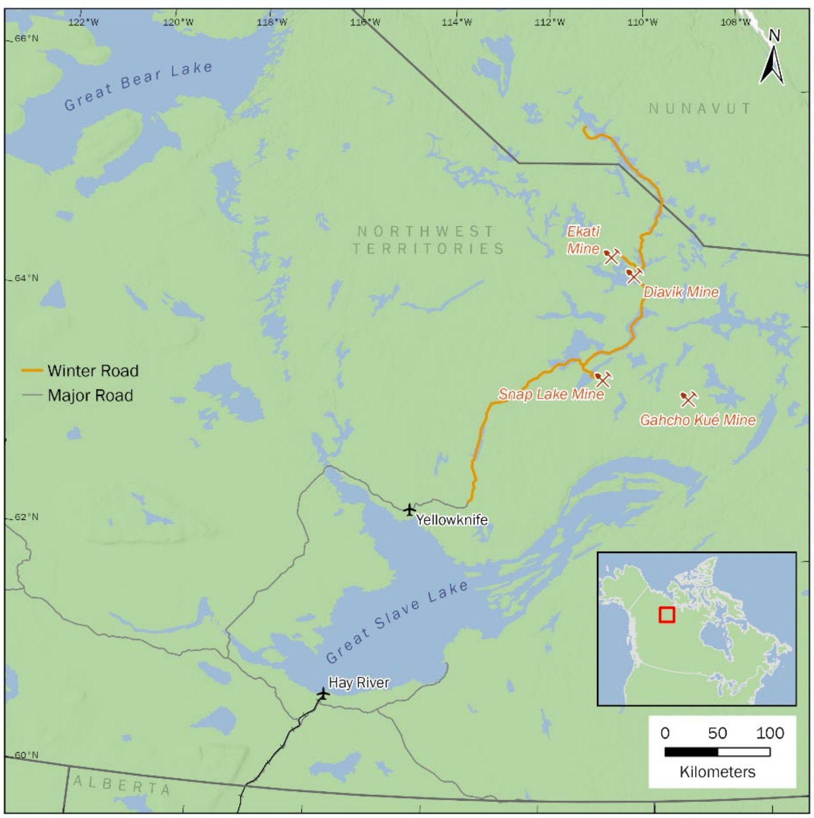


Fig. 1: Location map of Gahcho Kué Mine.

The Kennady Lake kimberlite field

Radiometric age dating of Gahcho Kue kimberlites suggests an Early Cambrian emplacement age (542-531Ma) that is similar to that of the Snap Lake kimberlite (ca. 537Ma), about 85km to the WNW, and of the Kennady North kimberlite cluster (546-531Ma), about 12km to the NE of Gahcho Kué (Fig. 2). The close spatial and age relationship of these bodies suggests that they belong to the same kimberlite field, which is called Kennady Lake Kimberlite field due to the location of both the discovery camp and the Gahcho Kué kimberlite cluster close to the shoreline of Kennady Lake.

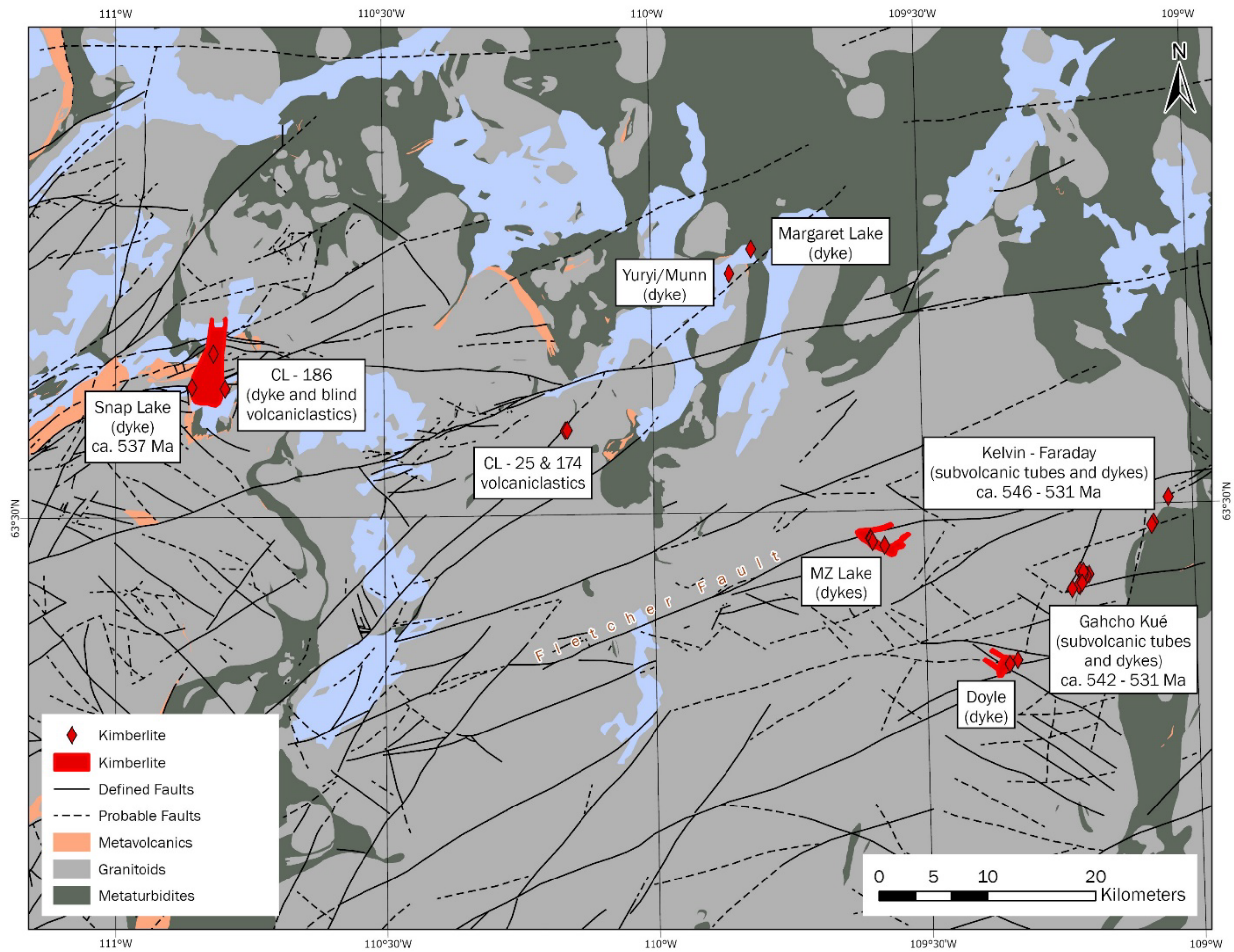
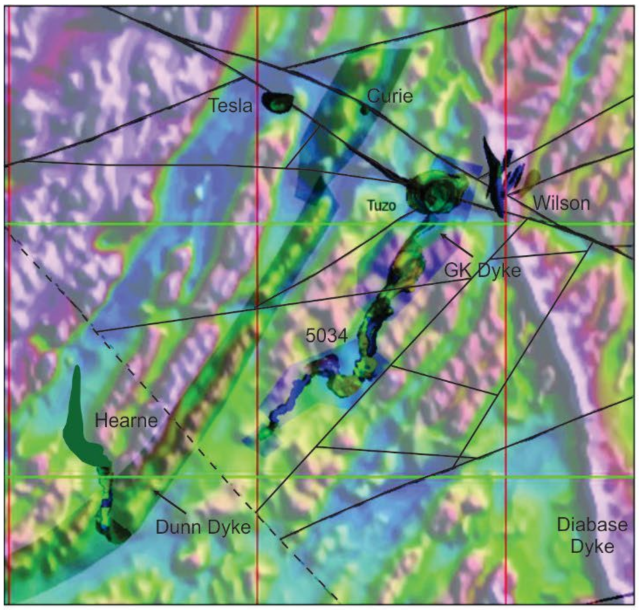


Fig. 2: Map showing the locations of kimberlites in the Kennady Lake Kimberlite Field and their radiometric emplacement ages. Map from Barnett et al. (2018).

Geological setting

The south-central Slave Craton of northern Canada is comprised of Archean granitoids, metaturbidites, and basic amphibolite-bearing meta-volcanic rocks (Fig. 2). All country rocks have undergone regional greenschist to amphibolite-facies metamorphism (Hoffman, 1988). Proterozoic granitic pegmatite and diabase dykes intrude all of the identified country rock types. The most prevalent faults on the Slave craton include a conjugate system of northeast-striking dextral and northwest-striking sinistral strike-slip faults, and penecontemporaneous northerly trending oblique-sinistral faults which have been active about 1.84 – 1.74Ga ago (e.g. Stubley, 1998). The fault and fold systems present locally in the vicinity of the Gahcho Kué cluster are striking in a SW-NE, E-W, and NW-SE direction (Fig. 3). Of the five major kimberlite bodies (Hearne, 5034, Tuzo, Tesla, and Wilson), only Tuzo appears to be located at the intersection of several major structures. The main northeasterly plunge direction of 5034 is parallel to the regional basement fold direction and some SW-NE striking faults in the vicinity while its local undulations appear to be related to E-W and NW-SE striking subordinate faults. Wilson, a sheet-like kimberlite body to the East of Tuzo, is both related to the local stress field imposed by Tuzo and, possibly, also the presence of a NNW striking diabase dyke (Fig. 3 left).



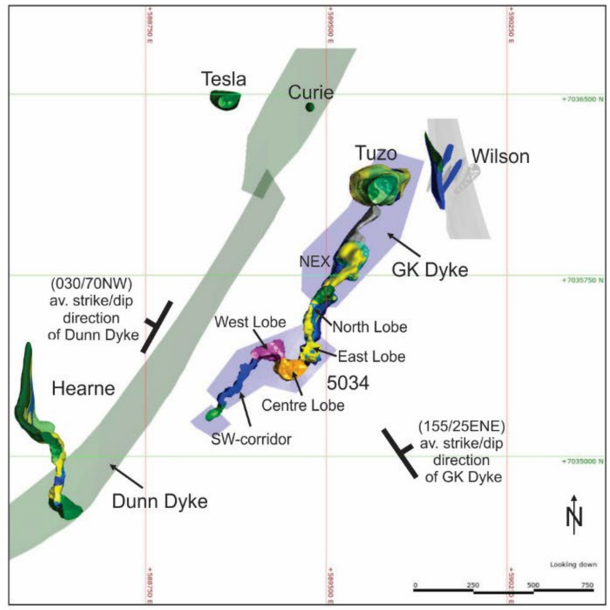


Fig. 3: Location map of the Gahcho Kué kimberlite cluster. Left: The map shows some of the major faults interpreted in the area (dark lines) and their relationship to the kimberlite bodies. The background image is an airborne total magnetic intensity (TMI) image. Grid spacing is 1000m. Right: The kimberlite bodies (projected to surface) with their feeder dyke system.

The Gahcho Kué kimberlite cluster

The Gahcho Kué kimberlite cluster comprises five steep-sided kimberlite bodies: Hearne, 5034, Tuzo, Wilson, and Tesla (Fig. 3). These bodies, except parts of 5034, originally occurred beneath the waters of Kennady Lake which has an average depth of 8m. The Tesla kimberlite body is not part of the current declared resources or reserves. Curie is another, small kimberlite body located between Tesla and Tuzo and is at present not of economic interest. The Quaternary overburden thickness varies between only a few meters and up to 20m.

The first discovered kimberlite body, “5034”, is an irregularly-shaped, elongated body with a structural length of at least 1000m that plunges to the NE (Fig. 3). It rises from the 25° NE dipping Gahcho Kué dyke and sub-crops with a surface area of approximately 2.1ha at the present-day land surface for a length of about 500m at its southwestern end. Towards the NE, 5034 is covered by an increasingly thick Archean basement. While the base of 5034 is defined by its feeder dyke, the sub-surface roof of the body shows several abrupt steps. It has lateral curves and “knolls” which let the width of the body vary from 20 to 120m. The 5034 kimberlite is modelled in four bodies, or Lobes, from SW to NE (Figs. 3 and 4): Southwest corridor, West Lobe, Centre Lobe and Northeast, which is itself comprised of East Lobe, North Lobe, and Northeast Extension (NEX). Due to the plunge of 5034 to the NE, North Lobe and Northeast Extension are covered by granite basement. The roof of North Lobe is rather horizontal and lies under 60 to 90m of granite cap rock. The roof above Northeast Extension steps down at the connection with North Lobe and again after about 200m to the NE, in the area of a localized “knoll” with a width of 120m. The overburden above Northeast Extension exceeds 200m. The granite country rock above the subsurface extensions is highly fenitized (and, to a minor extent, also the granites forming the side walls) and the fenitization halo can reach several tens of meters into the country rock. Southwest corridor, which is structurally closest to the feeder dyke, shows evidence for contact breccias at its base that were partially removed by later intruding coherent kimberlite. While the 5034 Lobes are overall connected and geologically continuous, they may have local granite “windows” which add complexity to their shape.

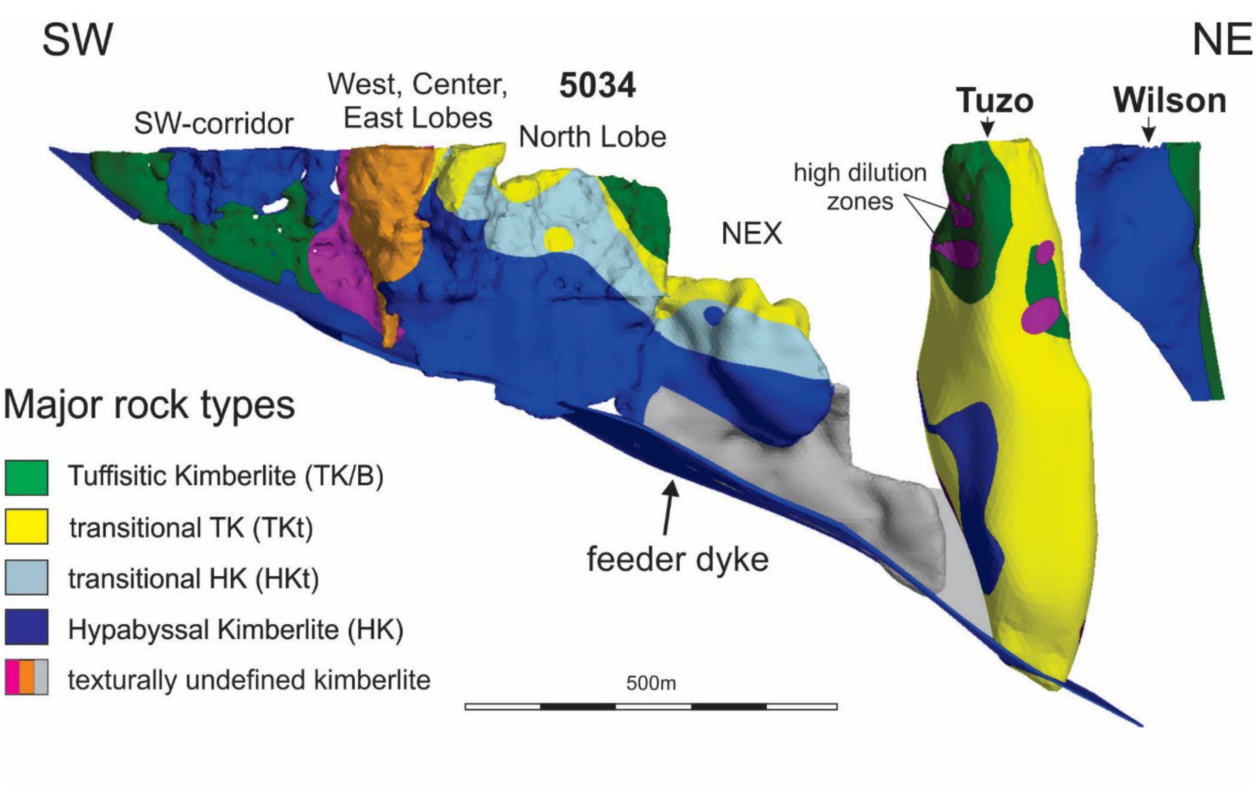


Fig. 4: Side view of 5034, Tuzo and Wilson, looking NW. 5034 and Tuzo rise from the inclined Gahcho Kué feeder dyke and show an internal facies arrangement that is roughly parallel to the feeder dyke.

Tuzo is a 600m deep, spindle-shaped, vertical body (Fig. 5) that occurs at the northeastern tip of 5034 and is very likely connected to 5034 at depth. It reaches the present-day land surface and is filled by fragmental and coherent kimberlites relating to two separate emplacement events. Similar to 5034, Tuzo rises from the inclined feeder dyke and has no vertical depth extension below its feeder dyke.

Wilson is located to the East of Tuzo and is comprised of several fragmental and coherent, NNW striking kimberlite sheets that dip westwards towards the base of Tuzo. It appears to align with an NNW striking diabase dyke, but close examination in drill cores does not suggest a systematic relationship between the emplacement of the Wilson sheets with the diabase dyke.

Tuzo shows locally a high abundance of internal country rock dilution, which is most predominant along the deeper western wall where country rock breccias mixed with kimberlite occur (Fig. 5). Above this internal dilution zone, in the constricting top portion of Tuzo, the country rock itself is broken and has some minor kimberlite mixed in. On the opposite, eastern side of Tuzo, the main sheet of Wilson dips towards the base of Tuzo where it emerges from its inclined feeder dyke. Although the granite in between Wilson and Tuzo shows little evidence of brecciation, a rotational, hinge-like movement of the granite as a whole block towards Tuzo would explain the existence of Wilson, which should consequently be seen as a crevasse fault infill in between the rotated block and in situ country rock.

Both the granite breccia in the West and the rotated block in the East, together with the location of internal dilution zones along the wall of the kimberlite body, suggest that major subsidence processes have been at work and that Tuzo is an example of arrested juvenile pipe development. If the volcanic activity had continued, the breccias would have subsided into deeper levels of Tuzo and been mixed into volcaniclastic kimberlite during subsequent volcanic events. It is also interesting to note that such a continuation of subsidence and the succeeding consumption of breccias would have resulted in a rather normal pipe angle, which is merely a rock mechanical response to a low-density medium.

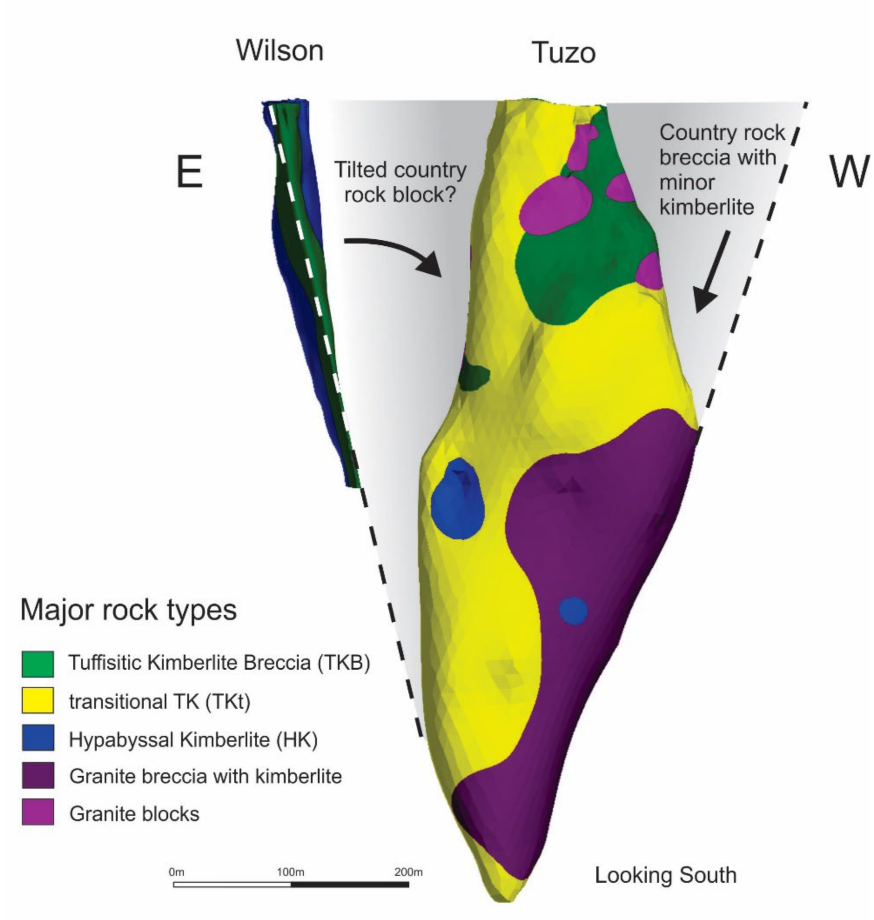


Fig. 5: Side view of Tuzo and Wilson, looking south. There are two volcaniclastic kimberlites, a highly diluted TKB and a transitional TK, which are related to different emplacement events. Tuzo has zones with very high internal dilution and the country rock itself shows signs of brecciation and subsidence towards the kimberlite body.

The Hearne kimberlite body is located on the second feeder dyke system, the NNE striking Dunn Dyke that dips steeply with about 70° to the NW (Fig. 6). Similarly to 5034, Hearne is an elongated body that sub-crops at its southern end and is covered by basement rocks towards the NW. Recent resource drilling showed that Hearne is comprised of North and Northwest plunging linear elements and drill data proved a length of the body of at least 800m and a depth of over 500m from the surface.

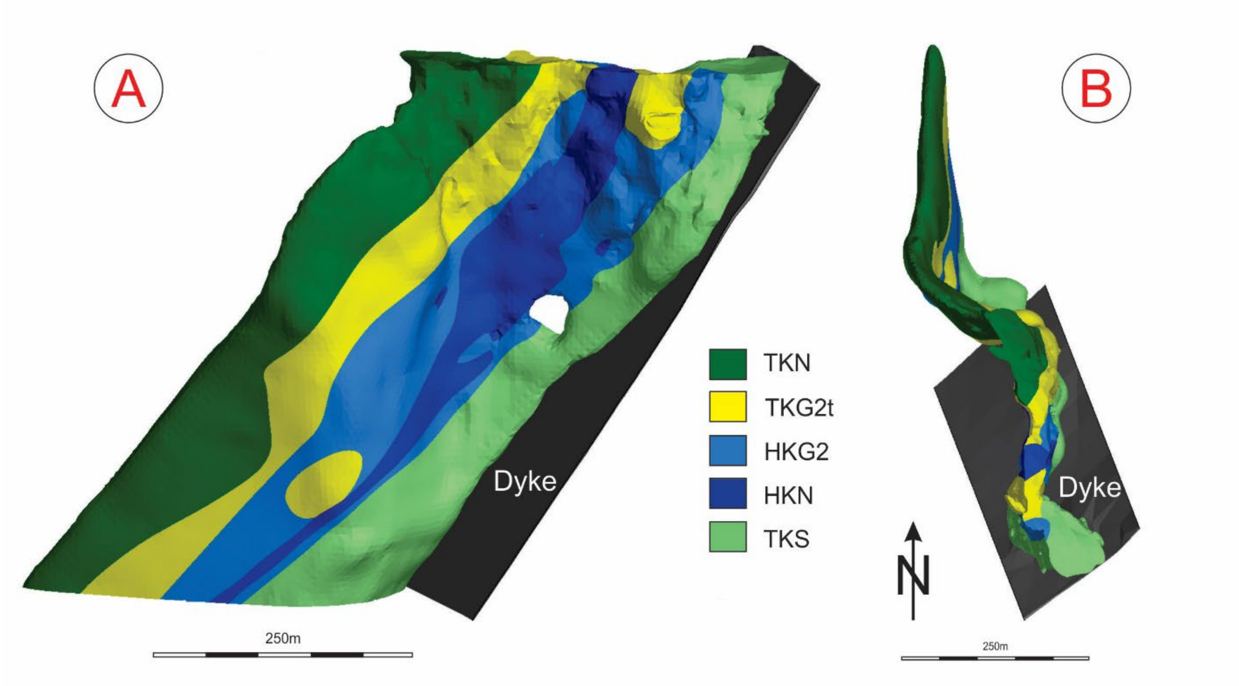


Fig. 6A,B: A) Hearne looking East; the kimberlite body is comprised of 5 different rock types: two HK, two TK and a TKt. The TKS is the oldest unit rising from the feeder dyke; renewed intrusion resulted in the emplacement of HKG2, TKG2t, and TKN. The last kimberlite intrusion is the HKN. B) Hearne looking down. The elongated kimberlite body consists of N-S and NW-SE striking linear segments.

Hearne consists of two coherent (HKG2 and HKN), two volcaniclastic (TKS and TKN), and one transitional volcaniclastic (TKG2t) facies that dip parallel to the feeder dyke. At first glance, the kimberlite facies arrangement appears different from that of 5034 in that the heavier coherent kimberlites are not at the base but in the center of the body. However, on closer inspection, Hearne is comprised of several separate intrusive events, with TKS at the base being the oldest phase that was emplaced in direct contact with the feeder dyke. After a hiatus that was long enough to consolidate the TKS, renewed intrusive activity occurred in the roof area of TKS and resulted in the emplacement of the HKG2, TKG2t, and TKN rock units (all of which are related to the same “G2” magma batch). A short time later the last kimberlite batch intruded into the cooling HKG2 magma which resulted in the emplacement of the HKN.

Groundmass spinel, whole rock chemistry, and diamond data confirm the presence of three separate magma batches (TKS, the “G2” rock units, and HKN). The time sequence of emplacement is indicated by TKS cognate xenoliths present in HKG2 and grain flows in the roof area of TKS, which indicates compaction of the underlying TKS tephra column and the creation of a gap which the later intruding G2 magma would have exploited. Also, “basement windows” between the TKS and the HKG2 (Fig. 6) represent the remnants of a physical barrier between the two kimberlites. The facies distribution of HKN and HKG2 is complex and it appears that the HKN intruded into the cooling HKG2 magma that was still liquid but likely had a viscosity difference to the hotter HKN magma. The interface between the two coherent magmas is often very difficult to see, but sometimes olivines in either the HKN or HKG2 mark the contact.

The feeder dyke system

A peculiarity of the Gahcho Kué cluster is that the kimberlite bodies rise from two inclined feeder dykes, the Gahcho Kué Dyke and the Dunn Dyke (Fig. 3). The Gahcho Kué Dyke strikes at about 155° and dips at about -25° to the ENE while the Dunn Dyke strikes at about 030°, and dips at -70° to the NW. Hearne is fed from the Dunn Dyke, while 5034, Tuzo, Wilson, and possibly Curie are fed from the Gahcho Kué Dyke system. There is not enough drill data to relate Tesla to either of the feeder dykes. The extent of the dyke systems along their strike directions is currently unknown. The feeder dyke systems are mostly comprised of one or a few dyke intersects that can be spread over up to 10m vertical distance. Individual dyke intersects are usually less than 3m thick, but often not more than a few centimeters or decimeters. Olivine flow alignment and sorting are commonplace in the dykes and may cause a drastic change in olivine size and abundance within a few centimeters (Fig. 7A,B). Also noticeable is the variance in garnet content within and between dyke intersects. Reactivation of the dyke system is evident from sharp boundaries between flow units within the same dyke intersect. Brecciation of older kimberlite or the adjacent country rock occurs occasionally (Fig. 7C) and the granite adjacent to the kimberlite can be locally fenitized.

There is no evidence for a vertical dyke beneath the inclined feeder sheet and only very few, minor and isolated dykes were intersected above it. A major vertical dyke system on which diatremes could have grown from the surface has so far not been intersected.

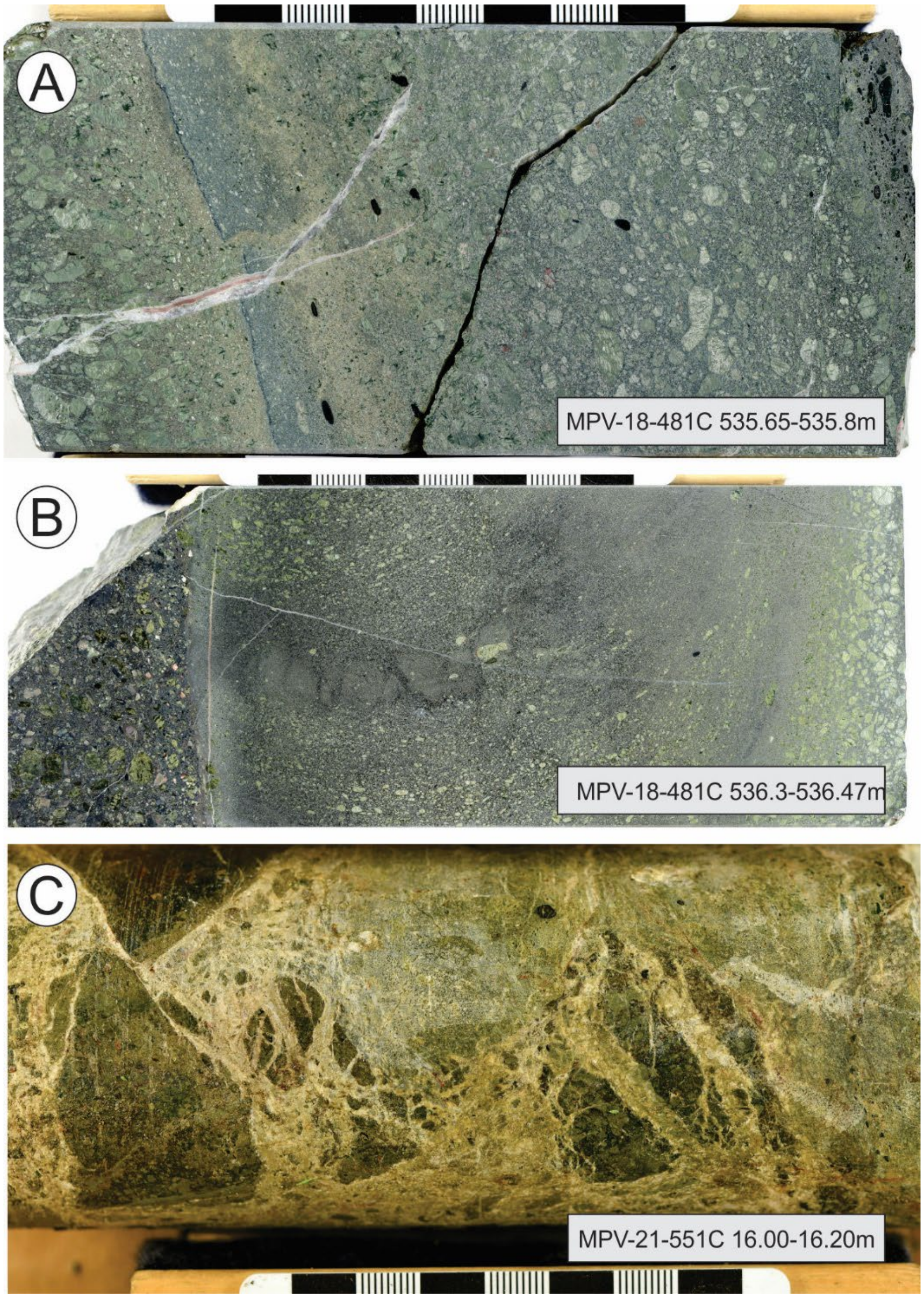


Fig. 7A-C: Polished slab photographs of the Gahcho Kué feeder dyke system in the area of 5034 Northeast Extension. A) and B): Both samples show flow sorting and -alignment as well as sharp interfaces, indicating reactivation of the feeder dyke system. C): Two generations of brecciation of the feeder dyke suggest repeated reactivation with hiatuses long enough to allow lithification of earlier kimberlite phases.

Kimberlite geology

Both 5034 and Hearne show stratification of coherent and fragmental kimberlite that is dipping more or less parallel to their respective feeder dykes (Fig. 4 and 6). Coherent kimberlite (hypabyssal kimberlite, or HK) dominates at the base of 5034 and is overlain by volcaniclastic kimberlite (Tuffisitic kimberlite, or TK) in higher levels of the body. Similarly, the G2 magma in Hearne also forms a layered body with coherent kimberlite at the base that is overlain by volcaniclastic kimberlite. Sandwiched in between these two end-member rock types are rocks that show transitional textures and are either called TKt if their nature is deemed fragmental or HKt if the rock is still seen as being coherent. The contacts between the kimberlite types can be sharp or transitional. The interface between coherent and fragmental kimberlite can also appear as intervals that are several meters to tens of meters in thickness in which rock textures vary until either coherent or fragmental kimberlite prevails.

Tuffisitic kimberlites, a legacy term still used in the Gahcho Kué mine, are volcaniclastic rocks that, according to Hetman et al. (2004), also occur in a transitional texture. However, we do not see a significant difference between a TKt and a TK, at least concerning xenolith sizes or their abundance. The patchy nature of matrix areas that appear either more fragmental or magmatic is in our view rather related to locally variable degrees of alteration or simply the variable thickness of a thin section. However, when compared to TKt, the features that we found typical for TK are the relative scarcity of juvenile silicates (i.e. the paucity of thicker rims around true juvenile pyroclasts and in general the lower number of thickly-rimmed juvenile pyroclasts) as well as the higher abundance of pelletal olivine that have either complete, thin rims that mimic the shape of the serpentinized olivine core, or olivines that have only partial rims or no rims at all. We regard a particle in a volcaniclastic kimberlite as a “true” juvenile pyroclast if the shape of the pyroclast was controlled by magma fragmentation in a fluid-ductile state and surface tension forms a sphere, often with an olivine or xenolith core (Fig. 8 A,B). The rims of these juvenile pyroclasts frequently contain finer-grained olivines than the olivines in the surrounding inter-clast matrix and show sorting, zonation, and tangential alignment of elongated minerals. In contrast, pelletal particles typically have thin rims of equal thickness that mimic the shape of the core (Fig. 8 C,D), which indicates that this type of rim is not related to the surface tension of a liquid but is rather an alteration feature and thus a reaction halo around the olivine.

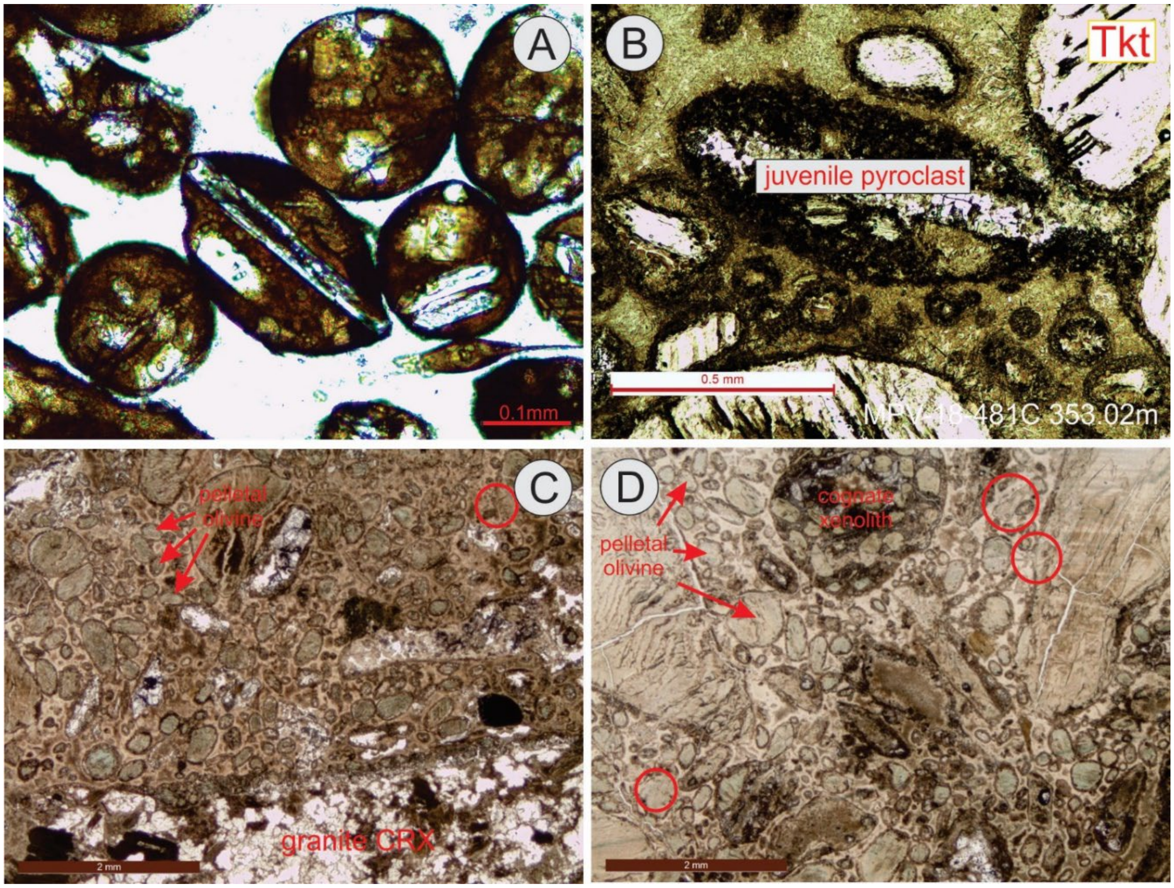


Fig. 8A-C: A) Ash-sized juvenile pyroclasts from remolten kimberlite fragmented during explosion experiments (Kurszlaukis et al., 1998). The kimberlite glass completely encloses olivine quench crystals and forms spheres due to the surface tension of the melt. Compare to the natural juvenile pyroclast in B), also confirming the fragmental nature of a TK. C) and D): Pelletal olivine in TK from Hearne. The ultra-thin rims mimic the shape of the olivine core and are therefore not primary but should be seen as subsolidus alteration products. Some olivines are partially devoid of a rim (red circles). CRX=Country Rock Xenolith.

In general, a TK has the highest degree of alteration of juvenile components like olivine while the country rock xenoliths are comparably fresh and show no or very minor signs of assimilation as often seen in coherent kimberlite. When compared to HK, a typical TK has no monticellite or carbonate in the matrix and a lower abundance of small olivines. The lack of small olivines can likely be attributed to the destructive serpentinization process and the influence of corroding fluids that percolate through the tephra after emplacement. Elutriation of fines into the atmosphere is not a probable process since the tube-like shape of the kimberlite bodies does not allow an efficient exchange with the atmosphere. While carbonate is generally absent as a matrix mineral in TK or TKt, it is present in late veins cutting through already consolidated volcaniclastic deposits. In contrast, carbonate is present as a cement in many bedded crater-floor kimberlites elsewhere (e.g. Orapa, Botswana (Gernon et al., 2009)), testifying to the transport and precipitation of carbonate under late-stage, hydrothermal conditions.

The mapping of the transitional kimberlite types as described by Hetman et al. (2004) was widely followed, although our interpretations of rock textures and emplacement processes are different. We do not regard transitional textures in kimberlites as being primary or that they are the product of a flash-frozen downward-migrating fragmentation zone. In coherent rocks, the textures defined as "transitional" are, in our interpretation, related to the nature, abundance, and retention time of kimberlite fluids and their ability to accumulate and migrate through the slowly cooling magma or tephra column after emplacement. The fluids are in disequilibrium with the silicate kimberlite host from which they exsolve before and after emplacement and start to pool and resorb the silicate minerals and xenoliths in their vicinity. In a post-emplacement environment, this process already starts in coherent, hypabyssal kimberlites (HK) and is more prevalent within a transitional hypabyssal kimberlite (HKt) magma, which typically also has a higher abundance of microxenoliths. HKt usually overlies HK and exsolving fluids would rise through the HK into the overlying HKt where they start to concentrate, forming abundant segregationary textures and coarse clinopyroxene haloes around (micro)xenoliths. Thin-rimmed "pelletal olivine" features are closely related to the presence of resorbing fluids and consequently start to form as subsolidus deuteric alteration features in HK and become more frequent in HKt (Fig. 9). Pelletal particles appear within and in the vicinity of poorly defined, high-temperature serpentine veins, segregationary serpentine pools, and in the haloes adjacent to assimilated xenoliths. Therefore, the presence of thin-rimmed pelletal olivine is not diagnostic for a fragmentation process and they should not be seen as primary juvenile pyroclasts, as it was suggested by Hetman et al. (2004) and Webb and Hetman (2021). Coherent kimberlite also frequently contains late-stage, poikilitic phlogopite which testifies to water-rich fluids retained in the cooling magma, or groundwater entering from the country rocks. Short-prismatic, euhedral or poikilitic, subhedral to anhedral phlogopite is absent in the fragmental kimberlites and phlogopite occurs only in the rims of pelletal olivine as an acicular deuteric alteration product. While the corrosive action of fluids which causes most of the characteristic textures of kimberlites in a transition zone already starts immediately after emplacement at high temperatures, it appears to be also effective in a subsolidus environment and is responsible for many of the pseudo-fragmental textures observed in HKt and TKt.

While the retention time of the fluids is significant in the hot hypabyssal kimberlites after emplacement, the migration of fluids is much faster in the lower levels of the overlying, cooler tephra due to the highly permeable condition of the volcaniclastic deposit. The rise of the corrosive fluids through the tephra pile is temporarily halted in the roof area of the deposit. Here the fluids will pool at lower temperatures and the corroding action of the fluids focuses on the smallest, ash-sized juvenile particles or olivines which have a larger surface area in relation to their volume. They are often completely dissolved, explaining their lower abundance in TK when compared to their coherent kimberlite equivalent. The thickness of the rims of juvenile pyroclasts is also reduced due to corrosive action, increasing the number of solitary, pelletal or thin-rimmed particles.

Finally, the fluids will penetrate the overlying granite roof, where they also leave evidence of their corrosive nature. Quartz in the granite is dissolved which may result in a vuggy, feldspar and mica-dominated rock. More frequently, however, quartz is replaced by serpentine, chlorite, or in some cases carbonate. The replacement of quartz with serpentine is also very common in granite xenoliths from TKs and TKts. This fenitization process can dissolve or replace almost the entire granite, as observed in the roof area of 5034 North Lobe. Here intensive fenitization only leaves behind some feldspars or micas close to the kimberlite contact for about 5 to 15m. Further away from the kimberlite body, the fenitization of the country rock is concentrated along cracks in the granite along which the fluids can move. The fenitization halo can reach a width of 30-40m above the kimberlite and varies from 0 to a few meters on the sides of the body.

Examples of the variably textured kimberlites comprising a transition zone are shown as slabs in Fig. 10 and thin sections in Fig. 11. For explanations see figure captions.

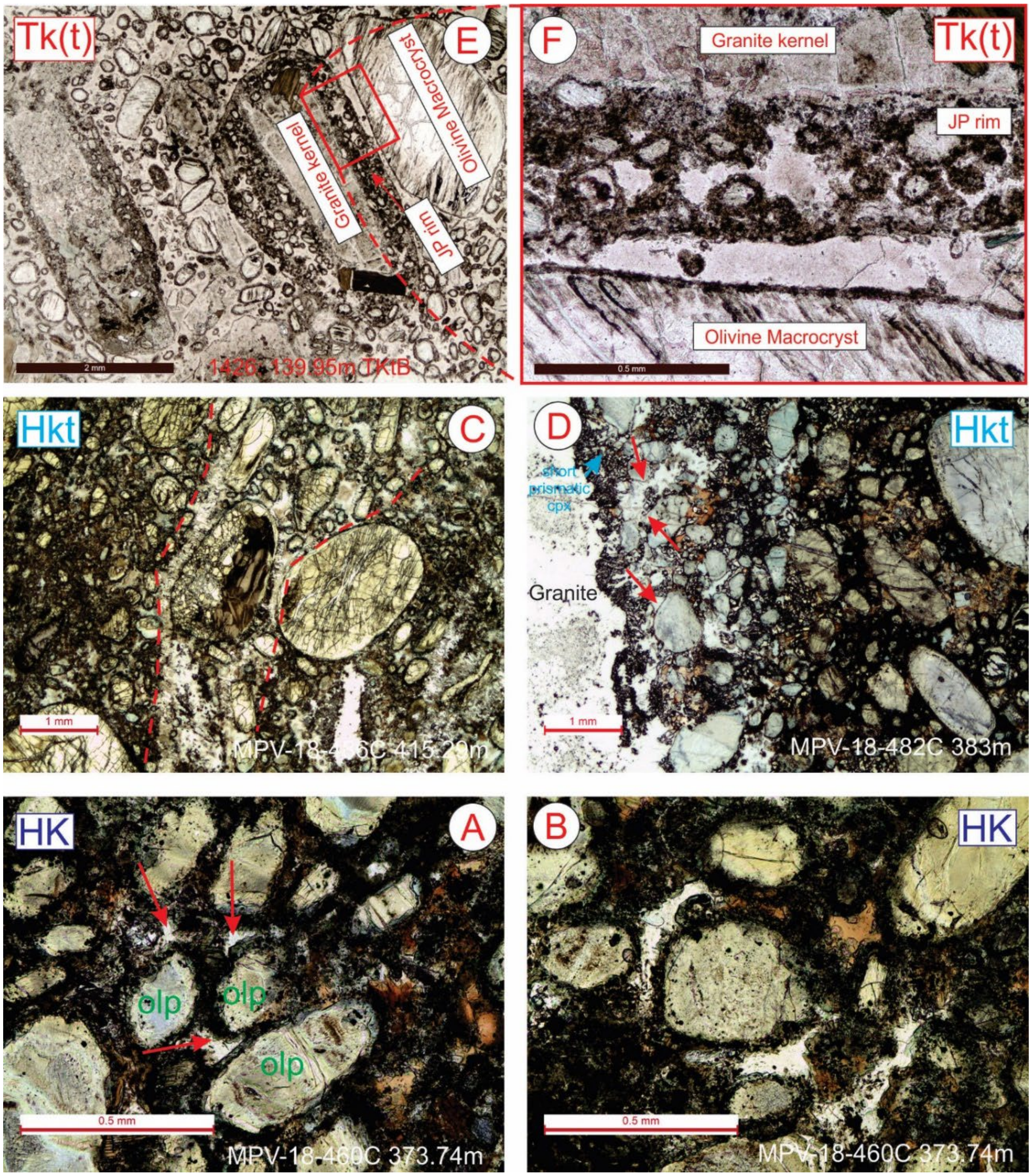


Fig. 9: Generation of pelletal olivine in thin sections of variably textured kimberlite. A), B): In the vicinity of segregationary serpentine and carbonate pools (red arrows), olivine in hypabyssal kimberlite develops thin rims that mimic the shape of the olivine phenocryst (olp). Seen in isolation, these features would be called "pelletal olivine", but are clearly sub-solidus alteration features in a coherent rock. C): Olivines within and in the vicinity of a high-temperature serpentine vein (red dashed line) are completely isolated and classify as "pelletal"; some olivines even miss a rim partially or completely. D): Alteration in the halo surrounding a granite xenolith also dissolves the silicate groundmass and leaves pelletal and partially rimless (red arrows) olivines behind. E): the thin section shows pelletal olivine and two juvenile pyroclasts with magmatic rims. F): Enlargement of one of the juvenile pyroclast rims showing pelletal olivine as an alteration product within the magmatic rim. E) and F): JP=juvenile pyroclast.

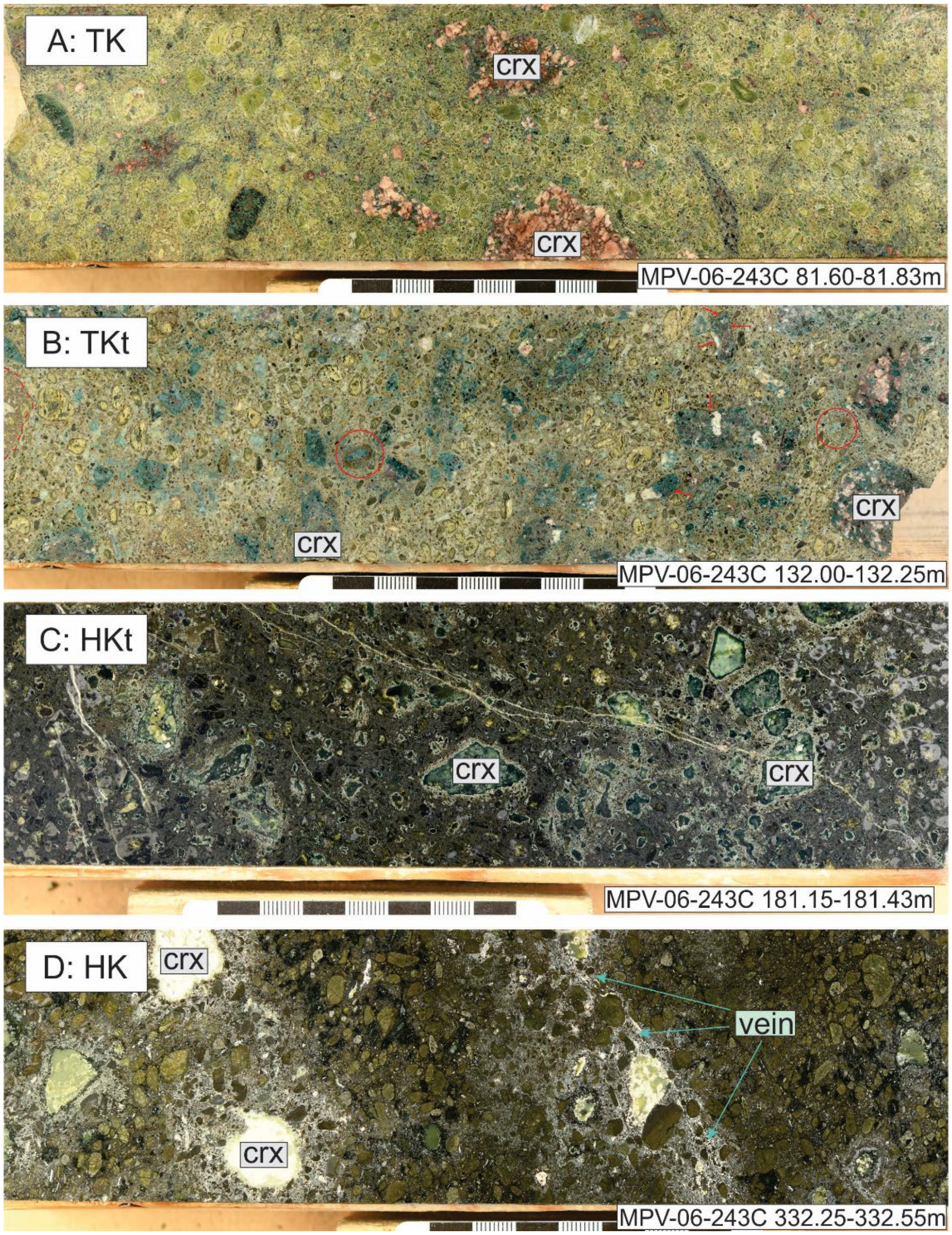


Fig. 10: Polished slab photographs of the four main textural kimberlite types of a Gahcho Kué transition zone (all samples from 5034 North Lobe). A) TK: Olivine is completely serpentinized and matrix-supported. Very fine olivine phenocrysts are not very abundant. Granite xenoliths are fresh and angular. B) TKt: Olivine is still serpentine-altered. There is a high abundance of small, angular to subangular granite xenoliths which are typically altered in light blue color. Some granite clasts serve as cores for juvenile pyroclasts with thin (red arrows) to thick (red circles) rims. A HK cognate xenolith is present (red dashed line). C) HKt: The coherent rock is much darker than the fragmental rock types (A and B). The granite xenoliths are angular, highly altered, and surrounded by a light-colored halo of coarse microlitic clinopyroxene. D) HK: The sample has a higher abundance of olivine macrocrysts and is denser packed compared to the transitional and fragmental samples. The xenolith content is low and the fine xenolith population, which was abundant in the previous samples, is not present anymore. The granite xenoliths are highly altered and surrounded by a light-colored halo that is highly segregationary. The abundance of segregations is also higher in the vicinity of diffuse high-temperature veins. CRX=country rock xenoliths.

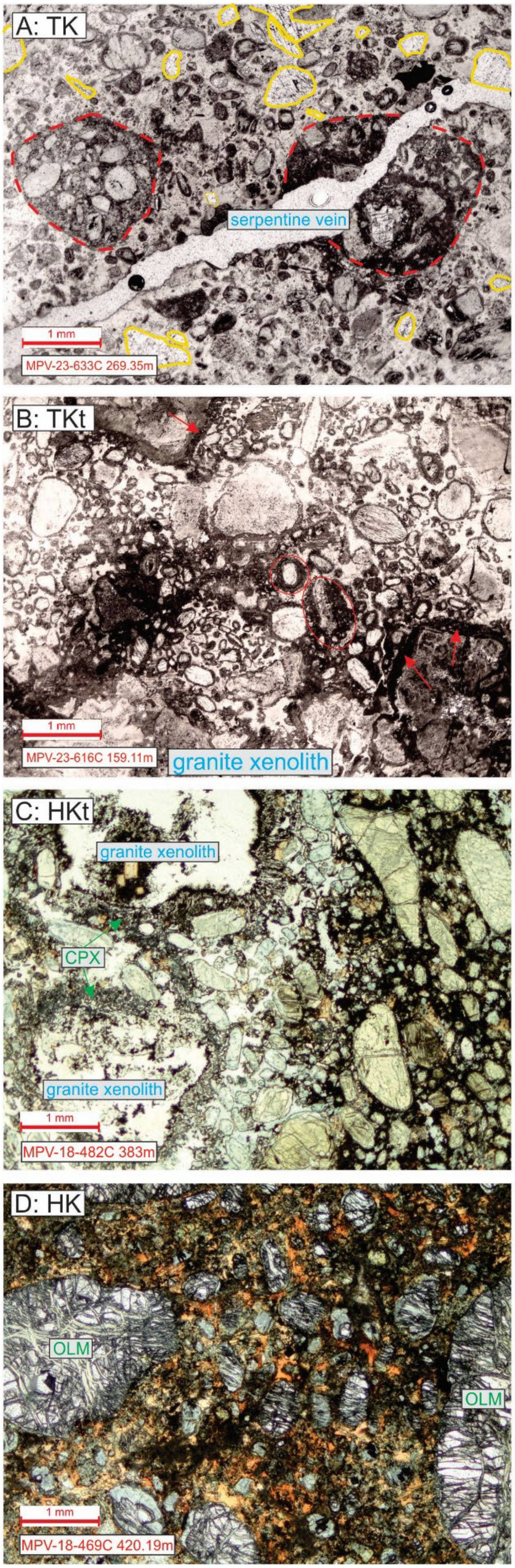


Fig. 11 A-D: Thin section photographs of typical transition zone kimberlite samples, all parallel Nichols.

A): TK from Hearne. Two cognate HK xenoliths (red dashed lines) are present while thickly-rimmed juvenile pyroclasts are absent. Pelletal olivine is present but very thinly-rimmed, or partly-rimmed, or even completely without rims. Angular, fresh, sub-mm feldspar micro xenocrysts (yellow lines) do not have rims. Granite-derived quartz grains are absent. The rock is overall matrix-supported and very fine olivine is less abundant than in the other rock types. A late serpentine vein cuts through the sample.

B): TKt from Hearne. The rims of pelletal olivines are slightly thicker while partly rimmed or isolated olivines are absent. Thickly-rimmed juvenile pyroclasts are present (red circles and arrows). The matrix has dark, coherent-looking patches. The granite xenoliths are more altered when compared to a TK, but much less when compared to a HKt or HK.

C): HKt from 5034 Northeast Extension. The right-hand portion of the photo shows a typical HKt with serpentinized olivine and a groundmass consisting of phlogopite, monticellite, and felty, very fine clinopyroxene. To the left, granite xenoliths are altered and show a reaction halo of radial, coarse clinopyroxene (CPX) and segregationary serpentine pools which isolate olivines, forming thin-rimmed pelletal olivine. Seen in isolation, these segregationary areas appear as a pseudo-fragmental texture.

D): HK from 5034 Northeast Extension. Large olivine macrocrysts (OLM) are partly serpentinized. The groundmass consists of poikilitic phlogopite and some minor monticellite. Xenoliths are rare and typically highly altered. They are often in various stages of assimilation.

Another interesting feature of the subsurface Gahcho Kué bodies is the presence of grain flows directly under the granite roof of Hearne, 5034 North Lobe, and NEX. The grain flows are typically fine-grained (sand fraction), well to moderately sorted, and may show some bedding on a cm-scale as well as soft sediment deformations (Fig. 12). They are comprised of granulated granite mixed with olivine, as well as accidental and cognate xenoliths. Compaction of the tephra (Moore et al., 1992) led to the opening of a gap between the tephra and the granite roof, which, together with the sloping nature of the roof morphology, led to the development of grain flows.

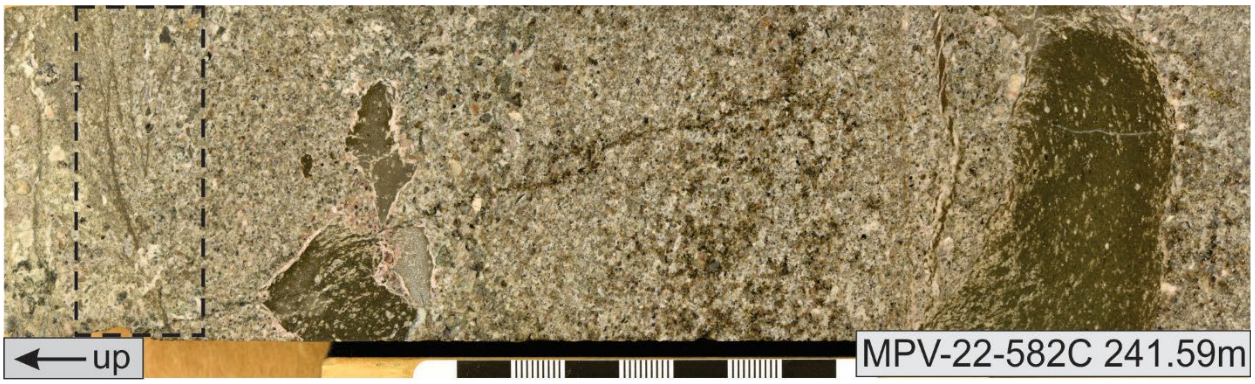


Fig. 12: Granite-kimberlite grain flow in a polished slab. The larger clasts are soft-sediment deformed clasts of earlier sediments. Note the layering and presence of cross-bedding (dashed line box).

Table 1 summarizes the features characterizing the kimberlite rock types in a Gahcho Kué transition zone. While these features are regarded as typical for a specific rock type, exceptions and overlaps can occur.

	HK	HKt	TKt	TK
colour	dark green to black	dark green, grey and black; mottled appearance due to reaction haloes and segregations	medium green to brown	light green to brown
clay alteration	rare to low	rare to moderate	patchy matrix replacement	complete matrix replacement
phlogopite	present to abundant; euhedral laths and poikilitic	low to moderate; euhedral laths and poikilitic	rare; may occurs in pelletal rims	rare; may occur in pelletal rims
monticellite	frequent	rare to moderate	absent	absent
xenoliths	low	moderate	moderate to high	moderate to high
xenolith fine fragmentation (CRX <1cm)	almost none	can be high, platy	moderate to high	moderate to high
xenolith alteration	high	moderate to high	variable, low to moderate	variable, low
olivine abundance	high (OLM and OLP)	High (OLM and OLP)	moderate to high	moderate, OLP abundance reduced
olivine alteration	fresh to partial	mostly serpentinized or clay altered	clay altered or serpentinized	clay altered or serpentinized
carbonate	present, in segregations and veins	abundant, in segregations and veins	rare to absent; in veins	in veins
cpx and microlithic textures	coarse short prismatic replacing CRX	coarse short prismatic replacing CRX	mostly acicular in haloes around CRX and OL	acicular in haloes around CRX and OL
juvenile pyroclasts	absent	very rare (cognate)	moderately abundant	low to moderately abundant
segregations	small, low to moderately abundant, not very connected	larger, more abundant and more connected	absent	absent
general texture	coherent	coherent	fragmental	fragmental

Table 1: Characterization of the typical kimberlite rock type features in a Gahcho Kué transition zone. OLM=Olivine Macrocryst, OLP=Olivine Phenocryst, CRX=Country rock xenolith.

Kimberlite emplacement

Petrographic information as well as quantitative data sets like groundmass spinel chemistry indicate that the emplacement of the Gahcho Kué bodies occurred in several phases, often with intermittent hiatuses that were long enough to let earlier kimberlite solidify, as testified by the presence of cognate xenoliths of both coherent and fragmental kimberlites. Explosive fragmentation of both country rock and kimberlite initially created the elongated, tephra-filled bodies on their inclined feeder dykes which were then, in a later phase, intruded by heavier coherent kimberlite magma at their base. Structural control on the emplacement of the kimberlite bodies is indicated by their linear shape and the convergence of several faults across Tuzo. While 5034 follows folding in the basement (Fig. 3), the linear segments in Hearne most likely follow pre-existing faults.

The mechanism of kimberlite magma fragmentation is a long-standing topic of debate. One mechanism is the exsolution and expansion of a juvenile gas phase like H_2O or CO_2, but there is little evidence in the rocks that suggests that such an expanding gas phase was actually responsible for the fragmentation of magma and large quantities of country rocks. In blast engineering, the surface area of particles produced by an explosion is directly proportional to the energy used to create the surface (Cho and Kaneko, 2004; Gao et al., 2023). In other words, the more energy is dispersed into a rock during an explosion, the finer the particles that are produced. The Gahcho Kué volcaniclastic rocks show a very high abundance of finely fragmented (down to microscopic level; Fig. 11A), highly angular xenoliths that must have been produced as a consequence of an explosion emitting shock waves into the country rock. Kurszlaukis et al. (1998) showed in experimental work conducted on re-melted kimberlite that a molten fuel-coolant explosion (MFCI) emits a shock wave that is equivalent in strength to that produced during a chemical explosion like TNT (see also Raue et al., 2000 and Barnett et al., 2011).

Meteoric water was evidently present during the emplacement of the kimberlite bodies, as shown by soft-sediment deformed sand consisting of kimberlite and granite particles comprising grain flows (Fig. 12) and similar material that filled the interstitial spaces of a contact breccia adjacent to Hearne (Fig. 13). In addition, the linear segments comprising the kimberlite bodies of Hearne and 5034 suggest structural control on their emplacement. Groundwater available along these faults and joints would have contributed the "coolant" for direct thermohydraulic explosive interaction with the kimberlite magma.

Fig. 13: soft-sediment deformation of kimberlite-granite sand derived from a pocket in a contact breccia next to Hearne gives evidence that water was present at the time of emplacement.

The kimberlite bodies reach, at least in some sections, the present-day land surface, but there is no evidence that they also had a vertical connection to the Cambrian land surface. The erosion rate since emplacement is difficult to quantify, but estimates vary between 900 and 2000m (Flowers et al., 2006; Ault et al., 2009; Zhang et al., 2012). Valentine et al. (2014) have shown that a volcanic explosion cannot breach the surface from a depth of more than 200m (in exceptions 400m) and so any explosion that happened at a depth of 900m or more would have to be contained. There is no evidence for a vertical dyke system in Gahcho Kué that could have let kimberlite pipes grow from close to the Cambrian surface toward the present-day erosion level, as it is suggested by many authors for maar-diatreme volcanoes (e.g. Sparks et al., 2006; Lorenz and Kurszlaukis, 2007). The xenolith lithologies found in the kimberlites also suggest an exclusively local origin; sedimentary xenoliths that may have occurred at the Cambrian surface are absent but would be expected to be found if a vertical connection to the Cambrian land surface existed.

It seems more likely that the kimberlites reached the Cambrian land surface in the nowadays eroded, lateral-shallow sections of the inclined feeder dykes and then grew downdip along their feeder dykes as tube-like fragmental bodies (Fig. 14). Several individual intrusive phases of kimberlite were emplaced in a fragmental or coherent manner and the length of a hiatus between the phases controlled the degree of consolidation of the earlier emplaced kimberlite. This in turn caused either sharp or transitional interfaces between the kimberlite rock types. The heavier coherent kimberlites tend to emplace within and erode the base of a volcaniclastic pile closer to the feeder dyke. The exception is Hearne, where the underlying fragmental kimberlite belongs to a separate, older emplacement phase and the feeder dyke shifted to a slightly higher level within the already consolidated volcaniclastic body.

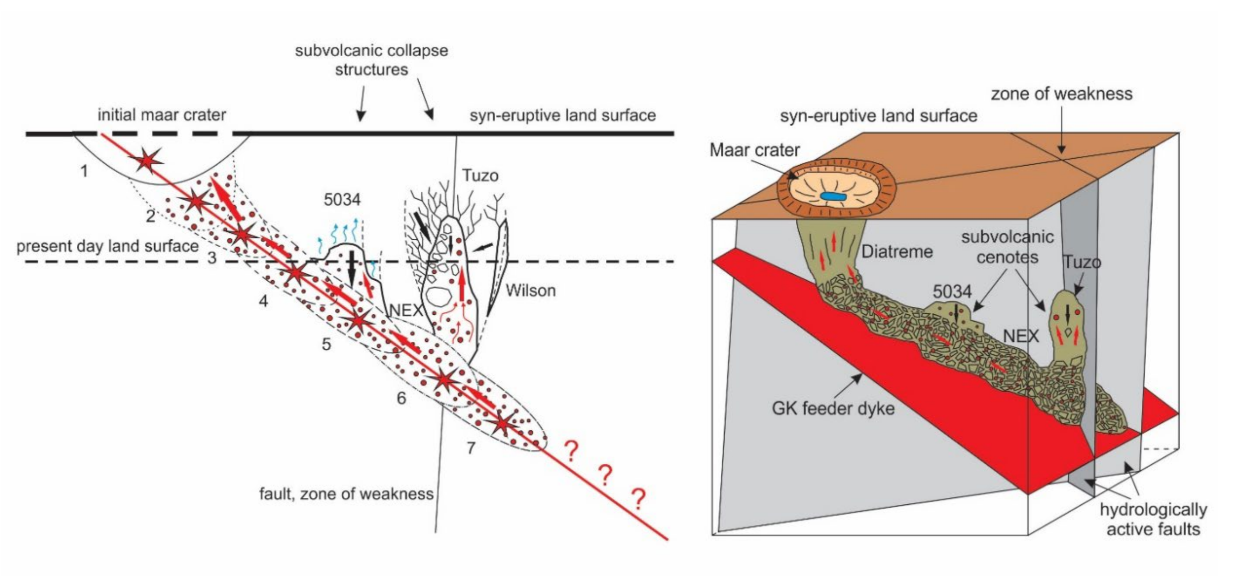


Fig. 14: Simplified emplacement of the Gahcho Kué kimberlite bodies. Due to extensive overburden thickness, explosive vertical breakthrough from the feeder dyke to the Cambrian land surface was not possible. It is more likely that the first explosive maar crater occurred closer to the land surface sidewards on the inclined feeder dyke. Subsequently, the volcanic system grew deeper by following the magma supply from the feeder dyke, brecciating and removing country rocks while simultaneously replacing them with volcaniclastic kimberlite. Only later coherent kimberlites were intruding non-explosively at the base of the volcanic tunnel system (not shown in figure). Local roof collapse controlled by zones of weakness in the granites triggered the vertical growth of the kimberlite bodies. Tuzo is located at the intersection of several faults that locally weakened the granite roof more than in other areas, leading to a vertical subvolcanic "sinkhole", similar to cenotes formed in karst areas.

The vertical, tall shape of Tuzo forms an exception when compared to the remaining Gahcho Kué bodies. Tuzo is located at the intersection of several faults (Fig. 3) that have likely played a key role in the emplacement of Tuzo in that they weakened the country rock which resulted in the preferential gravitational collapse of the roof area. At its base, Tuzo rises from the Gahcho Kué feeder dyke and is connected to 5034 at depth. Locally collapsing granite in the roof area of Tuzo would have been transported away sidewards by the sidewards-upwards streaming fragmental kimberlites in the 5034 tube, while the vertically growing cavity would have been filled, to its larger part, by low-density kimberlite tephra and debris. This cavity-forming process is similar to that proposed for the generation of karst sinkholes or “cenotes” on the Yucatan peninsula of Mexico (Back and Hanshaw, 1970). Continued roof collapse into an upwards-growing cavity also caused large-scale rock mechanical instability of the side walls which resulted in the mass collapse of large granite blocks towards Tuzo. The granite in the shallow-western portion of Tuzo is highly brecciated and slumped towards Tuzo, constricting the kimberlite body in its shallower top portion. In the East, the projected extension of the sheet-like Wilson kimberlite towards depth intersects the base of Tuzo at its feeder dyke level. This and the thickening character of the Wilson sheets towards the surface suggest that Wilson represents a kimberlite-filled crevasse-fault of a large country rock block that submerged and rotated towards the Tuzo tephra cenote.

Next to subsidence breccias, Tuzo also comprises two different volcaniclastic units, a highly diluted TKB unit in the western upper levels of the body and a TKt unit that occupies the mid-lower part of the kimberlite body (Fig. 5 and 15D). Late intruding HK is present in very deep levels of Tuzo and infiltrates subsidence breccias or occurs along the pipe wall.

The volcaniclastic kimberlites in Tuzo differ in several key features: while the TKB has more granite dilution (about 50 vol.%, but variable due to crude layering) and the xenoliths are generally fresh and poorly sorted, the TKt has lower dilution (15-35 vol.%) with better sorted, finer and more angular xenoliths that often have a blue color due to partial serpentinization. The TKB has common irregular-shaped coherent clasts (CMP; Seghedi et al., 2009) that are rare in the TKt, while the TKt contains common spherical, fine-grained juvenile pyroclasts that are absent in the TKB. The contacts between the volcaniclastic units can be quite sharp or show a mixing zone where features of both rocks can be found. Domains of TKB in TKt are more frequent than the opposite configuration, but grain-in-grain mixing also appears to be common along the contact.

When CMPs occur in the TKt, they sometimes have a fine-grained kimberlite coating, that is of the same material that comprises the juvenile pyroclasts only found in the TKt. This established an age relationship in which the TKB is older than the TKt, but not yet lithified at the time of TKt emplacement.

Subsidence processes played an important role in the facies distribution of the Tuzo kimberlites. The slumping of large amounts of granite started already during the emplacement of the TKB (Fig. 5 and 15A). This is shown by groundmass spinel chemistry, where the spinels derived from the kimberlite matrix in the granite breccias in the West (Fig. 15A: BCR) and spinels from Wilson are chemically identical to the Tuzo TKB (Fig. 16). During the subsidence of the granite breccias, a large floating reef moved into an off-center position in Tuzo at a depth of about 300m from the present surface. This granite block has a lateral extent of up to 120m and a vertical depth of 60m. The bottom contact of the floating reef to the TKt is sharp while the top contact is typically brecciated. It appears that this floating reef played a significant role in the facies distribution and emplacement of the TKt, which was diverted to the East, away from the overlying subsidence breccias and preserving remnants of the TKB above the granite block (Fig. 15B). After the passing of the TKt pyroclastic cloud, the granite breccias and TKB subsided towards the eastern region of Tuzo where the pyroclastic cloud previously pierced through the kimberlite body (Fig. 15C). This resulted in remnants of TKt being still present along the breccia-free eastern wall, the presence of crude layering in the TKB, and the mixing zone between TKB and TKt (Fig. 15D).

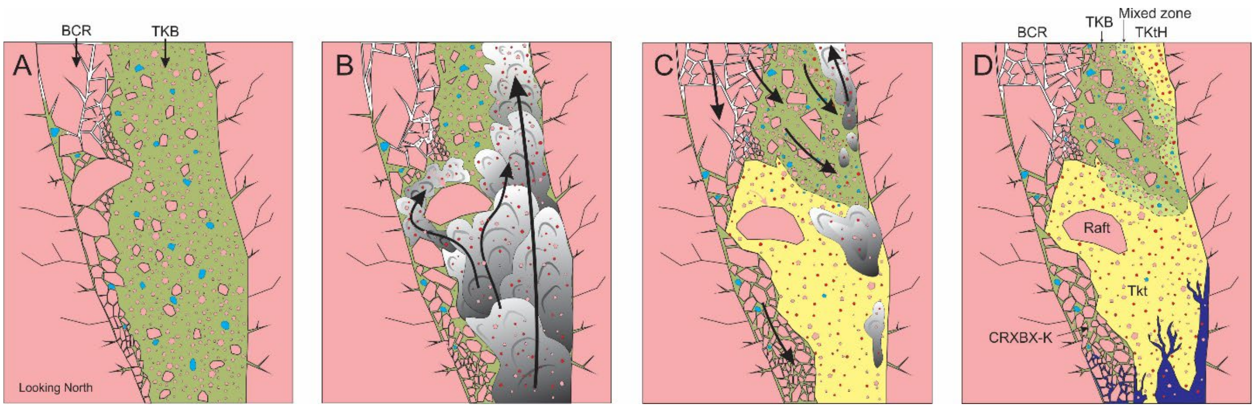


Fig. 15 A to D: Emplacement sequence of Tuzo. A) Tuzo after TKB emplacement. The country rock in the West of Tuzo is brecciated (BCR) by the TKB event and starts to subside along the wall of the kimberlite body. B) TKt event. The pyroclastic TKt cloud occupies most of the lower portion of Tuzo but is diverted and channeled side wards and upwards by a large floating reef in the central part of Tuzo. Wall rock erosion occurs in the East, while further subsidence characterizes the country rock breccias in the West. C) Collapse event. The TKt pyroclastic cloud evacuates the lower-central portion of Tuzo and TKB material together with a large amount of country rock blocks collapses locally towards and into the depleting TKt feeder conduit, forming crudely layered deposits and also well-developed grain flows. A mixing zone with both TKB and TKt material develops, either on a grain-in-grain basis or in domains of either material. The pre-conditioned country rock breccia along the western margin subsides further. D) Final stage. The asymmetric shape of Tuzo is a consequence of the subsidence of country rock breccias at its western wall and the tilting of a large country rock block on the eastern side towards Tuzo, opening a crevasse fault that was responsible for the generation of the Wilson sheet-like body (Fig. 5). Late intruding HK dykes form a complex interface with textures transitional between coherent and fragmental rocks.

It appears that the large, low-density Tuzo body also had a regional effect on the stress field (Fig. 16). There are three vertical steps in the roof area of 5034 North Lobe and NEX, each vertically stepping down the roof towards Tuzo in a regular 200-250m distance. Wilson is at the same distance from Tuzo as the closest step in the roof of NEX, while the second step is equidistant to Curie and the third step furthest away from Tuzo is equidistant to Tesla. Le Corvec et al. (2018) described a petal-shaped decompression stress field at the base of a diatreme that may have been at play at the bottom of the Tuzo cenote as well. It would further support the model that Tuzo represents a collapse cavity filled with low-density material.

A close relationship of the Gahcho Kué kimberlite bodies with Tuzo is also suggested by groundmass spinel chemistry data. Groundmass spinels crystallize throughout much of the kimberlite ascent and emplacement history and thus their chemistry monitors the evolution of a kimberlite batch (e.g. Roeder and Schulze, 2008). As can be seen in Fig. 16, Tuzo has two major kimberlite types, TKB and TKt, that show significantly different groundmass spinel compositions. Spinels from Wilson and Curie have the same geochemical signature as the TKB from Tuzo, while spinels from 5034 NEX overlap with the TKt from Tuzo.

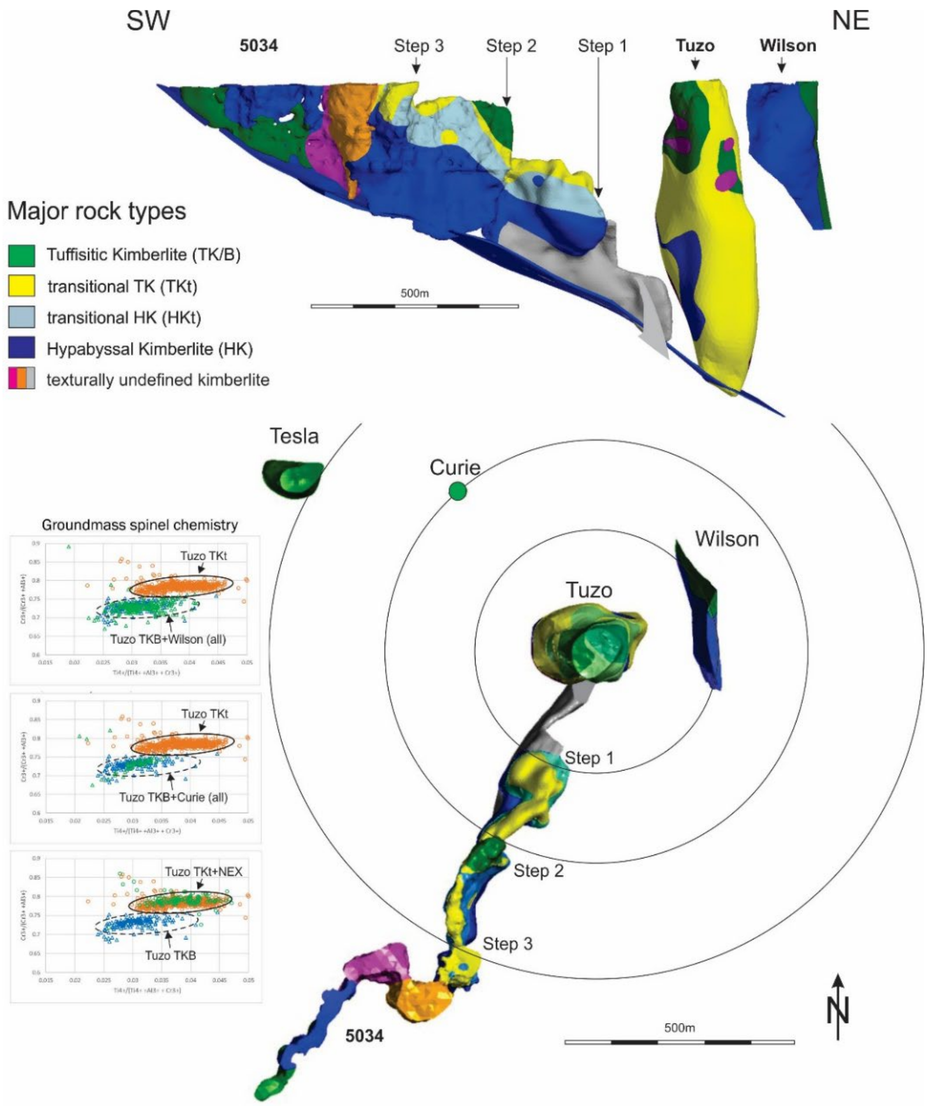


Fig. 16: The emplacement of Tuzo may have induced a local stress field at the base of Tuzo that may be responsible for the stepping granite roof above 5034 North Lobe and NEX as well as equidistant kimberlite bodies in the area.

Conclusions:

The detailed study of the Gahcho Kué kimberlite cluster reveals a unique subsurface emplacement style due to the presence of inclined feeder dykes and thick overburden at the time of emplacement. The combination of these parameters most likely did not permit the fragmental kimberlites to vertically breach the Cambrian land surface but resulted in the growth of tube-like volcaniclastic bodies that grew laterally downwards on their feeder dykes while crosscutting hydrologically active faults. Learnings from Gahcho Kué can also be applied to other kimberlites, like gravitational wall rock collapse that produces floating reefs in many diatremes as well as the confined subsurface magma and country rock fragmentation as pipe growth mechanisms. A fresh look at post-emplacement, subsolidus deuteric corrosion textures in kimberlites may also offer a better understanding of diamond etching and dissolution features.

References:

Ault, A.K., Flowers, R. and Bowring, S. (2009): Phanerozoic burial and unroofing history of the western Slave craton and Wopmay orogen from apatite (U–Th)/He thermochronometry. Earth and Planetary Science Letters 284: 1-11.

Back, W. and Hanshaw, W. (1970): Comparison of chemical hydrogeology of the carbonate peninsulas of Florida and Yucatan. Journal of Hydrology 10: 119–130.

Barnett, W.P., Kurszlaukis, S., Tait, M., and Dirks, P. (2011): Kimberlite wall-rock fragmentation processes: Venetia K08 pipe development. Bulletin of Volcanology 73: 941-958.

Barnett, W., Stubley, M., Hetman, C. et al. Kelvin and Faraday kimberlite emplacement geometries and implications for subterranean magmatic processes. Miner Petrol 112 (Suppl 2), 447–462 (2018).

Cho, S.H. and Kaneko, K. (2004): Rock fragmentation control in blasting. Materials Transactions, Vol. 45, No. 5: 1722-1730.

Le Corvec, N., Muirhead, J.D. and White, J.D.L. (2018): Shallow magma diversions during explosive diatreme-forming eruptions. Nature Communications. 9: 1459 1-8. DOI 10.1038/s41467-018-03865-x.

Flowers, R., Bowring, S. and Reiners, P. (2006): Low long-term erosion rates and extreme continental stability documented by ancient (U–Th)/He dates. Geology 34 (11), 925.

Gao, P., Pan, C., Zong, Q., and Dong. C. (2023): Rock fragmentation size distribution control in Blasting: a case study of blasting mining in Changjiu Shenshan limestone mine. Frontiers in Materials. 10: 1330354 DOI 10.3389/fmats.2023.1330354.

Gernon, T.M., Field, M. and Sparks, R.S.J. (2009): Depositional processes in a kimberlite crater: the Upper Cretaceous Orapa South Pipe (Botswana). Sedimentology 56: 623-643.

Hetman, C. M., Smith, B. H. S., Paul, J. L. and Winter, F. (2004): Geology of the Gahcho Kué kimberlite pipes, NWT, Canada: root to diatreme magmatic transition zones. Lithos 76: 51–74.

Hoffman, P.F. (1988): Geology and tectonics: East Arm of Great Slave Lake, Northwest Territories; Geological Survey of Canada, Map 1628A, scale 1:250,000.

Kurszlaukis, S., Büttner, R., Zimanowski, B., and Lorenz, V. (1998): On the first experimental phreatomagmatic explosion of a kimberlite melt. Journal of Volcanology and Geothermal Research 80: 323–326.

Lorenz, V. and Kurszlaukis, S. (2007): Root zone processes in the phreatomagmatic pipe emplacement model and consequences for the evolution of maar-diatreme volcanoes. Journal of Volcanology and Geothermal Research Special Volume 150: 4-32.

Moore, J.G., Jakobsson, S. and Holmjarn, J. (1992): Subsidence of Surtsey volcano, 1967–1991. Bulletin of Volcanology 55(1–2): 17–24.

Pehrsson, S.J., van Breemen, O. and Hanmer, S. (1993): Ages of diabase dyke intrusions, Great Slave Lake shear zone, Northwest Territories; in Radiogenic Age and Isotopic Studies: Report 7; Geological Survey of Canada Paper 93-2: 23-28.

Raue, H., Büttner, R., Lorenz, V., and Zimanowski, B. (2000): Energy budget of a typical Eifel maar volcanic explosion. In: International maar conference, Daun/Vulkaneifel, extended abstracts, Terra Nostra 2000(6): 418–422.

Roeder, P.L. and Schulze, D.J. (2008): Crystallization of Groundmass Spinel in Kimberlite. Journal of Petrology, 49(8): 1473-1495.

Seghedi, I., Maicher, D. and Kurszlaukis, S. (2009): Volcanology of Tuzo pipe (Gahcho Kué cluster) — Root–diatreme processes

re-interpreted. Lithos 112S: 553-565.

Sparks, R.S.J., Baker, L., Brown, R.J., Field, M., Schumacher, J., Stripp., G., and Walters, A. (2006): Dynamical constraints on kimberlite volcanism. Journal of Volcanology and Geothermal Research 155: 18–48.

Stubley, M.P. (1998): Bedrock geology of the Snap Lake area. A report to accompany a 1:10.000 scale geological map.

Stubley Geoscience. 31pp.

Valentine, G.A., Graettinger, A.E. and Sonder, I. (2014): Explosion depths for phreatomagmatic eruptions. Geophysical Research Letters 41: 3045-3051.

Webb, K. and Hetman, C. (2021): Magmaclasts in kimberlite. Lithos 396-397 (106197).

Zhang, N., Zhong, S. and Flowers, R. (2012): Predicting and testing continental vertical motion histories since the Paleozoic. Earth and Planetary Science Letters 317-318:426-435.

Ekati Diamond Mine Field Trip Guide, Friday July 5th, 2024

Compiled by B. Elliott
Northwest Territories Geological Survey, Yellowknife, NWT, Canada

Introduction

The Ekati Diamond Mine, Canada's first surface and underground diamond mine, commenced operations in October of 1998 following extensive exploration and development work dating back to 1981. It was named after the Tłı̨chǫ word for "fat lake" and is located in the Northwest Territories (NWT) approximately 300 kilometers north-north east of Yellowknife, approximately 200 km south of the Arctic Circle (**Figure 1**).

This remote mine site is located in sub-arctic tundra and is accessible year-round by air and overland by winter road, typically from mid-January to late March. The Ekati property is owned and operated by Burgundy Diamonds Mines Ltd. 178 kimberlites have been discovered on the original Ekati claim block to date. There are two active mining operations at Ekati, including the Sable open pit and Misery underground operations.

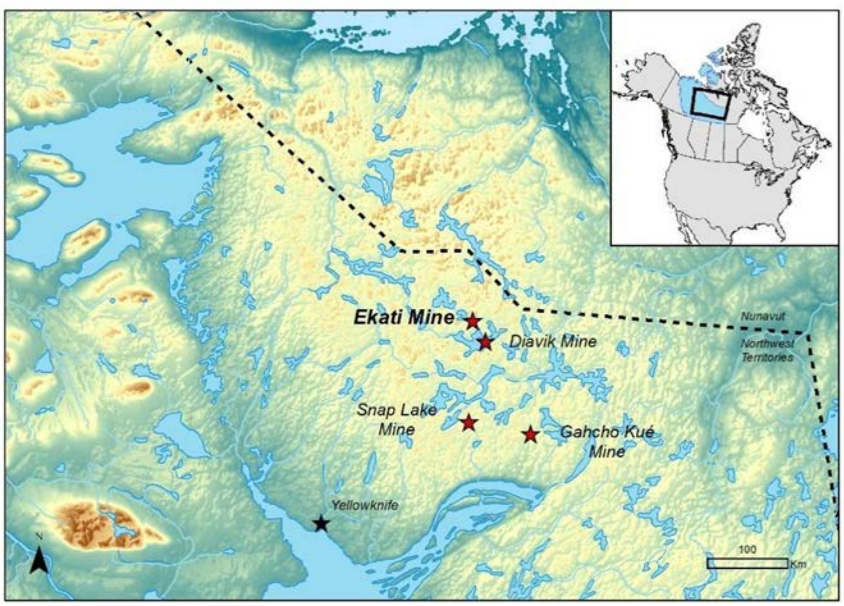


Figure 1: Location of the Ekati Diamond Mine

The current mine-life plan for Ekati extends to 2028 and includes the addition of a new open pit operation at the Point Lake kimberlite (CSA Global, 2023). Potential developments at Sable, Fox and optimization of the currently planned operations at Point Lake are being evaluated and may have the potential to further extend mine life (Burgundy 2024). A prefeasibility study is underway at Sable examining the economics for a sublevel retreat underground mining operation below the final extent of the open pit. Underground mining is also being considered below the Fox open pit. The development of an underwater remote mining system is underway and could be used to extract the deeper resources from the Point Lake and /or other kimberlite deposits. If successful, the mining of these deeper portions of existing orebodies could extend the life of Ekati for many years to come. As of December 31, 2023, Ore Reserves for the Ekati property totaled 20.3 million carats (Mcts) in 43.9 million tonnes (Mt) of ore for an overall grade of 0.5 carats per tonne (Ct/t). Indicated Mineral Resource totaled 140.3 Mct in 133.7 Mt of ore for an overall grade of 1.0 Ct/t, and Inferred Mineral Resource totaled 48.7 Mct in 82.6 Mt of ore for an overall grade of 0.6 Ct/t (Burgundy 2024).

This field guide aims to provide a brief outline of the discovery and development of the Ekati Diamond Mine, as well as providing a discussion of the geology, geochronology and diamond resources and reserves is presented below. More detailed information will be given for the kimberlites that will be part of this field trip.

Land Tenure

The Ekati claim block originally comprised approximately 3,320 km2,approximately one third (1,140 km2) of its original size, and now consists of 121 mining leases. The locations and outlines of the mineral leases are shown in **Figure 2** along with the locations of the various kimberlite pipes with Ore Reserve estimates.

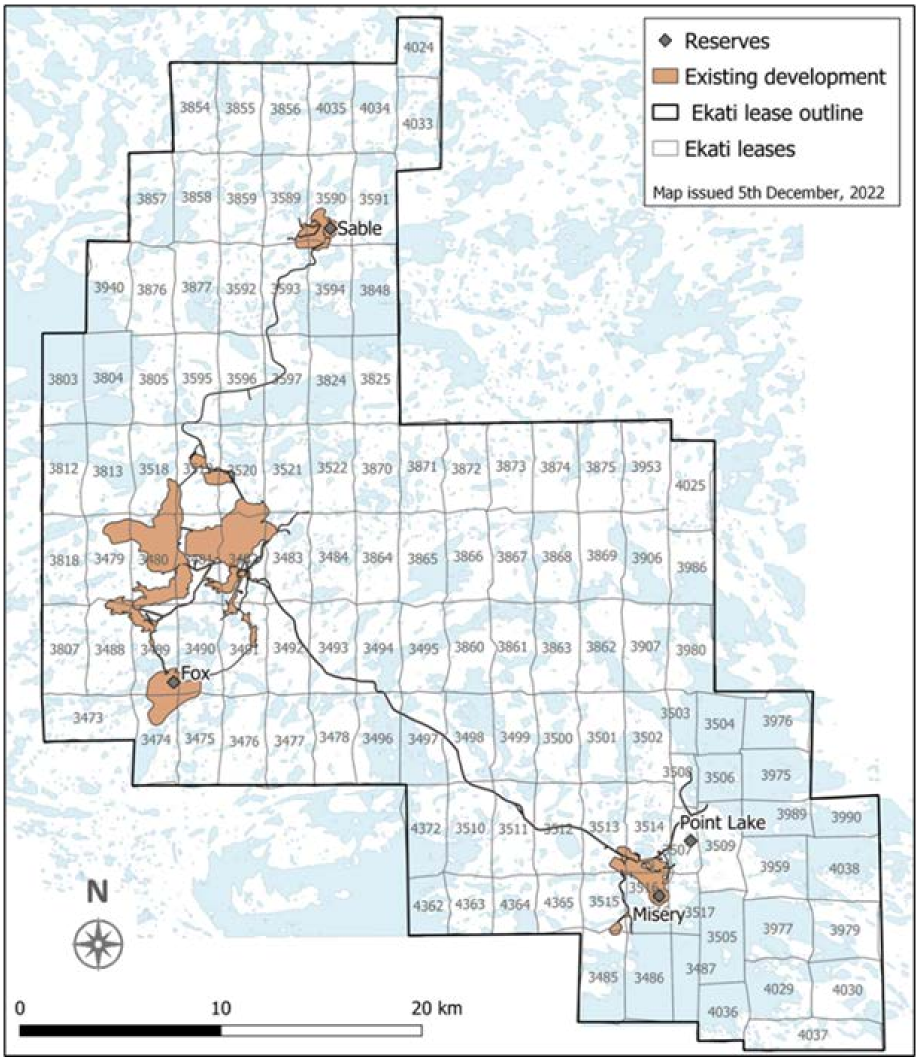


Figure 2: Ekati Mineral Leases and Mineral Reserve locations

Exploration History

A combination of kimberlite indicator mineral sampling from glacial tills and airborne geophysics were used to identify potential kimberlite targets, which were then prioritized with further indicator mineral samples and detailed geophysics. The initial discovery at Ekati was the Point Lake kimberlite in 1991, which set off the largest claim staking rush in North American history.

This was preceded by ten years of systematic heavy mineral sampling by Dr. Charles E. Fipke and Dr. Stewart Blusson in the NWT. In 1989, Dia Met Minerals staked claims in the area and continued exploration programs which resulted in the discovery of significant anomalies of kimberlite indicator minerals on the property . The Core Zone joint venture agreement was signed in 1990 by BHP, Dia Met, Dr. Charles Fipke and Dr. Stewart Blusson .   Dia Met was eventually acquired by BHP in 2001. (Carlson et al., 2016).

To date, exploration activities included till sampling, airborne and ground geophysical surveys, and drilling programs. More than 400 geophysical and/or indicator dispersion targets were drilled from 1991 to 2023, with a total of 178 kimberlites discovered across the original Ekati property. The kimberlites were prioritized for drilling using microdiamond and indicator mineral chemistry. Thirty-nine kimberlite occurrences were further tested for diamond content using reverse circulation (RC) drilling and/or surface bulk samples.

Mining

Ekati mineral deposits have been mined using both open pit and underground mining methods. The Ekati operations can be divided into three main mining areas which are the Central Area (including the Main Camp), the Sable Open Pit Area, approximately 20 km to the northeast of the processing plant and the Misery Area, approximately 29 km to the southeast of the processing plant (**Figure 3**).

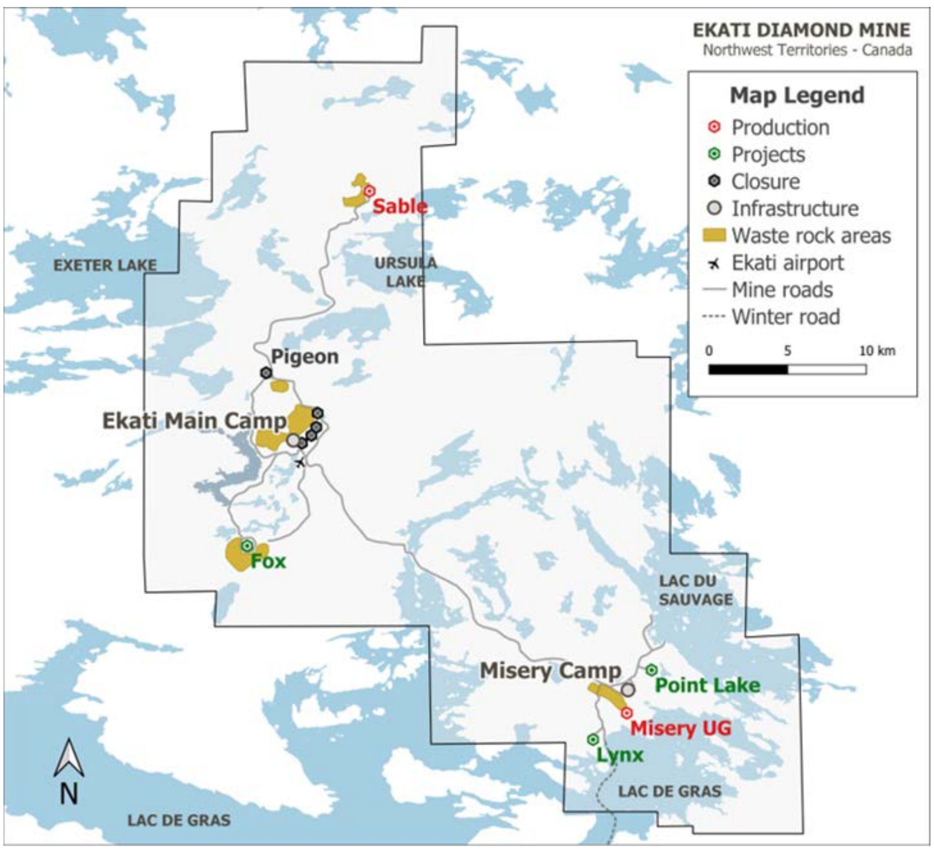


Figure 3: Ekati Diamond Mine Infrastructure

Mining operations at Ekati began with the Panda open pit in 1998, followed by the Misery, Koala, Beartooth and Fox open pits in 2002, 2003, 2004 and 2005 respectively. Underground operations commenced at Panda, Koala, Koala North and Misery in 2005, 2007, 2010 and 2018 respectively. In 2015, an open pit

was developed at Pigeon, followed by open pits at Lynx in 2017, and Sable in 2019. Locations of current of previously mined kimberlites are presented above in **Figure 3**.
A brief outline of the mining sequence at the Ekati mine is presented below and summarized in **Figure 4**.

- 1998 - Initial mining operations commenced at the Panda open pit, which was mined from August 1998 until June 2003.
- 2002 – Open pit operations commenced at the Misery kimberlite and continued until 2006, with stockpiled ore from Misery being processed into 2007.
- 2003 – Open pit mining began at the Koala kimberlite and continued until 2007.
- 2003 – A trial underground mining operation at Koala North was implemented between 2003 and 2004.
- 2004 – Open pit operations at the Beartooth kimberlite commenced in 2004, which was sporadically mined until 2008 and is now depleted.
- 2005 – Open pit operations at the Fox kimberlite, which continued until 2014. Underground reserves remain.
- 2005 -Underground operations at Panda commenced in June 2005 and continued until 2010. The Panda kimberlite is fully depleted.
- 2007 – Underground mining at Koala commenced in 2007 and continued until the end of 2018 when it was depleted.
- 2010 – Underground production at Koala North between 2010 and 2015. The Koala North kimberlite is depleted.
- 2015 – Open pit operations at the Pigeon kimberlite from 2015 until early 2022 when it was fully depleted.
- 2016 – Open pit operations at the pushback Misery open pit from 2016 to 2018.
- 2017 – Mining operations at the Lynx open pit commenced in 2017 and which continued until 2019. There are resources below the pit shell that could be potentially extracted by remote underwater mining.
- 2019 – Sable Open pit commenced in 2019 and is currently still active.
- 2021 – The extension of Misery open pit into an underground operation began in 2018 and commercial production was achieved in 2021 and is currently still active.
- 2024 – Pre-stripping began for the Point Lake open pit operation, which is scheduled to begin full scale production in early 2025.

Current Mining Operations

There are two active mining operations at Ekati, including the Sable open pit and Misery underground operations, and the Point Lake open pit is scheduled for full production in 202 5 (**Figure 3,4**). The current mine life of Ekati, including the addition of a new open pit development at Point Lake, runs to 2028. Exploration and project evaluation activities are ongoing, including the development of an innovative mining technique that could be used to extract the deeper resources from the Sable, Fox, and Point Lake kimberlite deposits. If successful, the mining of these deeper portions of existing orebodies are believed to be able to extend the life of Ekati for many years to come.

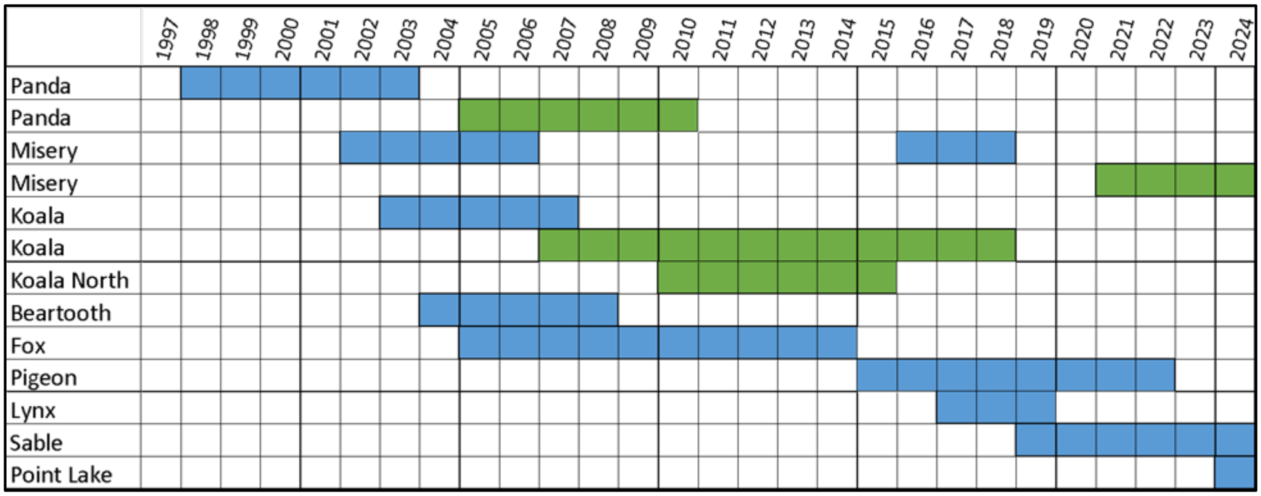


Figure 4: Summary of mining operations at the Ekati Diamond Mine

Additional options include development of an underground mine at Fox and possibly a hybrid open pit/alternative mining scenario for the Jay kimberlite.
Ekati mineral deposits have been mined using both open pit and underground mining methods over time. The Ekati operations can be divided into three main mining areas which are the Central Area (including the Main Camp), the Sable Open Pit Area, approximately 20 km to the northeast of the processing plant and the Misery Area, approximately 29 km to the southeast of the processing plant.

Sable Open Pit

The Sable open pit is situated approximately 17 km north-northeast of the Ekati main camp. Construction at Sable pit took approximately two years (2016 to 2017), with full production achieved in 2019 followed by an approximate seven-year operational period (2018 to 2024). The Sable pit is being mined using conventional open-pit truck-and-shovel operations (**Figure 5**).

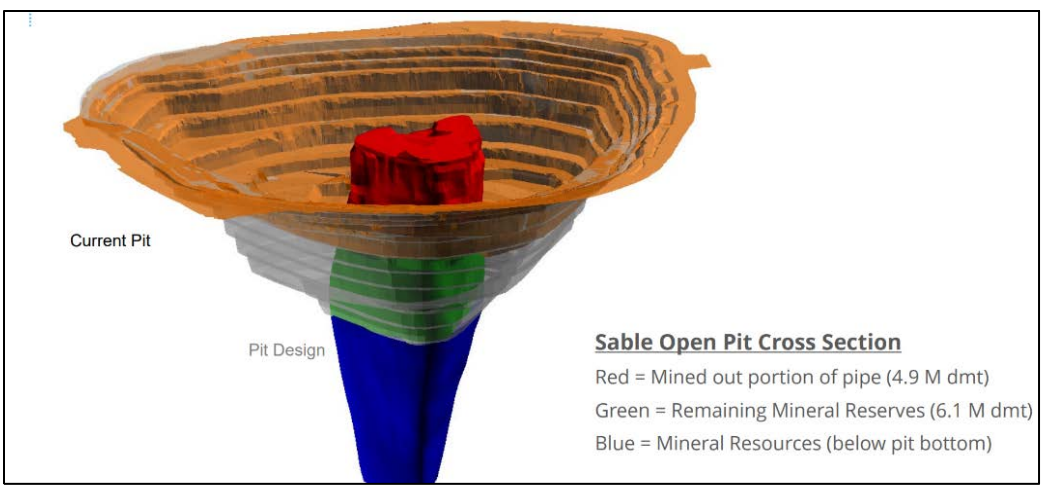


Figure 5: Sable open pit mineral reserves as of Dec 31st 2022

Misery Underground

The Misery Main kimberlite pipe was and still is an important mining area on the Ekati property due its existing infrastructure and high grade. The Misery Underground is a continuation of Misery open pit which was fully depleted in 2018. The Misery open pit yielded a total of 20.8 million recovered carats from 7.6 million tonnes of kimberlite for an average grade of 2.7 carats per tonne. A prefeasibility study was completed in 2017 to support the underground development and mining of the kimberlite pipe below the final extent of the open pit.

The Misery underground operation utilises a sublevel retreat mining method at a nominal mining rate of 3,000 tpd providing 2,750 tpd of ore to the process plant. The Misery underground operation is currently underway (**Figure 6**) and is scheduled to continue beyond 2024.

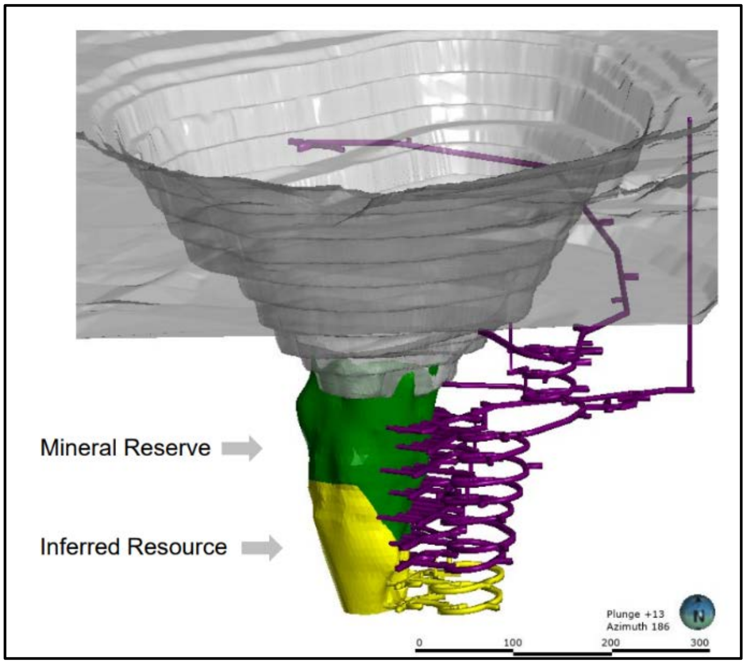


Figure 6: Misery sub-level retreat underground operation

Point Lake Open Pit

The Point Lake complex (PLC, consisting of the Point Lake, Phoenix and Challenge kimberlite pipes) is located beneath Point Lake, which is a medium-sized lake located within 2 km of Misery Camp. Point Lake open pit comprises Ore Reserves from the Point Lake pipe (69%) and Inferred Mineral Resources (31%) from the Point Lake, Phoenix and Challenge pipes and these are shown below in **Figure 7**.

A prefeasibility study was completed for the Point Lake project in November 2020. The study comprised the Point Lake, Phoenix, and Challenge pipes. Point Lake is considered an important undeveloped deposit and is scheduled for production in 2025.

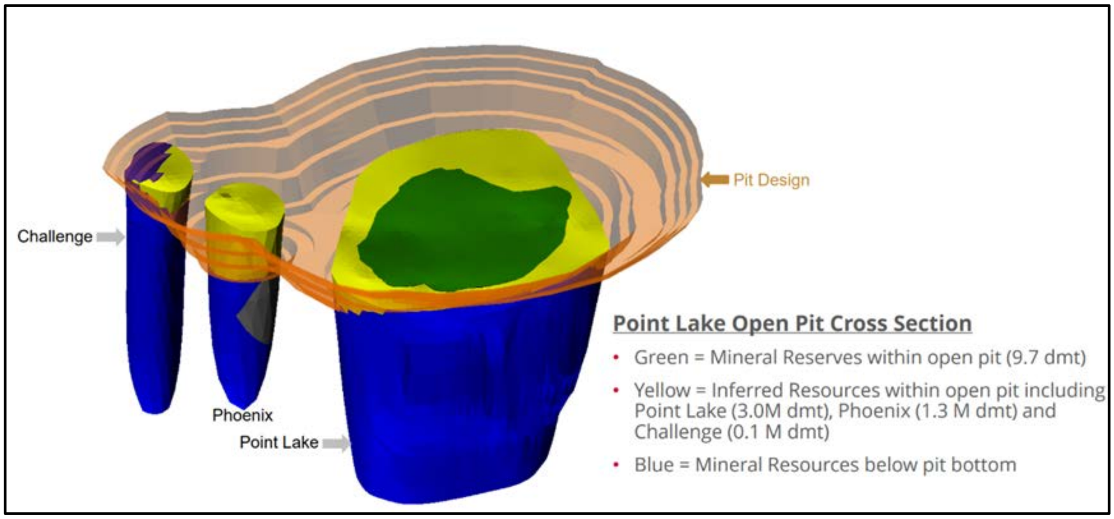


Figure 7: Point Lake open pit with Point Lake, Phoenix and Challenge pipes

Future Mining Operations

Sable Underground

Sable underground is an undeveloped future project located approximately 18 km north of Ekati's processing plant. In late 2023, a prefeasibility study on the development of the underground operation as a sublevel retreat was initiated (**Figure 8**). A reverse circulation drilling program was completed in early 2024 to assess diamond grade at depth, and delineation/geotechnical drilling programs are in progress at the time of writing.

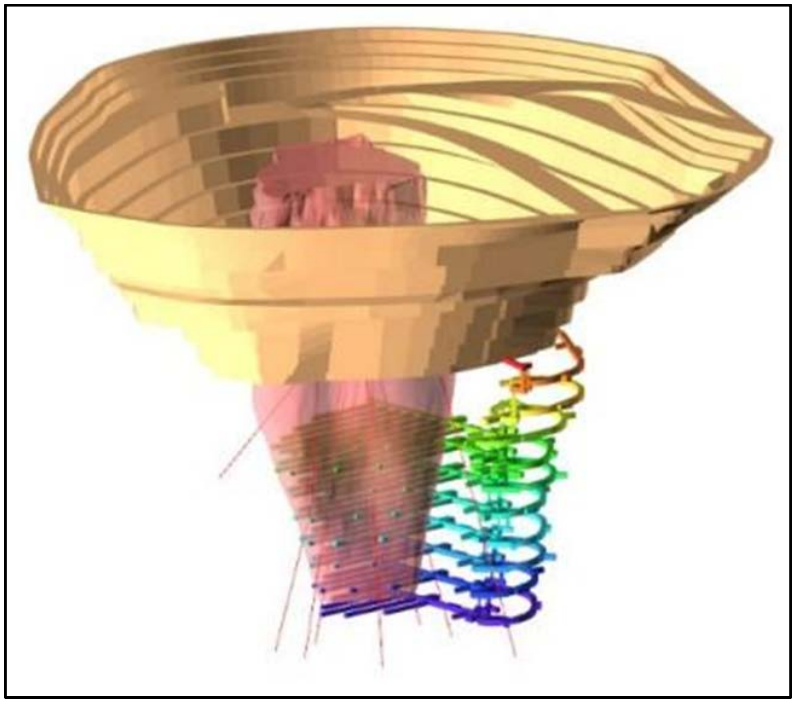


Figure 8: Preliminary mine design for Sable underground (sublevel retreat)

Fox Underground

Fox underground is an undeveloped future project located approximately 7 km southwest of Ekati's processing plant. In 2018, a prefeasibility study on the development of the underground operation as an incline cave was completed. The study found that over a nine-year production period, Fox underground could provide approximately 31.3 Mt of kimberlite yielding approximately 10 Mct. The conceptual mine design for Fox underground is shown in **Figure 9**.

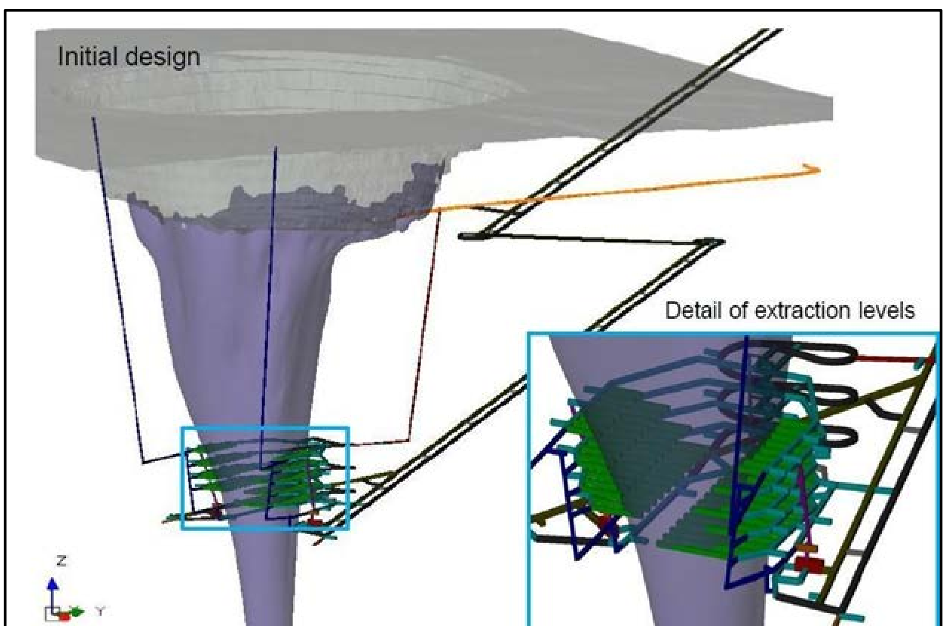


Figure 9: Conceptual layout inclined cave mining of Fox underground

Underwater Remote Mining

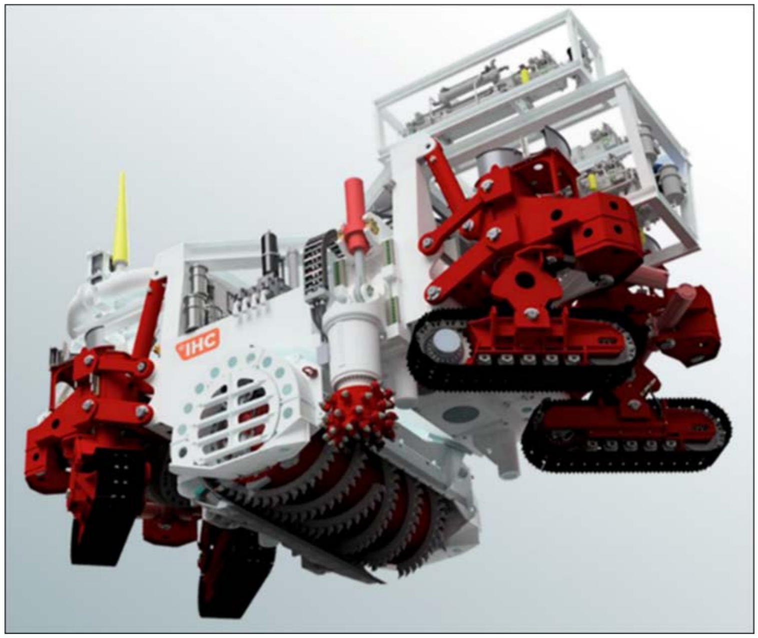


Figure 10: 3D model of an URM system.

Underwater Remote Mining (URM) technology is being developed by Netherlands-based IHC Mining (part of Royal IHC) in collaboration with Ekati (**Figure 10**). URM involves extracting kimberlite from flooded open pits with an underwater continuous mining crawler. The crawler is remote-operated and powered through a suspended umbilical cord. It has four independent tracks and a centrally located drum cutter that directly excavates the ore in small layers like a surface miner. The kimberlite cuttings produced by the crawler are pumped to the surface and passed through a dewatering plant positioned alongside the flooded pit. Fine material is removed together with the water in this process, increasing the diamond content of the kimberlite in proportion to the volume of fine material removed. With lower tonnages of higher-grade ore transported to the processing plant, there is an additional saving on transportation costs. As the URM crawler is only mining the kimberlite ore and minimal waste, it significantly minimizes the mine's footprint. The URM solution could allow the Ekati Diamond Mine to extend its life by many years.

IHC Mining has developed a three-part URM system for Ekati that involves a submersible mining crawler, a floating platform for launch and recovery of the mining crawler, and a dewatering plant for removing fines and dewatering the ore (**Figure 11**). It Is estimated that the crawler can operate at water depths of up to 400 m. It is currently planned for the crawler to be trialed in the Lynx pit, along with the surface components of the underwater mining system, in 2026.

Exploration Potential

Ekati has a long history of exploration. Since 1990, more than 15,000 samples have been taken, multiple airborne integrated geophysical surveys have been flown and approximately 400 targets have been drill-tested with 178 kimberlites discovered to date. More recently, Ekati has been explored with the application of new technology including high resolution airborne magnetic surveying using remote controlled unmanned aerial vehicles, remote boat bathymetry and new geophysical data processing methods such as EM inversions. Artificial intelligence and deep machine learning, which can lead to discovery of more subtle geophysical kimberlites, is also now being utilised at Ekati.

A property-wide exploration review was completed in the second quarter of 2022 based on the results from deep machine learning initiative carried out during 2021. Eleven drill targets were identified and five were prioritised using EM inversions and detailed geophysical analysis. Helicopter supported exploration drilling of prioritised targets were completed in the third quarter of 2022 and two of three targets that were drilled were confirmed as kimberlite pipes – named "Badger" and "Bear" pipes – located approximately 6 km northwest of the Sable pipe.

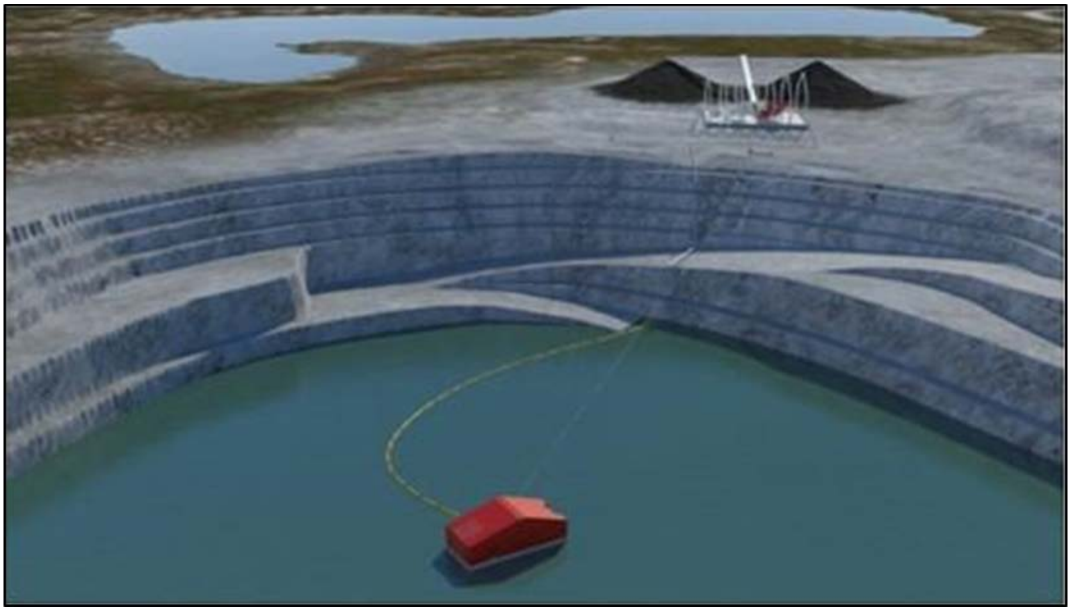


Figure 11: Conceptual illustration of URM operating within flooded open pit

Additional machine learning work along with geophysical data processing was used to develop targets for drill testing in summer 2023. One kimberlite discovery was made (Bear North). The new discoveries from 2022 and 2023 could be slated for future bulk sample programs.

Jay Deposit

The Jay deposit is an undeveloped future project. Located approximately 30 km northeast of Ekati's processing plant within a large lake (Lac du Sauvage), Jay is the largest undeveloped pipe at Ekati and likely one of the largest in the world (Indicated Resource of approximately 90 Mct). Development of Jay would require construction of a containment dike with subsequent dewatering prior to the start of mining activities. Permits are not in place for Jay, however, given the large Mineral Resource and high average grade, the LOM for Ekati could be extended considerably if Jay were to be developed.
Burgundy has indicated that it has no immediate plans to commence the development of the Jay deposit, but remains interested in exploring the feasibility of this project.

Reserves and Resources

Mineral Resources are considered to have reasonable potential to be mined, but do not have mining losses and/or dilution applied. Mineral Resource classification involves geologic, mining, processing and economic constraints, and the Mineral Resources have been defined with a conceptual stope design or a conceptual open pit shell. Drillhole spacing for indicated resources in this context is typically less than 60 m to the nearest sample, and typically less than 90 m to the nearest sample for inferred resources.

Ore Reserve estimates are based on material classed as Indicated Mineral Resources with dilution and mining/processing recovery factors applied. Factors which may affect Ore Reserve estimates include diamond price and valuation assumptions, changes to the assumptions used to estimate diamond carat content, horizontal block cave designs, open pit designs, geotechnical, mining and process plant recovery assumptions, appropriate dilution control being able to be maintained, changes to capital and operating cost estimates and variations to the permitting, operating or social licence regime assumptions.

As of December 31, 2023, the Ekati mine has a total of 43.9 Mt of reserves grading an average of 0.5 Ct/t for a total of 20.3 million carats (**Table 1**). An indicated resource of 133.7 Mt at 1.0 Ct/t for a total of 140.3 million carats and an inferred resource of 82.6 Mt at 0.6 Ct/t for a total of 48.7 million carts have also been reported (**Table 2**). Note diamond grades are highly variable within an individual kimberlite as between different kimberlites, with estimated average grades from bulk sampling kimberlites ranging from less than 0.05 Ct/t to more than 4 Ct/t (Carlson et al. 2016).

Table 1: Ekati Ore Reserves Table as of Dec 31 2023, 100% basis. All Ekati Ore Reserves are classified as Probable. Tonnes are expressed as dry metric tonnes. Grade is in carats per tonne (cpt). Carat estimate includes process plant recovery. Ore Reserve carats are reported according to 2020 Ekati process plant configuration (1.2 mm slot de-grit screens with final recovery using a 1.0 mm screen circular aperture cut-off).

Project / Operation	**Tonnes (millions)**	**Grade (cpt)**	**Carats (millions)**
Sable Open Pit	3.0	0.7	2.2
Point Lake Open Pit	9.1	0.6	5.3
Misery Underground	0.7	3.3	2.3
Fox Underground	31.0	0.3	10.3
Run of Mine Stockpiles	0.1	0.8	0.1
Total Ore Reserves	43.9	0.5	20.3

Table 2: Ekati Mineral Resources as of Dec 31st 2023, 100% basis. Ekati Mineral Resources are classified as Indicated and Inferred (no Measured category) and are reported on a 100% basis. Tonnes are expressed as dry metric tonnes. Grade is in carats per tonne (cpt). Mineral Resources are reported inclusive of Ore Reserves. Mineral Resources that are not Ore Reserves do not have demonstrated economic viability. Mineral Resources are reported at +0.5 mm (based upon diamonds that would be recovered by the Ekati Bulk Sample Plant using 0.5 mm width slot de-grit screens and retained on a 1.0 mm circular aperture screen.

Kimberlite Pipes	Type	Measured Resources			Indicated Resources			Inferred Resources		
		Mt	Ct/t	Mct	Mt	Ct/t	Mct	Mt	Ct/t	Mct
Sable	OP	-	-	-	7.1	0.9	6.8	0.3	1	0.3
Point Lake	OP	-	-	-	31.7	0.8	24	9.6	0.8	7.3
Phoenix	OP	-	-	-	0	0	0	1.8	1.4	2.5
Challenge	OP	-	-	-	0	0	0	2.6	1.3	3.4
Leslie	OP	-	-	-	0	0	0	50.8	0.3	16.3
Misery Main	UG	-	-	-	0.5	5.1	2.7	1.2	5.6	6.9
Fox	UG	-	-	-	45.6	0.4	16.5	5.1	0.4	2.2
Stockpile	OP	-	-	-	0.1	1.7	0.1	6.7	0.2	1.0
Jay	OP	-	-	-	48.1	1.9	89.8	4.2	2.1	8.7
Lynx	OP	-	-	-	0.5	0.8	0.4	0.2	0.8	0.2
Total Mineral Resources		-	-	-	133.7	1.0	140.3	82.6	0.6	48.7

Production History

Since it began production in 1998 through 2022, the Ekati Diamond Mine has produced a total of 91.2 Mct from 93.3 Mdmt with an average grade of 0.98 cpt. See **Table 3** below for a yearly breakdown.

Table 3: Historical production of the Ekati Mine.

Year	Tonnes processed (Mdmt)	Carats recovered (Mct)	Grade (cpt)	Year	Tonnes processed (Mdmt)	Carats recovered (Mct)	Grade (cpt)
1998	0.4	0.3	0.74	2011	4.6	2.6	0.56
1999	3.1	2.5	0.81	2012	4.2	1.8	0.43
2000	2.9	2.5	0.88	2013	4.1	1.9	0.47
2001	3.3	3.7	1.11	2014	4	3.1	0.77
2002	3.7	5	1.34	2015	3.6	3.6	0.98
2003	4.5	7	1.56	2016	2.9	4.8	1.65
2004	4.5	5.1	1.14	2017	4	7.4	1.88
2005	4.4	4	0.91	2018	3.7	6.3	1.71
2006	4.5	3.1	0.7	2019	4.1	2.5	0.62
2007	4.3	4.5	1.04	2020	0.9	0.7	0.81
2008	4.4	3.6	0.81	2021	3.4	3.1	0.89
2009	5.1	4.2	0.83	2022	3.8	4.1	1.07
2010	4.9	3.6	0.74	2023	4.2	5.1	1.21
				Total	**97.6**	**96.4**	**0.99**

Geology Overview

Slave Geological Province Overview

The Slave Geological Province is a composite Archean greenstone-granite terrain overlying older sialic basement and juvenile basement rocks that formed via the tectonic accretion of the pre-3 Ga Central Slave Basement Complex with the Neoarchean juvenile Hackett River Arc (**Figure 12**). Their contact is inferred to dip eastward and is covered by a thick sequence of Neoarchean metaturbites (<2.66 Ga), which are preserved in the central Contwoyto terrane. Post accretion and turbidite deposition, the Slave Geological Province was deformed and intruded by ca. 2.64 to 2.595 Ga syn-tectonic granodiorites and tonalites, and then intruded and overlapped with 2.605 to 2.58 Ga post-tectonic granites. Numerous Proterozoic dyke swarms cut the Slave Geological Province.

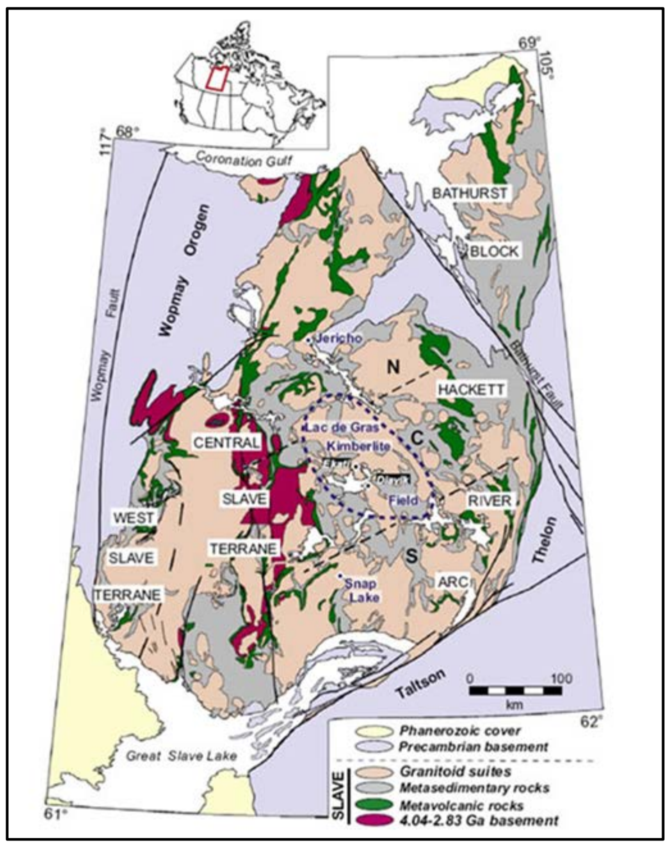


Figure 12: General Geology of the Slave Geological Province (Reproduced from Tappe et al. 2013, modified from Bleeker 2003)

The Slave Geological Province is bounded east of Great Slave Lake to the Arctic coast by the 2.02 to 1.91 Ga Thelon Tectonic Zone, and to the west by the 1.91 to 1.84 Ga Wopmay Orogen. To the south it is bound by the 1.99 to 1.91 Ga Taltson Magmatic Zone and the 1.98 to 1.93 Great Slave Lake Shear Zone. To the north, parts of the SGP are locally overlain by Proterozoic cover sequences in the Kilohigok basin, which formed during crustal flexure due to the Wopmay Orogen. The Slave Craton extends further northward towards Victoria Island, where it is overlain by Proterozoic and Phanerozoic cover sequences. The northeastern portion of the SGP is bound by the Bathurst Fault, and the southeastern portion is bound by the McDonald Fault.

Regional Geology

The Ekati project area is underlain by the Slave Geological Province, a granite–greenstone terrane that grew by tectonic accretion around a pre-3 Ga nucleus that is preserved in the central and western parts of the province, with a Neoarchean juvenile arc in the east. Rock types within the Slave Province can be assigned to three broad lithostratigraphic groups: metasedimentary schists, migmatites and various syn- and post-tectonic intrusive complexes.

The metasediments represent a metamorphosed greywacke sequence and are widespread in the central and southern portions of the Ekati project area. Typically, these metasediments are fine-grained with a high proportion of sheet silicates and are generally foliated. Sulphide minerals are present at trace concentrations but occasionally at concentrations of up to 2% at centimetre scale.

The metasediments are intruded by voluminous neo-Archean granitoids. Syntectonic (ca. 2.64–2.60 Ga) tonalites and granodiorites occur predominantly in the central and northern portions of the property, while post-tectonic (ca. 2.59–2.58 Ga) granites (two-mica granite and biotite granite) form large plutons in the eastern and north-eastern portions of the property. The granodiorites are generally white to grey in colour, medium to coarse-grained and weakly foliated to massive.

The western part of the Ekati project area is dominated by migmatites which reflect melting of metasediments due to widespread granite intrusion and associated heat input.

Dykes of five major Proterozoic diabase dyke swarms (ages varying from 2.23 Ga to 1.27 Ga) intrude the Archean rocks in the region. The dykes are a few centimetres to over 30 m wide and can be magnetic or non-magnetic. Generally, they are near vertical with sharp or fractured contacts of variable orientation. Magnetic dykes are very dark grey to black, fine-grained, and contain magnetite and traces of pyrite, chalcopyrite, with lesser amounts of pyrrhotite. Sulphide mineral concentrations of up to 2% are rarely observed but only over widths of a few centimetres. Non-magnetic dykes have very similar overall composition to magnetic dykes except that they lack abundant magnetite.

The kimberlite intrusions are of Phanerozoic age (i.e. younger than ~530 Ma) and therefore cut across the older stratigraphy. Preferential erosion of the kimberlite pipes resulted in surface depressions, many of which became permanent, shallow lakes, which typically have several metres of silty sand sediments deposited on the lakebed.

The Wisconsinan Laurentide ice-sheet deposited glacial till, glaciofluvial eskers and related kames in the Lac de Gras area. Three glacial transport directions have been recognized: early transport to the southwest, followed by transport to the west, and finally by flow to the northwest.

Bedrock generally crops out at surface across the Ekati project area or is partially overlain by a thin (as much as 5 m thick) veneer of Quaternary sediments. Based on geomorphology work, these sediments consist mainly of silty gravel, sands, and organic matter (Nowicki et al, 2003).

Property Geology

The local geology surrounding the Ekati mining operations (**Figure 13**) has been subdivided into three main Archean units, a two-mica porphyritic granite / granodiorite, a biotite +/- hornblende tonalite / quartz diorite and a greywacke / mudstone metaturbidite (Stubley and Irwin, 2019). Phanerozoic strata are not currently present but are preserved as xenoliths in local kimberlites and the area is thought to have once been overlain by a 50 to 200 m thick succession of Cretaceous marine shales, terrigenous arenite and organic peat (Moss 2009).

There are five observed diabase dyke swarms present in the Lac De Gras region, the Malley dykes, the MacKay dykes, the Lac De Gras, the 305° dykes and the Mackenzie dykes which range in thickness from approximately 10 to 50 m. Refer to **Table 4** below for more detailed information. The Malley, MacKay and Lac De Gras dykes have been associated with kimberlite bodies (Wilkinson et al. 2001).

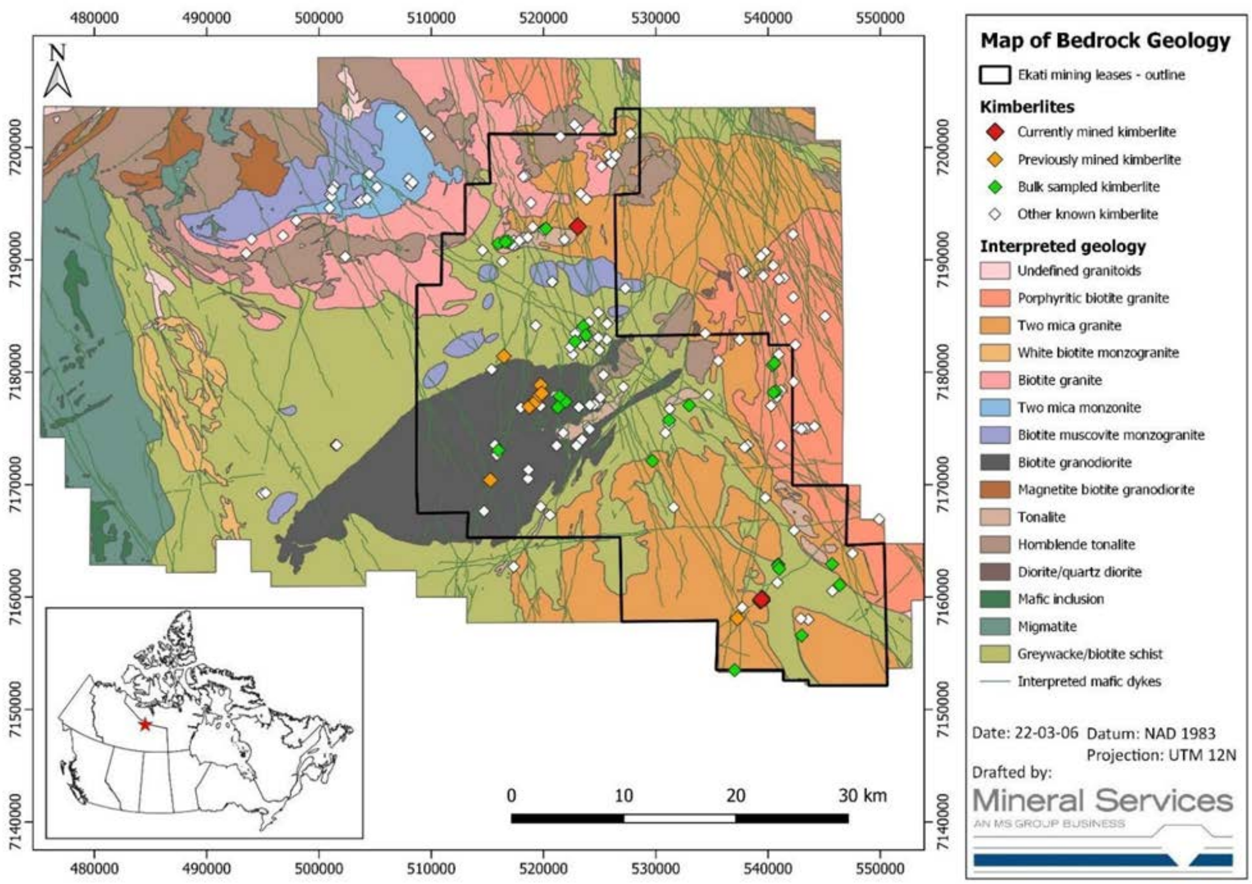


Figure 13: Ekati property geology map

Table 4: Diabase dykes in the Lac de Gras region

Name	**Age (Ga)**	**Orientation**	**Width (m)**
Malley	2.23	45°	10-40
MacKay	2.21	80°	40-50
Lac De Gras	2.020 - 2.030	10°	20-40
305°	1.27	305°	15-30
Mackenzie	1.27	NNW radiating	20-50

Quaternary Geology

The advance and subsequent retreat of the Laurentide ice sheet has had a significant impact on both the landscape and diamond exploration in the NWT and is responsible for the glacial tills, eskers and other glacial features that currently dominate the landscape. Bedrock in the area is variably covered by Quaternary sedimentary deposits, typically under 5 m thick, and large esker systems are present in the region running approximately EW (**Figure 14)**. Broadly speaking, the region is discontinuously overlying till ranging from thin veneers, to over 20 m in buried bedrock valleys, with large esker systems running approximately EW (Ward et al. 2014). Three main glacial advance directions have been recognized, an initial southwest transport direction, a subsequent westward transport direction, followed by a Northwest transport direction (Ward et al. 2014).

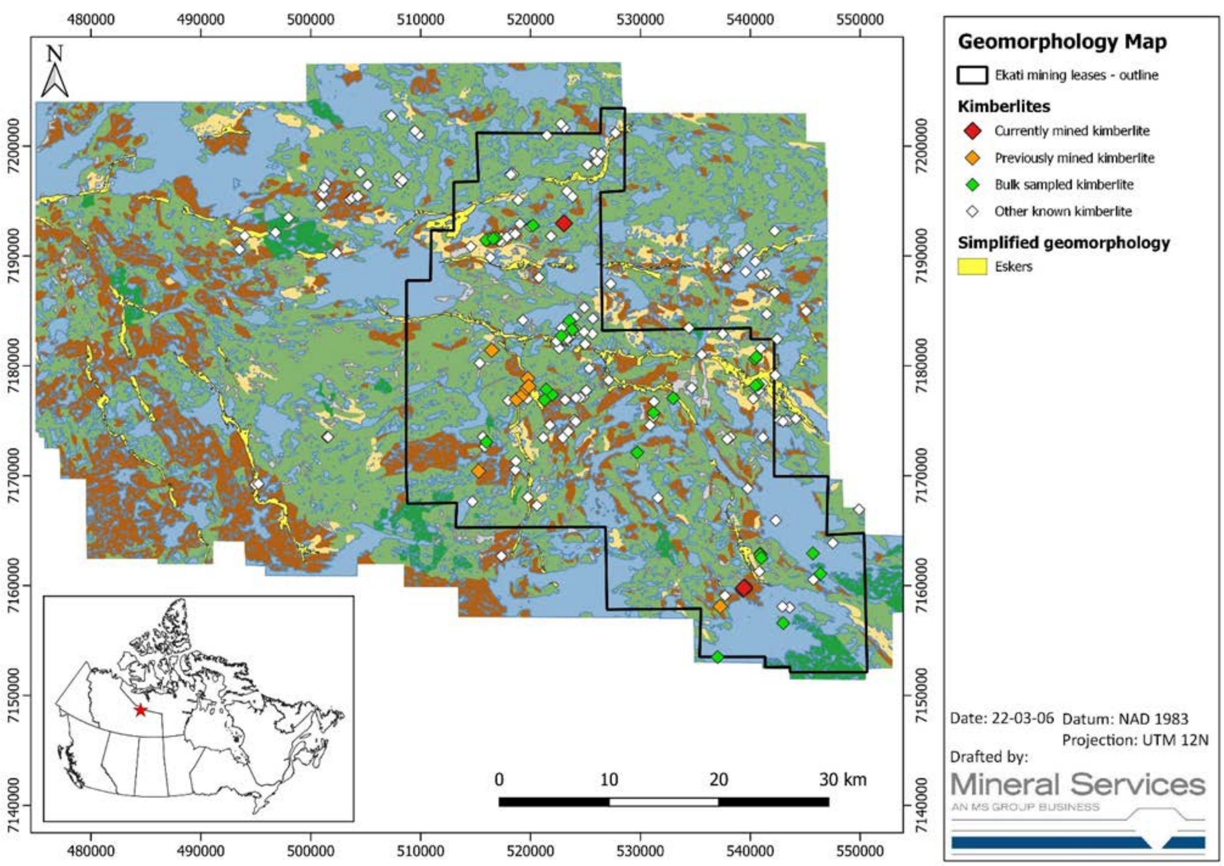


Figure 14: Simplified geomorphology of the Lac de Gras region

Overview of Ekati Kimberlites

The 178 known kimberlites on the Ekati mine site are part of the Lac de Gras kimberlite field and are Eocene to late Cretaceous (45 to 75 Ma) in age (**Figure 13,14**). These kimberlites are typically small pipe-like bodies with surface expressions mostly less than 3 ha, but ranging up to 20 ha. They are known to extend 400 to 600 m below the current surface level. While they define several linear trends and are typically associated with dykes and lineaments, there is no dominant or unique structural association of the kimberlites.

The Ekati kimberlites are mostly made up of olivine-rich volcaniclastic kimberlite (VK), with lesser mud-rich resedimented volcaniclastic kimberlite and primary volcaniclastic kimberlite (RVK). Rarely, kimberlites here contain significant amounts of primary volcaniclastic kimberlite (PVK). To date, most economic mineralization is found in olivine-rich RVK and PVK.

Ekati Kimberlite Geology

The Ekati kimberlites are primarily steep-sided volcanic pipes that are mostly filled with volcaniclastic material interpreted to be resedimented and lesser primary volcaniclastic (pyroclastic) kimberlite (e.g. **Figure 15**, Nowicki et al., 2003). While narrow coherent kimberlite dykes are present, these are not volumetrically significant. These mostly appear to predate kimberlite volcanism and are commonly transected by the volcanic pipes. Coherent kimberlite is present in some pipes either as late-stage intrusive material emplaced into volcaniclastic kimberlite (e.g. Koala; **Figure 15**), or as large pipe-filling bodies (e.g. Leslie; Grizzly).

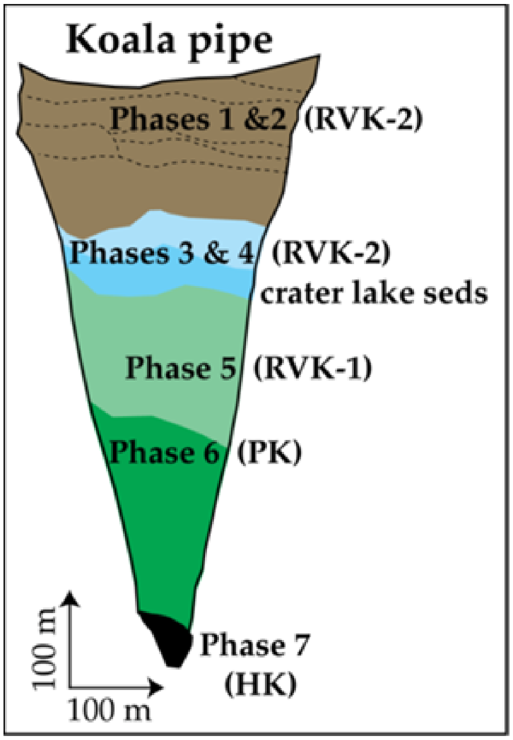


Figure 15: Geological cross-section of inverted cone shaped Koala kimberlite body, Ekati Mine, Lac de Gras field. Phase 7 is hypabyssal kimberlite (HK) and Phase 6 is pyroclastic kimberlite (PK) (Crawford et al., 2006). Phase 5 is interpreted here as syn-eruption resedimented volcaniclastic kimberlite (RVK-1), Phase 4 and Phase 3 are interpreted here as crater-lake sediments, and Phase 2 and Phase 1 are interpreted as post-eruption resedimented volcaniclastic kimberlite (RVK-2). Internal phases within Phase 1 and Phase 2 are demarcated by dashed lines. Source: Modified after Nowicki et al. (2003) and Crawford et al. (2006) by Kjarsgaard (2007)

Fine grained sedimentary rocks are present in the Ekati kimberlites as both xenoliths and disaggregated material, indicating that sedimentary cover was present at the time of emplacement. These inclusions in kimberlites represent the only record of these cover units which have since been eroded. While some peripheral kimberlite dykes are present, the geological investigations carried out to date have not yielded any evidence for the presence of complex root zone or flared crater zones.

At Ekati, the extent of mantle sampling, the degree of dilution by wall-rock and surface sediments and volcanic sorting processes are considered to be the main factors controlling variation in total diamond grade. The diamond size distribution characteristics are inherited from the original population of diamonds sampled from the mantle but can be affected by a number of secondary processes, including resorption and sorting during eruption and deposition of volcaniclastic kimberlite deposits. Diamond breakage due to geological processes is not expected to be significant enough to notice on the overall size distribution.

The Ekati kimberlites have been broadly classified into 6 rocks types: Magmatic kimberlite (MK) – hypabyssal, Tuffisitic kimberlite (TK), Primary volcaniclastic kimberlite (PVK), Olivine-rich volcaniclastic kimberlite (VK), Mud-rich resedimented volcaniclastic kimberlite (RVK), Kimberlitic sediments. Note that if using currently accepted kimberlite nomenclature systems MK would be referred to as coherent kimberlite (CK), TK as Kimberly-type pyroclastic kimberlite (KPK) and PVK as pyroclastic kimberlite (PK).

With a few exceptions, kimberlite on the Ekati property is mostly composed of VK, including very fine-grained to medium-grained kimberlitic sediments, RVK and PVK. RVK represents pyroclastic material that was transported from its original location of deposition by slumping and flow processes into an open pipe, undergoing varying degrees of reworking and incorporation of other materials such as mudstone and plant material. Ekati kimberlites typically contain wood fragments, which are related to the redwood Sequoia and Metasequoia genera, ranging in size up to several meters, with size abundance typically decreasing with depth. In rare cases, some kimberlites are dominated by or contain significant amounts of MK (e.g. Pigeon, Leslie).

In some units, mud can make up a significant proportion of the kimberlite, and can be present as mm to cm scale xenoliths which are typically uniformly fine grained, dark grey to black in colour and can contain minerals such as olivine and serpentine with the majority consisting of clay minerals, quartz and pyrite.

Economic mineralization is mostly limited to olivine-rich resedimented volcaniclastic and primary volcaniclastic types. Approximately 10% of the known kimberlite pipes in the Ekati Project are of economic interest or have exploration potential. Diamond grades are highly variable. Estimated average grades for kimberlites that have been bulk sampled range from less than 0.05 cpt to more than 4 cpt.

Sable Kimberlite

The Sable pipe is hosted by Archean two-mica granite. Linear magnetic features have been observed under and adjacent to Sable Lake and are interpreted to be mafic dikes. The pipe lies under Sable Lake and is covered by water and boulder- and gravel-dominated glacial till overburden. The pipe sub-surface area is approximately 2 ha and surface dimensions of 180 m by 140 m. It has an irregular triangular outline in plan view and a steep-sided vase shape; the pipe at approximately 200 m below surface is wider (2.4 ha) than the top or bottom of the model.

The Sable kimberlite comprises a package of fragmental, volcaniclastic kimberlite (VK). As for other VK at Ekati, Sable kimberlite is made up primarily of olivine set in variable amounts of dark, fine-grained matrix material, in most cases believed to be dominated by mud. Other important components include variable (but generally low) amounts of mudstone clasts and granite xenoliths, small carbonised wood fragments and kimberlitic indicator minerals (primarily garnet and Cr-diopside).

The Sable kimberlite contains two main kimberlite lithologies, olivine-rich RVK and Very olivine-rich VK (**Figure 16**).

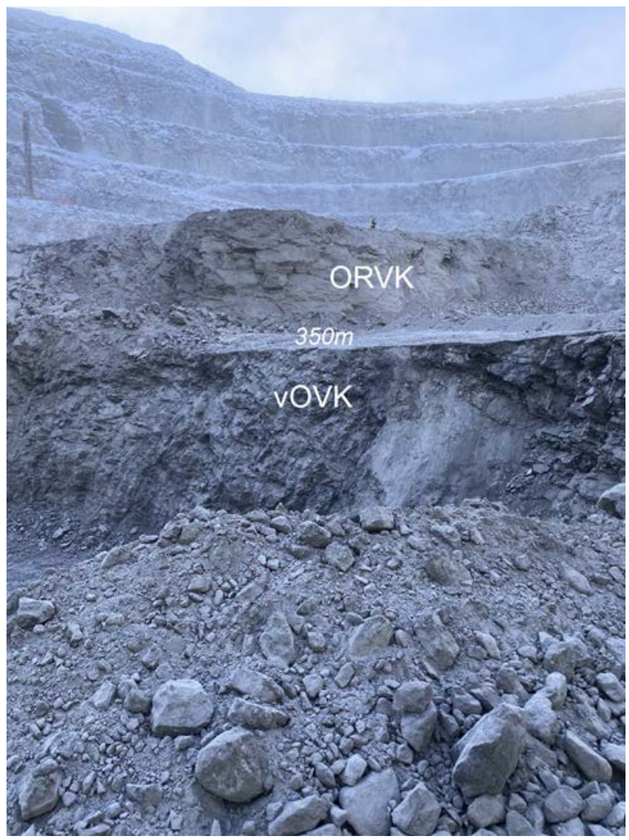


Figure 16: Contact between upper Olivine-rich resedimented volcaniclastic kimberlite (ORVK) and lower very olivine rich volcaniclastic kimberlite (vOVK).

Olivine-rich RVK (ORVK): Massive, matrix-supported, kimberlite with relatively minor amounts of olivine (<30%), scattered mudstone clasts, rare small granite xenoliths and common wood fragments set in a dark, fine-grained matrix dominated by mud (**Figure 17,18**). The kimberlite is very poorly sorted. Olivine is typically fine or medium grained but scattered very large olivine macrocrysts (up to 20 mm) are present. This material is classified as resedimented volcaniclastic kimberlite (RVK) and is designated olivine-rich (ORVK) where overall olivine content exceeds approximately 15%.

Very olivine-rich VK (vOVK): Clast-supported, very olivine-rich volcaniclastic kimberlite with common mudstone clasts, scattered granite xenoliths and carbonised wood fragments. Olivine content commonly exceeds approximately 50% and, due to the significantly lower proportion of muddy matrix material, the kimberlite is generally pale to dark greenish-brown/grey in colour. The kimberlite ranges from poorly sorted to moderately sorted and is generally medium-grained. Granite xenoliths are commonly extensively altered. Bedding is common and varies from crude, centimetre- to decimetre-scale beds to fine laminations (mm scale). The beds are defined by a combination of olivine grain size, olivine abundance and proportion of dark fine-grained matrix material.

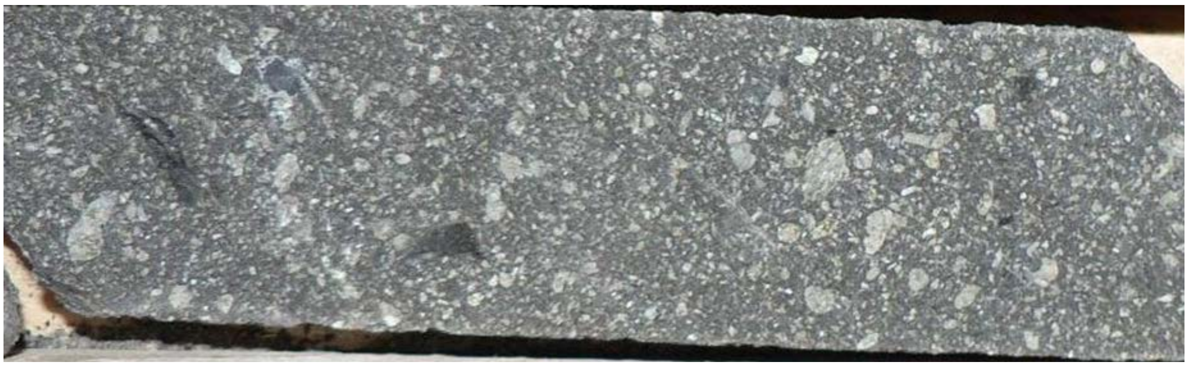


Figure 17: ORVK drill core with pale olivine grains and small dark mudstone clasts are set in a fine-grained, mud-rich matrix

Figure 18: vOCK drill core showing close-packed texture and high olivine content.

Other minor rock types encountered at Sable include fine-grained crater sediments (mudstone to fine-grained sandstone) and a single narrow intersection of possible pyroclastic kimberlite (95-25 218.6 – 226.2

m). The latter is matrix-supported, olivine-rich kimberlite with a dark fine- grained matrix and is superficially similar to ORVK as described above. However, it has a more uniform distribution of olivine grains and the matrix has a more crystalline appearance suggesting it may have formed by direct deposition of pyroclasts. This unit is classified as OVK.

Kimberlite intersections have been assigned to two major domains based on drill core observations. An Upper Crater zone (RVK domain) domain is characterized by a significant proportion of ORVK. This kimberlite type generally dominates the upper portion of the kimberlite with increasing amounts of interbedded pale vOVK occurring with depth. The Lower Crater zone (VK domain) is dominated by vOVK, with the presence of scattered large (4 to 15 cm) granite xenoliths. The domain boundary is currently defined at the point below which matrix supported ORVK becomes an insignificant component.

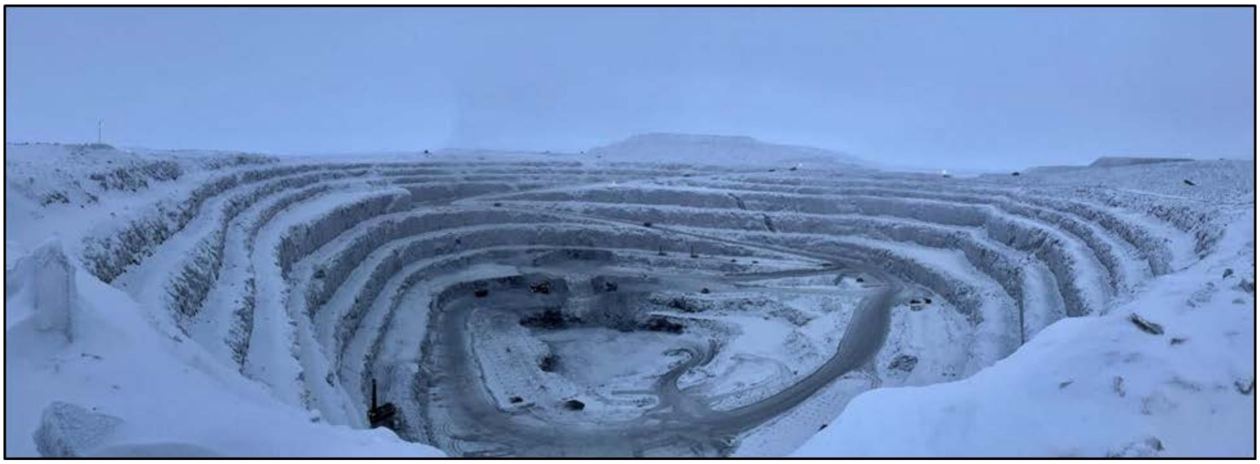


Figure 19: Aerial view of Sable pit 2022

Misery Kimberlite

The Misery Complex was emplaced into Archean rocks approximately 56 to 75 Ma. The Main pipe was originally situated below Misery Lake, covered by water and glacial till overburden. The original surface expression of the Main pipe was 1.5 ha with a roughly circular shape.

The Misery Main pipe and associated satellite pipes and dykes intruded along the regional geological contact between older metasediments and younger Archean granite on the northeast and southwest sides of the pipe respectively (**Figure 20**). This likely represented a zone of weakness that was exploited by the Misery kimberlites during emplacement.

A diabase dyke of the Contwoyto Lake suite runs northeast to southwest to the west of the Main pipe. The metasediments are weathered and commonly foliated, containing trace andalusite and porphyroblasts that are typically overgrown by sillimanite. The granitic rocks are weathered to a white to light grey colour and contain abundant primary muscovite. The granitic rock textures vary from fine to coarse grained pegmatitic and equigranular to weakly porphyritic. The granite is generally massive.

The main structural features that characterize the area are the steeply dipping contact between the metasediments and two-mica granite and diabase dyke emplacement. The granite/metasediment contact appears to be defined by a sharp contact surface with little intermixing. The diabase dykes generally trend perpendicular to the metasediment-granite contact.

Other structural elements tend to follow parallel to these major structures. The satellite kimberlite bodies in the Misery Complex including the East Dike, and Southeast pipe are roughly parallel to the granite-metasediment contact. The North pipe and Southwest Extension are parallel to sub-parallel to a diabase dyke. Other small kimberlite bodies radiate out from the Main pipe, mostly parallel or sub-parallel to the main structural features.

The Main pipe is central with the remaining bodies situated as satellites. Misery Main is the largest pipe in the cluster followed by the Southwest Extension and South pipe. There are other small kimberlite dykes and pipe-like bodies throughout the complex (**Figure 20**).

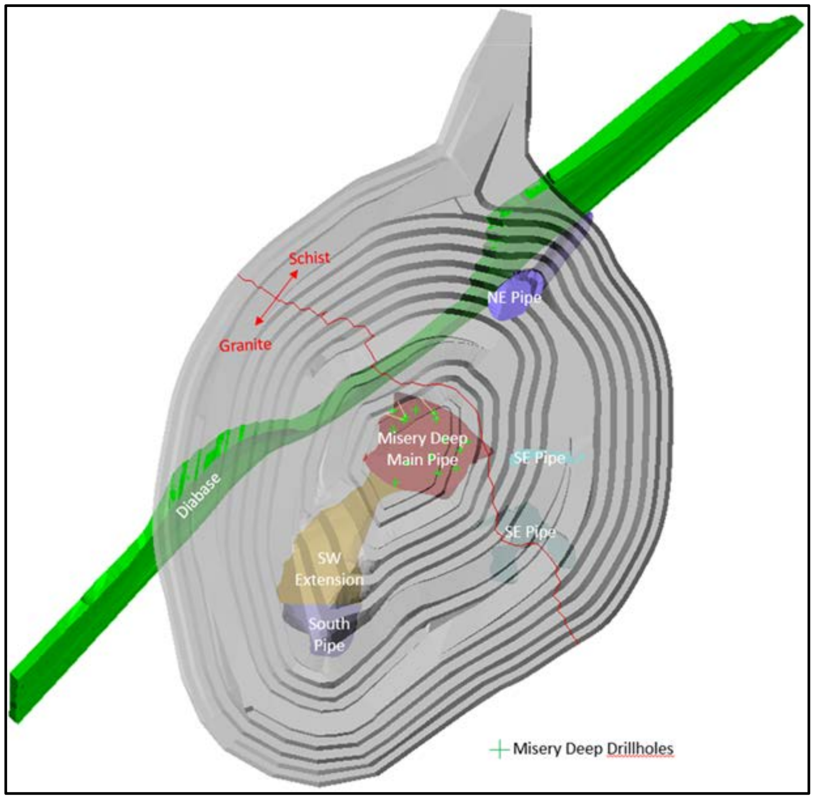


Figure 20: Plan view of Misery geology with open pit extent.

The Misery Main, Southwest Extension, and South pipe are mostly infilled with resedimented volcaniclastic kimberlite (RVK). The East, Northeast and Southeast kimberlite bodies are largely infilled with a domina comprised of coherent kimberlite. Other small bodies throughout the complex are magmatic or coherent kimberlite, with lesser RVK infill.

The Main pipe was initially logged as an RVK domain termed “KIMB3” along with a deep domain interpreted to contain coherent kimberlite. The geological model was updated after the most recent drill program. The KIMB3 material modeled as the Main pipe has now been modeled into two domains, KIMB3S and KIMB3N on the basis of detailed core logging (**Figure 21, 22**).

The KIMB3N domain is characterized as olivine-rich to locally very olivine rich material, fine to medium or coarse grained with graded bedded RVK (**Figure 23d,e**). There is increased mud content at the pipe margins and mantle derived garnet xenocrysts are abundant and peridotite xenoliths are present. Large xenoliths (greater than 0.5m) occur but are rare.

There are subunits within KIMB3N, the most dominant being KIMB3Ngb which is comprised of thick to very thick graded bedding characterized by changes in olivine and country rock size and abundance. KIM3No is similar to KIMB3Ngb but finer grained and locally more mud-rich. Other sub-units are fine grained, massive, have bedding variations or have different xenolith populations, but these units comprise less than 10% of the logged core.

The KIMB3S domain is variably mud- and olivine- rich, very fine to medium grained, locally coarse grained, chaotic to variably bedded RVK. More heterogeneous and more mud-rich than KIMB3N. The mantle xenocrysts are similarly abundant but the mantle xenoliths are smaller and less common than in KIMB3N.

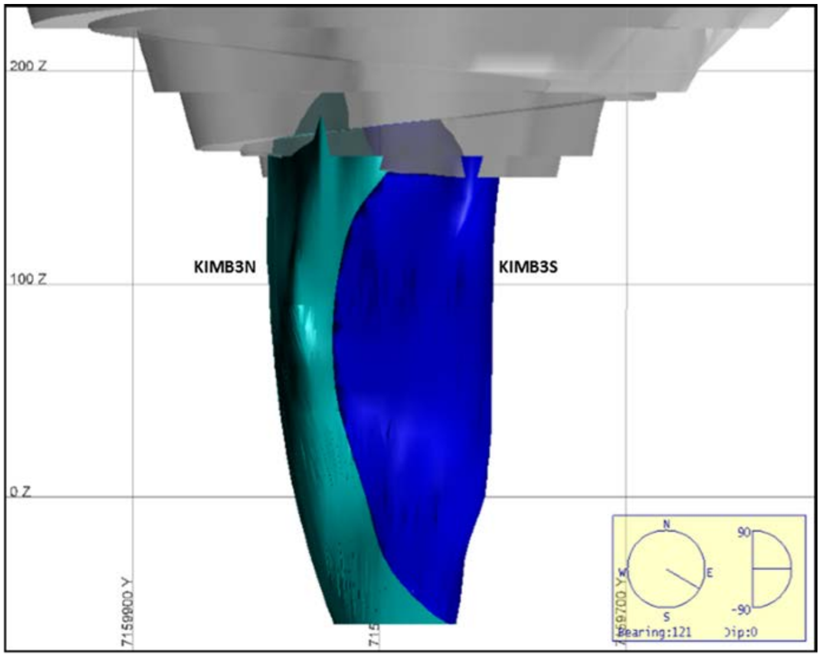


Figure 21: Vertical cross section showing Misery Pipe kimberlite

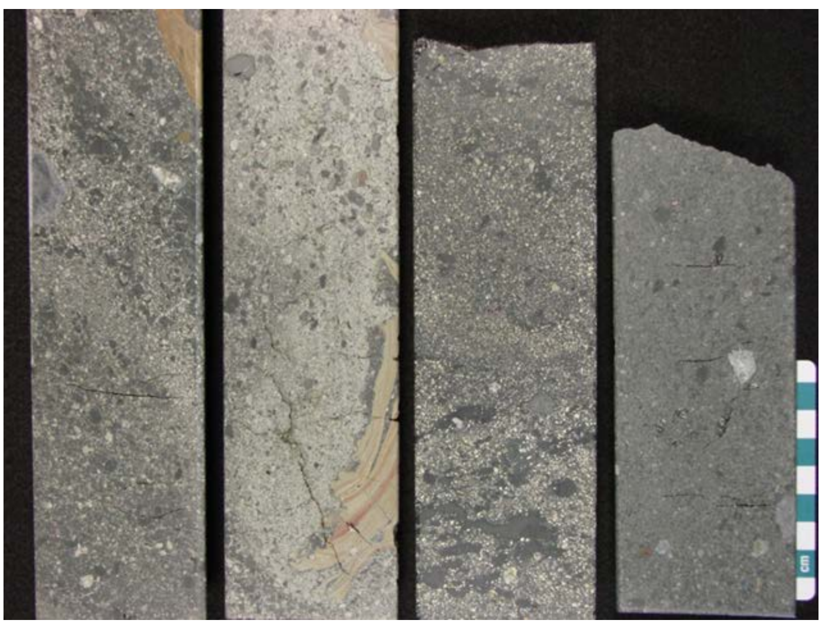
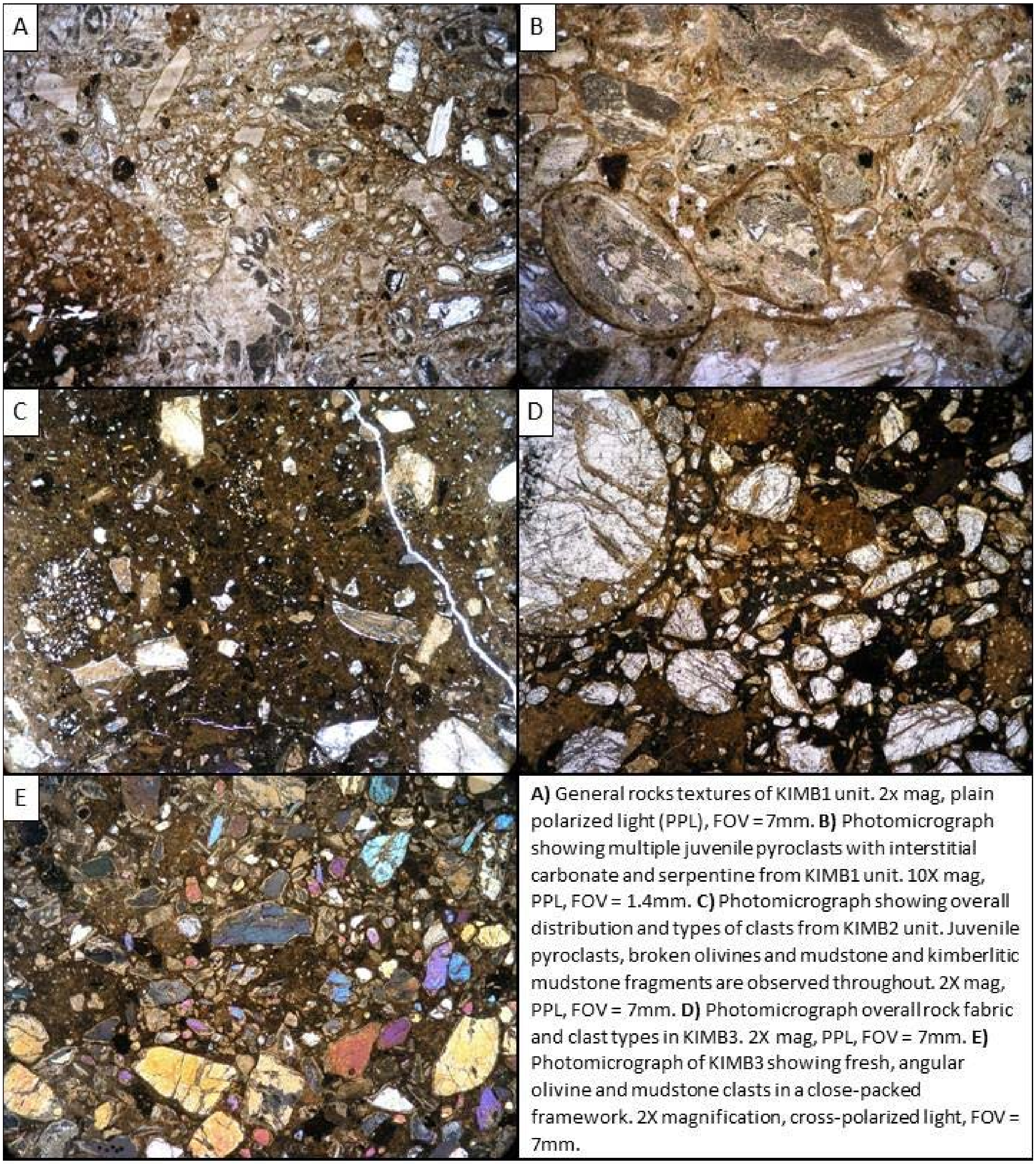


Figure 22: Photographs of polished slabs of the KIMB3 rock type from the Misery Main domain pipe (Left to right: MGT-51, 342.75 m; MGT-60, 153.54 m; MGT-52, 342.70 m; MGT-54,312.27 m). This rock type is highly variable, as show in the slabs above. One of the characteristic features is the presence of orange brown, highly deformed silty mudstone xenoliths like the one shown in MGT-60 above.

The dominant sub-unit within KIMB3S is KIMB3Svb which has highly variable bedding, variability in olivine size and olivine to mud ratio. Two smaller but significant units occur in KIMB3S, KIMB3Sf – fine grained, country rock xenolith poor, and KIMB3Smm – a mainly mud-rich RVK with short, irregular intervals of olivine-rich RVK.

At depth, the Misery Main domain appears to be dominated by KIMB4, which is a fine grained, well sorted equivalent to KIMB3. This rock type has only been identified in two deep drill cores and exists below the vertical RC holes completed, so limited information is available. Due to the fine-grained nature of this rock type it is considered to be of lower interest than KIMB3.

In addition to KIMB3 and KIMB 4, two other minor rock types (volumetrically insignificant based on current drilling) have been identified within the Misery main domain. These are KIMB1, a M-C grained massive PVK (**Figure 23a**) and KIMB2, a mud rich, F-M grained variably bedded resedimented volcaniclastic kimberlite (**Figure 23b**). Because these rock types have only been identified in a few drill cores over short intersections, individual solids have not been developed at this time.



A) General rocks textures of KIMB1 unit. 2x mag, plain polarized light (PPL), FOV = 7mm. **B)** Photomicrograph showing multiple juvenile pyroclasts with interstitial carbonate and serpentine from KIMB1 unit. 10X mag, PPL, FOV = 1.4mm. **C)** Photomicrograph showing overall distribution and types of clasts from KIMB2 unit. Juvenile pyroclasts, broken olivines and mudstone and kimberlitic mudstone fragments are observed throughout. 2X mag, PPL, FOV = 7mm. **D)** Photomicrograph overall rock fabric and clast types in KIMB3. 2X mag, PPL, FOV = 7mm. **E)** Photomicrograph of KIMB3 showing fresh, angular olivine and mudstone clasts in a close-packed framework. 2X magnification, cross-polarized light, FOV = 7mm.

Figure 23: Photomicrographs of thin sections from the Misery Main kimberlite.

Point Lake Open Pit

All three Point Lake Complex (PLC) kimberlites occur as volcanic pipes that were emplaced into foliated metasedimentary rocks. The PLC kimberlites are steep-sided tapering volcanic pipes that vary considerably in size and in the nature of their infill (**Figure 24**). The Point Lake pipe is the largest of the three kimberlites in the PLC, covering an area of approximately 10.9 ha at the contact with overburden. Logging of drill core and reverse circulation (RC) drill chips has identified two main kimberlite domains (internal zones with broadly equivalent geological characteristics).

RVK – bedded, resedimented, olivine-poor to olivine-rich, volcaniclastic kimberlite with variable and significant amounts of mud dilution. This is the dominant material occupying the upper part of the pipe. RVK at Point lake can be further subdivided into KIMB1 (**Figure 25**, mud-rich, common large meta-sed xenoltihs) and KIMB2 (**Figure 26**, more olivine-rich than KIMB1, scarce met-sed xenoliths, more altered matrix).

KIMB1 is a massive to crudely bedded mud-rich RVK with common mudstone clasts. It is a matrix supported with irregular / patchy distribution of poorly sorted fine to coarse grained olivine. Large (>10 cm) xenoltihs are common, as are smaller altered / bleached xenoliths throughout. KIMB2 is a massive to crudely bedded RVK similar to KIMB1, but with only rare large metased xenoliths, an apparent higher olivine content and a more uniform fine to medium olivine grain size.

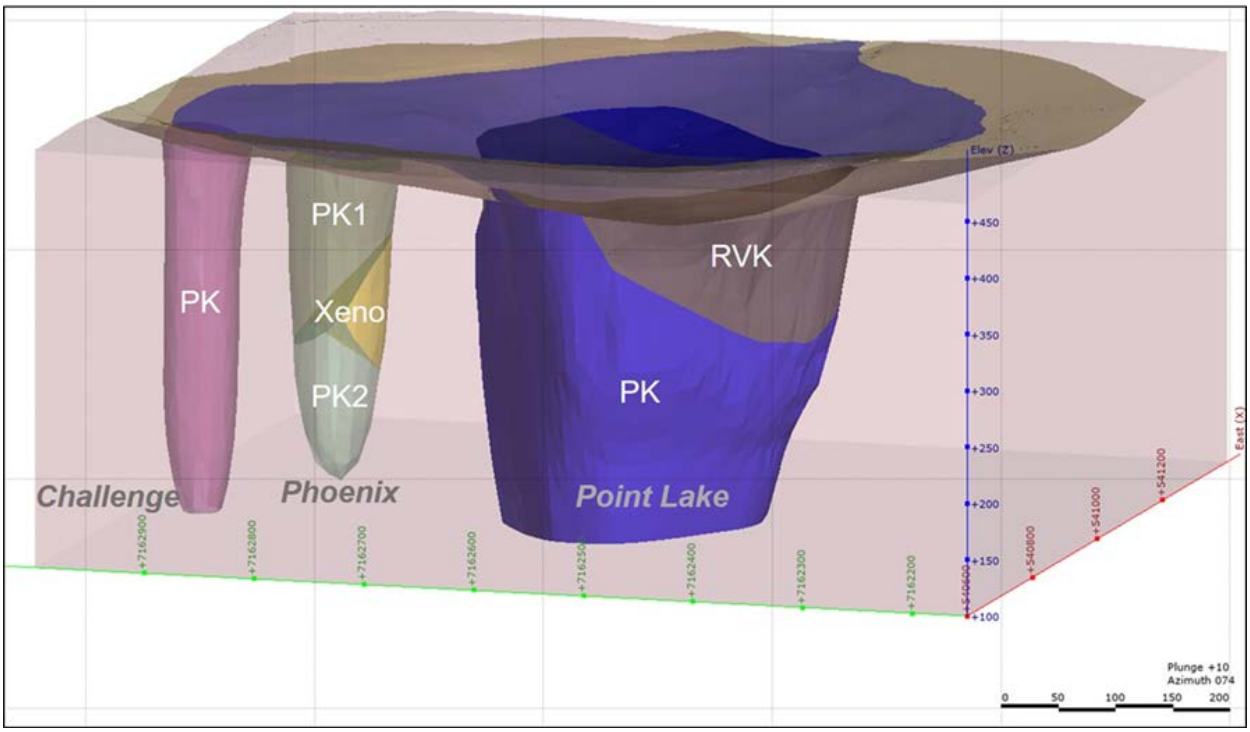


Figure 24: 3D view of the PLC looking to the northeast showing the shape, relative size and internal domains of each pipe.

PK – massive, olivine-rich pyroclastic kimberlite. This is the dominant kimberlite variety at depth and extends up to the overburden contact on the eastern and western portion of the pipe. PK at point lake can be further divided into 4 subunits. KIMB3 is olivine-rich with dark alteration halos on metasedimentary xenoliths and an altered matrix. KIMB4 is similar to KIMB3 but is more competent and possibly finer


Figure 25: Drill core from Mud-rich RVK (KIMB1) from Point Lake kimberlite.


Figure 26: Drill core from mud-rich to olivine rich RVK (KIMB2)

grained. KIMB5 is also similar to KIMD3 but contains abundant magmaclasts. KIMB6 is similar to KIMB5 but with a more intensely darkly altered matrix.

KIMB3 is a fine to coarse grained olivine-rich volcanoclastic kimberlite dominated by pale altered olivine with a lesser dark, micro/cryptocrystalline matrix (**Figure 27**). It has a variable olivine abundance and grain size, but is generally clast supported. It can be characterised by regularly distributed small (<5 cm) highly altered metasedimentary xenoliths with distinct dark alteration haloes. It contains scattered small (generally < 5 mm) black clasts of mudstone (+/-mud-rich RVK) and is Interpreted to be probable pyroclastic kimberlite (PK) deposited at high temperatures and subjected to hydrothermal alteration. KIMB4 (**Figure 28**) is PK very similar to KIMB3 but more competent, apparently due to more intense alteration / cementation of the interclast matrix which has a paler, more altered appearance than that in KIMB3. Olivine grain size and the size of metasedimentary xenoliths appears to decrease gradually with depth.


Figure 27: Olivine-rich KIMB3. (MSC18_15R)


Figure 28: Competent olivine-rich PK (KIMB4). (MSC18_15R)

KIMB5 is PK similar to KIMB3/4 but with lower olivine content, darker micro/cryptocrystalline matrix and presence of abundant very small (generally < ~ 2 mm) apparent magmaclasts (**Figure 29**). The apparent magmaclasts comprise olivine grains or small country-rock xenoliths with rims of highly altered apparent granular material interpreted to be the altered groundmass rim of melt-bearing pyroclasts. The abundance of mudstone/RVK clasts appears to be slightly lower than in KIMB3/4. KIMB6 is a PK unit with a similar texture and components to KIMB5 but with a very dark and prominent fine-grained matrix giving the rock a "muddy" appearance (**Figure 30**). This stems from a pervasive "wash" of alteration obscuring the matrix texture with uniform, dark, very fine-grained (micro/cryptocrystalline) cement. The contact between KIMB5 to KIMB6 is transitional.

Other, volumetrically minor, domains include: VK1 - a zone of apparent mixing between RVK and PK; VK2 - probable contact material at the contacts between PK and wall-rock; and PK2 – distinctive


Figure 29: Magmaclastic PK (KIMB5). (MSC18_15R)


Figure 30: Dark magmaclastic PK (KIMB6). (MSC18_15R)

pyroclastic kimberlite intersected only in one drill hole (PL-53) that is not considered to be part of the main Point Lake pipe.

The Phoenix kimberlite covers an area of approximately 0.8 ha at the contact with overburden and is infilled predominantly by massive, altered pyroclastic kimberlite (PK) with a high proportion of fine-grained (<1 cm) wall-rock fragments (metasediment xenoliths). Drilling indicates the presence of large metasediment blocks (xenoliths) occupying the south-east portion of the pipe at depths below surface of approximately 60 to 170 m. These are underlain by pyroclastic kimberlite similar to that occupying the upper portion of the pipe.

The Challenge kimberlite is the smallest of the three PLC bodies, covering an area of 0.6 ha at the contact with overburden. Based on drilling undertaken to date, this small pipe is entirely infilled with dark, very competent xenolith-poor and olivine-rich pyroclastic kimberlite (PK).

Geochronology

The ages of thirty-seven kimberlite occurrences from the Ekati property, ranging from 47.2 to 74.7 Ma. are presented below in **Figure 31** and **Table 5**. The reader will note that the kimberlites which have been mined at Ekati range from 53 to 56 Ma in age, a very similar age range to those mined at the Diavik Diamond Mine. For further discussion on this, the reader is directed to Sarkar et. al 2015, Creaser at al. 2004 and Lockhart et al. 2004.

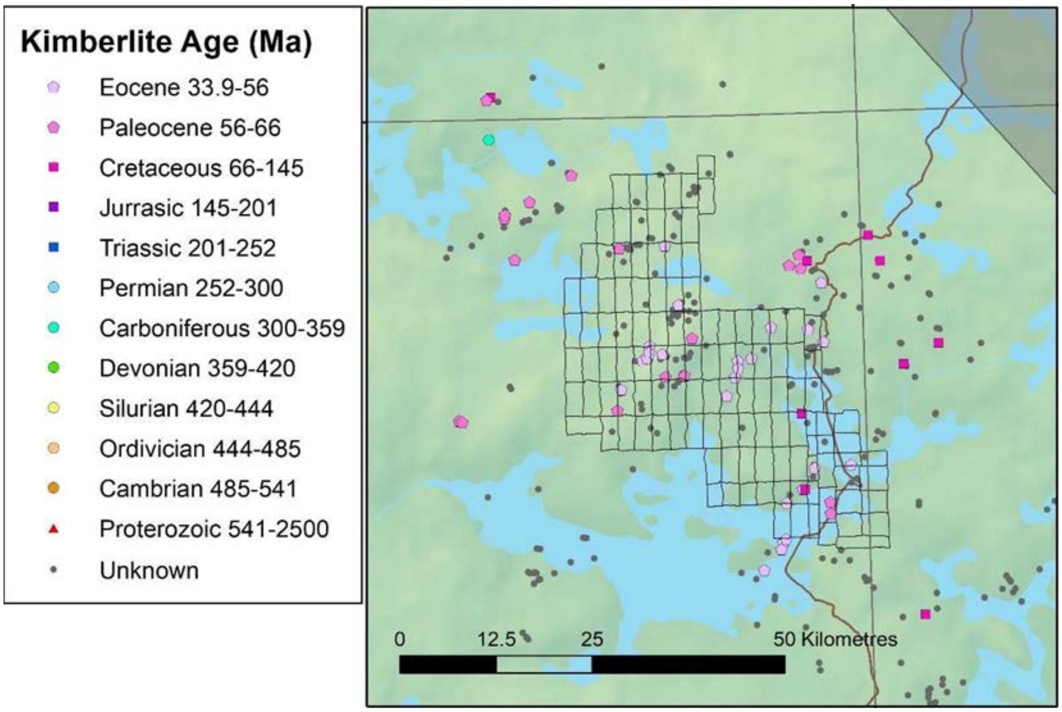


Figure 31: Age distribution of kimberlite in the Lac de Gras region after Stubley and Irwin 2019 and Elliott 2024.

Table 5: Summary of publicly available age dates for Ekati kimberlites. Referneces: a) Sarkar et al. 2015, recalculated from Creaser et al. 2004, b) Sarkar et al. 2015, c) Sarkar et al. 2015 recalculated from Armstrong & Moore 1998, d) Creaser et al. 2004, e) Sarkar et al. 2015; weighted average with Lockhart et al. 2004, f) Approx. age from Mustafa et al. 2006, g) Lockhart et al. 2004 and h) Sarkar et al. 2015, recalculated from Davis & Kjarsgaard 1997.

Kimberlite	Age (Ma)	Error (Ma)	Dating Method	Ref.	Kimberlite	Age (Ma)	Error (Ma)	Dating Method	Ref.
Aaron	48.8	3.4	U-Pb perovskite	*a*	Koala	53.3	0.9	Rb-Sr phlogopite	*d*
Anaconda	63.1	1.8	U-Pb perovskite	*b*	Koala North	53.3	0.9	Rb-Sr phlogopite	*d*
Antelope	62	2.6	U-Pb perovskite	*a*	Kodiak South	63.7	3.9	U-Pb perovskite	*f*
Arnie	49.3	2.1	U-Pb perovskite	*d*	Kudu	74.7	6.8	U-Pb perovskite	*g*
Beartooth	53.1	1.7	Rb-Sr phlogopite	*d*	Leslie	53.1	0.7	Rb-Sr phlogopite	*f*
Brent	47.2	1.6	Rb-Sr phlogopite	*d*	Mark	49.6	3.6	U-Pb perovskite	*h*
Cardinal	54.8	1.9	Rb-Sr phlogopite	*d*	Misery	56	0	N/A	*f*
Caribou West	65.7	2.8	U-Pb perovskite	*e*	Misery East dyke	68.7	3.9	U-Pb perovskite	*b*
Cobra South	59.7	0.4	Rb-Sr phlogopite	*d*	Panda	53.3	0.6	Rb-Sr phlogopite isochron	*d*
Crab	58.5	1.3	Rb-Sr phlogopite	*d*	Panther	52.5	3.9	U-Pb perovskite	*a*
Falcon	51.5	1.7	Rb-Sr phlogopite	*d*	Point Lake	51.5	1.1	Rb-Sr phlogopite	*d*
Flying V	64.4	3.4	U-Pb perovskite	*b*	Rattler	59.9	0.6	Rb-Sr phlogopite	*a*
Fox	56.2	3.2	U-Pb perovskite	*b*	Roger (aka Kirk)	58.7	5.4	U-Pb perovskite	*e*
Glory	61.3	3.4	Rb-Sr phlogopite	*d*	Rooster	58.7	2.3	Rb-Sr phlogopite	*d*
Grizzly	52.2	1.1	Rb-Sr phlogopite	*a*	Rufus	61.1	2.1	Rb-Sr phlogopite	*d*
Hawk (aka Willy Nilly)	48	1.3	Rb-Sr phlogopite	*d*	Shark (aka Rottweiler)	58.4	1.7	Rb-Sr phlogopite	*d*
Husky	61.6	2.9	U-Pb perovskite	*e*	Sprinkbok	61.6	2	U-Pb perovskite	*e*
Jaeger	66.5	5.1	U-Pb perovskite	*e*	Zach	52.8	0.8	Rb-Sr phlogopite	*d*
King	61.1	2.5	U-Pb perovskite	*e*					

Acknowledgments

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References

Armstrong, J.P. and Kjarsgaard, B.A. 2003. Geology Setting of Kimberlites in the Archean Slave Craton; in VIIIth International Kimberlite Conference, Salve Province and Northern Alberta Field Trip Guidebook, B.A. Kjarsgaard (ed.); p. 31-38

Armstrong, R.A., Moore, R.O., 1998. Rb-Sr ages on kimberlites from the Lac de Gras area, Northwest Territories, Canada; South African Journal of Geology, Volume 101, Issue 2, pp. 155-158.

Bleeker, W. 2003. The late Archean record: a puzzle in ca. 35 pieces. Lithos 71, 99-134

Burgundy, 2023. ASX Announcement, Ekati Diamond Mine Ore Reserves and Mineral Resources 14 March 2023

CSA Global, 2023, Independent Technical Assessment Report, Report No. R138.2023, 24 March, 2023.

Carlson, J.A., Ravenscroft, P.J., Lavoie, C., Cunning, J. 2016. Ekati Diamond Mine, Northwest Territories, Canada, NI 43-101 Technical Report.

Crawford, B., Porritt, L.A., Nowicki, T.E., Carlson, J.A., 2006. Key geological characteristics of the Koala kimberlite, Ekati Diamond Mine, Canada, 2006 Kimberlite Emplacement Workshop. Long Abstracts, Saskatoon, Canada

Creaser, R.A, Herman, G., Carlson, J., Crawford, B., 2004. Macrocrystal phlogopite Rb-Sr dates for the Ekati property kimberlites, Slave Province, Canada: evidence for multiple intrusive episodes in the Paleocene and Eocene; Lithos, Volume 76, Issue 1-4, pp. 399-414. https://doi.org/10.1016/j.lithos.2004.03.039

Davis, W.J., and Kjarsgaard, B.A., 1997. A Rb–Sr isochron for a kimberlite from the recently discovered Lac de Gras field, Slave Province, Northwest Canada; Journal of Geology, Volume 105, pp. 503-509.

Elliott, B, 2024. Compilation of Known Kimberlites in the Northwest Territories, Canada, NWT Open Report 2024-002.

Kjarsgaard, B. A. K., Wilkinson, L. & Armstrong, J. (2002). Geology, Lac de Gras kimberlite field, central Slave Province, Northwest Territories - Nunavut. Geological Survey of Canada, Open File, 3238. https://doi.org/10.4095/213473

Kjarsgaard, B.A., 2007. Kimberlite Pipe Models: Significance for Exploration: in Proceedings of Exploration 07: Fifth Decennial International Conference on Mineral Exploration, ed. B. Milkereit: pp. 667–677.

Lockhart, G., Grutter, H., Carlson, J., 2004. Temporal, geomagnetic and related attributes of kimberlite magmatism at Ekati, Northwest Territories, Canada; Lithos, Volume 77(1-4), pp. 665-682. https://doi.org/10.1016/j.lithos.2004.03.029

Moss, 2009. Volcanology of the A154N kimberlite at Diavik: implications for eruption dynamics. Ph.D. thesis, University of British Columbia, Vancouver, B.C., Canada.

Mustafa, J., Nowicki, T. E., Oshust, P. A., Dyck, D. R., Crawford, B., and Harrison, S. 2006. The geology of the Misery kimberlite, Ekati diamond mine, Canada. In Proceedings of the 8th International Kimberlite Conference, 8 (2003).

Nowicki, T.E., Carlson, J.A., Crawford, B.B., Lockhart, G.D., Oshust, P.A. and Dyck, D.R., 2003. Field Guide to the Ekati Diamond Mine, in VIIIth International Kimberlite Conference, Slave Province and Northern Alberta Field Trip Guidebook, B.A. Kjarsgaard (ed): p 39-59.

Sarkar, C., Heaman, L., Pearson, D.G, 2015. Duration and periodicity of kimberlite volcanic activity in the Lac de Gras kimberlite field, Canada and some recommendations for kimberlite geochronology; Lithos, Volume 218-219, pp. 155-166. https://doi.org/10.1016/j.lithos.2015.01.017

Stern, R. A., & Bleeker, W. (1998). Age of the world's oldest rocks refined using Canada's SHRIMP: The Acasta Gneiss Complex, Northwest Territories, Canada. Geoscience Canada, 25, 27–31.

Stubley, M.P. and Irwin, D., 2019. Bedrock Geology of the Slave Craton, Northwest Territories and Nunavut; Northwest Territories Geological Survey, NWT Open File 2019-01

Tappe, S., Pearson, G.D., Kjarsgaard, B.A., Nowell, G., and Dowall, D., 2013. Mantle Transition Zone Input to Kimberlite Magmatism near a Subduction Zone: Origin of Anomalous Nd–Hf Isotope Systematic at Lac de Gras, Canada: Earth and Planetary Science Letters, 2013.

Ward, B., Dredge, L., and Kerr D., 2014. Surficial geology, Lac de Gras, Northwest Territories, NTS 76-D; Geological Survey of Canada, Canadian Geoscience Map 184 (preliminary, Surficial Data Model v. 2.0 conversion of Map 1870A), scale 1:125 000. doi:10.4095/293964

Wilkinson, L., Kjarsgaard, B.A., LeCheminant, A.N., and Harris, J., 2001: Diabase dyke swarms in the Lac de Gras area, Northwest Territories, and their significance to kimberlite exploration: initial results; Geological Survey of Canada, Current Research 2001-C8, 17 p.

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