COMPOSITION OF CRYSTALLINE INCLUSIONS AND C-ISOTOPIC COMPOSITION OF ARGYLE AND ELLENDALE DIAMONDS

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This study continues the work reported by Hall and Smith (1984). Futher data on syngenetic inclusion abundances at Argyle has been given by Harris and Collins (1985).

Ellendale diamonds contain approximately equal proportions of peridotitic and eclogitic inclusions. The peridotitic suite includes olivine, chrome-pyrope, chrome-diopside, enstatite and chrome spinel. The eclogitic suite is dominated by orange garnet but clinopyroxene, coesite and rutile are also present. Sulphides occur in both parageneses.

Inclusions in the Argyle diamonds are dominantly of eclogitic paragenesis of which orange garnet is the major syngenetic inclusion, with lesser clinopyroxene, coesite, kyanite, rutile and sulphide. Very rare ilmenite and moissanite were recovered. Peridotitic inclusions are dominantly olivine with rare purple chrome-pyrope and enstatite. Sulphide (chiefly pyrrhotite) also occurs in some peridotitic suites but can also occur solely associated with graphite. K-feldspar, determined by X-ray analysis to be orthoclase rather than sanidine, is a widespread inclusion. Although commonly having crystalline shape similar to the syngenetic inclusions it is assigned to the epigenetic suite as it is invariably rimmed by phlogopite or mixtures of other sheet silicates. Other epigenetic inclusions, also widespread, include abundant graphite together with phlogopite, talc, calcite, quartz, haematite, chlorite, anatase, sphene, rutile, kaolin and very rare priderite.

The Argyle eclogitic suite exhibits a wide range in Ca-Mg-Fe as shown by co-existing garnet and clinopyroxene (Fig. 1). Garnets range from relatively Ca-poor, pyrope-almandine (6 wt % CaO) through more calcium- and iron-rich varieties to rare grossular-rich garnet (17-18 wt % CaO). Ellendale eclogitic garnets have a more restricted range in Ca-Mg-Fe generally containing less than 10 wt % CaO. A characteristic of the Argyle eclogitic garnets is the very high Na contents, commonly 0.45-0.55 wt %, but range up to 0.71 wt %. These high Na contents are attended by high P and Ti (up to 0.39 wt % P_2O_5, 1.45 wt % TiO_2) but in contrast to the observations of Bishop et al (1976) in a number of the higher Na garnets Na exceeds P + Ti. In the most Na-rich garnets Si contents closely approximate ideal garnet stoichiometry and are unlike the Na-rich garnets with excess Si described by Moore and Gurney (1985). In contrast Ellendale eclogitic garnets are generally low in Na ($<$0.2 wt %) but can range up to 0.5 wt %. With no excess Na there is a balance with the P and Ti in the structural formula. There is also no excess Si implying no pyroxene component in the garnet.

The Argyle clinopyroxenes have very high jadeite components (up to 9.5 wt % Na_2O, 19 wt % Al_2O_3) and extremely high K_2O contents (up to 1.3 wt %). These are the highest K levels reported in pyroxene and indicate formation under very high pressure. There is little correlation between Na and K contents (Fig. 2). The clinopyroxenes from the Ellendale inclusions are more Mg-rich and have a lower jadeite component ($<$7 wt % Na_2O) and lower K_2O ($<$0.5 wt %) values than the Argyle inclusion clinopyroxenes.

The peridotitic inclusions from both Argyle and Ellendale are characterised by refractory compositions, i.e. high olivine with mg_{92-94} and Cr-rich pyrope (up to 15% Cr_2O_3). Alumina contents in enstatite are particularly low, as observed by Hall and Smith (1984).

Comparison of the C-isotopic compositions of Argyle and Ellendale inclusion-bearing diamonds shows that most of the Ellendale stones, both peridotitic and eclogitic, and the Argyle diamonds with peridotitic inclusions have small negative

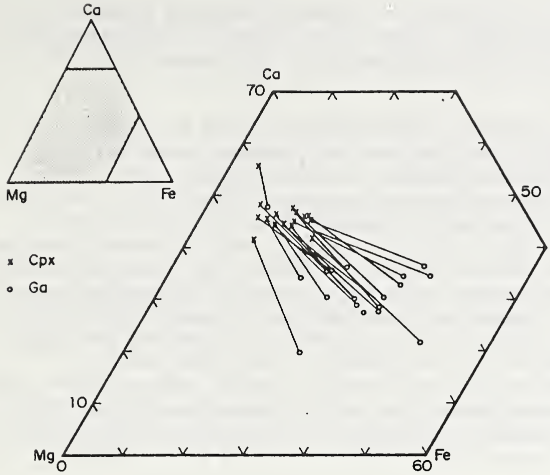

Fig. 1
Ca-Fe-Mg diagram for co-existing garnet and clinopyroxene inclusions from Argyle diamonds.

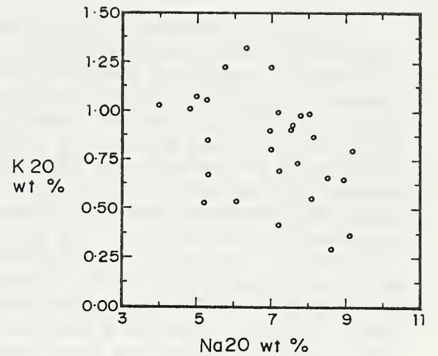

Fig. 2
Variation of Na_2O with K_2O in clinopyroxenes from Argyle diamonds.

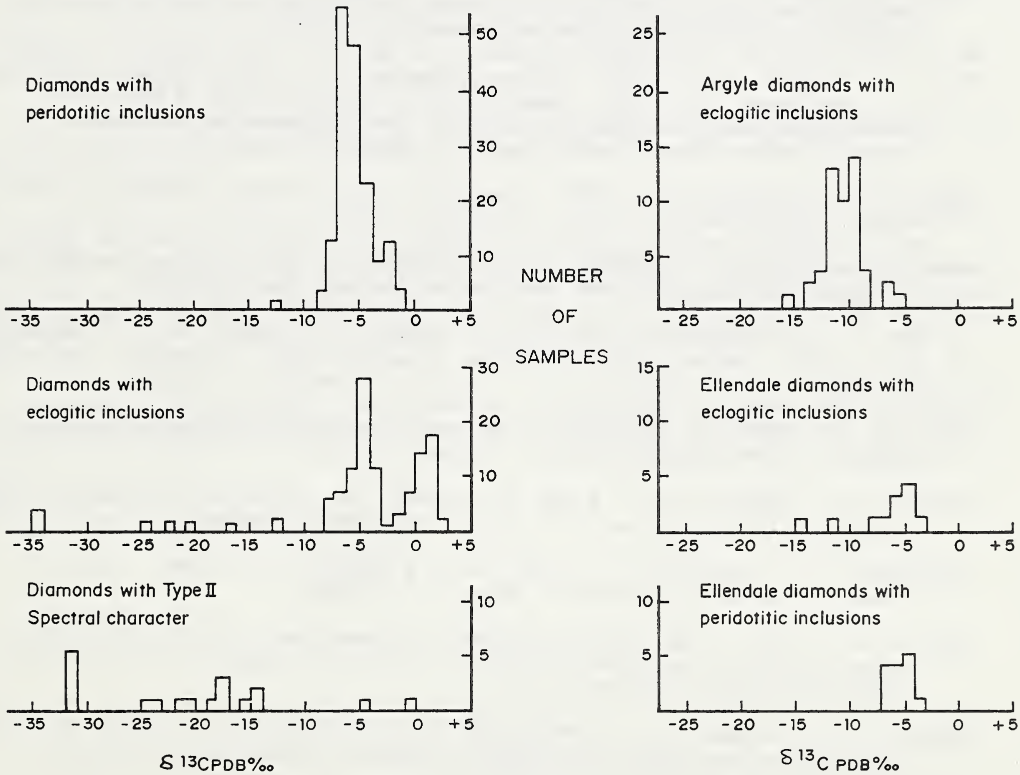

Fig. 3
Carbon isotopic compositions of inclusion-bearing diamonds from Argyle and Ellendale compared with inclusion-bearing stones elsewhere (data from Sobolev et al. (1979), Sobolev (1984), Deines et al. (1984)) and diamonds with Type II spectral character (Milledge et al., 1983).

$\delta^{13}C$ values (-4 to -6 ‰PDB) similar to the bulk of inclusion-bearing diamonds elsewhere (Fig. 3). The majority of the Argyle stones with eclogitic inclusions have significantly lighter C isotopic compositions lying mostly in the range -9 to -12 $\delta^{13}C$ ‰PDB.

At Argyle an association of stone morphology and inclusion type has been recognised. Sharp edged octahedra with etched and frosted surfaces contained only peridotitic inclusions and have a restricted range of isotopic compositions. These diamonds resemble the diamonds recovered from peridotite nodules from Argyle (Hall and Smith, 1984). Two distinct sources for the Argyle diamonds are therefore suggested. The octahedral (and associated forms) formed during a relaxed (low) geothermal gradient in Archaean (?) refractory, reduced peridotite comprising much of the lower lithosphere beneath the Kimberley craton which is inferred to be the residue of Precambrian magma extraction (Richardson et al, 1984). The bulk of the diamonds - rounded, resorbed dodecahedra - are of eclogitic paragenesis and it is tentatively suggested that these are derived from recycled crustal material and are younger in age than those of peridotitic paragenesis. This recycled crustal material may be the same as or related to the ancient (>2 By) enriched component identified in the lamproites (Nelson et al, 1986). A dual or multiple origin for the Argyle diamonds is consistent with the very wide range in $^3He/^4He$ and other noble gas ratios reported by Honda et al (1985).

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