GEOLOGY OF THE FORT A LA CORNE KIMBERLITES, SASKATCHEWAN

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Introduction : The Fort a la Corne (FALC) kimberlite province was discovered under 100m of glacial overburden by Uranerz Exploration and Mining Ltd. in 1988(Lehnert-Thiel et al. 1992). Since then evaluation of these bodies has been continuing with joint venture partners Cameco Corp., Monopros Ltd. and Kensington Resources Ltd. The province occurs 80km east of Prince Albert in Saskatchewan and includes at least 70 magnetically defined bodies which range in size to over 100ha. So far 41 of these anomalies have been confirmed as kimberlites by drilling. These bodies are located in a 45x30km zone and probably form one of the largest known kimberlite provinces in the world. Significant amounts of diamonds have been recovered but no economic deposits have been found yet. This study investigated 44 drillholes containing approximately 5km of kimberlite core from 25 bodies.

Geological setting : The 94-96Ma kimberlites were emplaced into poorly consolidated Cretaceous sediments comprising ±100m of clayey fine material, silts and sandstone (Mannville Formation; ±119-100Ma) overlain by ±100m of marine shales (Ashville Formation; ±100-91Ma). The Mannville formed in coastal marine, subaerial flood plain and/or lacustrine environments. The shales were deposited towards the edge of the Western Interior Seaway, a broad shallow epicontinental sea with migrating shorelines. The Mannville unconformably overlies Palaeozoic indurated carbonates below which is the Precambrian basement.

Classification : These bodies are classified as crater-facies kimberlites. No hypabyssal or diatreme-facies rocks have been encountered. The FALC rocks are typical Group 1 kimberlites.

Crater size, shape and formation : The FALC kimberlites are shallow saucer to champagne-glass shaped bodies with diameters mainly of 500 to 1300m and depths ranging up to 200m. These bodies represent craters explosively excavated into only the Cretaceous sediments. There is no evidence of the development of any diatremes or root zones. The main craters formed during the Ashville and were preceded by common small kimberlites which comprise conformable graded beds up to 5m thick of unreworked pyroclastic airfall material within the Mannville sediments. Stratigraphic constraints suggest that the FALC kimberlite eruptions span at least 25Ma. The main kimberlite crater formation was probably confined to the last ±5-10Ma (perhaps 97.5-91Ma) while the small precursors formed from 119 to at least 100 Ma. The main FALC craters were excavated with the deposition of little or none of the resulting primary or xenolithic material within the craters. No extra-crater deposits have been found to allow further evaluation of the crater forming events, but they were probably very similar to that of maars which are usually considered to result from phreatomagmatic eruptions. At FALC a porous sandstone unit occurs at the base of the Mannville. It is a modern aquifer which probably became saturated after the end of the Mannville following the marine transgression at the beginning of the Ashville. The position of this aquifer is the point from which many of the craters appear to flare. The timing of the formation of this aquifer is consistent with the presence of maar-like craters being formed during the Ashville but not during the earlier Mannville. In contrast, the crater infilling results from magmatic eruptions. The FALC bodies do not conform to the classic kimberlite pipe model but the remarkable similarity to both the geological setting and the nature of the kimberlites at Mbuji-Mayi in Zaire (e.g. Demaiffe et al. 1991) cannot be a coincidence. The deviations from the model, therefore, probably result from different near surface geology and support, rather than negate, the classic kimberlite pipe model.

Main constituents and rock types : These loosely packed, clast supported, poorly sorted volcaniclastic kimberlites are composed predominantly of a mixture of juvenile lapilli and single crystals which are mainly olivine (clasts mostly <10mm in size, up to 10cm). The lapilli vary in shape from spherical or ovoid to irregular-curvilinear or amoeboid showing that they formed from very fluidal magmas. The groundmasses are quenched and sometimes vesicular but no true glass is observed. The inter-clast matrix is composed of mainly serpentine, carbonate and magnetite. The proportion of juvenile lapilli to single grains of olivine varies so the main rock types range from juvenile lapilli tuffs (or coarse ash) to unusual crystal or olivine tuffs (or coarse ash). Most rocks have undergone some sorting. Overall at FALC ash and coarse ash sized clasts, comprising kimberlite matrix and often single olivine phenocrysts, are not common. Some, but not all, of the drillcores display well developed plane parallel normal graded bedding. Individual beds vary from a few millimetres to at least 90m in thickness. The latter appear to be unique in the geological record. Bedding dips vary from horizontal to 80° and some disturbed bedding is present.

Near surface emplacement : The main constituents of these kimberlites must have formed by pyroclastic processes. Many features show that resedimentation of the pyroclastic material was not an important process here. These features include: the low particle density; the presence of occasional welding or molding of plastic lapilli; bomb sags and possible draping; in situ impact fragmented xenolithic bombs; the occurrence of composite lapilli showing that mixed lapilli populations result from recycling not resedimentation; the presence of different phases of eruption with associated marker horizons and sharp internal contacts; evidence of large scale sorting resulting in the overall paucity of ash and the presence of mega-graded beds;

the very significant lack of abrasion or breakage of most and often fragile juvenile and xenolithic clasts; the lack of cross bedding and other sedimentary features; the overall lack of incorporation of crater wall material; and the paucity of imbricate structures.

The kimberlites were emplaced at a time of overall marine deposition leading to suggestions that they are likely to have erupted in submarine conditions. Features within the FALC kimberlites, however, show that most of the pyroclastic activity was subaerial. These features include the occurrence of fluidal not quenched lapilli shapes, welding and molding, vesicular lapilli, poor sorting of a wide range of clast sizes, lack of resedimentation and a general lack of fines. There is also stratigraphic evidence for a ±3Ma hiatus (approximately 94.5 - 91 Ma) in the marine sedimentation during a regression within the upper Ashville Formation. This suggests that the main process of deposition was pyroclastic airfall. Although the eruptions were predominantly subaerial, there is evidence for some subaqueous deposition of the airfall material into small volumes of standing water which must be crater lakes.

The styles of eruption were very variable. The less explosive activity ranged from Hawaiian to Strombolian-type eruptions resulting in the formation of amoeboid lapilli tuffs with bedding up to perhaps 12-15m thick. Other new and much more explosive eruptive styles must be kimberlite-specific and reflect the unusual properties of these magmas, mainly their low viscosities and high carbon dioxide contents. These eruptions resulted from the rapid degassing of some of the FALC magmas above the vent, a process which is the extrusive equivalent of the intrusive diatreme formation in other kimberlites. Similar pelletal lapilli to those characteristic of diatreme facies kimberlites were also produced. These explosive eruptions must have formed high energy eruption columns. The abundant carbon dioxide in the eruption column derived from the degassing as well as the high specific gravity of the clasts must have limited the height of the column and inhibited movement of the pyroclastic material from the vent resulting in the formation of the unique mega-graded beds within the craters. The unusual olivine tuffs are thought to form by the physical separation of the crystals from very low viscosity magmas. Kimberlites, being some of the most crystal-rich and fluidal magmas known, are good candidates for the formation of such crystal tuffs. The ash produced in the higher energy eruptions was often removed, presumably by wind action.

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