# VOLCANOLOGY OF THE BUFFALO HILLS KIMBERLITES, ALBERTA, CANADA: SOME PRELIMINARY OBSERVATIONS

**Liane Boyer[1] Chris Hood[2] Tom McCandless[2] Dave Skelton[2] and Richard Tosdal[1]**

*[1] Mineral Deposits Research Unit, University of British Columbia, Vancouver, Canada; [2] Ashton Mining of Canada, North Vancouver, Canada*

## INTRODUCTION

The Cretaceous Buffalo Hills kimberlite province presently consists of thirty-six bodies distributed over 6000 square kilometres in northern Alberta, Canada. The kimberlites were initially identified through geophysical exploration for oil and gas in the late 1990's. Four of the bodies outcrop at surface, and up to 130 metres of post-emplacement sedimentary rock and till cover can be found on the remaining bodies. Despite this cover, some of the kimberlites form subtle topographic highs as a consequence of preferential erosion of the softer country rock. The kimberlites range in size from less than one hectare up to 47 hectares, with circular to irregular shapes inferred largely from the outlines of their magnetic anomalies. (Carlson et al., 1999)

Of the thirty–six kimberlites identified to date all but one have been classified as crater facies at the level of outcrop or to the depth of the exploration drilling. The crater facies kimberlites are predominantly olivine crystal tuff and juvenile magmaclastic volcaniclastic kimberlite. Country rock xenoliths consist mainly of angular to irregular mudstone, sandstone and siltstone clasts. Bitumen is present in many kimberlites as intergranular fill and can serve to enhance or hide textural features. The mesostasis is usually serpentine, carbonate minerals and/or chlorite. Xenocrystal minerals observed include olivine, chromian pyrope garnet, eclogitic garnet, spinel, enstatite, and chromian diopside. Diamond was recovered from 24 of the crater facies kimberlites.

Limited drilling and seismic data suggest that most of the kimberlites are steep-sided bodies at depth. Seismic profiles suggest that the steep-sided geometry persist to 1500 metres depth and penetrate below the Phanerozoic sedimentary rocks into the Precambrian crystalline basement. (Carlson et al., 1999) In contrast to the dominant steep-sided or carrot shapes, tabular units also occur, where at least the upper contacts of the kimberlite approache a bowl shape in three dimensions. These tabular shapes dominate only a few of the kimberlites, notably K5 and the southeast lobe of the K6 bodies. Each of the tabular bodies contains interlayers of mudstone. Soft-sediment deformation of shale clasts observed in K6 and BM2 demonstrate that some country rocks were not lithified at the time of kimberlite eruption. Uranium-lead ages on perovskite of ~85Ma determined for several of the kimberlite bodies agree well with the deposition of host sediments as determined by palynology.

The similarity in ages between sedimentation and eruption and the evidence for soft-sediment deformation suggests kimberlite eruption into unlithified and water-saturated rocks. The mudstone interlayers could thus reflect contemporansous eruption and sedimentation, or a combination of eruption coupled with lateral intrusion into the wet sediments. Textural relations in the BM2 kimberlite, which has been classified as hypabyssal, clearly indicate intrusion into semi-lithified sedimentary rocks. However, this interpretation seems unlikely for the remainder of the kimberlites as they are composed, at the current level of exposure, of crater facies volcaniclastic rocks.

### *VOLCANICLASTIC KIMBERLITE*

Three of the crater facies kimberlites have sufficient preserved drill core to undertake a preliminary volcanic facies analysis. K281 is a typical volcaniclastic facies kimberlite, dominated by finely bedded olivine crystal matrix supported tuffs with intermittent intervals of coarse magmaclastic volcaniclastic kimberlite. In other crater facies kimberlites, such as K6, the olivine tuffs and coarser magmaclastic intervals are also present however these rocks tend to be less matrix supported.

In general, olivine tuffs dominate the volcaniclastic kimberlites. They consist of very fine to fine olivine crystals, interpreted as phenocrystal in origin, within a matrix of serpentine, carbonate, chlorite and opaques. Olivine macrocrysts and kimberlite magmaclasts constitute less than 5% of the rock. Country rock xenoliths constitute a minor proportion of the material present and consist mainly of shale showing evidence of soft sediment deformation (Figure 1). Bedding thickness can vary from millimetre scale to metre scale. The core-bedding can range from parallel to perpendicular to a vertical core axis, thereby implying considerable variation in primary bedding dips within the kimberlite.

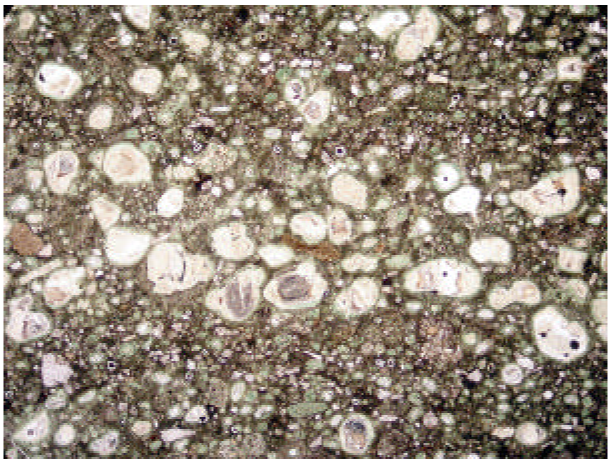

Figure 1: Olivine Phenocryst tuff showing alternating beds of finer and coarser material. Shale fragment squeezed between two olivine crystals in the centre of the photomicrograph is interpreted to provide evidence of soft sediment deformation. Field of view=1cm

Coarser volcaniclastic intervals are interspersed throughout the bodies, but tend to be more common and of slightly coarser grain size deeper in the body. They consist mainly of magmaclasts, which nucleated as thin selvages on olivine crystals or as discrete magmatic bodies with variable olivine content (Figure 2). Both varieties of magmaclasts vary in shape from rounded to amoeboid. Unmantled olivine phenocrysts and macrocrysts occur in varying abundance, with macrocrysts being more common deeper in the body.

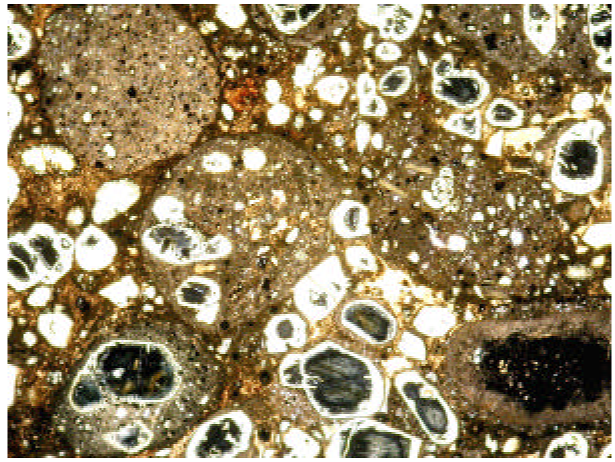

Figure 2: Medium-Coarse magmaclastic volcaniclastic kimberlite. Both nucleated and non-nucleated bodies occur. Field of View=1cm

A subtle upward-fining trend was observed in the olivine macrocryst population in K281and may represent a mega-graded bed similar to those documented in the Fort a La Corne area. (Field et al. 1999) The fine scale bedding and the variation of bedding angle observed throughout the vertical extent of the section are also similar to base surge deposits observed in other explosive volcanic eruption products. Emplacement of intermittent layers of coarser and magmaclastic material may represent sporadic or pulsating eruptive events that punctuated a steadily accumulating volcanic sequence.

### *HYPABYSSAL KIMBERLITE*

The most recent Cretaceous kimberlite, BM2, is the anomaly in the province. This kimberlite exhibits mineralogy and texture typical of hypabyssal facies kimberlite. The body is also younger than the crater facies kimberlites, which dominate the Buffalo Hills field. The kimberlite has an inequigranular texture typical of hypabyssal kimberlites (Figure 3). Alternating metre-scale intervals of hypabyssal kimberlite and grey shale/mudrock dominate the single drill hole through the body.

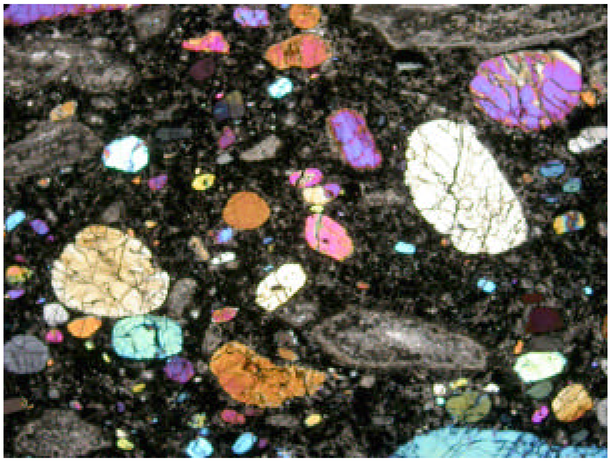

Figure 3: Hypabyssal kimberlite showing inequigranular texture. Olivine macrocrysts (>2mm) are subrounded while the smaller (<1mm) olivine phenocrysts are more euhedral in shape. Field of view = 1cm. Crossed Polars

Contacts between kimberlite and mudstone are relatively sharp or brecciated. Where contacts are preserved in the drill core, the mudstone shows alteration that distinguishes it from mudstone away from the contact. A mesh of carbonate veins cut the mudstone at the contact.

In addition to the inequigranular texture, BM2 also has evidence of segregation texture and flow alignment. Alteration of the primary minerals in BM2 is highly variable with unaltered olivine as well as olivine completely altered to serpentine and carbonate minerals.

The contact relationships between BM2 and surrounding country rock as well as its magmatic nature suggest that this deposit represents lateral injections of hypabyssal kimberlite into semi-unconsolidated sediments.

## PRELIMINARY OBSERVATIONS

The Buffalo Hills kimberlites share a number of physical similarities with other Cretaceous kimberlites in North America, particularly those in the Canadian interior. These characteristics include the dominance of crater facies material at the surface, evidence of maar-like eruptive behaviour, and apparent contemporaneous deposition with Cretaceous sedimentary sequences (Field et al.,1999). A distinctive feature of the Buffalo Hills kimberlites is the dominance of generally small, steep-sided shapes, in contrast to the extensive, pancake shapes that prevail in the Fort a la Corne kimberlites.

Additional work is being carried out to resolve whether the differences between these ostensibly similar kimberlite fields is due to variability in country rocks, or to variability in the primary components of the magmas themselves. One further difference between the Buffalo Hills kimberlite province and the kimberlites of Fort a la Corne is the presence of hypabyssal kimberlites, which to date have not been reported at Fort a la Corne.

## REFERENCES


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Contact: LP Boyer, Department of Earth and Ocean Sciences, The University of British Columbia, 6339 Stores Road, Vancouver, British Columbia V6T 1Z4
E-mail: lboyer@eos.ubc.ca