Corganites and corgaspinites: Two new types of aluminous assemblades from the Jagersfontein kimberlite pipe

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INTRODUCTION. Two new varieties of peraluminous xenoliths related to alkremites have been recovered from the Jagersfontein kimberlite pipe, South Africa. This paper will highlight some of the physical, petrographic and chemical characteristics of these nodules, compare them with alkremite samples, also from Jagersfontein, and provide a tentative working hypothesis concerning their origin.

SAMPLES AND PETROGRAPHY. The present nodule suite consists of 56 samples which can be categorized into 3 groups: a garnet+spinel assemblage (alkremite), a corundum+garnet assemblage (corganite) and a corundum+garnet+spinel assemblage (corgaspinite).

The alkremite nodules are similar to others previously described from Bellsbank and Jagersfontein kimberlites, South Africa^{1,2} and kimberlites from Moses Rock Dike, Utah³. They typically occur as oval nodules (up to 5 cm in length) containing flesh colored garnet and black spinel. The modal abundances of these two minerals are highly variable and rare samples contain >90% spinel while others consist of >90% garnet. Accessory phases may include any combination of clear corundum, brown pleochroic phlogopite and calcite confined to cracks and grain boundaries. In addition, clear anhedral pyroxene grains (usually < 1 mm) enclosing tan pleochroic amphibole, phlogopite and microscopic euhedral green spinels are confined to garnet cores. The corundum bearing corganites and less abundant corgaspinites are similar in size and shape to the alkremites but are easily distinguished from them by the presence of light to dark blue sapphire and rare ruby grains which vary widely in size (up to 1 cm) and abundance (5 to 75%). In many cases the corundum and, more rarely, the spinel grains in these assemblages are confined to discrete layers, with band widths between 1 and 2 cm. Garnet usually comprises 30 to 70% of the mode, may show kelyphite rims, and in a few cases displays extensive alteration to a submicroscopic, optically unidentifiable material. Spinel may vary between 0% (i.e. corganite) and 30% (i.e. corgaspinite) by mode. Accessory phases in these assemblages are similar to those of the alkremite suite, with the exception of amphibole which has not yet been identified in the corundum rich samples. One observation of note is that the pyroxene mineral clusters confined to garnet cores in the alkremite nodules are also present in the corganites and corgaspinites (with the exception of amphibole) and, in these latter assemblages, the pyroxene is usually much coarser (up to 3 mm) and more abundant. Green euhedral spinels within the pyroxenes also attain appreciable sizes (up to 1 mm).

MINERAL CHEMISTRY. Electron microbeam analyses for selected samples are shown in Table 1. All primary minerals are essentially homogeneous based on core and rim analyses of individual grains. Figure 1 shows the Ca-Mg-Fe atomic ratios of garnets, spinels and pyroxenes from the Jagerfontein nodule suite and published alkremite data¹⁻³.

Garnets are chromium-poor pyropes containing nearly constant almandine (Fe/Fe+Mg+Ca = 0.17-0.19), and variable grossular (Ca/Ca+Mg+Fe = 0.16-0.31). Alkremite (open symbols) garnets tend to cluster near the magnesian-rich part of the scatter, but one garnet grain (JAG ALK-17) lies above the main garnet trend (Fig. 1), and contains an anomalously high grossular content that resembles that of grospydite garnets⁵. Corundum grains in the corundum rich assemblages, as well as accessory corundum grains in the alkremites (not shown in Fig. 1) are generally pure, containing 98-99 wt.% Al₂O₃, minor amounts of FeO (0.5 to 1.0 wt.%), Cr_2O_3 (0.2 to 0.4 wt.%) and TiO₂ (0.2 to 0.6 wt.%). Primary spinels (SP1, Table 1) have variable Cr_2O_3 contents (up to 2.3 wt.% in the alkremites, open symbols, but generally <1.0 wt.% in the corganites and corgaspinites, solid symbols) and are essentially hercynite-bearing pleonastes. The Mg/Mg+Fe ratios of primary spinels are very similar to those of associated garnets ranging between 74 and 80. Brown spinels mantling corundum (SP3, Table 1) are compositionally very similar to primary spinel grains and completely overlap SP1 in Fig. 1. In contrast, green euhedral spinels (SP2, Table 1) contain highly variable Cr_2O_3 contents (1.0 to 10.8 wt.%) with cores being generally richer in Cr_2O_3 than rims. They contain higher Fe₂O₃ contents (calculated), lower FeO, and slightly lower Mg/Mg+Fe ratios than the other spinels and, although some overlap is present, as

a group they define a tail trending toward higher Fe contents on the Ca-Mg-Fe projection.

BULK CHEMISTRY. Bulk rock major element analyses of selected corganite, corgaspinite and alkremite nodules from Jagersfontein as well as calculated bulk rock alkremite compositions^{1,4} are given in Table 2 (total Fe is reported as Fe_2O_3 '). The corganites (CO) and corgaspinites (COS) have a wide compositional spectrum, specifically with respect to SiO_2 (2.41-40.48 wt. \mathfrak{X}) and Al_2O_3 (21.78-80.67 wt. \mathfrak{X}). Variations are also evident in Fe_2O_3 ' (4.17-12.21 wt. \mathfrak{X}), CaO (1.83-11.62 wt. \mathfrak{X}) and MgO (7.57-15.56 wt. \mathfrak{X}). Cr values for all samples are relatively constant and consistently low (0.05-0.29 wt. \mathfrak{X}). Generally, the corgaspinites contain higher amounts of A1 and lower amounts of Si, Ca and Mg than the corganites with no preference of Fe⁺ for either assemblage. The alkremite data (Table 2) are subdivided into two groups consisting of alkremites (ALK) and spinel- rich alkremites (SP-ALK). The first group (ALK) show variations in SiO_2 (29.5-41.0 wt. \mathfrak{X}) and MgO (16.4-19.7 wt. \mathfrak{X}). Cr values are again consistently low (0.1-0.5 wt. \mathfrak{X}). The spinel-rich alkremite group has very low, but variable SiO_2 (1.0 -13.1 wt. \mathfrak{X}) and relatively high Al_2O_3 (50.6-63.5 wt. \mathfrak{X}) and MgO (19.6-23.3 wt. \mathfrak{X}). These data are consistent with very high modal spinel (up to 95 \mathfrak{X}).

Data from Table 2 are presented in Figure 2, together with compositional fields for eclogites and average basalts⁵. The CaO-MgO-total FeO plot (Fig. 2a) shows that most of the Jagersfontein samples fall in the basalt field with relatively constant CaO/FeO ratios and variable MgO; the spinel-rich alkremites plot close to the MgO-FeO join. One calculated alkremite composition¹ conforms with the present alkremite trend, whereas the other⁴ is shifted toward slightly higher MgO contents. An alternate representation expressed as CaO-Al₂O₃-(FeO+MgO) in Fig. 2b, emphasizes the nature of these extreme bulk compositions relative to basalts and eclogites. Corganites and corgaspinites form a continuos trend, however, from near the Al₂O₃ apex toward the eclogite and basalt fields. In order to obtain a representative bulk composition for the suite, the corganite and corgaspinite, alkremite, and spinel-rich alkremite data were averaged, both as individual groups, and as a single group, thus generating four additional bulk compositions (Table 2). These calculated bulk compositions are too rich in Al and too poor in Ca to correspond to any variety of eclogites. In fact, any combination of group averages yields similar results.

DISCUSSION. Coherence in geochemical data (Fig. 1-2) imply a genetic link among alkremites, corgaspinites and corganites. Cotectic crystallization and subsequent fractionation of garnet and spinel from an aluminous partial mantle melt has been suggested for the production of alkremites¹. Arguments favoring this process are: (1) distinct cumulate textures and (2) only slight enrichment in mantle alumina, from that of average mantle composition⁶, is needed to cause coprecipitation of garnet+spinel in the CMAS system. If this is applicable to the corganite and corgaspinite suite, liquidus corundum +garnet and excessively high temperatures are required⁷. Al-enrichment in the source regions of alkremite "magmas" has been addressed², with subduction of chloritic oceanic crust generating local regions of upper mantle enrichment in Mg and Al. Pelitic sediments are capable of generating strongly peraluminous magmas⁸ and, although plausible, is restrictive. Metasomatic reaction between pyroxenitic melts and peridotite has also been suggested due to the presence of secondary minerals such as kornerupine and chlorite³. An alternate explanation for these peraluminous assemblages is fractional crystallization of feldspathic magmas at the base of the crust. Such liquids are, on rare occasions, capable of crystallizing corundum and spinel at reasonable temperatures and pressures⁹. Early accumulation of these phases would cause a density stratification resulting in layering of corundum followed by spinel. Subsequent metamorphism at higher pressures would stabilize garnet which could produce a garnet-corundum assemblage in the corundum rich layers, and a garnet-spinel assemblage in the spinel layers. Trace element and isotopic data in progress, may help to resolve the genesis of these unusual xenoliths.

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