

## Stratigraphy of the intra-crater volcanoclastic deposits of the Victor Northwest kimberlite (Canada)

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### INTRODUCTION

The Victor kimberlite is located in the James Bay Lowland, Northern Ontario. Production of diamonds from the open pit mine started in early 2008. The Victor Northwest pipe (diameter ~300 m) forms part of a Middle-Late Jurassic volcanic complex comprising several adjacent and cross-cutting kimberlite pipes. These steep-sided (~70°) pipes occur in a ~275 m thick Palaeozoic sedimentary succession, unconformably overlying granitoid basement (Fig. 1). Since emplacement, the upper part of the pipes have been eroded, and currently the kimberlite pipes are overlain by ~10-30 m of unconsolidated overburden.

This contribution documents the complex internal stratigraphy of Victor Northwest (VNW), one of the early-formed kimberlite pipes in the complex. The stratigraphic relations documented here are used to interpret the emplacement of this kimberlite pipe (van Straaten et al., this volume).

the VNW pipe, from around 200 meters below the present surface (mbs) to at least 396 mbs (deepest intersection of VNW kimberlite). Facies 1b is a dark, dense, competent, massive, CRF-poor (~3-8 vol.%), matrix- to clast-supported kimberlite. Both facies 1a and 1b contain broken olivines (Fig. 2b), and the abundance of broken olivine generally decreases upward and away from the lower pipe wall.

The central and deeper part of facies 1b contains minor intervals characterised by higher CRF abundances and more clast-supported textures. In both facies 1a and the central and deeper part of facies 1b, thin fine-grained envelopes around olivine or CRF kernels are present. These envelopes contain small broken olivines and thus represent clastic (or ash armoured) pyroclasts (Fig. 2a). Contacts between facies 1a and 1b are gradational in nature. Contact relationships and the textural evidence presented above indicate that facies 1b is clastic in origin. However,

### INTRA-CRATER STRATIGRAPHY

Twenty-two drill cores were available to reconstruct the three dimensional volcanic facies distribution within the VNW pipe. This study identified thirteen distinct volcanic facies characterised by contrasting textures as well as stratigraphic position within the pipe. Texturally, spatially and/or temporally related facies are grouped into five facies associations. Below, these five facies associations and their individual facies are described from depth to surface.

#### Lower facies association (FA 1)

FA 1 comprises two volcanic facies: facies 1a occurs as a thin veneer on the lower pipe wall (7-18 m thick, measured perpendicular to the pipe wall; Fig. 1). This facies is a bedded, variably country rock fragment (CRF) rich (~25-45 vol.%), ash-rich, volcanoclastic kimberlite. Facies 1b overlies facies 1a, and is volumetrically much more extensive. This facies is interpreted to occupy the entire central and deeper portion of

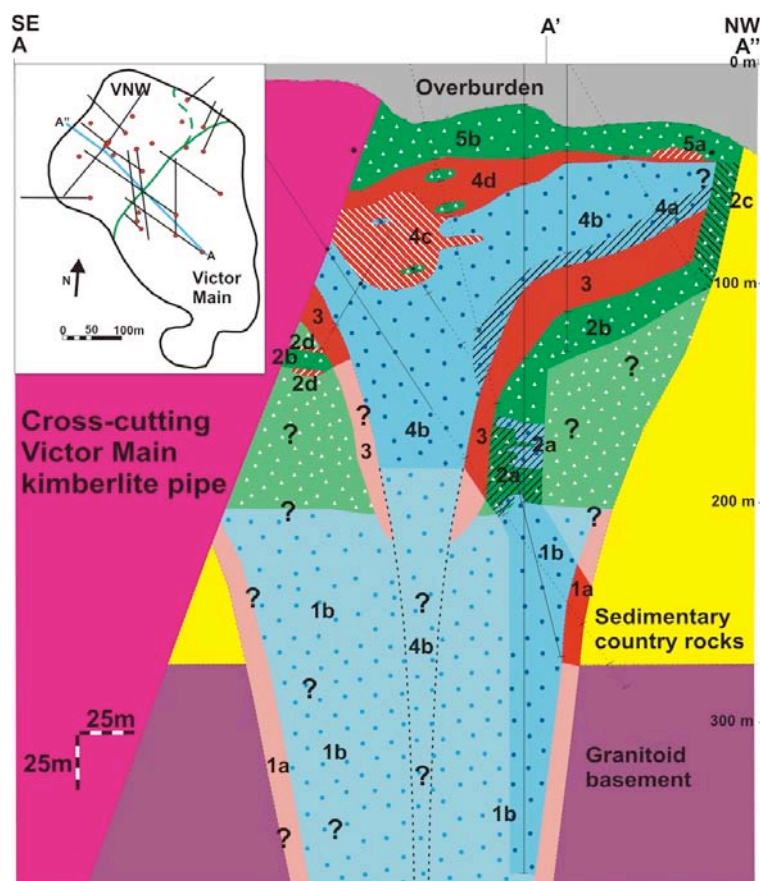


Figure 1: Cross section through the VNW pipe showing the 5 facies associations and 13 individual facies. Green denotes sedimentary country rock breccia bodies, reds are volcanoclastic kimberlite and blues indicate dense and competent lithologies. Extrapolated areas are lighter coloured. Inset shows location of cross section.

certain intervals in the upper and central part of facies 1b appear to be coherent in nature, as indicated by the dark, dense and featureless appearance, presence of only minor broken olivines, fairly evenly distributed olivines and, importantly, a well crystallised groundmass (similar to facies 4a/b, see Fig. 3b).

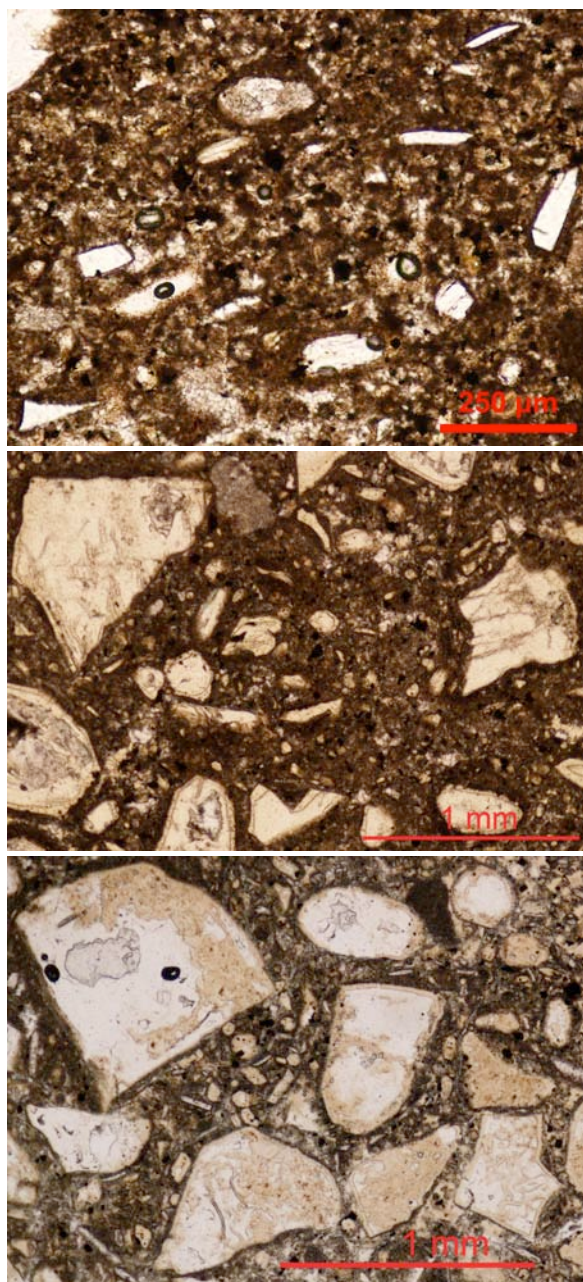


Figure 2: Broken olivines in (a) a thin fine grained envelope around a larger olivine (outside of field of view) of facies 1a, (b) the outer and lower part of facies 1b, and (c) facies 3.

#### Lower-central facies association (FA 2)

FA 2 is dominated by a distinct breccia (facies 2b) that is ~10-40 m thick and comprises a mixture of various 10 cm-m scale sedimentary country rock clasts. The contact of FA 2 with the underlying facies (1b) is intersected in six drill cores. The upper part of facies 1b is generally characterised by an upward increase in CRF abundance, and in certain cases a separate facies (facies 2a) can be distinguished. This facies commonly consists of alternating volcanoclastic kimberlite, dark, dense and competent kimberlite and sedimentary

country rock breccia. The dark and dense kimberlite generally contains minor broken olivines and is similar to the dark, dense and coherent-looking kimberlite in the upper and central part of facies 1b.

Facies 2c is a pipe-marginal, dominantly monolithic sedimentary country rock breccia (~23 m thick, measured perpendicular to the pipe wall). This facies is intersected in only one drill core; no other drill cores intersect the central to upper pipe contact. A number of drill cores intersect minor (~5 m) resedimented kimberlite: facies 2d. This facies is generally found overlying the country rock breccia, although one drill core intersects resedimented kimberlite both above and below/within the country rock breccia. Facies 2d is characterised by bedded, relatively well-sorted, closely-packed, generally CRF-rich (~25-50 vol.%) kimberlite deposits, these features suggest deposition into a local body of standing water.

#### Upper-central facies association (FA 3)

The basal contact of FA 3 (as observed in 12 drill cores) defines a concentric funnel-shaped depression within the larger VNW pipe fill. The geometry, together with the occurrence of cognate lithic clasts in the base of the deposit, suggests a cross-cutting nested crater was formed prior to and/or during deposition of this facies.

FA 3 is made up of only one facies: facies 3. This facies is a 16-32 m thick, bedded, CRF-rich (~15-40 vol.%) volcanoclastic kimberlite, which is matrix- to clast-supported and contains abundant small (<1-2 cm) and variable amounts of larger CRFs. The juvenile pyroclasts in this unit range from 50 µm juvenile ash particles to 3 mm uncored, irregular juvenile pyroclasts, which are variably vesicular (0-20%). The matrix-supported intervals are regarded as ash-rich volcanoclastic deposits. Additional components of this facies include common broken olivine crystals (Fig. 2c), and accretionary pyroclasts of ash with fine ash rims.

#### Upper facies association (FA 4)

FA 4 contains four individual facies, of which only facies 4a and 4b are volumetrically extensive. Facies 4a and 4b combined range in thickness from 45 m (near pipe margins) to >110 m (near pipe centre), and occur stratigraphically above facies 3 and 2c (Fig. 1). Facies 4a is distinguished from facies 4b largely on the basis of its finer grain size (largest dominant olivines are 1-5 mm vs. 2-10 mm), and more common occurrence of patchy grain size variations and clast-supported areas. Facies 4a lies below facies 4b and is about 12 m thick. Both facies 4a and 4b consist of dark, dense, competent, massive, CRF-poor (~2-10 vol.%), matrix-supported kimberlite that has gradational contacts with the volcanoclastic facies above and below. Bedding is rare to absent, although a subhorizontal preferred alignment of grains (fabric) is commonly observed (Fig. 3a). Broken olivines are present but not common. The fabric of these rocks and the presence of patchy grain size variations (Fig. 3a), clast-supported areas, and faint pyroclast outlines suggest that the dominant part of these facies is clastic in origin. However, certain

intersections in these facies appear to be coherent, as indicated by the dark, dense and featureless appearance, the uniform distribution of olivine and presence of a well crystallised groundmass (Fig. 3b).

Facies 4c is a small volume (~50x50x40 m) CRF-poor (~6 vol.%), mostly clast-supported volcanoclastic kimberlite that occurs in the centre of the pipe (Fig. 1). It displays local graded bedding and is characterized by variable, but generally higher, proportions of discrete olivines (crystal without melt selvage) to juvenile pyroclasts (crystal with melt selvage). Facies 4d is a laterally continuous, ~5-27 m thick, CRF-rich (~10-40 vol.%), clast- to matrix-supported, bedded volcanoclastic kimberlite that overlies all other facies, and grades upwards into country rock breccias (FA 5). Facies 4d comprises mainly discrete olivines and minor round-ovoid shaped juvenile pyroclasts. Graded beds (1-6 m thick) are common and country rock breccia intervals (4-5 m thick) occur locally within this facies.

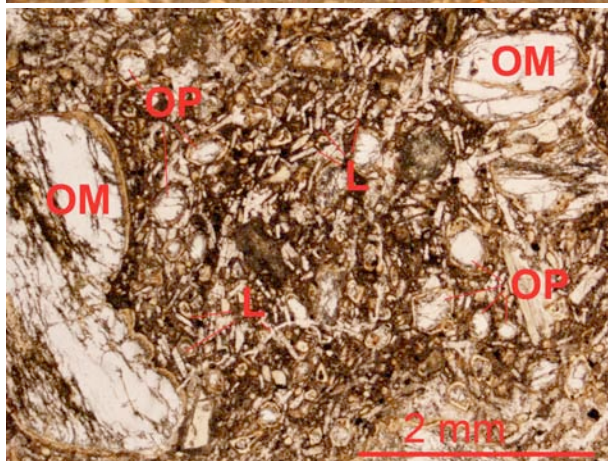
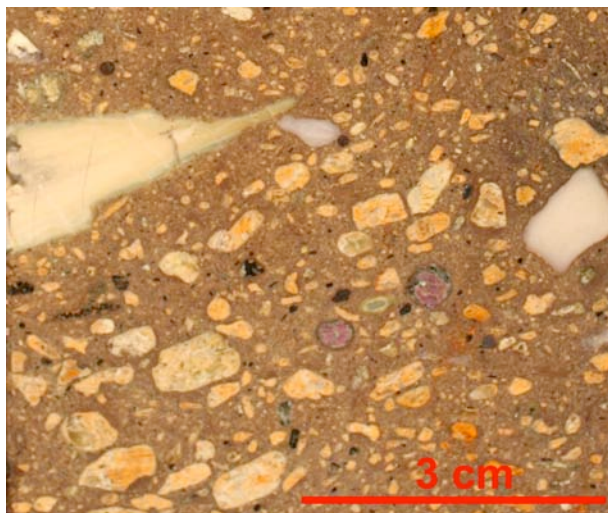


Figure 3: Dark and competent facies (4a/b) with (a) subhorizontal fabric and patchy grain size variation, and (b) coherent kimberlite composed of olivine macrocrysts (OM), olivine phenocrysts (OP) and well crystallised groundmass with opaque minerals and carbonate laths (L).

#### Uppermost facies association (FA 5)

One drill core intersects a short interval (~3 m) of in situ kimberlitic sediments (facies 5a) between the underlying volcanoclastic kimberlite (facies 4d) and overlying country rock breccia (facies 5b). Small-scale soft-sediment slump features, cross-bedding, fining

upward sequences with coarser quartz-rich lag deposits and massive to laminated mudstone intervals (Fig. 4) are all indicative of the presence of a small body of standing water at the time of deposition.

The bulk of FA 5 comprises a sedimentary country rock breccia (facies 5b) that ranges in thickness from 11 to 24 m (increasing to 35 m near the pipe wall). This facies consists of various types of large sedimentary country rock clasts (siltstones, limestones, dolostones and mudstones), with minor or no interclast kimberlite. Core loss is typically high in this facies.

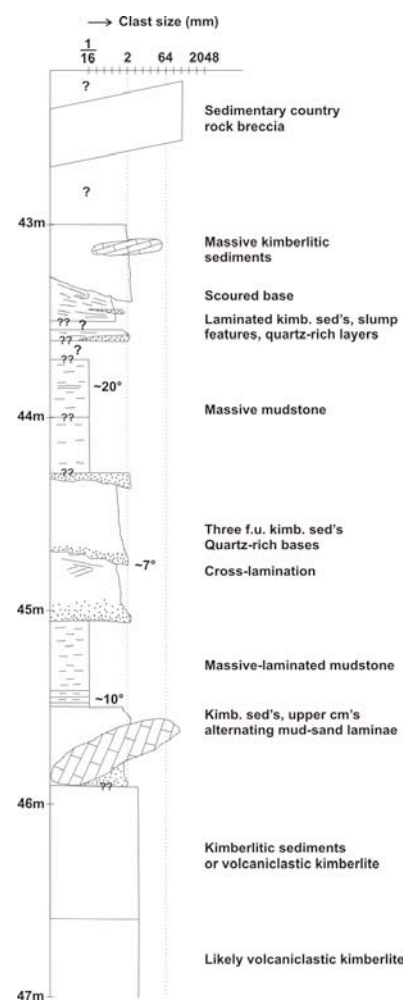


Figure 4: In-situ kimberlitic sediments (facies 5a) in 70° angled drill core. Depths are down hole in mbs.

## SUMMARY AND CONCLUSIONS

The Victor Northwest kimberlite pipe fill provides an example of the possible degree of complexity and small-scale variability within intra-crater volcanic deposits. The VNW pipe comprises numerous contrasting small-volume volcanic facies, including dark and coherent-looking kimberlite, sedimentary country rock breccias, volcanoclastic kimberlite, resedimented volcanoclastic kimberlite, and kimberlitic sediments.

The kimberlite deposits described above record an oscillation between variably explosive eruptions (facies associations 1, 3 and 4) vs. mass wasting and resedimentation events (facies associations 2 and 5). A detailed interpretation of the emplacement history of the VNW kimberlite pipe is presented by van Straaten et al. (this volume).

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## REFERENCES

van Straaten, B.I., Kopylova, M.G., Russell, J.K., Webb, K.J. and Scott Smith, B.H. (this volume). Explosive fragmentation and eruption of kimberlite, insights from the Victor Northwest pipe (Canada).