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THE VICTOR DIAMOND MINE, NORTHERN ONTARIO, CANADA: SUCCESSFUL MINING OF A RELIABLE RESOURCE

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INTRODUCTION

The Victor Diamond Mine was officially opened in 2008. Victor is the largest body in the Attawapiskat cluster of kimberlites, found in northern Ontario (Fig. 1; Kong et al. 1999). Different phases of evaluation used a variety of sampling methods ranging from microdiamond evaluation of drill core samples through macrodiamond bulk sampling by RC drilling and trenching (Fowler et al. 2001). Experiences gained from each successive program were used to systematically build a reliable resource based on both kimberlite geology and diamond results. Victor comprises two adjacent kimberlite pipes, termed Victor North (VN) and Victor South (VS) with a combined surface area of ~15 hectares (Fig. 2). This paper focuses on comparing the development of the Resource Model with mining data for Victor North, the only part of Victor to be mined until 2011 (Cut 1, Fig. 2).

1988-1999: DISCOVERY TO EARLY EVALUATION

The kimberlites were discovered in 1988/9 by core drilling. Initial results, including the identification of hypabyssal kimberlite, low microdiamond recoveries and indicator mineral compositions, suggested the bodies were only of moderate interest and further work was deferred until 1995-97 when the claims were due to lapse. After the discovery of new types of kimberlite at Fort à la Corne (Scott Smith et al. 1994), in 1995 a more detailed investigation of the 1988/9 drillcores, was undertaken. This showed that the bodies contained olivine-rich pyroclastic kimberlite (Kong et al. 1999). The remaining drillcore from Victor was treated for microdiamond content to improve grade predictions, and for macrodiamonds to support the apparent coarse size frequency distribution. In 1997 mini-bulk sampling of Victor yielded 6.99 +1mm carats (cts) from 24 tonnes (t) of kimberlite extracted from 20 RC holes (132mm diameter to depths of up to 87m from surface). This showed that Victor was of greater interest than initially thought, both in terms of grade and stone quality, and a scoping study indicated an optimistic project return.

Early evaluation in 1998/9 included more bulk sampling and core drilling. The latter showed that Victor North (VN) comprises two distinctly different parts termed Victor Main (VM) and Victor Northwest (VNW; Fig. 2 inset. VM appeared to be composed of uniform pyroclastic kimberlite (VMPK) expected to have a homogeneous diamond content except for VM NE (Fig. 3a). In contrast, VNW is complex with an upper country-rock rich zone overlying several different types of hypabyssal-like kimberlites. The 1998/9 small bulk samples of VN produced (i) 55 cts of +1mm diamonds from 195t of kimberlite recovered from 21 RC holes (diameter of 184mm to variable depths up to 185m; 50m sample intervals; Fig. 3a). These data showed that the grade varies as predicted with the kimberlite geology: (i) much of VM has sample grades >30 cts per hundred tonnes (cpht), and (ii) both VM NE as well as VNW have different sample grades (<5cpht, Fig. 3a). Although the diamond content is variable, the results indicated that advanced evaluation on VM (and VS) was warranted.

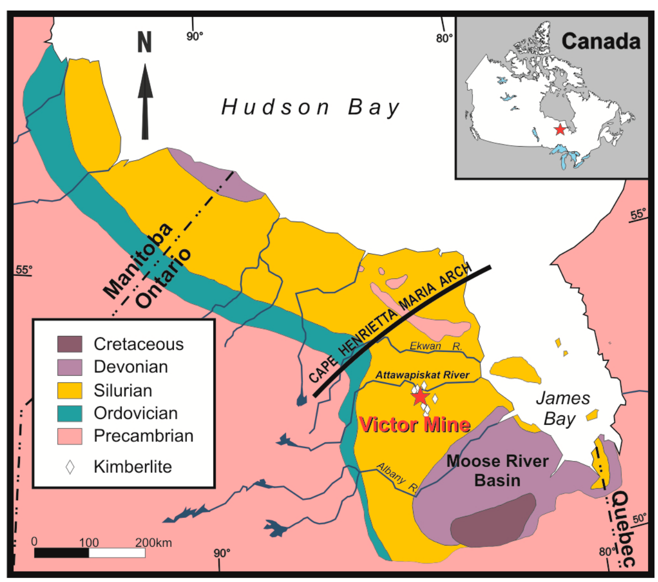

Fig. 1 Location and geological setting of the Victor Mine, Ontario.

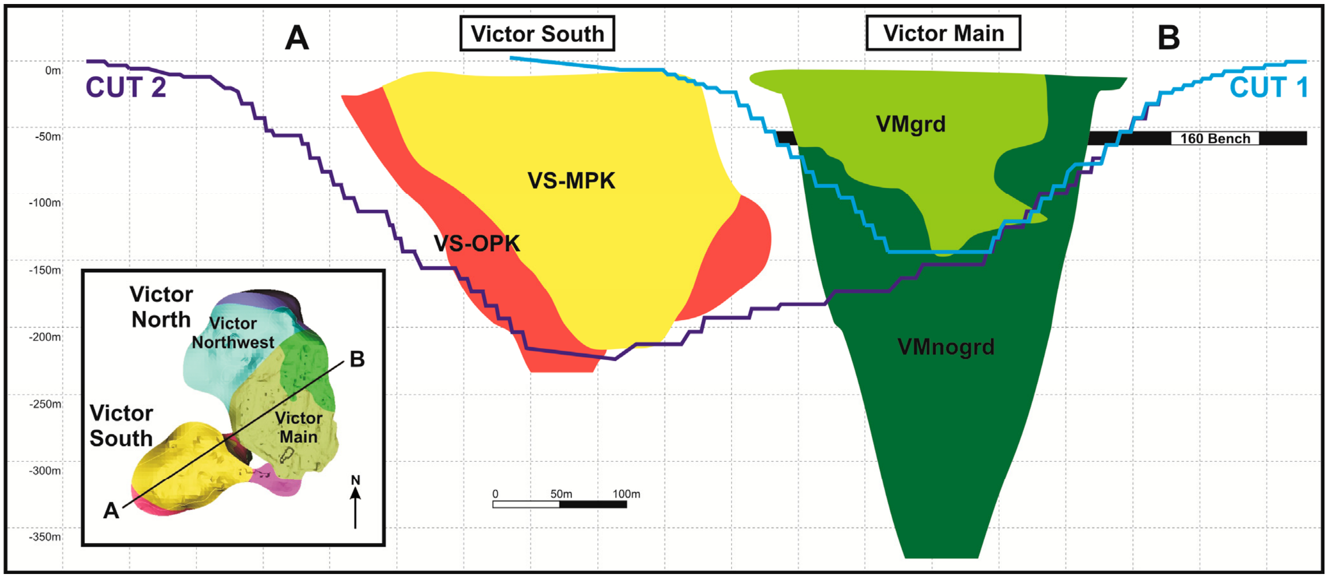

Fig. 2 Cross section of the Victor Resource showing the two pipes Victor North and South and the two phases of open pit development (Cuts 1, 2). The inset shows the subdivisions of Victor North into Victor Northwest and Victor Main (VM). For mining purposes VM is subdivided into ore (VMgrd; grd = grade) and waste (VMnogrd). Data for the 160 Bench (53-63m below surface) are shown in Fig. 3.

2000-2007: ADVANCED EVALUATION

Advanced evaluation in 2000/2001 focused on the high grade area of VN as shown by previous results (Fig. 3a) and was based on bulk sampling utilising (i) 26 RC holes to investigate grade (diameter of 610mm, 40m grid, variable depths to 242m) and (ii) a trench to investigate stone value (Fig. 3a). A total of 2332 cts of +1.5mm diamonds were recovered from 3750t of trenched kimberlite. The RC bulk samples had small vertical sample intervals of 12m (Fig. 4) providing detailed data which showed that the diamond distribution was more complex than expected, both laterally and vertically (Figs. 3a, 4). This prompted further examination of the internal geology. Distinct changes in diamond content, both spht and cpht, were used to develop initial 3D internal geological boundaries within VM (Figs. 3a, 4). The model indicated three spatially coherent zones (Fig. 8 of Webb et al. 2004). Using this model, the geology of VM was examined in stages (Webb et al. 2004; van Straaten et al. 2008 unpublished internal reports, some by K.J. Webb). These studies showed the VM pyroclastic kimberlite infill (VMPK) resulted from two separate eruptions of different batches of magma with different diamond contents. The central high grade PK (VMhgPK, >30 cpht) formed two later nested craters within previous low grade infill (VMlgPK, <5cpht) before lithification. This resulted in extensive mixing of pyroclasts from each eruption producing a wide (~100m), inhomogeneous gradational internal contact zone with variable but overall intermediate moderate grades (VMmgPK, 5-30 cpht). The VMhgPK, VMmgPK and VMlgPK have average bulk sample grades of 52, 24 and 2 cpht, respectively.

The products of the two different eruptions of kimberlite can only be distinguished using micropetrography, primarily the abundance and size of olivine phenocrysts within the melt-bearing pyroclasts (Fig. 3b; VMhoPK and VMloPK = high and low olivine phenocryst contents respectively; Webb et al. 2004). The mixed zone contains mixtures of the two different pyroclasts (VMmoPK). The grade and petrography correlation (based on 1160 samples from 56 core and RC holes, Figs. 3a,b, 4) is as follows:

VMhgPK	VMloPK	(pink)
VMmgPK	VMmoPK	(yellow)
VMlgPK	VMhoPK	(green)

The VMhoPK is low grade and the later VMloPK is high grade (Figs. 3a,b, 4). The poorer correlation between VMmgPK and VMmoPK reflects the complex nature of this gradational mixed zone. Variations in grade within this zone result from variable proportions of pyroclasts from VMloPK and VMhoPK. The somewhat different VM NE, which was initially separated from the rest of VM based on logging (Fig. 3a), was petrographically shown to be part of the VMlgPK and this internal boundary was removed (Fig. 3b). The so-called VM-Blip was shown to be a separate earlier low grade pipe cross cut by VM (Fig. 3).

For the Block Model, four separate geological units were used. VNW and VM-Blip were separated using extrapolations of the sharp internal contacts observed in drillcores within VN. Within VM, given the wide and inhomogeneous gradational internal contact zone, a different approach based on the diamond results alone was used. The central higher grade kimberlite was separated

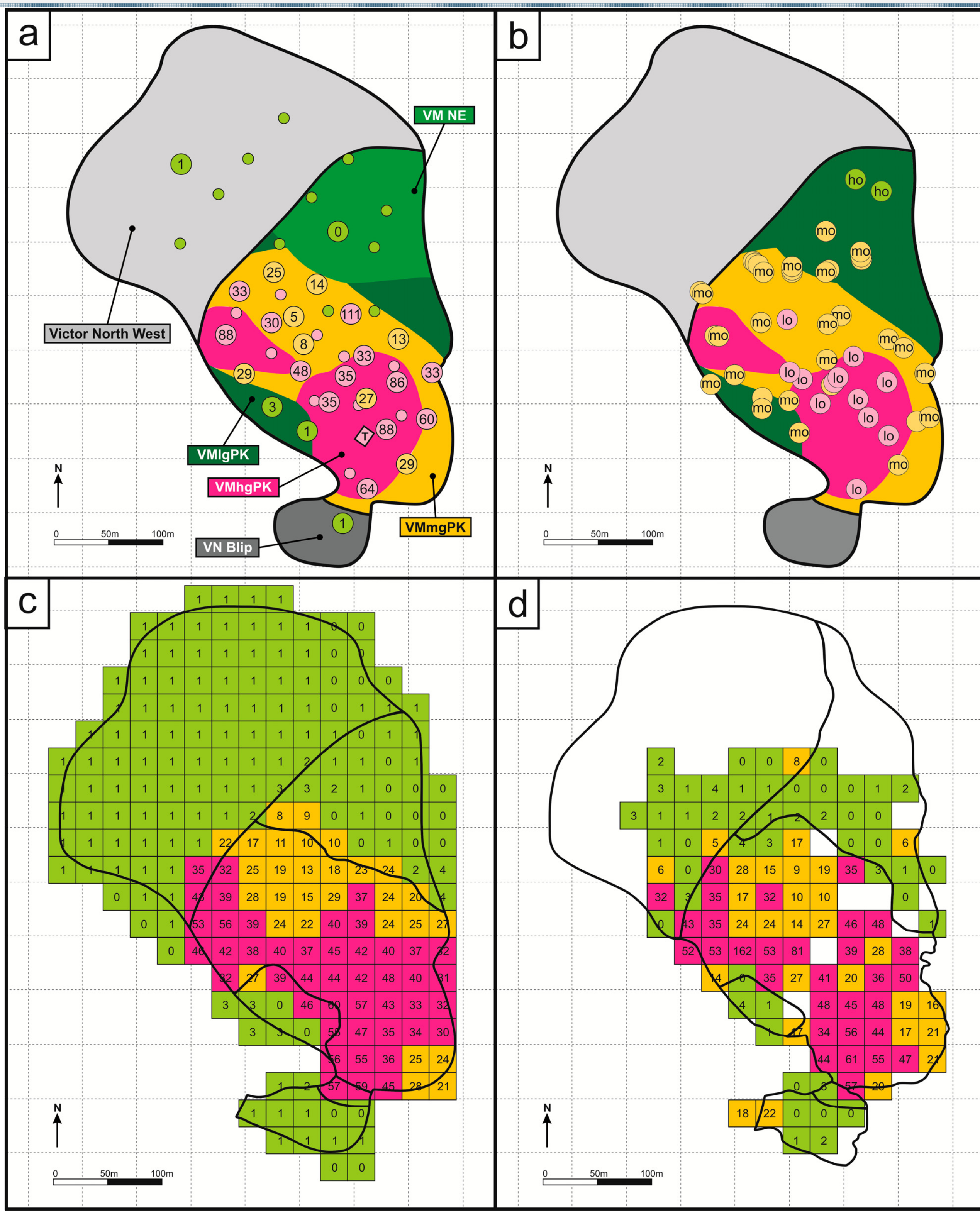

Fig. 3 Victor North shown in plan views of Bench 160 (Fig. 2). Numbers = grades in carats per hundred tonnes (cpht). Pink = ≥30 cpht; yellow = 5-<30 cpht; green = <5cpht. (a) 2002 geological model. Black lines = sharp internal boundaries. T = trench. Coloured circles = RC drillholes; small = 1999, large = 2000/2001. (b) 2003 geological model showing the petrographic samples and results lo, mo, ho = VMloPK, VMmoPK, VMhoPK. (c) 2007 Mineral Resource Block Model. Black lines in VM subdivide ore (VMgrd) and waste (VMnogrd). Four separate block models were developed for VMgrd, VMnogrd, VNW and VM Blip (where models overlap near boundaries data are for VMgrd. (d) 2011 boundaries refined using mining bulk samples that coincide with the blocks shown in (c).

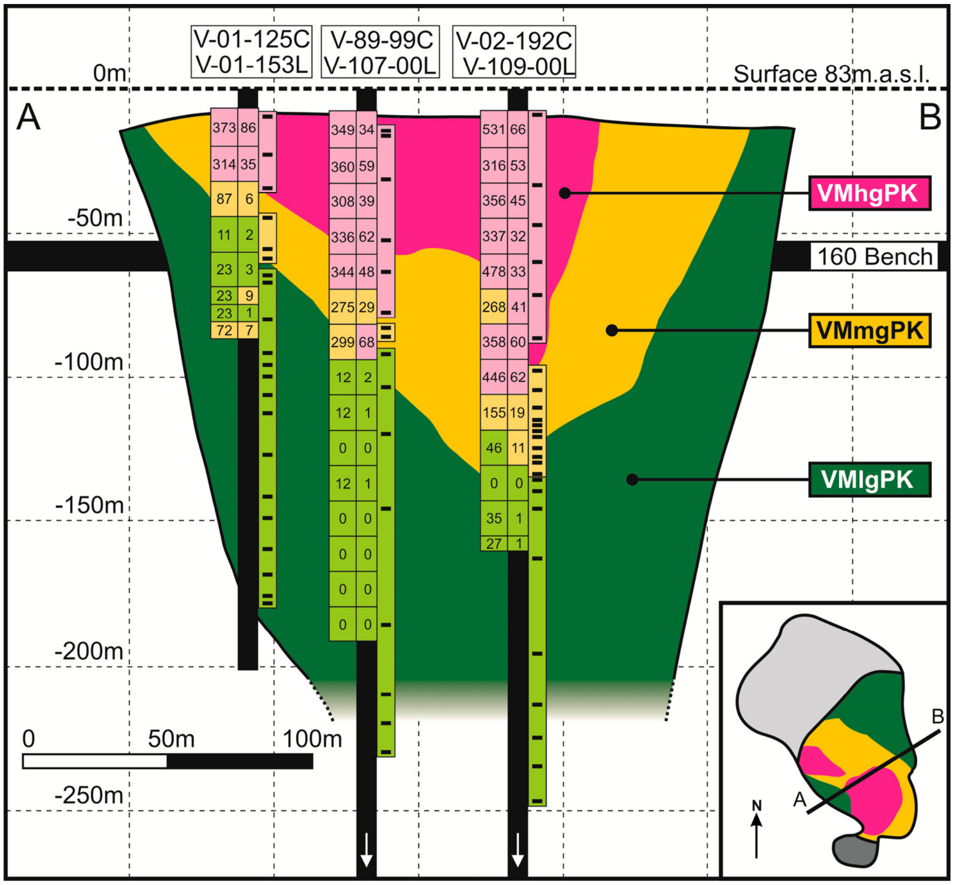

Fig. 4 Cross section through the 2003 geological model of Victor Main (VM Fig. 3b; similar location to Fig. 2). Black line = external kimberlite contact. Three pairs of nearby large diameter (L) 2000-2001 RC and core (C) holes are shown (vertical thick black line includes location of both holes in each pair and indicate depths of the core holes; the sample results indicate depths of the RC holes). Also shown are (i) bulk sample results as stones and carats per hundred tonnes (left, centre), and (ii) location of petrographic samples (black dashes in right hand column) and subdivisions (pink = VMloPK, yellow = VMmoPK, green = VMhoPK). Note the correlation between VMhgPK, VMmgPK, VMlgPK and VMloPK, VMmoPK, VMhoPK, respectively. The depths defining mining ore from waste (VMgrd to VMnogrd Fig. 2) that correspond to each pair of holes are 38.7, 93 and 23m from left to right.

from the two zones expected to be non-economic using statistically-derived internal boundaries (< 5cpht; Fig. 3c). Comparing Figs. 3b and c shows that these boundaries occur within the VMmoPK which in turn shows the complex nature of the gradational contact zone. Kriging of the diamond results within each of the four defined 3D volumes was used to populate separate block models with predicted diamond mining grades (Fig. 3c). The resulting Resource Model suggested that the grade of VM is variable and overall relatively low by worldwide standards but, that the diamonds would be of high value. The 2007 feasibility study classified 12mt at 33cpht (VMgrd; Figs. 2, 3c) as an Indicated Resource.

2008-2011: MINING

Victor Main with the highest predicted grades in the Victor Resource is the focus of current open pit mining (Cut 1, Fig. 2). The fact that the contrasting grade zones in VM can only be differentiated using micropetrography and that the VMgrd to VMnogrd boundary is irregular (Fig. 2) and occurs within the complex mixed zone (Figs. 3b,c) creates a practical mining issue in the separation of ore from waste. The low grade waste (VMnogrd) and high grade ore (VMnogrd) is distinguished in the open pit to some extent using 3D delineation based on the Resource Model (Figs. 2, 3c). More importantly, the mine design included a bulk sample plant to routinely test newly exposed kimberlite and identify ore, especially in the complex mixed zone (Fig. 3d). An example of this is shown by the modification of the VMnogrd to VMgrd boundary during mining in Fig. 3d compared to the resource in Fig. 3c. Overall, the bulk sample results (Fig. 3d) show that the diamond grades are, as predicted, extremely variable but consistent with both the geological model and the 2007 block model (Fig. 3). The bulk sample results (Fig. 3d) and the mine production data

(Fig. 5) show that the Victor Mineral Resource is reliable which in turn validates the geological and emplacement models. Also, the diamonds with an average value of over $400/ct are currently amongst the highest in the world.

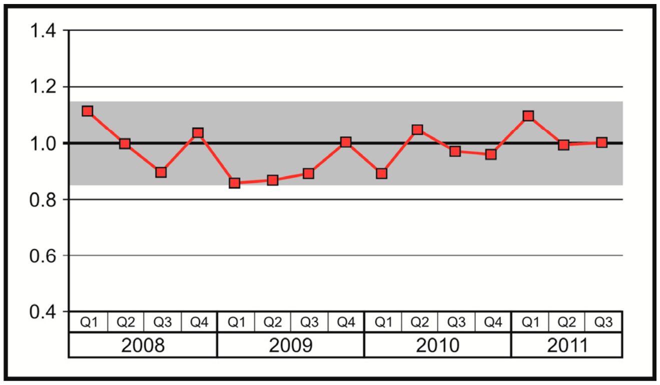

Fig. 5 Mine Call Factor for mining to date. Red data points: ratio recovered carats from mining/predicted carats based on the Mineral Reserve. Correct predictions have a value of 1. Values above and below 1 indicate recoveries higher or lower than predicted, respectively. Shaded area shows adherence of 15%, the threshold defining a Measured Resource.

FUTURE MINING

The development of Cut 2 started in 2011 which focuses on the mining of two separate phases of kimberlite within Victor South (VS-MPK, VS-OPK, Fig. 2). These phases are distinct and bounded by sharp internal contacts (Webb et al. 2006) making grade predictions and the separation of ore from waste during mining more straightforward than in VM. Much of the apparently low grade VNW (Fig. 3a) was extracted as waste during the development of Cut 1 (Fig. 2). The VNW 'waste kimberlite' is being stockpiled because of the potential for profitable treatment of some, or all, of this material later in the mine life. As it is mined, evaluation is undertaken using bulk sample plant results (Fig. 3d) and the internally complex geological model (based on van Straaten et al. 2011 and references therein). The diverse infill of VNW ranges from a different type of PK than VM resulting from highly explosive eruptions to a rare well-documented example of a nested-crater-filling, effusive, coherent-to-clastogenic kimberlite lava pond.

CONCLUSIONS

The data presented in this paper shows that the Victor Main Mineral Resource has proven to be accurate which has significantly contributed to the success and reliability of commissioning and operating the mine. The development of a detailed and robust geological model together with an understanding of the emplacement processes was critical to the successful design and implementation of sampling programs and to the establishment of the reliable Resource as well as mine planning. The variability in grades throughout Victor reflects a complex multi-phase kimberlite emplacement history with adjacent and cross cutting pipes containing contrasting infill formed by diverse pyroclastic processes. Continued monitoring of the Resource performance through understanding the geology of the Resource, run of mine bulk sampling, careful ore tracking and analysis of the processing plant efficiency will ensure continued confidence in the Reserve. Future sustainability of the mine depends on aggressively evaluating other kimberlites within the Attawapiskat cluster of eighteen pipes while continually improving operating costs.

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