SYSTEMATIC VARIATIONS IN XENOCRYST MINERAL COMPOSITION AT THE PROVINCE SCALE, BUFFALO HILLS KIMBERLITES, ALBERTA, CANADA

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The Buffalo Hills Kimberlite Province consists of thirty-seven known bodies, situated within the Paleoproterozoic Buffalo Head Terrane in north-central Alberta. The kimberlite province has been the site of systematic exploration since 1997 (Carlson *et al*., 1998), with most kimberlites identified as the result of diamond drill or reverse circulation programs. Nearly all of the kimberlites are presently classified as crater facies (Boyer *et al*., this volume), with twenty-four bodies known to contain diamond at the time of writing. Most of the Buffalo Hills kimberlites also contain a diverse xenocryst mineral assemblage, typically in the form of discrete grains or, less commonly, as part of a mantle nodule suite. The latter occurrence is included as part of a parallel study (Aulbach *et al*., this volume).

Indicator mineral assemblages have been assessed for twenty-nine of the Buffalo Hills kimberlites, with forsteritic olivine forming the dominant xenocryst or cryptogenic mineral species. Chromian pyrope garnet and chromite are also important constituents, although some pipes (eg. K8, K7B, K7C, and BM3) are devoid of these minerals. Eclogitic pyrope-almandine, titanian pyrope, chromian augite/ diopside, and picroilmenite are also present in lesser amounts, and some bodies contain chromian corundum, zircon, edenitic amphibole, and Mg-Cr-Al spinel. Mineral contents and compositions have been found to be relatively consistent across larger, more complex kimberlites such as K14, allowing for direct comparison between kimberlites without the influence of multiple local-scale variations. Indicator content was not found to parallel diamond content, as moderately to highly diamondiferous bodies such as K252 and K6 were found to contain relatively few indicators when compared to weakly diamondiferous pipes such as K2 and K95.

Chromian pyrope garnet of peridotitic paragenesis occurs in most of the Buffalo Hills kimberlites and provides the best measure of indicator mineral compositional trends. In all pyrope-bearing kimberlites, grains are generally calcic and fall along trends associated with lherzolitic or wehrlitic sources (Figure 1). Lherzolitic trends are slightly less calcic for the northerly, more diamond-rich bodies (eg. K14, K6, K5), whereas compositionally-restricted, higher Ca pyrope is more abundant in the southern and southeastern part of the province (eg. LL8, K15, K1). The highly diamondiferous K252 kimberlite is distinctive in that pyrope tends to contain coincident elevated Ca and Cr contents, with a small proportion of grains occurring as greenish-tinted, moderately subcalcic grains with Cr contents up to 18 weight percent. These grains are present to a lesser extent in concentrates from the moderately diamondiferous K14 and K6 kimberlites, suggesting a possible link between elevated Cr-in-garnet and diamond.

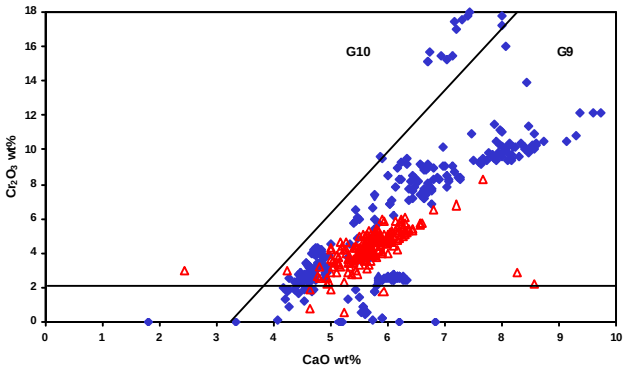

Figure 1: Garnet compositions in Cr-Ca space. Solid diamonds are for diamondiferous K252 and K14 kimberlites. Open triangles are for weakly diamondiferous LL8, K1, and K15 kimberlites.

Chromite compositions follow a similar pattern to peridotitic pyrope, with the northern, more diamondiferous kimberlites exhibiting a trend of increasing Cr with decreasing Mg, and coincident increasing Cr and Mg for bodies in the south and southeast (Figure 2). Titanium contents are highly variable in most bodies, with abundant, high-Ti grains noted in diamondiferous bodies as well as barren ones. A secondary population of Mg-Cr-Al spinel is also present in a few bodies, becoming relatively important in the K6 and K252 kimberlites, but a paragenetic relationship has not been established. The presence of this mineral in the essentially barren K7A kimberlite indicates that the mineral may not be related to elevated diamond content.

Eclogitic pyrope-almandine is present in some kimberlites in the Buffalo Hills, occurring in a range of kimberlites such as K14, K2, K10, and K11. Sodium contents are

variable, with the highest values noted in the weakly to moderately diamondiferous K10 and K11 kimberlites.

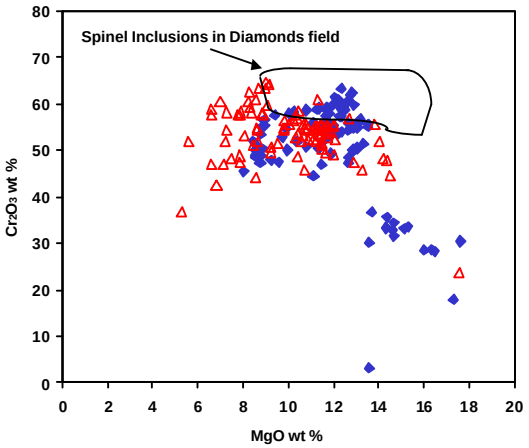

Figure 2: Chromite compositions in Mg-Cr space. Solid diamonds are for diamondiferous K252 and K14 kimberlites. Open triangles are for weakly diamondiferous LL8 and K2 kimberlites.

Conversely, the K14 kimberlite, which includes diamonds with eclogitic inclusions (Davies *et al.*, this volume), contains an eclogitic garnet suite with very low (<0.03 wt%) Na_2O contents. Low chromium, titanian pyrope garnets are also variously represented in the Buffalo Hills, with contents generally highest in kimberlites from the southern part of the province (eg. K2, K3).

Magnesian ilmenite is a relatively sparsely distributed mineral in the Buffalo Hills, with most occurrences noted in pipes from the southern group. Compositions are distinctive in that Nb_2O_5 contents up to 3 to 4 weight percent are present in some bodies (K1, K2, and K15). Interestingly, ilmenite appears to negatively correlate with diamond content, although the diamondiferous K10 and K11 kimberlites also contain the mineral. Ilmenite from these pipes is distinctive in that Nb_2O_5 content is generally quite low, implying that the presence of Nb in the ilmenite population may signify a mantle event that was diamond destructive.

Selected kimberlite garnet, chromite, and pyroxene populations were subjected to a more rigorous analytical program for determination of trace element contents, including analysis of Ni in peridotitic garnet and Zn in chromian spinel for the purposes of rough geothermometry. Garnet populations from the highly diamondiferous K252 and weakly diamondiferous K160 kimberlite in particular were examined, for comparison of the northern and southern kimberlite clusters. The application of Ni-in-garnet analysis to these kimberlites was also compared with results obtained by application of the Mn-in-garnet geothermometer proposed by Grutter *et al.* (1998), with the relatively good correlation between the two analytical approaches allowing for expansion into other kimberlites defined only by the standard major element analytical package.

Ni-in-garnet temperatures for the K252 and K160 kimberlite both display concentrations between 900 and 1200° C, with the K252 garnets including a dense cluster at around 980° C. The garnet populations show distinct differences however, when plotted against Y and TiO_2 content. The K252 kimberlite displays relatively low levels of the "metasomatic indicator" elements, with little increase associated with increasing temperature. The K160 kimberlite, however, contains a well-defined population of higher Y, higher TiO_2 garnets at around 1200° C, suggesting possible derivation from sheared lherzolites associated with the base of the lithosphere. The appearance of the metasomatized population within the diamond-poor kimberlite may imply a thinner lithosphere associated with the K160 garnets, or a diamond-destructive event that has altered the bulk of the lithosphere within the diamond stability field.

Single grain thermobarometry has also been applied to clinopyroxene grains recovered from diamondiferous and diamond-poor kimberlites, using the method defined by Nimis and Taylor (2000). Grains from the diamondiferous K252 and K14 kimberlites define a maximum pressure of 41.7 kb at a temperature of 882° C, although most grains imply much lower P and T. The grains fall outside of the diamond stability field, suggesting a source other than clinopyroxene-bearing rocks for the diamond population, or lack of representation of deeper-source clinopyroxene. A few grains from the K2 and K95 kimberlites define anomalously high pressures of up to 58.5 kb, but the significance of these grains is unknown.

The Buffalo Hills Province is unusual in that the more diamondiferous kimberlites (eg. K6, K14, and K252) do not have typical "diamond prospective" indicator chemical signatures. The paucity of harzburgitic garnet is typical of Proterozoic or younger mantle lithosphere, and agrees with the few U-Pb age dates generated for basement material in the Buffalo Head Terrane. The presence of high-Cr, subcalcic garnet with high-Cr, "xenocrystic" chromite and eclogitic pyrope-almandine appears to represent the best method of predicting diamond potential in the region, suggesting lherzolitic and eclogitic sources for Buffalo Head diamonds. The southern bodies, and those proximal to the axis of the Peace River Arch, have grades of 1 cpht or less and are dominated by compositionally restricted, lower-Cr pyrope and chromite. The absence of the higher-Cr assemblage, coupled with the presence of niobian picroilmenite and elevated "metasomatic" elements in the south may indicate that a chemical or thermal event has modified the southern part of the Buffalo Head mantle lithosphere.

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