A DIAMOND-GRAPHITE ECLOGITE FROM THE SLOAN 2 KIMBERLITE, COLORADO, USA

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Numerous kimberlites have produced peridotite and eclogite xenoliths with diamond present as a primary mineral. Most of these xenoliths come from South Africa and the USSR, although one diamondiferous peridotite comes from Australia, and one has been found in southern Wyoming, USA (Hall and Smith, 1984; McCallum and Eggler, 1976). In this study we examine in detail the first diamond-graphite eclogite reported in North America; from the Sloan 2 kimberlite in northern Colorado, USA (Collins, 1982).

Xenolith TP121 is a small subangular fragment, roughly two centimeters in diameter and weighing just over 32 grams. The rock is coarse-grained, with orange, subhedral garnets set in a matrix of mostly altered clinopyroxene. Texturally, it is a group I eclogite (MacGregor and Carter, 1970).

Four diamonds 1-2 mm in size are exposed at the surface of the eclogite. from 1-2 mm. Two are octahedra, with little or no effects of resorption. A third octahedron is slightly resorbed and has a graphite mass which wraps around the corner of the stone and curves into the altered clinopyroxene matrix. The fourth diamond is a fragment which is broken off at the surface of the nodule. Graphite comprises 5% of the rock, occurring as plates and masses up to 2 mm in size. The graphite has forms similar to those observed for primary graphite in eclogites from Orapa (Robinson et al, 1984).

Microprobe analysis of the eclogite in thin section indicates heterogeneity in the minerals. The garnets contain 46-55% pyrope, 30-33% almandine, and 14-20% grossular. Garnet grains taken from the nodule surface have higher grossular and almandine contents than those in thin section, with 44-45% pyrope, 34% almandine, and 22% grossular. The clinopyroxenes are omphacitic, with jadeite components from 35-42%, diopside-hedenbergite from 47-54%, and enstatite-ferrosilite from 8-10%. Pyroxenes taken from the nodule surface are higher in jadeite (41-43%) and lower in diopside-hedenbergite (44-46%) than grains in thin section. Values of 0.07-0.12% K_2O in the clinopyroxene and 0.09-0.11% Na_2O in the garnet classify the nodule as a group I eclogite, and are in the range for diamondiferous eclogites from other localities (McCandless and Gurney, this volume). K_2O in the clinopyroxene was found to vary with respect to crystal orientation, with the highest values produced from crystal surfaces at 90° to the z-axis. Secondary minerals include spinel and phlogopite after garnet, and a fine-grained diopside after omphacite. The diopside is depleted in K_2O, and is higher in diopside-hedenbergite (60-79%) and lower in jadeite (2-18%) than the fresh omphacites. Veins containing vermiculite, carbonate, an unidentified Ca-Al silicate, magnetite, and amphibole are also present, and have been introduced presumably from metasomatizing fluids or kimberlite magma.

Using the geothermometer of Ellis and Green (1979), for mineral compositions measured in the interior of the xenolith, temperatures from 1080-1140°C (average 1112°C) are obtained at 50 kb. This agrees with temperatures of 1088-1114°C at 50 kb, obtained from eclogitic inclusions in diamonds from the Sloan 1 kimberlite (Otter and Gurney, this volume). Temperatures calculated from garnet and pyroxene grains taken from the nodule surface are significantly higher, from 1144-1205°C (average 1174°C).

Extreme variability can be encountered during diamond eclogite formation, and involves fluctuations in temperature, pressure, and oxygen fugacity, occurring over long periods of time before the eclogites are finally brought to the surface in an ascending magma (Haggerty, 1986). Such processes are evident in the case of nodule TP121. The graphite crystals probably formed in a liquid, where their growth was not restricted by the presence of other solid phases. Diamonds also formed at this time. The eclogite was subsequently exposed to metasomatism and/or decompression melting, with spinel and phlogopite forming after garnet and diopside forming after omphacite. Veins of micaceous minerals, magnetite, and amphibole also developed. Higher temperatures obtained from the nodule surface indicate that the surface reequilibrated probably during transport in the kimberlite. Secondary phases produced by metasomatism were subsequently replaced by vermiculite and carbonate as a result of weathering processes.

Recent studies of mantle eclogites from Colorado-Wyoming kimberlites have shown a lack of group I eclogites (Ater, 1982; Ater et al, 1984). The diamond graphite eclogite TP121 is a group I eclogite, both in textural and chemical characteristics (MacGregor and Carter, 1970; McCandless and Gurney, 1986). It is believed that metasomatism and/or decompression melting, coupled with abrasion in the kimberlite, and weathering since the Devonian, have made the group I eclogites from the xenolith suite in Colorado-Wyoming kimberlites very rare.

A metamorphic origin has been postulated for the Colorado-Wyoming eclogites, as group I eclogites were absent, and no differentiation trend could be recognized for the different chemical groups (Ater et al., 1984). Recalculated temperatures for the Colorado-Wyoming eclogites at 50kb show that several could have formed at conditions similar to those inferred for TP121 and for eclogitic inclusions in diamond (Fig. 1). These may be transitional to the group I eclogites which it is proposed formerly existed in the mantle. Hatton and Gurney (1986) have proposed a model for eclogites at Roberts Victor, in which group I eclogites formed from a volatile-induced differentiated magma, which in turn provided the heat and volatiles necessary to form a suite of undifferentiated group II eclogites from partial melting, metamorphism, and contamination of the overlying garnet lherzolite. Such a model, though on a smaller scale, may apply to the Colorado-Wyoming eclogites. It is not unreasonable that eclogites (and diamonds) may have formed under both metamorphic (Haggerty, 1986) or igneous (Sunagawa et al., 1984) conditions, and until further evidence of group I eclogites is found, such a model for eclogites from Colorado-Wyoming kimberlites must remain speculative.

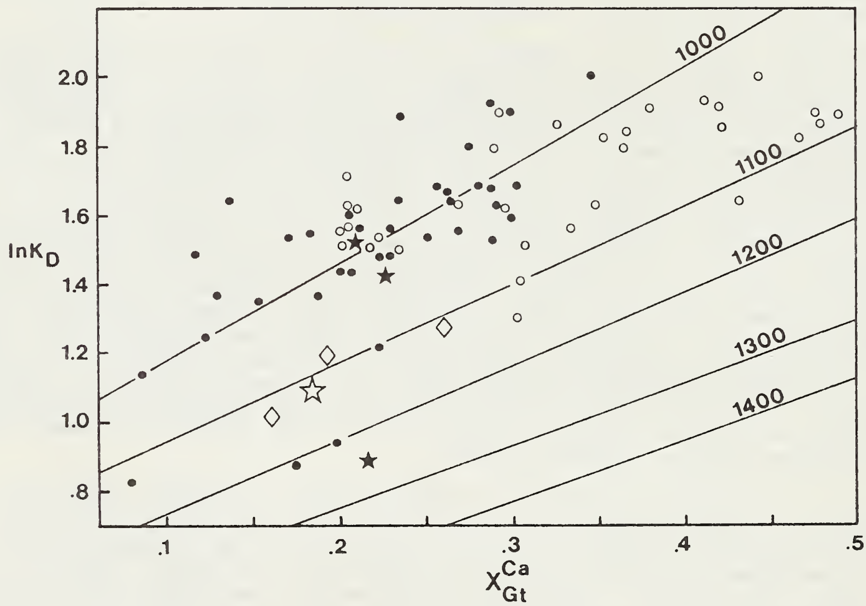

Figure 1. Ln K_D versus X^{Ca} garnet at 50kb for diamond-graphite nodule TP121 (open star), eclogitic inclusions in diamonds (diamonds), and eclogites from Colorado-Wyoming kimberlites; including bimineralic (solid circles), kyanite-bearing (open circles), and graphite-bearing (solid stars). Data from this study; Otter and Gurney, 1986; Ater, 1982.

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