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Evolution of Kimberlite Exploration – Kimberlite Indicator Mineral (KIM) Dispersion on the Kennady North Project, Southern Slave Craton, NWT

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Introduction

KIM have been key to the initial discovery of every kimberlite diamond mine in the world, and the Slave craton is no exception. A few years after Ekati, the 5034 kimberlite was discovered in the southern Slave through systematic drilling of an up-ice termination of a westward-oriented KIM dispersal. The 5034 kimberlite and other bodies in the southern Slave are >500 million years old, and were emplaced when Canada was in the southern hemisphere. They have been exposed to far greater chemical weathering and erosion than their Eocene counterparts at Ekati. Exploration is approached differently for these bodies.

The southern Slave kimberlites are eroded to lower diatreme/root zone facies; tilted, with sheet-like to sinuous shapes (Barnett et al., 2018). This translates to limited and complex surface expressions that do not generate linear KIM dispersions seen at less eroded kimberlites (McClenaghan and Kjarsgaard, 2007). Extreme chemical weathering over millions of years has also destroyed KIM in many of the known kimberlites, which reduces the number of KIM that remain for glacial dispersion. A final challenge in sourcing KIM back to kimberlite in the southern Slave is that extensive deglacial and postglacial reworking of glacial drift has obscured the KIM dispersions, leaving a complex distribution of KIM in glacial sediments.

Each of these challenges are addressed, through detailed 3D kimberlite modeling (Barnett et al., 2018; Kurszlakis and Pell, 2024), improved understanding of KIM morphology (McCandless et al, 2024), and a complete reinterpretation of glacial geology (Sacco et al., 2024; DeRosiers et al., 2024).

Methods

The Kennady North Project extends over 1,130 km^2 and surrounds the Gahcho Kué diamond mine. Known kimberlites include Kelvin, Faraday 1-3, Faraday 2, MZ, Doyle, NA, SA, KS, and KE. All of these discoveries are completely or partially associated with swarms of hypabyssal kimberlite sheets that served as feeders to the fragmental kimberlites that comprise larger volume, economic bodies. The sheets reside at the base or the sides of the larger bodies, rarely above them, and are mostly northwest-dipping (Figure 1). This means that when sheets are intersected and their orientation is determined, the direction in which to explore for larger volume fragmental kimberlite can be anticipated.

Kimberlite sheets (dykes) also generate broad, diffuse KIM dispersions in the southern Slave, as demonstrated at Snap Lake (Kirkley et al, 2003). This and the kimberlite modeling were considered when over 1,000 new KIM samples were collected over the project area. Historical samples were also reassigned to their correct glacial geology, all leading to four high priority target areas for the project.

Results

The historic Southwest Train is the most enigmatic dispersal of the four areas, but with the greatest potential. It is a strong train that extends for tens of kilometers southwest of the Kennady North Project, and 'leads' back to the Doyle kimberlite (Figure 2). However, Doyle is a series of northwest-dipping sheets; based on the Snap Lake KIM dispersion, it cannot account for this long and linear dispersion of KIM.

The new and historical KIM data, constrained by the new glacial mapping, demonstrate the processes at work in the Southwest Train. A short, diffuse KIM dispersion can be seen in the till samples down-ice from the Doyle sheets (Figure 3). A longer, sinuous dispersal from Doyle can be seen in the glaciofluvial/esker samples, that diverges west of the main Southwest Train. Separate from both of these dispersions, a southwest till dispersion that fits with the historic dispersal can be identified. This dispersion terminates south-southwest of Doyle (Figure 3). The area of interest will contain a new kimberlite, to be found by geophysics via methods discussed elsewhere in this volume (Epp et al, 2024; Lyon et al., 2024).

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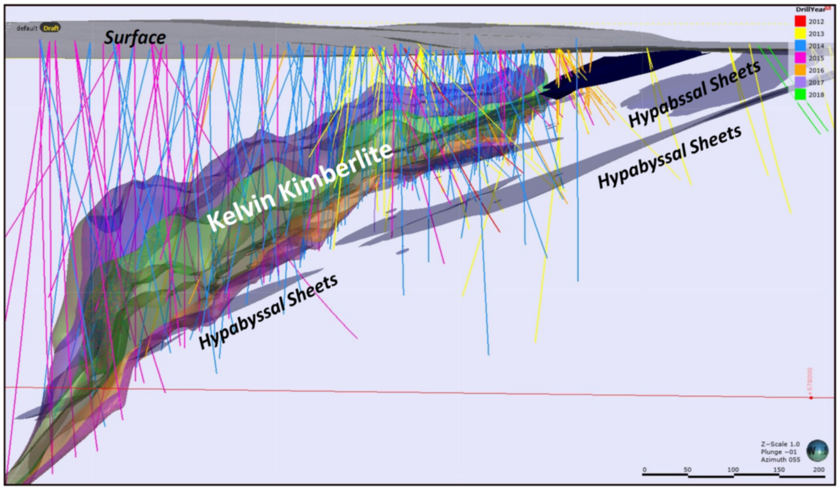

Figure 1. Kelvin kimberlite looking NW, with hypabyssal sheets, and drill traces by year.

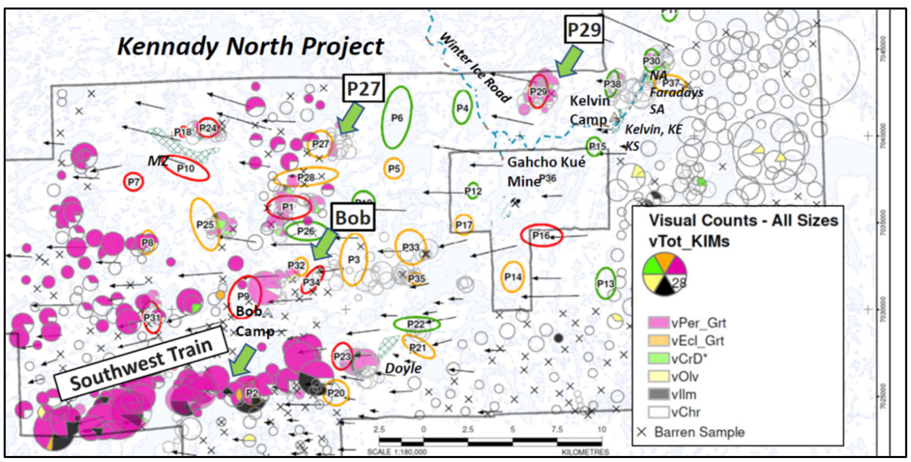

Figure 2. New and historic KIM dispersions, with four areas of interest noted by the green arrows. The Southwest Train is shown in detail in Figure 3, with an apparent source at Doyle kimberlite.

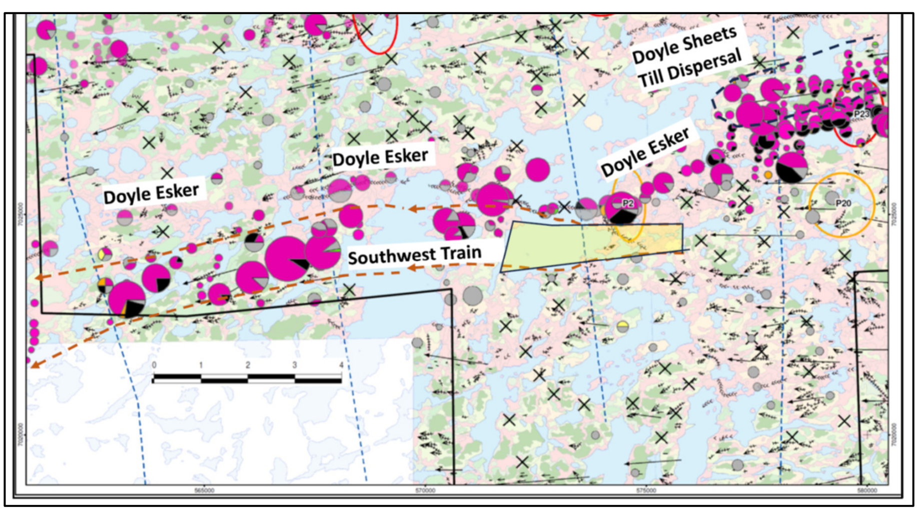

Figure 3. Southwest Train, divided into the short diffuse till dispersal from Doyle, the long, sinuous esker dispersion of Doyle grains in the Doyle Esker, and the strong till dispersion of the actual Southwest Train. The area highlighted in yellow is interpreted to contain the kimberlite source of the Southwest Train.