THE CROSS DIATREME: A KIMBERLITE IN A YOUNG OROGENIC BELT

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The Cross kimberlite is one of about forty diatremes located along the western edge of the Paleozoic carbonate platform in the Front and Main ranges of the Rocky Mountains in southeastern British Columbia, Canada. The Cross diatreme is the only one of this group that has been recognized as a kimberlite (Roberts et al., 1980). It outcrops on a steep south-facing slope at an elevation of 2200 m, and has an exposed diameter of approximately 70 m. It has intruded carbonates of the Permo-Carboniferous Rocky Mountain Group that, in the vicinity of the diatreme, are generally flat-lying. The contacts are steeply dipping, and although the wall rocks show no evidence of thermal alteration, the carbonate beds are locally distorted along the eastern margin. The diatreme appears to have been deformed together with the country rocks, which are part of the Bourgeau thrust sheet.

Phlogopite separates have been dated by the Rb/Sr method and have yielded an Upper Permian age (Smith, 1983). Thus the diatreme is older than the deformation which formed the Rocky Mountains, and suggests that it has been thrust eastwards relative to the mantle and basement through which it intruded. Palinspastic reconstruction suggests that the horizontal displacement may be in excess of 100 km (Norris, 1965).

Throughout, the kimberlite consists of phlogopite and serpentinized olivine macrocrysts in a matrix of calcite, serpentine, and fine-grained (<120 microns) opaque oxides (rutile, ilmenite, and spinel), sulphides, and apatite. Fresh olivine has not been observed. Serpentinized olivine relics commonly possess carbonated cores. Xenoliths of serpentinized peridotite and sedimentary rock are common, as are spinel xenocrysts. Also observed, although not as abundant, are garnet lherzolite and glimmerite xenoliths, and garnet xenocrysts.

Several kimberlite phases have been recognized. The central portion of the outcrop is occupied by a friable, tuffisitic kimberlite breccia. The eastern and western extremities contain massive kimberlite. A phlogopite-rich, sub-vertical dyke, approximately 20 cm wide, has intruded the central breccia. The northern margin of the outcrop contains massive kimberlite which is distinctly red-spotted, due to hematite staining.

The eastern massive phase (EMP) is a serpentine-calcite macrocrystic kimberlite. Phlogopite macrocrysts have ragged margins, and are rimmed by very fine-grained opaque oxides. The cores of some micas are biotite, which are sharply transitional to the phlogopite rim. Groundmass spinels are zoned and may be rimmed by ilmenite or sulphide, which also occur as discrete grains. Skeletal rutile grains are common. Serpentinized peridotite xenoliths are abundant in this phase.

The western massive phase (WMP) is also a serpentine-calcite macrocrystic kimberlite, however phlogopite macrocysts are more abundant, and the occurrence of biotite cores is widespread. Narrow rim zones exhibit reverse pleochroism. Groundmass opaque grains are predominantly ilmenite and skeletal rutile. Zoned spinels and sulphides also occur. Ilmenite also occurs as rims on rutile and spinel. Serpentinized peridotite xenoliths are not as common as in the EMP.

The central breccia (CB) is a calcite tuffisitic kimberlite breccia. Fragments of shale, limestone, and kimberlite locally comprise up to 50% of the rock volume. Relics of olivine possess thin talc rims. Phlogopite macrocrysts are virtually absent. Groundmass opaque minerals are predominantly rutile and sulphide. Ilmenite is absent. Spinels are rare, and are commonly rimmed by rutile or sulphide.

The dyke (D1) is a phlogopite-serpentine macrocrystic kimberlite. Macrocrysts are more abundant than in the EMP and WMP. Phlogopite macrocrysts are short and stubby, and many have biotite cores. Reversely pleochroic rims occur on some grains. Groundmass opaque grains are predominantly skeletal rutile and zoned spinel. Ilmenite occurs as discrete grains and as rims on spinel, and may in turn be rimmed by sulphide. Xenoliths are virtually absent, although spinel xenocrysts are moderately abundant.

The hematite-stained, red-spotted phase (RSP) is a opaque-mineral-rich serpentine macrocrystic kimberlite. Phlogopite macrocyrysts are euhedral, and biotite cores are rare. Reversely pleochroic rims are absent. Weathering has produced many small hematite patches, generally less than 2 cm in diameter. These are mainly associated with peridotite xenoliths and olivine macrocrysts, but also partially replace the groundmass. Grounmass opaque grains are predominantly rutile and zoned spinel. Ilmenite and sulphide are rare. Rutile occurs as discrete grains and as rims on spinel, and may itself be rimmed by spongy magnetite haloes.

Eroded material down-slope contains boulders of a friable, phlogopite-serpentine tuffisitic kimberlite breccia (BB). Clasts consist primarily of sedimentary fragments, as well as serpentinized peridotite xenoliths. Unlike the CB, this breccia contains abundant, spherical kimberlite accretionary pellets averaging 2 cm in diameter. Most of these pellets accreted on nucleii of sedimentary xenoliths. Accretionary kimberlite growth also occurs on olivine relics. In sharp contrast to the CB, phlogopite macrocrysts are abundant. Both the macrocrystic and groundmass phlogopite commonly possess reversely pleochroic rims. Groundmass opaque grains are predominantly ilmenite, which also rims rutile. Spinel is not common, and sulphide is observed only in the cores of olivine relics.

Large accretionary pellets up to 6 cm in diameter occur in boulders of massive kimberlite (ARP) that are similar in appearance to the EMP but are not found in outcrop. The pellets accreted on nucleii of serpentinized peridotite xenoliths. The pelletal phase is a phlogopite-calcite macrocrystic kimberlite. Macrocrysts are not as abundant as in the host phase. Phlogopite is abundant in the groundmass, and is reversely pleochroic. Opaque grains in the groundmass are predominantly skeletal rutile. Zoned spinel and ilmenite are also abundant, but sulphides are virtually absent. The ilmenite is commonly rimmed by rutile.

The dark, strongly pleochroic cores of mica macrocrysts are mainly biotites (mg=0.30-0.88) with low chromium contents (<0.3 wt.% Cr_2O_3) and a wide range of titanium contents (1.8-5.2 wt.% TiO_2). These resemble the Type I micas noted in several South African kimberlites by Smith et al. (1978), who suggested that they may be derived from a related precursor intrusion. Pale phlogopite rims on the dark cores have a restricted mg (0.83-0.88), and are chrome-free. Pale mica macrocrysts that lack biotite cores, and pale, normally pleochroic groundmass grains are more magnesium-rich (mg=0.88-0.90) and contain >0.6 wt.% Cr_2O_3. Reversely pleochroic micas, which are found as rims on some macrocrysts and in the groundmass of the ARP pellets and the BB kimberlite, are characterized by low silica contents, and partial substitution of barium for potassium.

Ilmenites are magnesium-poor (<1.2 wt.% MgO) and manganese-rich (2.4-10.4 wt.% MnO). Calculated ferric iron contents are low. Niobium is detected, but has not been determined quantitatively. Thus, they are not typical of kimberlite ilmenites as defined by Mitchell (1979), but they are compositionally similar to ilmenites from carbonatites and carbonate-rich rocks in kimberlites (Gaspar and Wyllie, 1984). Rutile contains detectable niobium and tantalum.

Zoning is common in the fine-grained groundmass spinels. All are aluminum-poor. A compositional trend extends from titaniferous magnesian chromite towards magnesian ulvospinel - magnetite (Fig. 1). The latter occur both as rims on the former, and as discrete grains. This trend is similar to that developed in the groundmass spinels of the Koidu kimberlite dykes in Sierra Leone (Tompkins and Haggerty, 1985). In the D1 kimberlite, the latter stages of this trend are accompanied by magnesium depletion. Mantles of magnesian titaniferous magnetite are developed on the spinels in the ARP, RSP, and D1 kimberlite.

Spinels of separate kimberlite phases are distinguishable by their Mg and Al contents. Within each phase, the number of Mg and Al ions per formula unit is relatively invariant (with the exception of the Mg depletion noted in D1), despite the increases in Fe and Ti, and the decrease in Cr. Thus, in a Mg vs. Al cation-cation plot, the spinels of each phase occupy a restricted field. These fields are slightly overlapping, and define an overall trend of decreasing Mg as Al decreases (Fig.2), which suggests that the several phases of the diatreme may represent separate intrusions drawn from a single fractionating source.

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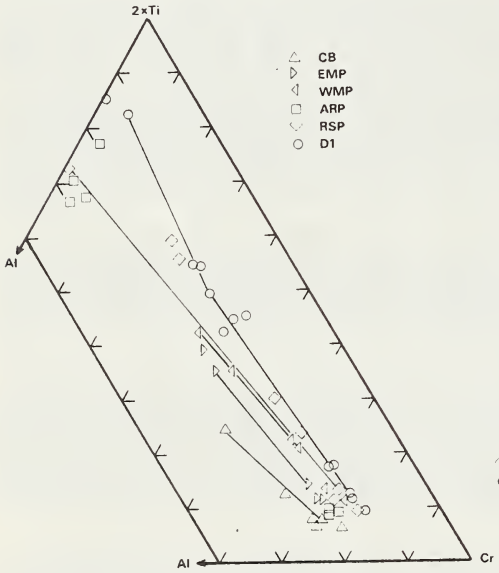

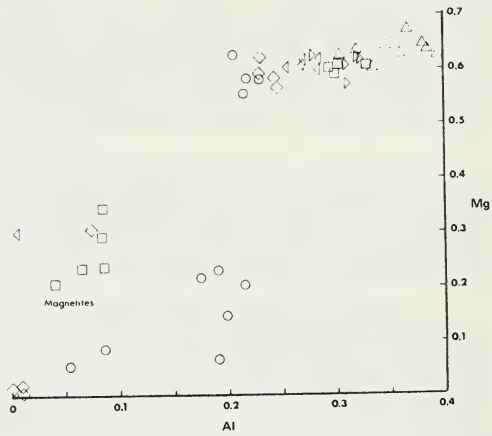

Figure 1 (left). Al-Cr-(2xTi) plot of groundmass spinel compositions. The tie lines connect cores (lower right) to rims (upper left) of selected analyses. Some analyses are omitted for clarity.

Figure 2 (right). Mg vs. Al cation-cation plot of groundmass spinel compositions, based on four oxygens per formula unit. Symbols as for Fig. 1. The aluminum-poor spinels (<0.1 Al p.f.u.) are magnetites.