

SYNTHESIS OF PYROPE-KNORRINGITE GARNET AND THE ORIGIN OF DIAMONDS OF PERIDOTITE PARAGENESIS

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The garnet solid solution series between pyrope ($\text{Mg}_3\text{Al}_2\text{Si}_3\text{O}_{12}$) and knorringite ($\text{Mg}_3\text{Cr}_2\text{Si}_3\text{O}_{12}$) was synthesised from oxide mixtures at 60-80 kbar and 1400-1500°C using Bridgman anvils. Lattice parameters and refractive indices were found to vary linearly with composition (Table 1 and Figure 1). Pure knorringite, synthesised for the first time, has a lattice parameter of 11.600 Å and a refractive index of 1.83. Synthesis of pure chromium kyanite Cr_2SiO_5 proved unsuccessful, however, Cr-rich kyanites ($\text{Al}_{0.5}\text{Cr}_{1.5}\text{SiO}_5$) were synthesised at 70 kbar, 1500°C. Refractive index data indicate complete solid solution from Al_2SiO_5 to at least $\text{Al}_{0.5}\text{Cr}_{1.5}\text{SiO}_5$.

The common occurrence of knorringite-rich garnets as inclusions in natural diamonds may provide a key to diamond genesis. Most diamonds occur in one of two major mineral parageneses (i) eclogitic, and (ii) peridotitic. The latter, either in close association with diamond or as inclusions within diamond, typically consists of olivine, enstatite and knorringite-rich garnet. Calcic pyroxene is absent and, moreover, the very low CaO content of the orthopyroxene would appear to preclude any prior coexistence of calcic pyroxene (Sobolev et al., 1973). These assemblages differ from normal mantle-derived garnet peridotites not only by lower CaO contents (and hence an absence of calcic pyroxene) but also in the much higher Cr_2O_3 contents exhibited by garnet and higher 100 Mg/(Mg + Fe) ratios in all phases.

The above chemical and mineralogical characteristics are inconsistent with the hypothesis that diamonds crystallised directly from kimberlite parent magmas (e.g. Williams, 1932), and point towards a more complex petrogenesis. It is suggested that the magnesian olivine + enstatite + knorringite-rich garnet paragenesis ultimately may have been derived from olivine + orthopyroxene + Cr-spinel cumulates (with minor sulfides) precipitated within the oceanic crust, and subsequently recycled into the mantle by subduction. Low-grade alteration may have introduced minor amounts of carbonates and hydrated phases (e.g. serpentine) into the cumulate assemblage. During subduction, partial melting is believed to have occurred, accompanied by metamorphic re-equilibration of the magnesian residual mineralogy to Cr-rich, Ca-poor garnet and orthopyroxene plus Fe-rich olivine. The lower redox state imposed by the low $\text{Fe}^{3+}/\text{Fe}^{2+}$ of the original cumulates (compared to their parental magma) together with the presence of minor sulfides, resulted in the breakdown of carbonate phases and CO_2 -bearing fluids in fluid inclusions, and precipitation of diamond within its P,T stability field. The wide range of carbon isotope compositions observed in natural diamonds (Sheppard and Dawson, 1975) appears to be compatible with this hypothesis. Moreover, the conclusions of Fesq et al. (1975) that some diamonds crystallised in the presence of a H_2O and CO_2 -rich picritic magma (the partial melt produced during subduction) and an immiscible sulfide phase, is consistent with the above hypothesis for diamond genesis.

References

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Table 1. Lattice parameters and refractive indices of pyrope-knorringite solid solutions

Composition	Lattice parameter Å	Refractive Index
$\text{Mg}_3\text{Al}_2\text{Si}_3\text{O}_{12}$	11.460 ± 0.001	1.714
$\text{Mg}_3\text{AlCrSi}_3\text{O}_{12}$	11.537 ± 0.002	1.768 ± 0.005
$\text{Mg}_3\text{Al}_{0.5}\text{Cr}_{1.5}\text{Si}_3\text{O}_{12}$	11.571 ± 0.002	1.795 ± 0.005
$\text{Mg}_3\text{Al}_{0.2}\text{Cr}_{1.8}\text{Si}_3\text{O}_{12}$	11.586 ± 0.002	1.82 ± 0.01
$\text{Mg}_3\text{Cr}_2\text{Si}_3\text{O}_{12}$	11.600 ± 0.001	1.83 ± 0.01 (extrap)

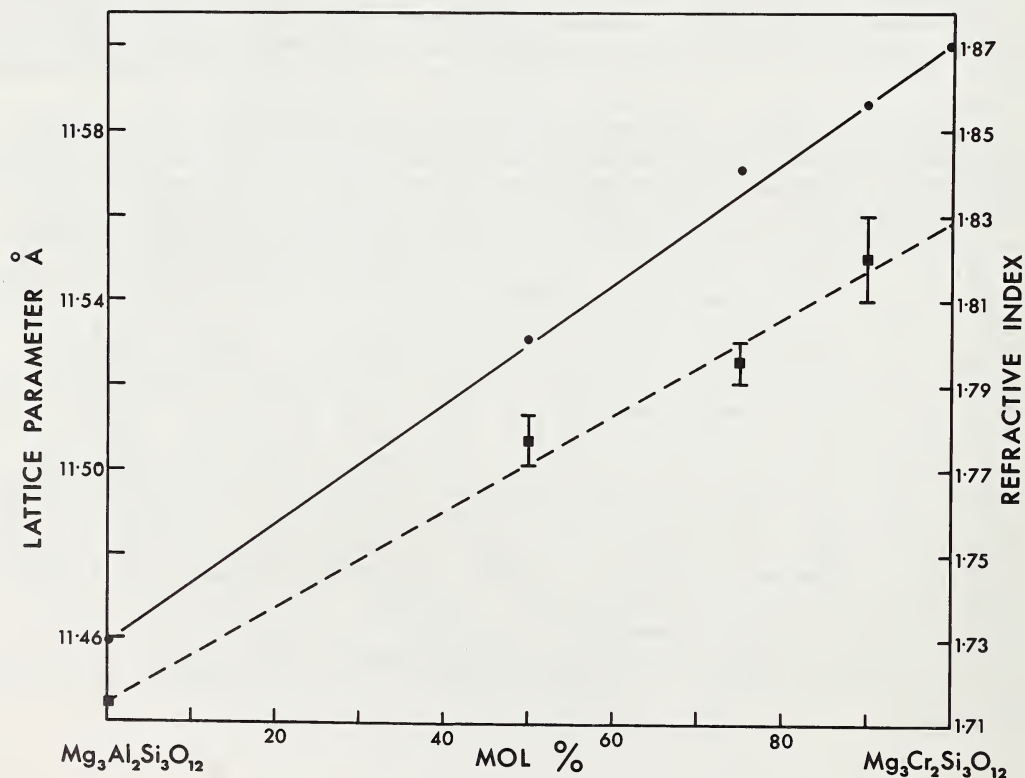


Figure 1.