The Renard 2 Coherent Kimberlitic Units, Québec Canada – Spatial Distribution and Economic Implications

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Introduction

Situated in the Otish Region of northern Québec, Canada, the Renard cluster consists of nine diamondiferous kimberlite pipes and associated kimberlite dykes. Renard 2, the principal body currently being mined by Stornoway Diamond Corporation at the Renard Mine, was emplaced approximately 640 Ma into Archean granitic and gneissic rocks of the south-eastern portion of the Superior Province and is interpreted as a diatreme-zone kimberlite (Fitzgerald et al., 2009). It has an overall regular three dimensional (3D) shape and is slightly elongated north-south with a sub-circular outline at surface of approximately 2.3 hectares.

Renard 2 consists of two main pipe-infills, Kimb2a and Kimb2b, with contrasting primary textures and diamond content. Both units are classified as Kimberley-type pyroclastic kimberlite (KPK; formerly known as tuffisitic kimberlite) similar to "typical" South African-style kimberlites (Fitzgerald et al., 2009; Zhuk et al., 2017). A marginal country rock breccia, CRB, interpreted as part of the pipe emplacement event, surrounds the kimberlitic units. Finally, a third intrusive coherent kimberlite phase, Kimb2c, occurs as cross cutting discontinuous late stage dykes and irregular intrusions, ranging from a few cm up to 15 m in thickness. Kimb2c occurs throughout the Kimb2a and Kimb2b phases, along pipe contacts and within the CRB, representing approximately 17 % of kimberlite logged in drill core. Extensive drilling (over 45 km cumulative, and to depth of 1,000 m) allowed creation of a 3D geological model that was later divided into a series of 50 m thick horizontal depth slices (or levels) allowing detailed studies including geology, volume, internal dilution, geochemistry and diamond content per level. This resulted in a more comprehensive understanding of the spatial distribution of Kimb2c and enabled use of a single diamond content estimate for this phase in the resource model.

Geology

The Kimb2c phase is characterised by a spectrum of primary groundmass mineral assemblages, ranging from monticellite-bearing carbonate-dominated to phlogopite-dominated, each of which consists of common serpentine, spinel and perovskite. It is typically characterised by medium to coarse grained, partially to completely serpentinised/carbonatised olivine (47-51 modal %). Olivine macrocrysts and phenocrysts comprise 25 and 24 modal % of the Kimb2c, respectively. In general, Kimb2c contains between 7 and 13 modal % country rock xenoliths which are typically less than 5 cm in size, irregular in shape and highly altered. Garnet, picroilmenite, chrome diopside and chromite are the most commonly observed indicator minerals. Detailed petrographic observations suggest that Kimb2c may potentially be divided into three subunits (Kimb2c-1, Kimb2c-2 and Kimb2c-3) on the basis of subtle differences in the amount, size and crystal habit of the groundmass phlogopite, with Kimb2c-1 being dominant throughout the pipe and the other two subunits being volumetrically insignificant. More work would be needed to confirm this hypothesis as phlogopite variations alone are not a solid enough line of evidence to prove that these subunits represent different kimberlites. Kimb2c, including each of the possible subunits, are distributed throughout all geological units in the pipe.

Volume

The complex spatial distribution of Kimb2c intersections encountered in the drill holes and underground exploration development made separate 3D modelling of this unit unfeasible, a decision supported by recent open pit mining activities. As such, Kimb2c was include in each of the 3D geological domains (Lépine and Farrow, 2017). Volumetric proportions of Kimb2c were established on a proportionate length basis using geological logging of surface and underground drill holes as well as underground workings. Volume distribution of the Kimb2c was compared spatially within the overall 3D model, within and between the different geological units, on an overall level by level basis using the 50m horizontal depth slices, and on a level by level basis using geological units. Based on this work, approximately 14% Kimb2c is observed in Kimb2a, 25% in Kimb2b and 10% in the CRB representing an average bulk contribution of 17% (Figure 1).

Internal Dilution

Kimb2c country rock xenolith content (i.e. internal dilution) measured from drill core and underground exposures on a metre by metre basis using 0.5 cm resolution was used to create statistically relevant 3D models of dilution. Individual measurements from the Kimb2c units show that internal dilution varies from 0 to 85 modal % (average 12%). Results were evaluated within the overall 3D model, within and between the different geological units, and on a 50m horizontal depth slice basis using both a bulk approach and individual geological units. In spite of the relatively large range of internal dilution, there are no significant observed trends over the 850 m vertical extent of the geological model for each geological unit (Figure 1). On a level by level basis, the internal dilution of the Kimb2c ranges from 5 to 41 modal % (average of 11%) in Kimb2a, between 5 and 25 modal % (average 14%) in Kimb2b and between 8 and 54 modal % (average 17%) in the CRB domains.

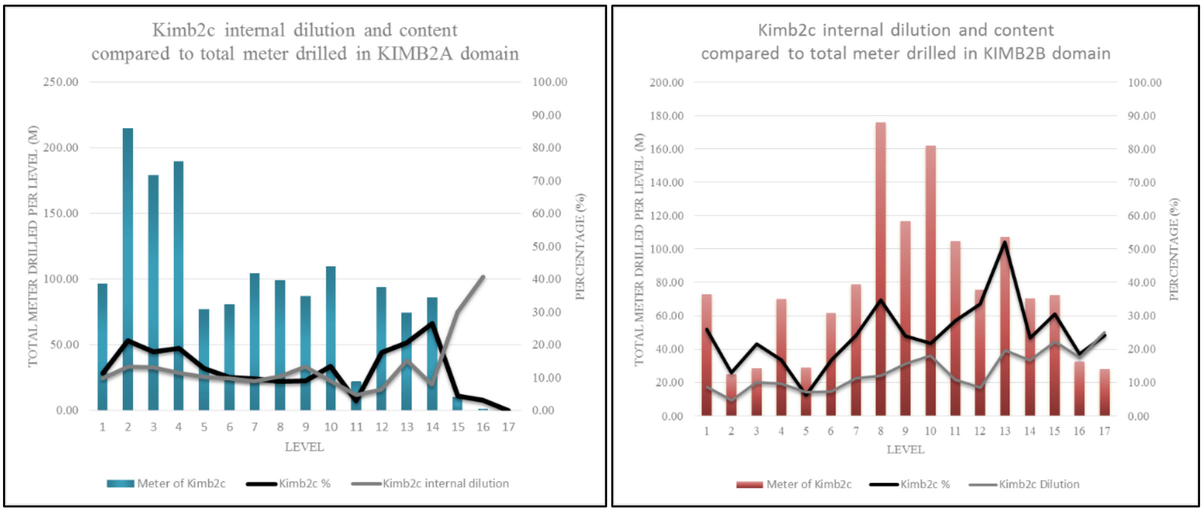

Figure 1: Kimb2c content and internal dilution percentage per 50m level for the KIMB2A domain (on the left) and the KIMB2B domain (on the right) with regards to the total meter of Kimb2c drilled in each domain.

Geochemistry

Compared to Kimb2a and Kimb2b, the Kimb2c samples are relatively enriched in Ta, Nb, and Ti. Kimb2c geochemical samples have a relatively low contamination index of <= to 1.5 (Clement, 1982). Whole rock, REE and incompatible trace element signatures of Kimb2c within each of the geological units (Kimb2a, Kimb2b and CRB) are remarkably similar, and consistent throughout all depth levels of Renard 2. A closer look at the possible Kimb2c subunits may suggest a potential difference between Kimb2c-1 and Kimb2c-2/3, based mainly on the contamination index, with Kimb2c-1 demonstrating greater contamination index raging between 1.15 – 1.5 (compared to 0.98 to 1.27 for Kimb2c-2/3) and also slightly higher contents of Fe_2O_3, MgO, CaO, TiO_2 and Cr_2O_3. However, the sample dataset for subunits Kimb2c-2/3 is too small to comfortably distinguish between subunits.

Diamond Content

Samples of Kimb2c were submitted for both microdiamond (caustic dissolution) and macrodiamond (dense media separation - DMS) recovery. A total of 2,850 diamonds larger than 0.106mm square mesh were recovered from 126 individual samples of Kimb2c ranging in size from 2.8 to 76.9 kg and averaging 12 modal % internal dilution. A total of 7.4 tonnes of Kimb2c in 22 different samples were submitted for DMS processing at an average measured internal dilution of 11.5 modal %. The composite as recovered +1DTC total diamond content was 296cpht.

Diamond size frequency distribution (SFD) plots on a stones per hundred tonnes per unit interval (SPHTUI) basis, using both the micro- and macrodiamond data for Kimb2c in each of the 50m depth slices, demonstrates grade continuity with depth and the interpretation of a single diamond source population for Kimb2c. Visual assessment of the diamond characteristics from individual Kimb2c samples show a strong degree of similarity also supporting a single diamond source.

Kimb2c grade models derived from micro- and macrodiamond data are consistent between samples and on a level by level basis, and robust when combined. The best fit +1-23DTC carat grade model, adjusted downwards to reflect the loss of smaller stones associated with commercial recoveries, is 294 cpht. This Kimb2c diamond content is supported by larger tonnage geologically mixed DMS samples where Kimb2c grade has been back-calculated based on volumetric contributions, and demonstrates the economic implications of understanding late stage Kimb2c intrusions during the creation of a resource model.

Discussion and Conclusion

Increasing the dataset of geochemical samples to attempt further discriminations between the different Kimb2c subunits may be warranted based on possible differences between Kimb2c-1 and Kimb2c-2/3 that may be present in the original dataset. However, our work clearly demonstrates that the geology, volume, percentage of internal dilution, geochemistry, diamond grade and diamond characteristics of Kimb2c are all very similar and consistent from the top of the pipe to 1,000 m below surface, suggesting that the Kimb2c intrusions, although varying petrographically in groundmass phlogopite, sampled the same diamondiferous part of the mantle and followed similar emplacement processes. These data therefore support the use of a single diamond grade for Kimb2c in the resource model and contribute to a more comprehensive emplacement model of the Renard 2 kimberlite pipe.

References

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