GEOLOGY OF THE DO27 PIPE: A PYROCLASTIC KIMBERLITE IN THE LAC DE GRAS PROVINCE, NWT, CANADA

Margaret Harder[1], Casey Hetman[2], Barbara Scott Smith[3], and Jennifer Pell[1]
[1]Peregrine Diamonds Ltd. [2]Mineral Services Canada Inc. [3]Scott-Smith Petrology Inc.

INTRODUCTION

The DO27 pipe is part of the Tli Kwi Cho kimberlite complex located within the Lac de Gras province, approximately 300 km northeast of Yellowknife, Northwest Territories, Canada, and approximately 30 km southeast of the Diavik diamond mine (Figure 1). The DO27 pipe is one of the larger pipes in the Lac de Gras area, with a surface area of over 8 hectares. The pipe was discovered in 1993 by Kennecott Canada Exploration Inc. (see Coopersmith et al., this volume). Numerous drill cores from DO27 were studied in 1995 and a geological interpretation was proposed by Doyle et al. (1999). This interpretation determined the main kimberlite type in the DO27 pipe to be pyroclastic in origin. The DO27 pyroclastic kimberlite has been the focus of extensive drilling by Peregrine Diamonds Ltd. during 2005 and 2006. Preliminary results of the detailed logging of 2005 and 2006 drill holes are presented here and in an updated geological model (Figures 2 and 3). The terminology is consistent with Field and Scott Smith (1998). Rocks termed pyroclastic kimberlite are dominated by juvenile volcanic constituents that lack any signs of significant re-working. The term volcaniclastic is used if the degree of re-working is unclear.

BACKGROUND AND GEOLOGY

The geology of the DO27 pipe is complex and includes volcaniclastic, pyroclastic, and magmatic kimberlite (Figure 2). Prior to the work of Doyle et al. (1999), the DO27 and DO18 anomalies were considered to be one large kimberlite complex, with the magmatic material between DO18 and DO27 interpreted as a diatreme. Doyle et al. (1999) presented a model with two distinct pipes (DO27 and DO18) infilled by contrasting types of volcaniclastic kimberlite (pyroclastic and/or resedimented kimberlite), separated by granite country rock containing irregular magmatic lenses (primarily as horizontal sheets). Further, it was proposed that the DO27 pipe was predominantly infilled by homogeneous pyroclastic kimberlite (termed the Main PK). Doyle et al. (1999) did not find evidence for multiple phases of kimberlite within the Main PK. Doyle et al. (1999) proposed two separate vents, the Main Vent and the Northeast Lobe, each formed by a separate kimberlite eruption (and therefore separate kimberlite phases). Different volcaniclastic kimberlite (VK), likely involving some resedimentation, was also observed in the DO27 pipe, but is volumetrically minor and is concentrated to the northeast of the pipe.

MAIN PYROCLASTIC KIMBERLITE

Pyroclastic kimberlite is the dominant infill of the DO27 pipe (Main PK/KIMB-1; Figures 2 and 3). The Main PK is extremely altered, and the upper 100 m of kimberlite generally displays poor mineral and textural preservation; particularly towards the centre of the pipe, with preservation improving towards the pipe margins. The variation in alteration is reflected in the total replacement of olivine by serpentine in the centre of the pipe with the more common fresh grains occurring towards the pipe margin and at depth. Within the more altered PK, better preserved areas occur as irregular lenses and as rims around granite xenoliths, providing fresher material for the investigation of the Main PK.

Preliminary results of this investigation suggest that the Main PK is massive with few significant internal variations. The Main PK comprises approximately 60-70% olivine and less common juvenile lapilli, which are clast-supported and moderately well-packed. The grain size of Main

PK appears to be very homogeneous, consisting of fine to medium-size grains (0.5-5 mm), with rare intervals containing up to 5% coarse grains (5-10 mm). No distinct bedding is evident and only very subtle grain size variations are observed. This suggests that pyroclastic air fall is the dominant depositional process involved in infilling of the pipe. Juvenile lapilli are generally altered and their mineralogy is difficult to determine. These lapilli typically contain approximately 20% olivine macrocrysts (>0.5 mm) and 20% finer-grained olivines, some of which are clearly phenocrysts. The groundmass is extremely fine-grained, and the only minerals that can be identified are fine-grained, scattered, often altered oxides (likely spinel). There are no obvious variations in the types of juvenile lapilli observed, suggesting that the Main PK may represent only one phase of kimberlite.

The altered nature of the Main PK precludes the reliable use of textural and mineralogical characteristics of juvenile constituents for determining whether more than one phase of kimberlite is present. Variations within the Main PK are indicated by the distribution of country rock xenoliths. Mudstone xenoliths are most common near the pipe margins, whereas granite xenoliths are most common in the centre of the pipe.

GRANITE XENOLITHS IN THE MAIN PYROCLASTIC KIMBERLITE

In some core holes from the centre of the DO27 pipe there is a systematic and consistent variation in proportion of granite xenoliths. All lithological xenolith types were recorded but the variation is defined only by granite xenoliths as shown in Figure 4. Other xenoliths, in particular mudstone, appear to be randomly distributed. Figure 4 shows a systematic increase in granite xenolith abundance, and possibly size, with depth to the bottom of the hole at 305 m (the hole ends in kimberlite). The increase in granite xenolith abundance is visually subtle and is only clearly evident in detailed xenolith counts. The total dilution throughout the Main PK remains <5% and therefore does not have significant implications for diamond grades. The increase in xenolith abundance, however, is important with respect to eruptive and depositional processes. The granite xenoliths must have been resident in the kimberlite magma prior to eruption. The systematic changes in xenolith content (i.e., large scale grading) suggest that this interval of the Main PK represents continuous deposition from a single phase of kimberlite. Similar systematic variations in juvenile component grain sizes are not apparent. The economic implications resulting from the identification of a single kimberlite phase in one large depositional unit are that the entire unit should carry the same mantle material. Any changes in diamond grade will therefore depend on depositional processes within that unit, such as size grading.

Comparable xenolith data from a second drill core slightly further north shows a distinct change in xenolith size and abundance at approximately 200 m. The change indicates the potential for the presence of a distinct earlier phase of kimberlite below 200 m, but again reinforces the interpretation of the Main PK representing one phase of kimberlite over at least the uppermost 200 m.

NORTHEAST ZONE

The main DO27 pipe is asymmetrical in shape (Figures 2 and 3). The pipe has a steep western margin (dipping at ~80°) but the northeast zone (Figure 2) has contact angles (defined by the base of the extrusive kimberlite) as low as 40-50°. The irregular shape and complex internal geology in the northeastern zone (Figure 3) has been interpreted to suggest that two separate, but related, eruptions could have been involved in pipe formation (Doyle et al., 1999). The northeastern zone contains several units of pyroclastic, magmatic, and volcaniclastic kimberlite that can be correlated between holes. Volumetrically the most significant kimberlite is PK (KIMB-1; Figure 2), which overlies more complex VK. In general, the northeast zone PK is very similar to the Main PK. It is characterized by similar grain sizes, similar proportions of single olivines and less common juvenile lapilli, similar clast supported textures and comparable (<5 %) xenoliths dominated by mudstone and granite. The granite xenoliths are typically less than 10 cm in diameter. The PK of the northeast zone does, however, have two visually distinct sub-units defined by unusually high concentrations of mud (KIMB-1b; Figure 2) or granite (KIMB-1c; Figure 2) xenoliths. The differences within the northeast PK could potentially indicate the presence of more than one phase of kimberlite.

The second most volumetrically important kimberlite (KIMB-2; Figure 2) is interpreted to be magmatic in origin and is likely related to the intrusive sheets which are common at this depth immediately to the north (Doyle et al., 1999). KIMB-2 is granite-rich (>25%), contains common fresh, coarse-grained olivine macrocrysts, and has a fine-grained crystalline groundmass that is composed of phlogopite, opaque minerals, monticellite, and carbonate. The rock is classified as a macrocrystic hypabyssal monticellite carbonate kimberlite.

VK forms approximately 20% of the kimberlite in the northeast zone. It is characterized by highly variable grain sizes and xenolith contents, with some units (KGB; Figure 2) containing >30% granite boulders up to 2 m in size. These VK units likely represent early eruptive products and crater rim slumping. Also present in the northeast zone are thin units (Kimberlite Microbreccia; Figure 2) containing >25%, fine-grained, highly pulverized granite shards. This material is thought to represent the products of the fragmentation of the country rock during pipe excavation.

CONCLUSIONS

The DO27 pipe contains different types of kimberlite: pyroclastic, volcaniclastic, and magmatic kimberlite. The pipe is dominated by altered pyroclastic kimberlite which appears massive. The alteration obscures primary features and the identification of juvenile components, and therefore kimberlite phases, is difficult. Variations in the country-rock granite xenoliths, however, show consistent trends in certain areas of the pipe. The preliminary interpretation of xenolith data from DO27 suggests that the upper central part of the main pyroclastic kimberlite in the DO27 pipe, to at least 200 m depth, comprises a single phase of kimberlite. This phase of kimberlite appears to represent a single graded unit defined by a uniform increase in granite xenolith abundance with depth, over a vertical interval of at least 200 m. Variations in xenolith contents thus may define distinct eruption cycles and, in turn, phases of kimberlite. The xenoliths may provide critical information about eruption processes where the detailed study of juvenile kimberlite components may not be conclusive and/or masked by alteration.

ACKNOWLEDGEMENTS

The authors would like to thank Peregrine Diamonds Ltd. staff, in particular Peter Holmes and Wendy Mathison, for their support. Also thanks to Meilani Smith for drafting figures and modeling the DO27 pipe.

REFERENCES

Coopersmith, H., Pell, J., and Scott Smith, B.H., this volume. The importance of kimberlite geology in diamond deposit evaluation – a case study from the DO27/DO18 kimberlite, NWT, Canada.

Doyle, B.J., Kivi, K., and Scott Smith, B.H., 1999. The Tli Kwi Cho (DO27 and DO18) Diamondiferous Kimberlite Complex, Northwest Territories, Canada. In: *Proceedings of the VIIth International Kimberlite Conference*, Cape Town. Vol. 1, pp. 194-204.

Field, M. and Scott Smith, B.H., 1998. Textural and genetic classification schemes for kimberlites: a new perspective. In: *Extended Abstracts of the VIIth International Kimberlite Conference*, Cape Town. pp. 214-216.

Figure 1: Location of the DO27 pipe in the Northwest Territories, Canada.

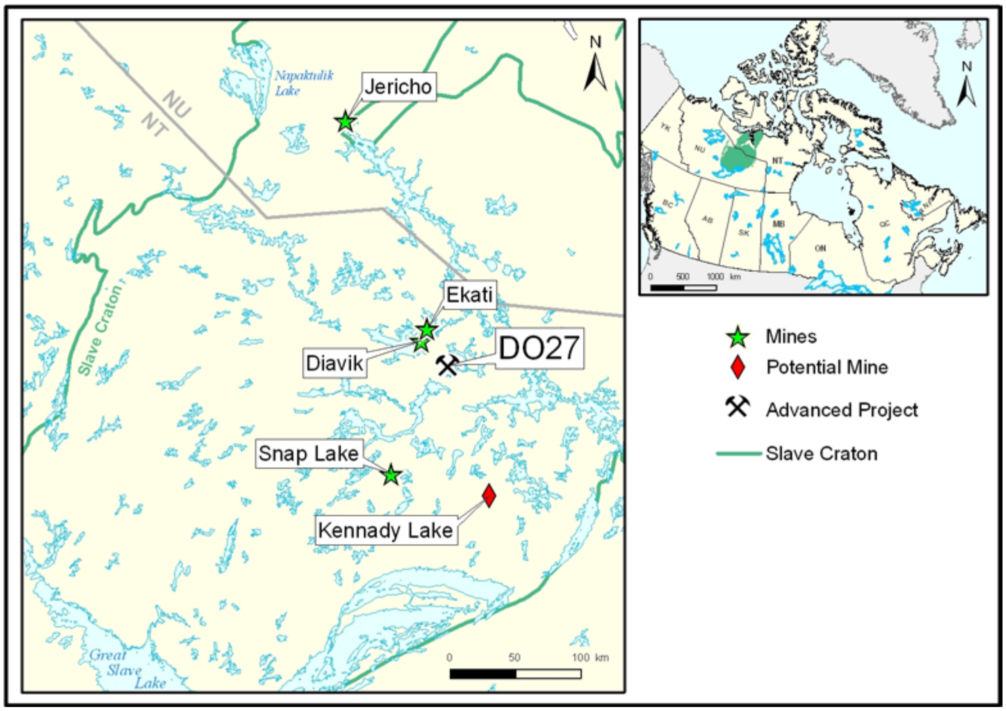


Figure 2: Cross section through the DO27 pipe showing the distribution of the main kimberlite types.

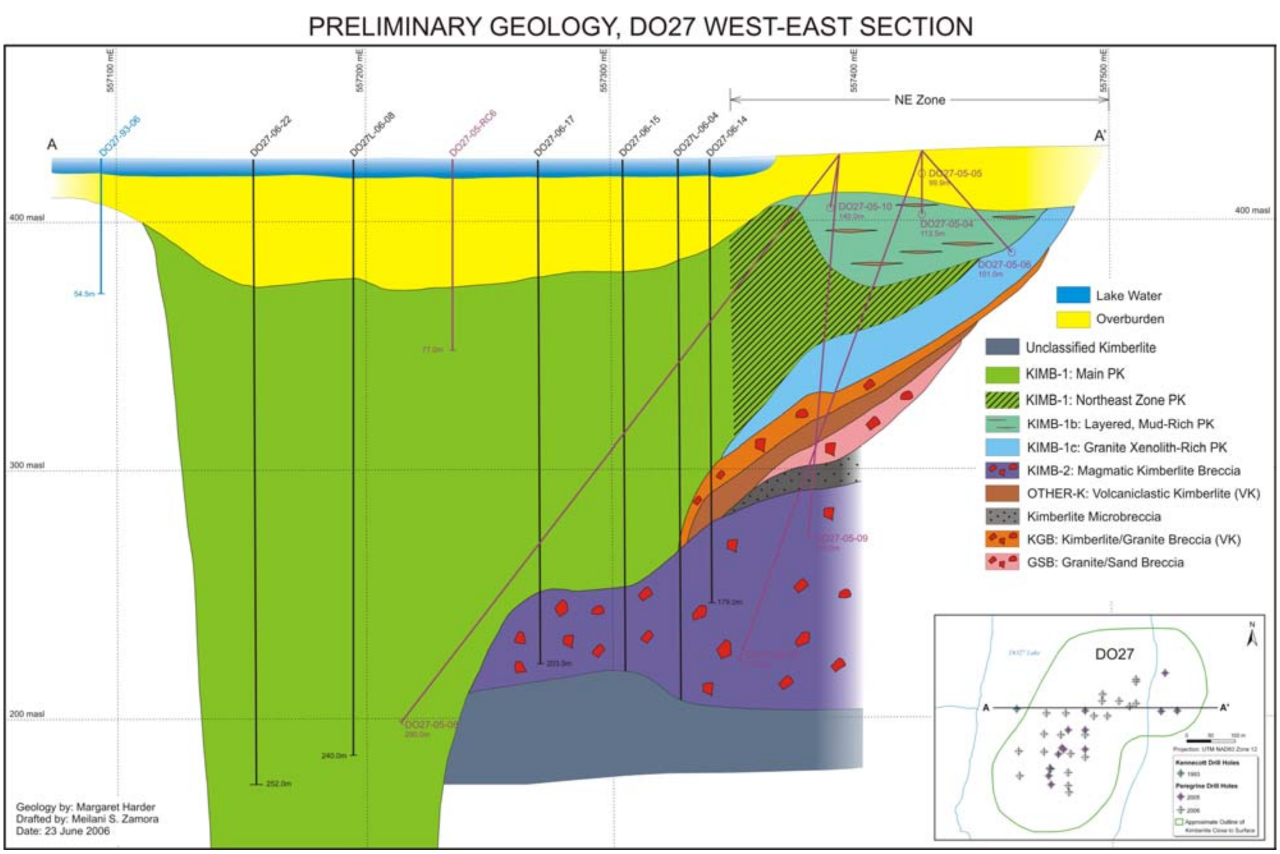


Figure 3: Three dimensional geological model of the DO27 pipe. The red pipe shell represents the inferred distribution of DO27 pyroclastic kimberlite (volcaniclastic and magmatic kimberlite types are not depicted). Also shown are all 2005 and 2006 Peregrine core holes. The white dashed line marks the approximate location of the NE zone.

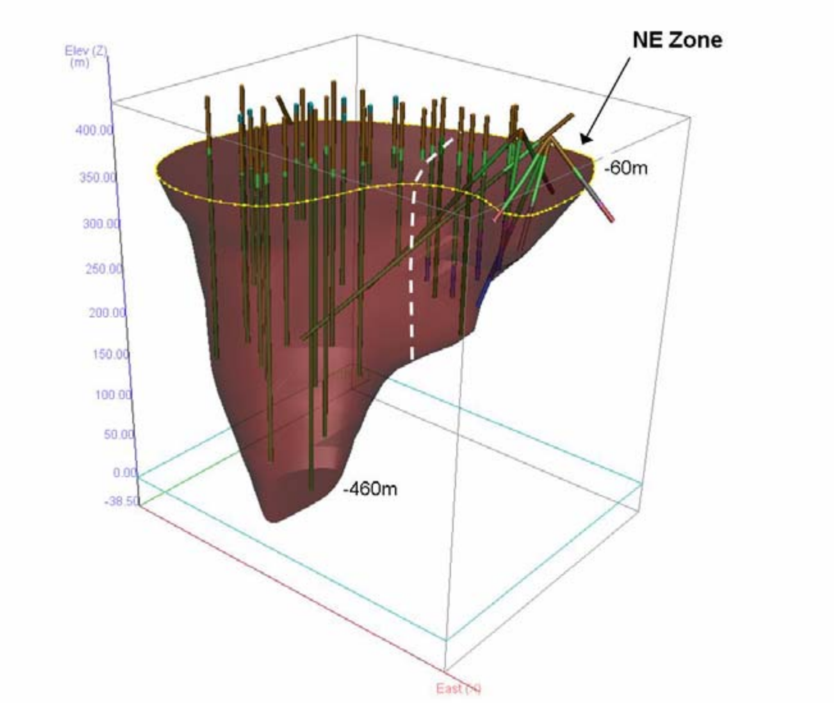
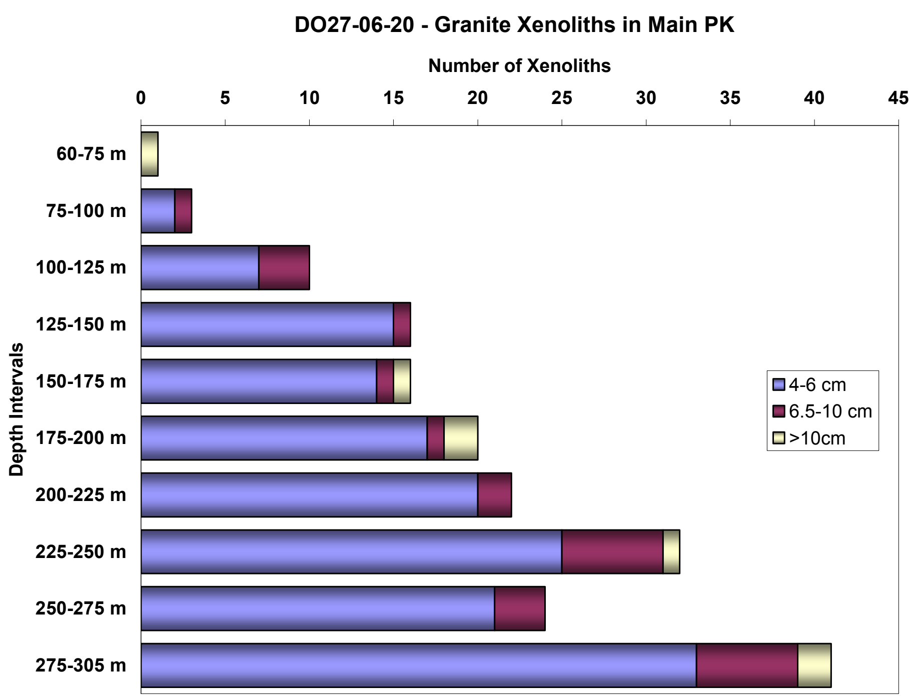


Figure 4: distribution of granite xenoliths >4cm in size in the DO27 Main PK in core hole DO27-06-20, located near the centre of the DO27 pipe. Granite xenoliths increase in abundance and possibly in size with depth to the base of the core hole at 305 m. Total granite dilution remains <5% throughout the Main PK.



8th international

KIMBERLITE conference

LONG ABSTRACTS

2006 Kimberlite Emplacement Workshop

Saskatoon, Canada September 7-12th, 2006