THE GEOLOGY OF THE MISERY KIMBERLITE, EKATI DIAMOND MINE™, CANADA

J. Mustafa[1], T. Nowicki[2], P. Oshust[3], D. Dyck[3], B. Crawford[3], S. Harrison[3]

[1]BHP Billiton Diamonds Inc., Yellowknife, Canada; [2]Mineral Services Canada Inc., Vancouver, Canada; [3]BHP Billiton Diamonds Inc., Kelowna, Canada

INTRODUCTION

The Misery Kimberlite Complex is located in the southeast of the Ekati main claim block, 7 km northeast of the Diavik mine. It was first identified in the 1992 *Dighem* airborne data as being two possible kimberlites. One was a moderately strong conductivity anomaly and the other, a strong magnetic low. Ground TFM and HLEM surveys were conducted at the end of the 1993 winter program and results indicated that there were five possible kimberlites. The discovery hole was collared in June 1993. Later that year, four kimberlites were intersected by diamond drilling, and two of these pipes, named Misery Main (or Misery North) and Misery South, were targeted for bulk sampling during the 1994 winter program. The 1995 exploration campaign focused largely on Misery Main with the collection of a significantly larger bulk sample. Preliminary results justified additional pipe wall delineation. A total of ten core holes and 29 reverse circulation holes were drilled in the 1995 winter program.

Open-pit mining operations of Misery were initiated in early 2001, with the first kimberlite and diamond production following in early 2002. Exploration drilling and mining activities have revealed a geologically complex kimberlite system involving numerous intrusives filled with a variety of rock types.

GEOLOGICAL SETTING

The Ekati property is located in the central part of the Slave Structural Province of the Canadian Shield, within the Contwoyto Terrane. The Misery Kimberlite Complex is less than 30 km southeast of the main Ekati Camp, near the northern shore of Lac de Gras. The topography of the Misery area is characterised by low to moderate relief coinciding with rolling hills, low-lying muskeg, and swamp covered areas. Topographic variations in the Misery area correspond with the change in lithology, with strongly resistant granitic rocks expressed by positive relief and less resistant biotite schist (metagreywacke) by low relief.

The Misery Kimberlite Complex occupies the contact between Archean biotite schist and two-mica granite. The biotite schist is weathered to a brown color, and is commonly foliated. The granitic rocks generally weather to a light-grey color and contain abundant primary muscovite. Textures vary from fine to coarse-grained, to pegmatitic, and range from equigranular to weakly porphyritic. The granite is younger than, and intrudes into the biotite schist. In addition, the granite does not display well-developed foliation or alignment of mineral grains and, therefore, is interpreted (Kjarsgaard and Willey, 1993) to be post-tectonic.

Misery was emplaced at approximately 56 Ma coinciding with one of two important episodes of emplacement of highly diamondiferous kimberlite in the Lac de Gras kimberlite field. This date is also consistent with 54.8 to 56.0 Ma isochron ages reported for economic kimberlites at Diavik (Graham et al., 1999).

KIMBERLITE GEOLOGY

Along with Misery Main Pipe, there are numerous other small kimberlite intrusives that occur in the immediate vicinity of, and in some instances abut against the main pipe (Figure 1).

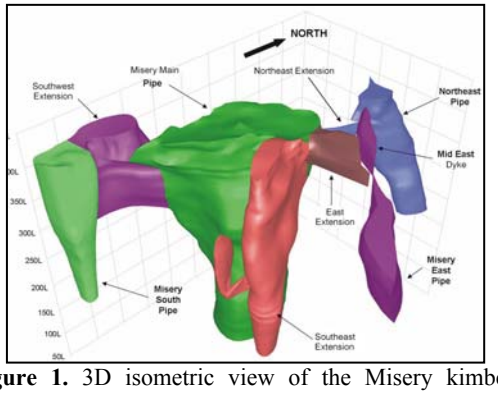

Figure 1. 3D isometric view of the Misery kimberlite complex, looking northwest.

Misery Main is the largest pipe in this cluster of nine known intrusive bodies. Misery South and Northeast

pipes are small and contain volcaniclastic kimberlite similar to that occupying the main pipe. Misery East pipe, Misery Southwest, East, and Northeast extensions, and Misery Mid-east dyke are all hypabyssal bodies that appear to radiate outwards from the main pipe. Misery Southeast extension is composed of both hypabyssal material and volcaniclastic kimberlite.

MISERY MAIN

The Misery Main Pipe (Figure 2) is the most economically important body in the Misery Kimberlite Complex.

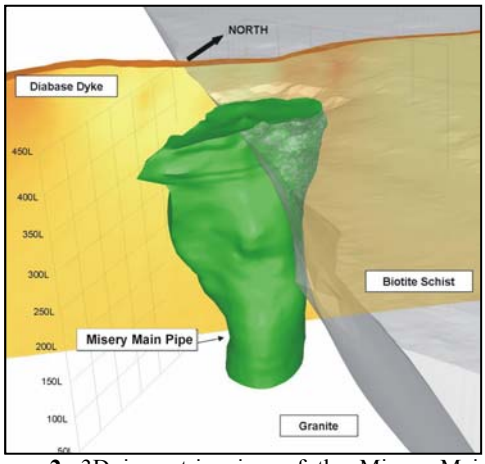

Figure 2. 3D isometric view of the Misery Main pipe showing the diabase dyke and Granite / Biotite schist wall rock contacts.

Morphology

Misery Main is an elongate, 1.5 ha, steep-sided pipe with dimensions of approximately 90 by 175 m at surface. The pipe wall is interpreted to dip at varying angles, but generally, portions of the pipe wall dip steeply inward at 85° to vertical to steeply outward at 85°. The trend of pipe elongation is northeast-southwest, parallel to a suspected fault and sub-parallel to a diabase dyke belonging to the Contwoyto Lake diabase dyke suite (Kjarsgaard and Willey, 1993). The dyke is approximately 60 m to the west of the main kimberlite body. Nearly perpendicular to this trend is a major northwest-southeast trending contact zone in the Archean basement between two-mica granite and schistose metagreywackes. The pipe was emplaced at this contact as shown in Figure 2.

Dominant rock types

Misery Main is infilled predominantly with volcaniclastic kimberlite (VK). Variable amounts of carbonized wood, mudstone clasts, granite and schist fragments, and altered peridotite xenoliths are present. In places, well-defined fine-scale bedding is evident, generally defined by variations in the abundance and grain size of olivine. Bedding angles appear to be highly variable with both shallow and steeply dipping beds present. Lesser amounts of fine-grained sedimentary material are also present.

Crater Sediments

Fine-grained crater sediments present at Misery Main include siltstones and mudstones that display a variety of colours, including grey, blue, green, buff, red, orange, and yellow. The sediments consist of fine-grained, silty muds; rare, serpentinised olivine; and pyritic nodules. Indicator minerals are absent. Soft sediment pressure loading, flame structures, and a ribbon-like textures suggest compaction in a shallow-water low-energy depositional environment.

Dark-grey to black mudstone is clay-rich and contains less than 3% olivine, typically less than 0.5 mm in size. Rare peridotitic and eclogitic garnet and chrome diopside are present. Locally the mudstone is laminated, and in places it is finely interbedded with relatively coarse-grained olivine-rich material. These 4 to 8 cm thick interbeds commonly contain up to 70% olivine along with abundant peridotitic garnet.

Olivine-Rich Resedimented Volcaniclastic Kimberlite

In Misery Main the olivine-rich resedimented volcaniclastic kimberlite (ORVK) can be separated into coarse-grained (CORVK) and fine-grained (FORVK) varieties. Both of these are mineralogically similar and differ primarily in terms of olivine grain size. Spatially, the volumetrically dominant FORVK occupies the southern "half" of the pipe and the CORVK the northern portion. The contact between the two types is distinct and is present to the modelled depth limit of the pipe. The mean bulk sample diamond grade from the CORVK is 6.2 ct/T compared to 2.7 ct/T for the FORVK unit.

CORVK typically contains two generations of olivine (Figure 3). One generation is comprised of subrounded to subangular grains greater than 2 mm in size that are fresh to moderately serpentinised, and comprises 10 to 30% of the rock. Pearly white ribbons of serpentine occur within the olivine grains and along grain margins. The second olivine assemblage is characterised by angular white to cloudy blue serpentinised grains of olivine that are

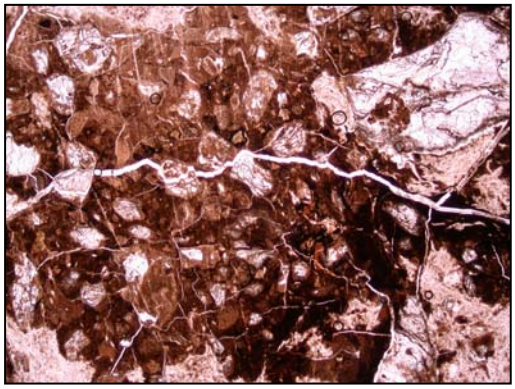

Figure 3. Photomicrograph of Misery Main CORVK photographed in plane polarized light. Field of view is 7 mm across.

less than 2 mm in size and comprises 15 to 25% of the rock. Olivine rarely reaches up to 3 mm. FORVK contains angular, fine-grained olivine (<1 mm) and exhibits varying degrees of serpentinisation. The matrix of these rocks (both FORVK and CORVK) comprises fine-grained serpentine and abundant very fine-grained, dark-brown, probable argillaceous material derived from disaggregation of mudstone. Well developed bedding, moderate to poor sorting of olivine, draping of beds, probable accretionary lapilli, and fining upward sequences have been observed in these units. Bedding is typically chaotic. However, in certain cases, bedding angles and 'way-up' indicators such as pebble dints suggest the presence of fining upward graded beds that dip towards the centre of the pipe.

Indicator minerals observed in CORVK are dominated by peridotitic and eclogitic garnets, with the former typically encased in a kelyphite rim. Chrome diopside is conspicuously absent or rare, and ilmenite and chromite are rare. In FORVK, when present, garnets and chrome diopside are frequently angular and fragmented with less prevalent kelyphite rims.

Xenoliths

Xenoliths observed in Misery Main include granite, biotite schist, mudstone, and siltstone. The most common and largest xenoliths (30 cm) are observed in the "basal portions" of the CORVK where a finely graded (fining upwards) sequence is present. Granite xenoliths are subrounded, and are characterised by a greenish-blue alteration rind on the surface and the presence of voids, possibly reflecting removal of quartz. Biotite-schist xenoliths are green, coarse-grained, and relatively muscovite-rich compared to the grey-brown, fine-grained biotite schist of the wall rock. The schist fragments are generally elongated subparallel to schistosity. Trace amounts of brown to blackened wood fragments, typically 2 to 4 mm in size, have been observed in the kimberlite.

MISERY SOUTH

Misery South is located approximately 200 m southwest of Misery Main. While it is occupied by similar rocks to those observed at Misery Main, the distribution and orientation of different lithological units differs.

Morphology

Misery South is roughly elliptical in shape with dimensions of approximately 75 by 100 m. The average pipe wall dip appears to be 086°. Numerous faults have been mapped in the wall rock bounding the pipe.

Dominant Rock Types

Misery South is made up of a narrow lens of olivine-rich resedimented volcaniclastic kimberlite (ORVK) overlying a more massive interval of fine-grained sediments that are underlain by finer-grained olivine-rich volcaniclastic kimberlite (FORVK).

Olivine-Rich Resedimented Volcaniclastic Kimberlite

The upper ORVK material varies from 8 to 21 m in thickness and is characterised by abundant glassy olivine and abundant indicator minerals, particularly eclogitic and kelyphite-encrusted peridotitic garnets. A second generation of fine-grained olivine is moderately to strongly serpentinised to a cloudy blue-milky white color.

Misery South FORVK is very similar to the FORVK occurring in the Misery Main pipe and is characterised by relatively abundant (15 to 25%), angular, moderately to strongly serpentinised olivine grains less than 2 mm in size set in a fine-grained, mud-dominated matrix (Figure 4). Minor amounts of fine-grained, angular quartz are present. The more strongly serpentinised olivine grains typically show weak carbonate alteration around their rims, as well as partial to complete rims of finely crystalline pyrite in trace percentages. Xenocrysts of garnet, chrome diopside and minor chromite are distributed throughout this unit. Peridotitic garnet is more abundant than eclogitic garnet, which in turn is more abundant than chrome diopside. Ilmenite is present below 114 m elevation but diminishes with depth.

Xenoliths are rare, although locally comprise up to 8% of the rock, and consist primarily of altered granite fragments and minor eclogitic nodules. Trace amounts of wood have also been observed.

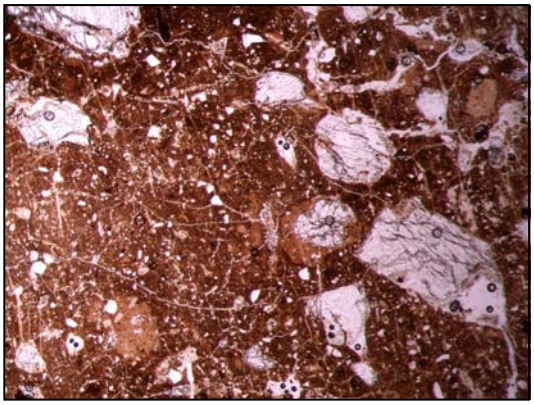

Figure 4. Photomicrograph of Misery South FORVK photographed in plane polarized light. Field of view is 7 mm across.

Crater Sediments

The crater sediments are typified by abundant, brightly coloured (red, orange and yellow), muddy siltstone with little or no olivine. When olivine is observed, it is very fine-grained (<0.25 mm) and angular. Slickensided green zeolite is commonly observed coating drill cuttings and possibly represents fluid movement along fractures.

MISERY SATELLITE INTRUSIONS

Numerous small kimberlite bodies have been encountered in drill holes and the open pit excavation in the immediate vicinity of the Misery Main pipe. These have been named based on their position relative to Misery Main (Figure 1).

Most of these bodies, including the Misery Southwest extension, East extension, Northeast extension, Misery Mid East Dyke, and Misery East Pipe, appear to consist entirely of macrocrystic magmatic kimberlite and are interpreted to be small precursor hypabyssal intrusions. The hypabyssal material intersected is generally characterised by dark greenish-grey, phlogopite- and clay-rich matrix material, with 15 to 25% glassy, yellow-green, coarse-grained (up to 8 mm), sub-round to ellipsoidal olivine macrocrysts (Figure 5a). Pyrope garnet occurs as broken to sub-rounded grains. Chrome diopside is rare and occurs as broken grains and as small (~0.5 mm) inclusions within the larger macrocrysts. Some elongate olivine grains appear to exhibit weak flow

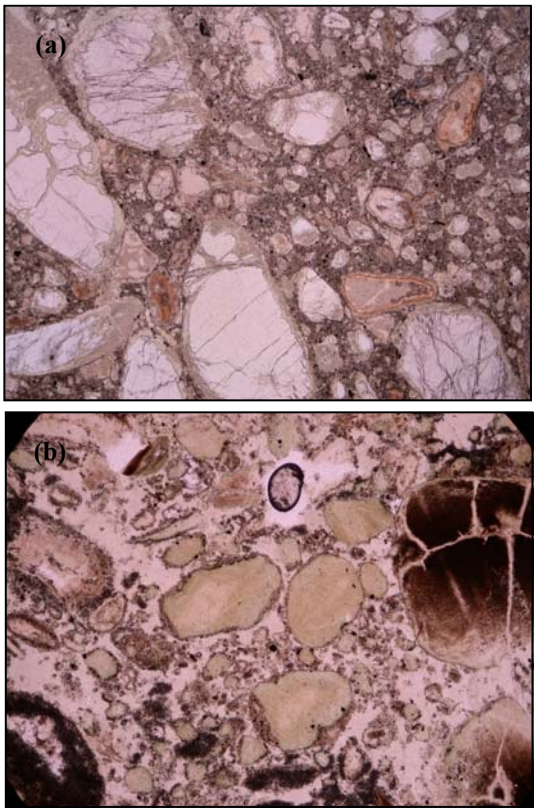

Figure 5. Photomicrograph of kimberlite in Southeast Extension pipe. (a) Macrocrystic hypabyssal kimberlite. (b) Volcaniclastic (tuffisitic?). Both images taken uder plane polarized light. Field of view for (a) is 7 mm across and for (b) is 2.8 mm across.

alignment. The matrix of these rocks is variable but generally consists of variably serpentinised microphenocrystic olivine in a fine-grained groundmass including abundant very fine-grained opaque minerals and scattered perovskite. The groundmass mineralogy is variable with monticellite, phlogopite-carbonate, and serpentine-carbonate varieties observed in thin section.

The margins of the hypabyssal intrusions are commonly strongly altered to iron oxides and serpentine. Alteration has moderately de-silicified, chloritised and saussuritised the host granite, and a bleached appearance is apparent over several metres adjacent to the contact with the dykes.

The Misery Southeast Extension is an elongate body made up of hypabyssal kimberlite as well as juvenile-lapillus-rich, volcaniclastic kimberlite that strongly resembles tuffisitic kimberlite (Clement and Skinner, 1985). The hypabyssal material is very similar to that observed in the other satellite intrusions. Preliminary petrographic studies of the volcaniclastic kimberlite indicate that it is characterised by abundant well

rounded narrow-rimmed juvenile lapilli, cored by pervasively serpentinised olivine macrocrysts. They are set in a "clean" matrix of very fine-grained serpentine with scattered very small microlites of clinopyroxene (Figure 5b). Altered country-rock xenoliths and scattered autoliths, with common

probable magmatic rims, are also present. The spatial relationship between the hypabyssal and volcaniclastic kimberlite in Misery Southeast Extension is not well constrained by drilling or exposure in the pit and more work is required to reliably model the internal geology of this body and its relationship to the Misery Main pipe.

EMPLACEMENT OF THE MISERY KIMBERLITE

The Misery kimberlite complex was formed by numerous overlapping eruptions and intrusions (Figure 6). All appear to have been structurally controlled by zones of weakness associated with faults, dykes, and a major contact in the Archean basement.

The satellite bodies are predominately hypabyssal and do not cross cut the RVK filled Misery Main or South pipes, indicating that they represent precursors to the larger Main and South pipes.

mud, and wood fragments found throughout the pipe. No evidence of multiple eruptions, such as cross-cutting vertical structures, has been found to date.

The current model is based on drill information and it is likely that more details will be revealed with open-pit exposure, resulting in a more thorough understanding of the emplacement of the Misery Complex.

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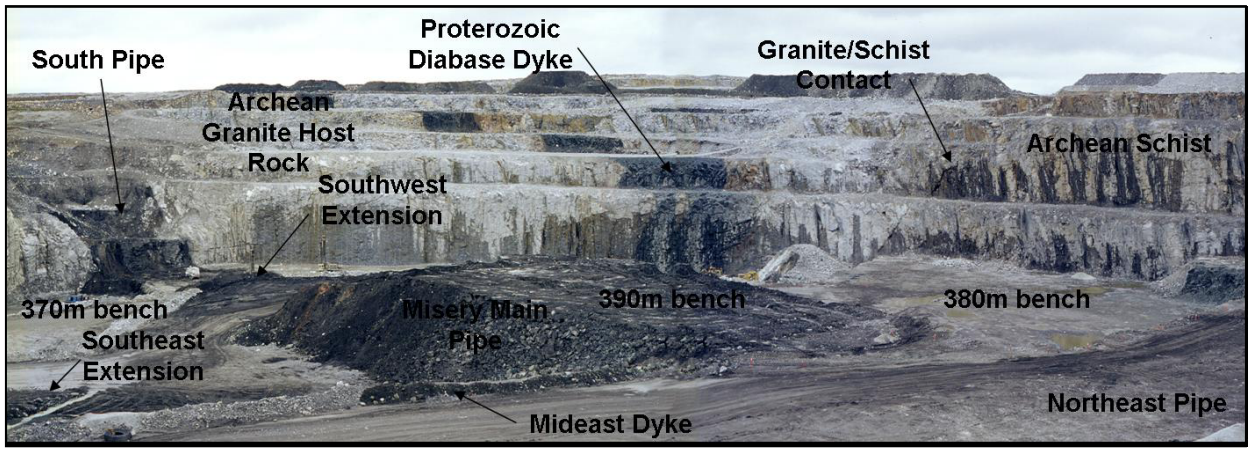

Figure 6. Panoramic view of Misery Pit showing the cross-cutting relationships of the wall rocks and kimberlite intrusions. View looking approximately southwest.

Misery Main and South represent a final stage violent eruption that excavated elongate pipes, which were subsequently filled in by resedimentation of .pyroclastic material from the crater rim. The Main pipe is filled with resedimented volcaniclatic (RVK) to the current known limits of the pipe. This is supported by the variety of crustal xenoliths, surficial