Geology and resource development of the Kelvin kimberlite pipe, NWT, Canada

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Introduction

The Kelvin kimberlite pipe is located in the southeast of the Archean Slave Craton in northern Canada, 8 km northeast of the recently opened Gahcho Kué diamond mine. Kelvin was initially discovered in 2000 by De Beers Canada, through glacial till sampling and subsequent drill testing of a horizontal-loop electromagnetic (HLEM) anomaly situated under a shallow lake. Further exploration by Kennady Diamonds Inc. (KDI) resulted in the discovery of significant thicknesses of volcaniclastic kimberlite that had not previously been identified. Exploration and evaluation work carried out by KDI during the period 2012 to 2016 has progressed the project rapidly to the point at which a well-constrained geological model has been developed. In combination with comprehensive microdiamond and commercial-sized diamond sampling this has supported the declaration of a maiden Indicated Mineral Resource of 13.62 million carats at Kelvin.

Methods

The geology and evaluation of the Kelvin kimberlite pipe are based on data generated from extensive delineation core and large diameter reverse circulation (RC) bulk sample drilling programs carried out between 2012 and 2016. The data collected includes logging observation of core from 71 NQ and 104 HQ diameter holes. Detailed logging of over 11,500 metres of kimberlite has been carried out and further verified by petrographic analysis of 730 representative thin sections and polished slabs. Drill cores have been subjected to comprehensive spatially-distributed sampling for bulk density (3,652 samples) and microdiamonds (2,524 samples comprising almost 20 tonnes). A total of 79 RC bulk sample holes provide representative sample coverage of the entire strike length of the body. Bulk sampling has yielded 2,198 ct of diamond (+0.85 mm) from 1,067 tonnes of kimberlite. Surface bedrock mapping, age dating, mantle-derived indicator mineral abundance and composition studies and 3-D modeling have also been completed.

Geology

Hosted in metaturbidites of the Yellowknife Supergroup, the Kelvin kimberlite pipe is an atypical, steep-sided inclined L-shaped pipe with a surface expression of only 0.08 ha. The pipe dips at approximately 15° towards the northwest before turning north and dipping at 20°. The Kelvin pipe is the largest of four pipes in an extensive pipe-sheet complex striking 4.5 km within the Kelvin-Faraday cluster that includes several inclined volcaniclastic pipes along a gently dipping hypabyssal kimberlite sheet system. The pipes represent a spectrum of volcanic maturity with Kelvin being the most well developed pipe. The Kelvin pipe has been defined to a current overall strike length of 700 m with vertical thickness varying 70 to 200 m and width from 30 to 70 m. The pipe infill comprises several units of sub-horizontally layered kimberlite resulting from multiple emplacement events. Infill is dominated by volcaniclastic kimberlite with less common coherent kimberlite and minor units with textures transitional between these end-members. The main volcaniclastic infill within Kelvin, KIMB3, is a massive, fine to medium plus coarse-grained olivine-rich to very olivine-poor, volcaniclastic phlogopite kimberlite. The country rock dilution is dominated by locally

derived gneissic and granitic xenoliths and has been is classified as a 'Kimberley-type' pyroclastic kimberlite (KPK) (Smith et al. 2013), historically referred to as a tuffisitic kimberlite breccia (TKB). KIMB3 has been sub-divided based on the abundance of locally derived country rock dilution into KIMB3A, KIMB3B and KIMB3C due to the horizontally consistent layered zones of the dilution and the distinct vertical gradational changes observed within this phase of kimberlite. The second most common infill, KIMB2, is a massive, fine to coarse-grained olivine macrocryst-rich, phlogopite kimberlite that is texturally variable between hypabyssal and volcaniclastic. KIMB2 has been sub-divided into KIMB2A and KIMB2B, where KIMB2A is a massive, fine to coarse-grained olivine macrocryst-rich, xenolith-poor to -rich, transitional phlogopite kimberlite. KIMB2B is a massive, fine to coarse olivine macrocryst-rich, xenolith-poor, hypabyssal phlogopite kimberlite. Several other minor kimberlites (KIMB1, KIMB4, KIMB5, KIMB6 and KIMB7) have been identified and make up less than 20% of the overall pipe infill and will not be described here. In addition to the kimberlite infill, marginal breccias with trace amounts of kimberlite are present above the south limb of the pipe as well as the transition into the north limb.

The emplacement history of Kelvin is believed to have been initiated by the intrusion of HK phases as part of an early kimberlite sheet system. This was followed by the main pipe forming volcaniclastic event, during which the main KPK pipe infill, KIMB3, was emplaced. The pipe was formed along structural weaknesses into the host rock above thickened zones of the pre-existing sheet. The emplacement sequence concluded with a late stage emplacement of hypabyssal and transitional phases along the upper contact of the pipe, cross-cutting the main KPK infill at depth. Dating of phlogopite using Rb-Sr methods have established ages of 531 ± 8 Ma and 546 ±8 Ma.

Evaluation in Support of Resource Classification

A 3-D geological model of Kelvin was developed from detailed drill core logging and petrography data. The geological model provides constraints on the volume of kimberlite present, and in combination with a spatial (block) model of bulk density, provides estimates of the tonnes of kimberlite present. Microdiamond and commercial-size diamond results from corresponding kimberlite material in each domain were used to define the total content diamond size frequency distribution (SFD) in each domain. In conjunction with appropriate recovery correction factors these SFD models establish a ratio between microdiamond stone frequency (+212 micron stones per kilogram) and commercially recoverable grade (+1 mm carats per tonne). Average diamond values per domain (in US Dollars per carat) are based on a value distribution model (representing the value of diamonds per carat in each sieve size class) combined with the recoverable SFD models for each domain. A maiden Indicated Mineral Resource for the Kelvin kimberlite has been established at 8.5 million tonnes of kimberlite at an average grade of 1.6 carats per tonne with an average value of US$63 per carat. The Kelvin kimberlite remains open at depth.

Conclusion

The textures, diamond grade, and emplacement age of Kelvin are very similar to those documented at the Gahcho Kué mine immediately to the south (Hetman et al. 2004). The geology of the Kelvin kimberlite is texturally and mineralogically like other KPK systems globally, however, the external pipe morphology and specifically the sub-horizontal inclination of the pipe are unique. The morphology displayed by Kelvin and the other kimberlites discovered within the Kelvin-Faraday cluster have defined a new type of exploration target; and one that is likely not unique to this project. Due to the extremely small surface expression of Kelvin (0.08ha), this pipe as well as others within the cluster are almost blind and therefore traditional exploration methods applied by previous operators on the project were unsuccessful in determining the full extent of the pipe. Our understanding of the emplacement, and deep geology of the Kelvin pipe is still developing and further drilling and sampling are required as Kelvin is open at depth.

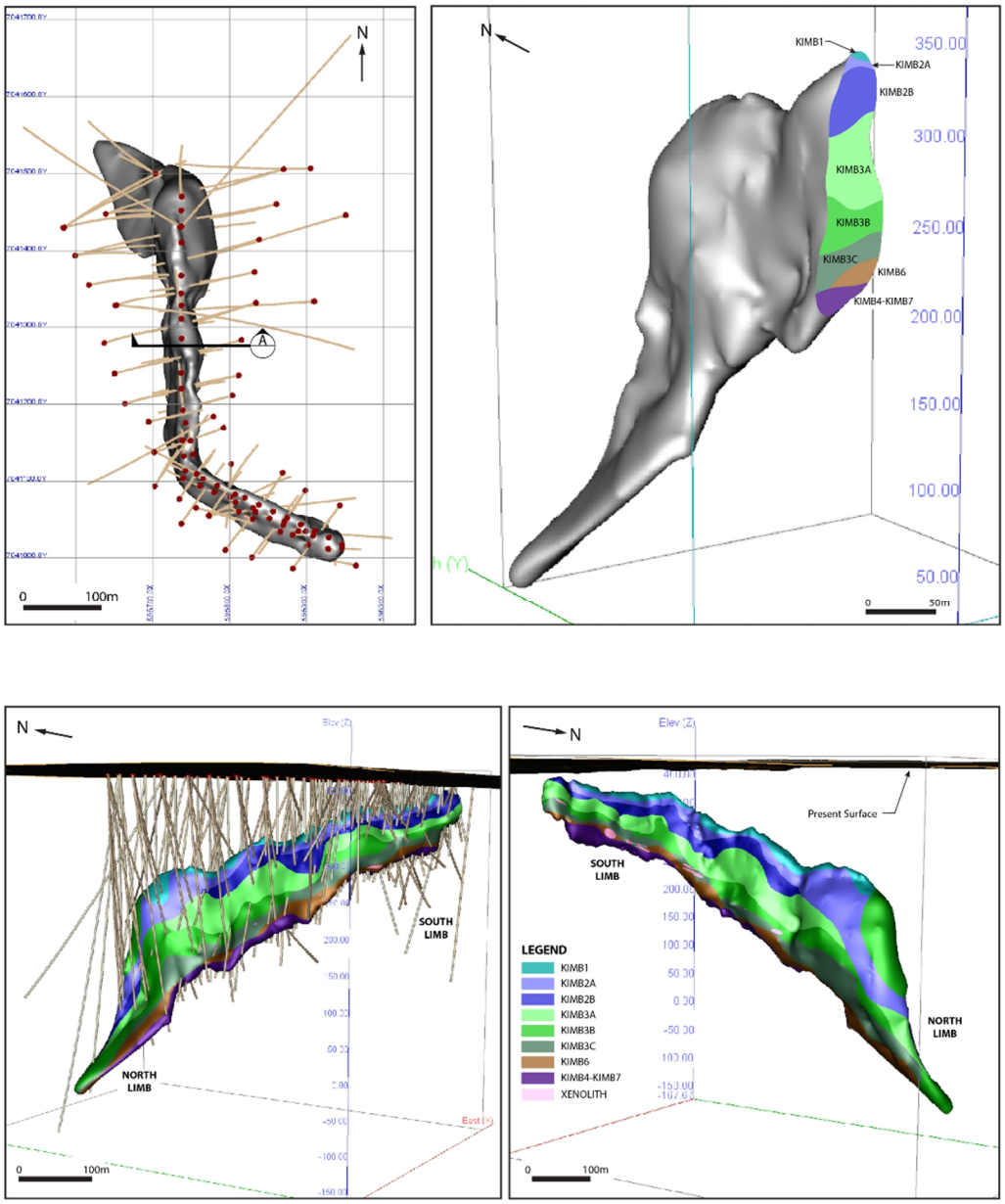

Figure 1. Top Left: Plan view of the Kelvin kimberlite pipe projected to surface with diamond drill holes. Top Right: Cross section view through the north limb pipe showing the horizontal layering of the different kimberlite infills found with in the pipe. Bottom Left: Side view of the Kelvin kimberlite pipe looking northeast with all exploration and delineation diamond drill holes. Bottom Right: View of the Kelvin kimberlite pipe looking southwest.

References

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