The following examples illustrate how information obtained from the geological studies could directly influence mining method selection, strategy and design.

Pipe emplacement – This is one of the fundamental studies that help to understand the kimberlite pipe geology. Although the importance of the pipe emplacement model is commonly recognized in the resource geology, its importance to the mine design is not always appreciated by the mining engineers. The knowledge of the pipe, character of the contact zones, internal structures and distribution of inclusions could directly influence pit wall stability (thus striping ratio), underground mining method selection, dilution, treatibility, dewatering strategy etc.

Kimberlite geology – Understanding the internal geology of the pipe mainly includes the geometry and character of individual phases and facies, and the orientation and character of internal structures that transect the rock mass. For any mining method it is important to know "where the less and where the more competent rocks are located". On the other hand the detailed facies studies may not be important for the resource and mine design if the rock types have similar physical properties and diamond content.

Kimberlite petrology/mineralogy – Forming a good understanding of the kimberlite petrology and mineralogy could be crucial to the treatability (namely diamond damage and liberation), but also to the pit wall and underground excavation stability, support design, mine safety (mudrush risk assessment) and mine dewatering.

There is no doubt that a better understanding of the geology has a direct impact on the safety and economics of the mining operations. The process of mine design could start right at the beginning of the discovery without necessarily significantly increasing the exploration budget. On the other hand it is important to appreciate fundamental geological research and its impact on the increased confidence in mine design. Such studies must not be viewed as cost items but as an investment.

1.4 GEOLOGY OF THE VICTOR KIMBERLITE, ATTAWAPISKAT, NORTHERN ONTARIO, CANADA: CROSS-CUTTING AND NESTED CRATERS

Webb KJ*, Scott Smith BH, Paul JL and Hetman CH

The kimberlite pipes within the Attawapiskat cluster, including Victor, formed by an overall two-stage process of: (1) pipe excavation without the development of a diatreme (sensu stricto) and (2) subsequent pipe infilling. These pipes, therefore, differ from most of the southern African kimberlite pipes. The Victor kimberlite comprises two adjacent but separate pipes, Victor South and Victor North. The pipes are infilled with two contrasting textural types of kimberlite: pyroclastic and so-called hypabyssal. Victor South and much of Victor North are composed of pyroclastic, spinel carbonate kimberlites, the main features of which are similar: they consist predominantly of clast supported, discrete olivine macrocrysts and phenocrysts and lesser pyroclastic juvenile lapilli, mantle-derived xenocrysts and minor country rock xenoliths. These partly bedded, juvenile lapilli-bearing olivine tuffs appear to have been formed by subaerial fire-fountaining airfall processes. The Victor South pipe has a simple bowl-like shape that flares from just below the basal sandstone of the sediments that overlie the basement. The sandstone is a known aquifer, suggesting that the crater excavation process was possibly phreatomagmatic.

In contrast, the pipe shape and internal geology of Victor North are more complex. The northwestern part of the pipe is dominated by dark competent rocks, which superficially resemble fresh hypabyssal kimberlite, but have unusual textures and are closely associated with pyroclastic juvenile lapilli tuffs and country rock breccias ± volcaniclastic kimberlite. Current evidence suggests that the so-called hypabyssal kimberlite is, in fact, not intrusive and that the northwestern part of Victor North represents an early-formed crater infilled with contrasting extrusive kimberlites and associated breccias. The remaining part of Victor North consists of macroscopically similar, but petrographically distinct, pyroclastic kimberlites that have contrasting macrodiamond sample grades. Only microscopically can the juvenile lapilli of each pyroclastic kimberlite be distinguished. The nature and relative proportion of primary olivine phenocrysts in the juvenile lapilli are different, indicating derivation from different magma pulses, or phases of kimberlite, and thus separate eruptions. The initial excavation of a crater, cross-cutting the earlier northwestern crater, was followed by emplacement of phase (i), a low grade olivine phenocryst-rich pyroclastic kimberlite, and the subsequent eruption of phase (ii), a high grade olivine phenocryst-poor pyroclastic kimberlite, as two separate vents nested within the original phase (i) crater. The second eruption was accompanied by the formation of an intermediate mixed zone with moderate grade. Thus, the final pyroclastic pipe infill of the main part of the Victor North pipe appears to consist of at least three geological/grade zones.

In conclusion, the Victor kimberlite was formed by several eruptive events resulting in adjacent and cross-cutting craters that were infilled with either pyroclastic kimberlite or so-called hypabyssal kimberlite, which is now interpreted to be of probable extrusive origin. Within the pyroclastic kimberlites, there are two nested vents, a feature seldom documented in kimberlites elsewhere. This study highlights the meaningful role of kimberlite petrography in the evaluation of diamond deposits and provides further insight into the emplacement and volcanic processes occurring in kimberlites.

1.5 GEOLOGY OF THE GAHCHO KUÉ KIMBERLITE PIPES, NWT, CANADA: ROOT TO DIATREME TRANSITION ZONES

Hetman CM*, Scott Smith BH, Paul JL and Winter FW

The Cambrian Gahcho Kué kimberlite cluster includes four main pipes which have been emplaced into the Archaean basement granitoids of the Slave Craton. Each of the steep-sided pipes was formed by the intrusion of several distinct phases of kimberlite in which the textures vary from hypabyssal kimberlite (HK) to diatreme-facies tuffisitic kimberlite breccia (TKB). The TKB displays many diagnostic features including abundant unaltered country rock xenoliths, pelletal lapilli, serpentinised olivines and a matrix composed of microlitic clinopyroxene and serpentine without carbonate. The HK contains common fresh olivine set in a groundmass composed of monticellite, phlogopite, perovskite, serpentine and carbonate. A number of separate phases of kimberlite display a magmatic textural gradation from TK to HK which is characterised by a decrease in the proportion of pelletal lapilli and country rock xenoliths and an increase in groundmass crystallinity, proportion of fresh olivine and the degree of xenolith digestion.

The four pipes, 5034, Hearne, Tuzo and Tesla (up to 2 ha. in size), have contrasting shapes, internal geology and dominant kimberlite textures. The 5034 pipe has a very irregular shape comprising four main lobes, one of which is blind. The pipe is composed mainly of HK characterised by extensive xenolith digestion. Some gradational textures to TK are present. In contrast, the Hearne pipe has a more regular elongate shape. The complex internal geology includes approximately equal proportions of TK and HK. The dominant phase of kimberlite includes a complete gradation from TKB through a textural transition zone to HK. The more regularly shaped circular Tuzo pipe has relatively simple internal geology which is dominated by TKB. The main phase of xenolith-rich TKB grades with depth through a

textural transition zone into HK. The Tesla pipe is intermediate in character between Hearne and Tuzo. A composite model of the four pipes comprises the base of the diatreme zone (TKB; Tuzo) which grades with depth (Hearne, Tesla) into the root zone (HK; 5034). Thus, the kimberlites appear to be partly eroded pipes in which the diatreme zone has developed to different depths from the original surface. The geometry of the main HK to TK textural transition zones in Hearne and Tuzo are different. In Hearne, the transition from TK to HK occurs as a 115m wide zone which dips at ~45deg. down the long axis of the pipe. The Tuzo transition zone appears to be ~70m wide with its upper limit being basin-shaped and coinciding with the lower limit of the massive granite dilution in the overlying TKB.
The pipe shapes and infills of the Gahcho Kué kimberlites are similar to the classic South African pipes, particularly those of the Kimberley area. Similar intrusive magmatic emplacement processes are proposed in which the diatreme-zone results from the degassing, after breakthrough, of the intruding magma column. The transition zones represent 'frozen' degassing fronts. The style of emplacement of the Gahcho Kué kimberlites is very different from that of many other pipes in Canada such as at Lac de Gras, Fort a la Corne or Attawapiskat.

1.6 GEOLOGY AND DIAMOND DISTRIBUTION OF THE 140/141 KIMBERLITE, FORT À LA CORNE, CENTRAL SASKATCHEWAN, CANADA

Berryman A*, Scott Smith BH and Jellicoe B

The Cretaceous Fort à la Corne kimberlite province comprises at least 70 bodies, which were emplaced near the edge of the Western Canadian Interior Seaway during cycles of marine transgression and regression. The bodies formed during a marine regression by a two stage process, firstly the excavation of shallow, but wide craters and subsequent infilling by xenolith-poor, crater-facies, subaerial, primary pyroclastic kimberlite. The bodies range up to 2000m in diameter and are mainly less than 200m thick and thus comprise relatively thin, but high volume, pyroclastic kimberlite deposits. Each body is composed of contrasting types of kimberlite reflecting different volcanic histories and, therefore, must be considered separately for evaluation purposes.
Exploration of this province has been ongoing since 1989. Recently the Fort à la Corne Joint Venture (De Beers Canada Exploration Inc., Kensington Resources Ltd., Cameco Corporation and UEM Inc.) has focussed their attention on the 140/141 kimberlite. Programmes of core drilling, ground geophysics and large diameter drilling have increased the understanding of the internal geology, which in turn assists to explain the diamond distribution within the body.
The 140/141 kimberlite is the largest delineated body in the province, estimated to have an areal extent in excess of 200ha. The infilling of the 140/141 crater is complex, resulting from multiple phases of kimberlite. The central and younger parts of the infill are dominated by several contrasting phases of kimberlite. One of these phases represents a single primary pyroclastic airfall mega-graded bed up to 130m in thickness. The constituents grade in size from very fine to coarse macrocrystic kimberlite, through to a basal breccia. The mega-graded bed is a widespread feature within some parts of the body and at this current stage of evaluation appears to explain the variable diamond distribution within the tested portion of the pipe. A second different phase of kimberlite is interpreted as representing a younger nested crater within the mega-graded bed. Centrally located thicker intersections (>450m) of this younger kimberlite may indicate a vent for the kimberlite crater. The thickness of the mega-graded bed increases with proximity to the younger kimberlite in the study area.
Macrodiamond bulk sample grades from the mega-graded bed have been obtained from nine large diameter drill holes, from an area of ~20ha, which represents approximately 10% of the currently modeled kimberlite area. The trend of diamond grade increases with depth within the mega-graded bed and increases, within the same unit, towards the centre. Macrodiamond sample grades (collected over 12m drill hole intersections to +1mm) vary from low diamond grades at the top of the mega-graded bed, to considerably higher grades near the base. Total sample grade per drill hole varies from moderate grades near the vent feature to lower grades only 200-300m from the vent feature. Macrodiamond stone frequency, measured in stones per tonne (spt) shows a more pronounced relationship with depth and proximity to the vent feature within the mega-graded bed. There is a strong correlation between depth and increased spt, and a similar correlation between spt and proximity to the vent feature. The data supports aspects of the mega-graded bed and in turn, these conclusions are useful in understanding the macrodiamond distribution within this bed.

1.7 SEDIMENTOLOGIC AND STRATIGRAPHIC CONSTRAINTS ON EMPLACEMENT OF THE STAR KIMBERLITE, EAST-CENTRAL SASKATCHEWAN

Zonneveld JP*, Kjarsgaard BA, Harvey SE, Marcia KY, McNeil D, Heaman LM and White DJ

Diamond-bearing kimberlites in the Fort à la Corne region, east-central Saskatchewan, consist primarily of pyroclastic deposits which are interstratified with Lower Cretaceous (Albian) marine, marginal marine and continental sediments. Approximately 70 individual kimberlite occurrences have been documented. Of these, the Star Kimberlite, at the southeastern end of the main Fort à la Corne trend, has been identified as being of economic interest, and thus is characterized by an excellent drill core database.
Integration of multi-disciplinary data-sets has helped to refine and resolve models for emplacement of the Star Kimberlite. Detailed core logging has provided the foundation for sedimentological and volcanological studies and in constructing a regionally consistent stratigraphic and architectural framework for the study interval. Micropaleontologic and biostratigraphic analysis of selected sedimentary rocks, and U-Pb perovskite geochronology on kimberlite samples have been integrated to define periods of kimberlite emplacement. High-resolution 2-D and 3-D shallow seismic studies, complemented by multi-parameter borehole geophysics on drill holes within the same body, has aided in determining the 3-D geometry and internal lithologies of the Star Kimberlite.
Radiometric age determination and micropaleontologic evidence support the hypothesis that multiple kimberlite eruptive phases occurred. The oldest kimberlite in the Star body erupted during deposition of the predominantly continental strata of the lower Mannville Group (Cantuar Formation). Kimberlites within the Cantuar Formation include terrestrial airfall deposits as well as fluvially transported kimberlitic sandstone and conglomerate. Successive eruptive events occurred contemporaneous with deposition of the marginal marine upper Mannville Group (Pense Formation). Kimberlites within the Pense Formation consist primarily of terrestrial airfall deposits and associated massive kimberlite vent deposits within the underlying feeder pipe. Fine- to medium-grained cross-stratified kimberlitic (olivine dominated) sandstone in this interval reflects reworking of airfall deposits during a regional marine transgression. The youngest eruptive events associated with the Star Kimberlite occur within the predominantly marine Lower Colorado Group (Joli Fou, Westgate and Belle Fourche formations). Kimberlite beds, which occur at several horizons within these units, consist of marine airfall deposits that commonly exhibit evidence of wave-reworking. Black shale-encased kimberlite beds, deposited as subaqueous debris flows and turbidites are particularly common in the Lower Colorado Group.

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