KIMBERLITES, MELNOITES AND LOOK-ALIKES IN BRITISH COLUMBIA, CANADA

Pell* JA[1] and Ijewliw OJ[2]

[1] *Dunsmuir Ventures Ltd., Canada,* [2] *Geological Survey of Canada, Canada*

INTRODUCTION

Kimberlites, ultramafic and alkaline lamprophyres and other alkalic ultrabasic rocks occur within a broad belt in the eastern Canadian Cordillera that parallels the Rocky Mountain Trench (Figure 1). Most occur in the Foreland Belt, east of the Trench; however, there are a few documented occurrences in the Omineca Belt, west of the Trench. All were emplaced into the passive continental margin sedimentary prism prior to the deformation and metamorphism associated with the Jura-Cretaceous Columbian orogeny. They were variably deformed, metamorphosed and transported north-eastwards relative to the mantle and basement which they penetrated. These rocks are part of an alkaline igneous province that also includes carbonatites, nepheline and sodalite syenites and ijolites (Pell, 1994).

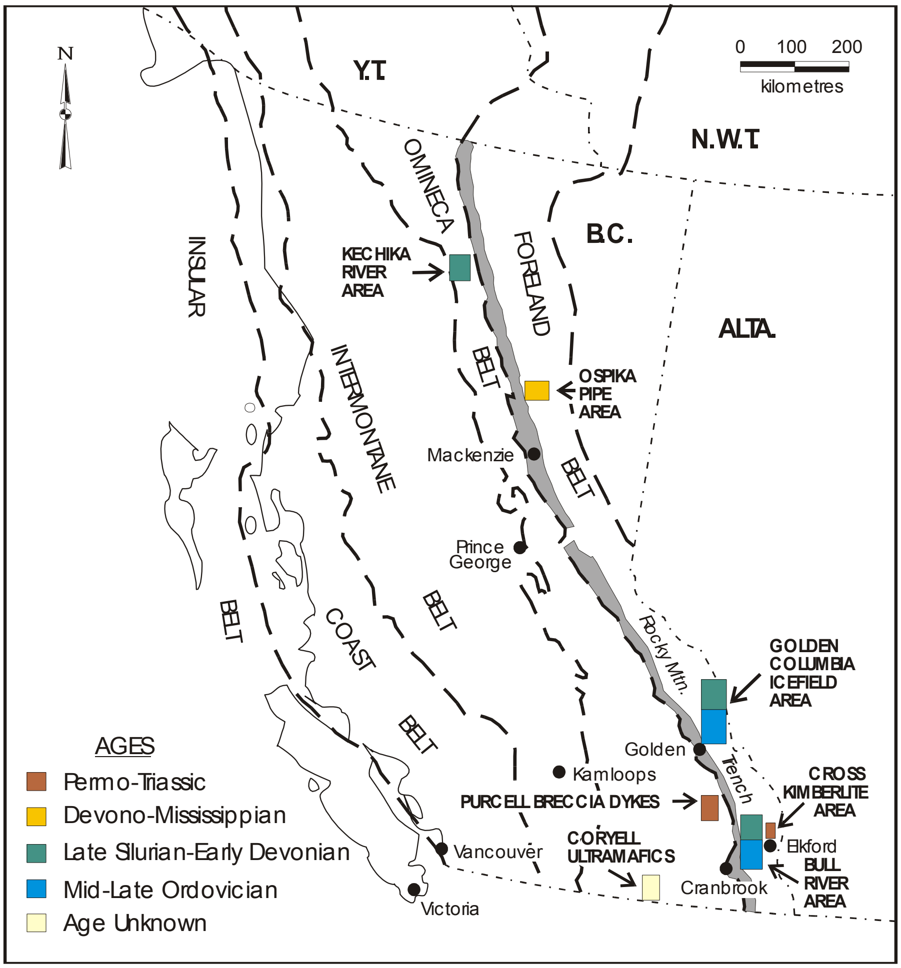

Figure 1: Locations and ages of kimberlites, ultramafic and alkaline lamprophyres and associated rocks in British Columbia.

OCCURRENCES

KIMBERLITES

True kimberlites, five pipes and two dykes, have been identified near Elkford. The Cross diatreme was discovered in the late 1950's but first recognized as a kimberlite in 1976. The Bonus pipe was discovered shortly afterwards and the Ram pipes were discovered in the early 1990's. They intrude Pennsylvanian-Permian carbonate rocks and the Cross Pipe has been dated as late Permian, circa 245 ma (Grieve, 1982; Smith, 1983).

The Cross kimberlite is the best studied of this group (Grieve, 1982; Hall et. al. 1989). It is a multiphase intrusion that contains macrocrysts of phlogopite and serpentinized olivine and xenocrysts of pyrope garnet (G-9 & G-10), chrome diopside, picro-ilmenite, and chromite in a matrix of calcite, serpentine, talc, phlogopite, oxides (rutile, ilmenite and spinel) and apatite. Xenoliths of altered spinel and garnet peridotites, rare fresh garnet lherzolites and glimmerites, and abundant sedimentary rocks are present. Some phases are characterized by spherical structures: peridotite xenoliths coated with kimberlite magma material (Figure 2).

Figure 2: Small peridotite xenolith armoured with kimberlite, Cross Pipe.

A few small diamonds are reported to have been recovered from the Ram 5 and Ram 6.5 pipes, the largest weighing 0.225 cts.

ULTRAMAFIC LAMPROPHYRES

Aillikites, a variety of ultramafic lamprophyre, are found north of Golden (HP Pipe) and north of Mackenzie (Ospika Pipe). The HP Pipe is the southern most of a series of diatremes in the area north of Golden, the rest of which are better classified as alkaline lamprophyres (see below). The Ospika Pipe is located approximately 150 metres to the west of the Aley carbonatite complex (Pell, 1994). Radiometric dates on the HP Pipe suggest it was emplaced in the early Devonian, circa 390 to 400 Ma; the Ospika pipe yielded a Mississippian age of 340 to 350 Ma (Pell, 1994).

Both are multiple intrusions containing a number of different breccia phases and dykes (Figure 3) hosted by Lower Paleozoic carbonate strata. Both have spherical structure (globular segregation) -rich phases (Figure 4) and contain autoliths and macrocrysts of mica (biotite or phlogopite), black titaniferous clinopyroxene and chrome diopside in a matrix dominated by carbonate (calcite or dolomite), mica (biotite or phlogopite), chlorite, amphibole, opaque oxides and pyrite +/- talc. Serpentine is present in the HP Pipe and altered olivine was found in the Ospika Pipe. The HP Pipe also contains melanite (Ti-andradite) garnets in the matrix (Ijewliw, 1991). No mantle xenoliths or diamonds have been recovered from either pipe.

Figure 3: Half-metre wide dyke intruding breccias, HP pipe.

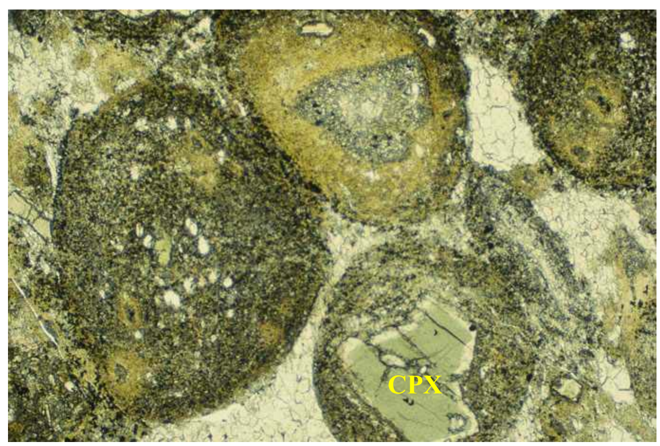

Figure 4: Spherical structures, with a reversely zoned clinopyroxene (CPX) in the core of one, HP pipe. Field of view = 2.8 mm.

ALKALINE LAMPROPHYRES

Another two dozen diatremes and related dykes that bear strong affinities to alkaline lamprophyres have been discovered north of Golden, east of the Rocky Mountain Trench. They occur in a belt some 50 kilometres long immediately west of the BC-Alberta border, stretching from the headwaters of the Bush River, to Lens Mountain, Mons Creek and Valencia River. All are hosted in Cambrian or Cambro-Ordovician strata and deformed and metamorphosed to the extent that original mineralogy is often hard to determine, making classification difficult. A Late Silurian/Early Devonian radiometric date of 410 Ma was obtained from a dyke in the Bush River area (Pell, 1994). Zircons obtained from a number of the intrusions in the Golden area were, for the most part xenocrystic, yielding Proterozoic and late Archean ages; however one euhedral zircon from a dyke at Mons Creek returned a mid- to late-Ordovician age of around 470 Ma (Parrish and Reichenbach, 1991, Pell, 1994,), which possibly represents the age of zircon crystallization and may be equivalent to, or slightly older than the age of emplacement.

A number of different lithologies are present. Rusty to buff to light-green weathered breccias consisting of sedimentary rock fragments and sedimentary quartz xenocrysts in a matrix of carbonate, chlorite, iron oxides and talc or serpentine are common to all areas. Those found at Bush River are considerably coarser and more clast-rich than in the other areas.

Rusty to dark-green weathered breccias, with more recognizable igneous components occur in all areas. They contain variable amounts of altered macrocrysts of mica (Figure 5) and olivine in a matrix of carbonate, chlorite, mica (muscovite or biotite), spinel, quartz and apatite +/- altered olivine, serpentine, talc, pyrophyllite, pyrite, altered plagioclase and clay. Armoured xenoliths (Figure 6), nucleated autoliths and spherical structures (globular segregations or pelletal lapilli) were found at Bush River.

Plate 5: Altered mica megacryst, Bush River

Dykes associated with the breccias generally contain macrocrysts or phenocrysts of olivine or olivine pseudomorphs, mica (commonly biotite), pyroxene or pyroxene pseudomorphs +/- amphibole and plagioclase or sanadine in a fine-grained matix of carbonate, serpentine, biotite or altered biotite and opaque oxides +/- chlorite, clinopyroxene, plagioclase, sphene and quartz.

Figure 6: Armoured granitic xenolith, Bush River.

The metamorphism and alteration that these rocks have been subjected to makes their identification difficult. They appear to best fit the alkaline lamprophyre clan (Pell, 1987; Ijewliw, 1992, McCallum, 1994), but in some cases, have been described as olivine kersantite, a variety of calc-alkaline lamprophyre (eg. Bush River, Ijewliw, 1992), or possibly as lamproitic (McCallum, 1994).

Mantle xenoliths are rare, some altered spinel peridotites have been found in the Valencia River pipes. The Golden Pipes were the target of diamond exploration, predominantly in the late 1980's and pyrope garnet, picro-ilmenite, chromite and a few small diamonds have reportedly been recovered from them.

ALKALI BASALTS

Over forty diatreme breccia pipes and related dykes that bear some affinities to limbugites or to the alkali basalt-nephelinite family occur in the Bull River area, east and northeast of Cranbrook. Most were discovered in the mid 1970's during a regional exploration program conducted in the southern Rocky Mountains after the discovery of the Cross Kimberlite (Roberts et. al., 1980). They are hosted in Cambro-Ordovician to Silurian strata and, in some cases, can be seen to be unconformably overlain either by late Odovician strata (eg. White River diatreme, Helmstaedt et. al., 1988 and Mount Dingley Diatreme, Norford and Cecile, 1994) or by basal Devonian rocks (eg. Russell Peak diatreme, Pell, 1987; 1994). No radiometric dates were obtained from these bodies and, therefore, their ages can only be estimated using stratigraphic relationships.

Most of these intrusions are moderately well foliated and contain altered vesicular glass lapilli (Figure 7), altered olivine and possible pyroxene crystals along with calcite and chrome spinel in a groundmass of carbonate, chlorite, talc and minor plagioclase. They are generally devoid of primary hydrous phases such as mica. In a few areas, unaltered porphyritic magmatic rocks that contain titanaugite and olivine phenocrysts with titanaugite, olivine, labradorite and opaque oxide microphenocrysts in a fine-grained groundmass were observed. Autoliths as well as pyroxenite, peridotite and hornblendite xenoliths are present in some pipes and eclogite nodules have been reported; however, no diamonds have been recovered from any of these occurrences.

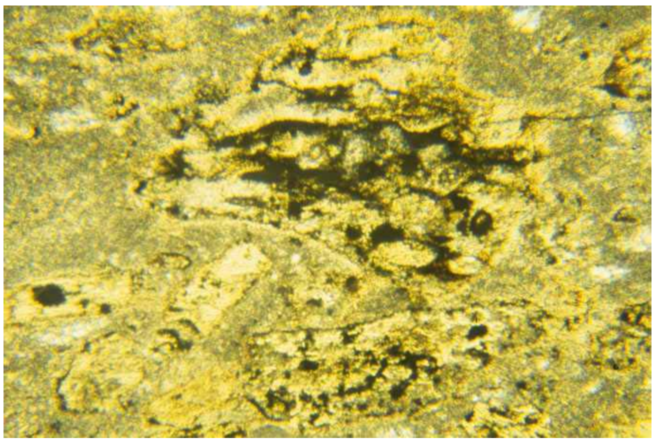

Figure 7: Altered glass lapilli, Blackfoot Pipe. Field of view = 1.8 mm.

ULTABASIC-ULTRPOTASSIC ROCKS

Two areas west of the Rocky Mountain Trench contain ultrabasic-ultrapotassic rocks. Breccia dykes occur in the northern Purcell Mountains, in southern British Columbia, and a diatreme breccia and related dykes are present in the Kechika River area, northern British Columbia.

Two types of breccia dykes have been identified in the Purcell Mountains (Pope and Thrilwall, 1992). The first contain pseudomorphed phenocrysts of olivine +/- phlogopite in a matrix of carbonate, opaques and an unidentified altered lath-shaped phase (phlogopite?). The second are characterized by phenocrysts of phlogopite and apatite in a matrix of carbonates, chlorite, phlogopite and apatite. Pyroxenite xenoliths have been identified in these dykes. A radiometric date of 245 Ma has been obtained from one of these dykes (Pope and Thirlwall, 1992). Although these dykes were staked in the late 1990's as diamond prospects, there is no public record of any being tested for diamonds.

The Kechika diatreme and associated dykes are located in the Cassiar Mountains of northern British Columbia and appear to be part of a suite of alkaline rocks which includes trachytes, syenites, malignites and carbonatites (Pell, 1994). No radiometric ages have been obtained for these rocks, but based on stratigraphic relationships, they appear to be Silurian or slightly younger and may be part of the late Silurian to Early Devonian emplacement episode. The Kechika diatreme comprises heterolithic breccias containing juvenile and vesiculated glass lapilli, chrome spinel xenocrysts and phlogopite and K-feldspar crystal fragments in a matrix rich in carbonate minerals and potassium feldspars with muscovite and chrome mica. One small diamond has reportedly been recovered from the Kechika diatreme.

OTHER DIAMOND-BEARING ROCKS

Fifteen small diamonds have reportedly been recovered from two 1000 kg samples of harzburgitic to dunitic rocks associated with the Coryell Batholith in southern B.C., east of Christina Lake (Walker, 1995). The rocks are described as massive to sheared, fine to coarse-grained, and consisting of olivine and varying amounts of orthopyroxene with some chromite and clinopyroxene. They do not appear to be related to the other intrusions discussed here and require additional study.

GEOCHEMISTRY

Not surprisingly, the majority of these alkaline rocks are as hard to classify on the basis of geochemistry as they are petrologically. The age of the rocks, tectonic displacement and metamorphic overprint has probably resulted in some chemical mobility precluding easy classification. The majority of the Bull River suite overlap the basalt and alkaline lamprophyre fields on an alkali-silica plot; the Golden Pipes scatter with a mean composition near the alkaline lamprophyre field; and the HP and Ospika pipes cluster around the alnoite (ultramafic lamprophyre) field (Figure 8). Only the Cross rocks plot uniquely within a field: the kimberlite field.

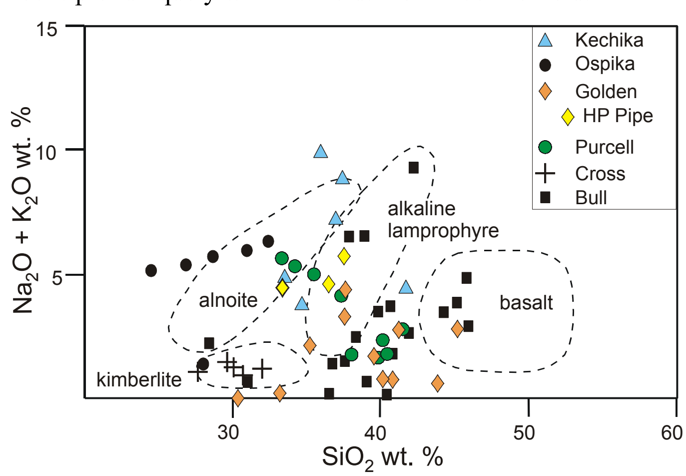

Figure 8: Alakali-silica plot, BC diatremes

CONCLUSIONS

An alkaline igneous province in the Canadian Cordillera comprises rocks emplaced into the passive continental margin sedimentary prism prior to the deformation and metamorphism associated with the Jura-Cretaceous Columbian orogeny. Four main periods of emplacement are recorded: mid- to late-Ordovician (~455 Ma - some Cranbrook intrusions, and possibly some dykes in the Golden area); late Silurian to early Devonian (~400 Ma – some Cranbrook and Golden pipes and possibly the Kechika diatreme); Early Mississippian (~350 Ma – Ospika Pipe); and Permo-Triassic (~245 Ma – Cross Kimberlite and Purcell Dykes). These represent periods of extension or rifting along the western margin of North America.

Although small numbers of diamonds have been recovered from some of these intrusions, the bulk of these bodies do not fit traditional diamond exploration models and many have not been thoroughly explored. Few are true kimberlites or bona-fide lamproites. All have been transported and cut off from their roots during orogenesis and therefore have limited volume potential. However, xenocrystic zircons recovered from some of the Golden diatremes indicate that Archean rocks must have underlain the passive margin where they formed suggesting they were on or near craton when emplaced.

REFERENCES

Grieve, D.A., 1982. 1980-Petrology and chemistry of the Cross Kimberlite. BC Ministry of Energy, Mines and Petroleum Resources Geology in British Columbia, 1977-1981, 34-41, Victoria, BC, Canada.

Hall, D.C., Helmstaedt, H. and Schulze, D.J., 1989. The Cross diatreme, British Columbia, Canada: A kimberlite in a young orogenic belt. In Kimberlites and Related Rocks, Volume 1; Geological Society of Australia Special Publication No. 14, 97-108, Perth, W.A.

Helmstaedt, H.H., Mott, J.A., Hall, D.C., Schulze, D.J. and Dixon, J.M., 1988. Stratigraphic and Structural Setting of Intrusive Breccia Diatremes in the White River-Bull River area, southeastern British Columbia. *In* Geological Fieldwork 1987, BC Ministry of Energy, Mines and Petroleum Resources Paper 1988-1, pp. 363-368.

Ijewliw, O. J. 1991. Petrology of the Golden Cluster Lamprophyres, southeastern British Columbia, Canada. M.Sc thesis, Queen’s University, Kingston, ON, Canada., 270p.

Ijewliw, O.J., 1992. Petrology of the Golden cluster lamprophyres in southeastern British Columbia. *In* Geological Fieldwork 1991, BC Ministry of Energy, Mines and Petroleum Resources Paper 1992-1, pp. 37-45.

McCallum, M.E., 1994. Lamproitic (?) diatremes in the Golden area of the Rocky Mountain fold and thrust belt, British Columbia, Canada. *In* Proceedings of the Fifth International Kimberlite Conference: Kimberlites, Related Rocks and Mantle Xenoliths, H.O.A. Meyer and O.H. Leonardos (ed.), V. 1. Companhia de Pesquisa de Recursos Minerais, Special Publication 1/A, pp. 195-210.

Norford, B.S. and Cecile, M.P., 1994. Ordovician emplacement of the Mount Dingley Diatreme, Western Ranges of the Rocky Mountains, southeastern British Columbia. Canadian Journal of Earth Sciences 31, pp. 1491-1500.

Parrish, R.P. and Reichenback, I., 1991. Age of xenocrystic zircon from diatremes of western Canada. Canadian Journal of Earth Sciences 28, pp. 1232-1238.

Pell, J., 1994. Carbonatites, nepheline syenites, kimberlites and related rocks in British Columbia. BC Ministry of Energy, Mines and Petroleum Resources Bulletin 88, Victoria, BC, Canada.

Pell, J., 1987. Alkaline Ultrabasic Rocks in British Columbia: Carbonatites, Nepheline Syenites, Kimberlites, Ultramafic Lamprophyres and Related Rocks. BC Ministry of Energy, Mines and Petroleum Resources Open File 1987-17, Victoria, BC, Canada.

Pope, A.J. and Thirlwall, M.F., 1992. Tectonic setting, age and regional correlation of ultrabasic-ultrapotassic dykes in the northern Purcell Mountains, southeast British Columbia, Canadian Journal of Earth Sciences, Vol. 29, pp. 523-530.

Roberts, M.A., Skall, H. and Pighin, D.L., 1980. Diatremes in the Rocky Mountains of Southeastern B.C. Canadian Institute of Mining and Metallurgy Bulletin, V. 71, # 821, Abstracts, pp. 74-75.

Smith, C.B., 1983. Rubidium-strontium, uranium-lead and samarium-neodymium isotopic studies of kimberlites and selected mantle-derived xenoliths. Unpublished Ph. D. thesis, University of the Witswatersrand, Johannesburg.

Walker, R.T., 1995. Assessment Report on the 49th Parallel Claim Group, Trail-Creek Mining Division, 82E/1E. BC Ministry of Energy, Mines and Petroleum Resources Assessment Report 23862.