DIAMOND AND GRAPHITE IN ECLOGITE XENOLITHS FROM KIMBERLITE

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Some characteristics of nine diamond eclogite xenoliths, five diamond-graphite eclogite xenoliths and ten graphite eclogite xenoliths are summarised below.

SPECIMEN	KIMBERLITE LOCALITY	MASS, g	± MODAL COMP. cpx	ga	ky	cor	NO. OF DIAMONDS	LARGEST, ± carat	NO. OF GRAPHITE XLS.
AK1/9	Orapa	7,4	60	40			14[x]	0,06	
AK1/10	"	14,7	60	40			2[x]	0,2	
DB/1	Doornkloof	15,2	50	50			1[x]	5	
DB/2	"	13,3	30	70			1[x]	1,8	
DB/3	"	3,1	30	70			1[x]	0,15	
DB/4	Bobbejaan	9,1	60	40			1[x]	1	
DB/5	Jagersfont.	1,5	65	35			5[x]	0,01	
DB/6	Excelsior	24,2	75	20	5		1[x]	1	
DB/7	"	10,8	50	45	5		1[x]	4	
HRV 247	Rob.Victor	943,0	30	70			49	0,2	± 200
XRV 22	"	248,1	70	30			119	0,006	± 200
PJL/18	"	115,7	25	25			3	0,002	6
JJG 531	Jagersfont.	13,1	85	15			5	0,3	± 150
AK1/25	Orapa	12,0	55	45			1	0,003	16
AK1/13	"	8,5	30	70					3
AK1/24	"	8,4	50	50					25
AK1/26	"	2,1	65	35					3[x]
AK1/28	"	1,8	80	20					28[x]
AK1/29	"	8,8	20	80					11
AK1/30	"	8,5	15	85					11
AK1/31	"	24,4	35	65					3[x]
AK1/12	"	11,6	60	30	10				3
AK1/27	"	4,9	50	50	tr				5
AK1/34	"	21,2	60	35		5			2[x]

[x] exposed at xenolith surface only.

The xenoliths are from both kimberlite pipes and dykes and kyanite - and corundum-bearing varieties are represented. In some cases diamond and graphite were recovered by dissolving the eclogite but in other cases only exposed portions of these minerals were examined.

DIAMOND

Diamond-bearing xenoliths contain either a single, fairly large diamond or a number of small diamonds. Crystals as small as 3×10^{-6} carat were recovered (eg. XRV 22) and much of the range in diamond size found in kimberlite is represented in the xenoliths. In all diamond-bearing xenoliths diamond is considerably more common than in kimberlite, e.g. in AK1/9, HRV 247 and JJG 531 diamond is more than 10 000 times as abundant, by mass, as in host kimberlite and in XRV 22 and JPL/18 it is more than 1 000 times as abundant. In some small xenoliths diamond constitutes a few per cent of the specimen. Only a very small proportion (i.e. a few hundred ppm) of disaggregated diamond-bearing eclogite can, therefore, account for all of the diamond in some kimberlite.

Primary growth forms of diamond are the octahedron and cube, with the latter forming at relatively low temperatures (Giardini and Tydings, 1962), while the dodecahedron is a dissolution form (Seal, 1962; Moore and Lang, 1974). Dodecahedral diamond examined in situ in HRV 247 was seen to be directly in contact with clinopyroxene and garnet (and phlogopite) indicating that partial dissolution of diamond occurred before crystallisation of the eclogite. A variety of diamond crystal forms is represented in the xenoliths, including octahedra, cubes, dodecahedra and, most commonly, combined forms. In individual diamond eclogite specimens, all diamond crystals are similar in habit, e.g. the diamonds in AK1/9 are all octahedral-dodecahedral combined forms. In diamond-graphite eclogite specimens, however, an assortment of diamond crystal forms can be present. eg. in HRV 247, XRV 22 and JJG 531 the dodecahedral form is strongly developed among the larger crystals while the smallest are octahedra. This suggests that either two populations of diamond, of which one experienced little or no dissolution, are represented or the smallest crystals were protected from dissolution, in some diamond-graphite eclogite. Diamond cubes are also present in HRV 247 and XRV 22, suggesting that some of their diamond crystallised at relatively low temperature. Contact- and interpenetrantly-twinned crystals are common in some xenoliths and many diamonds are broken. In XRV 22 some crystals are hoppered at one side as if their growth was impeded.

Surface textures, such as trigons on octahedral surfaces, which are common features of diamonds from kimberlite and are indicative (Phaal, 1965) of etching at temperatures above about 1000°C, are developed on most of the diamonds. The diamonds of two xenoliths (DB/7 and JJG 531) exhibit black surface coatings, however, beneath which irregular and hexagonal pits, the latter of which suggests (Phaal, 1965) etching at 900-1000°C, are developed in diamond.

GRAPHITE

Graphite in both diamond-graphite eclogite and graphite eclogite occurs as discrete crystals, up to 2,5 mm in diameter, which are predominantly tabular hexagonal prisms with slightly rounded edges. Embayed and irregular graphite crystals, which can be interpreted either to have grown in a confined space or to have experienced partial dissolution, are also present in some specimens (eg. AK1/25, AK1/13, AK1/30 and AK1/27). Excepting for the black coatings noted on diamonds of two specimens, nothing suggests that graphite is not a primary mineral in the xenoliths.

Because of the low density of graphite (even at very high pressure if temperature is high; see Berman, 1965), graphite-bearing eclogite is unlikely to be igneous crystal cumulate.

DIAMOND-GRAPHITE RELATIONSHIPS

In diamond-graphite eclogite xenoliths, diamond and graphite crystals can be either interspersed (eg. JJG 531) or each concentrated in a portion of the specimen (eg. HRV 247 and XRV 22). Xenoliths consisting of a diamond-rich and a graphite-rich portion can only have crystallised from liquid, and are likely to be samples of common, very small volumes of carbon-bearing eclogite rather than of diamondiferous-graphitic interfaces in large bodies of carbon-bearing eclogite. In eclogite in which diamond and graphite are interspersed, carbon must have crystallised late if from magma.

PETROGENESIS

Evidence that partial dissolution of diamond pre-dated eclogite crystallisation, and the association of diamond-rich and graphite-rich eclogite in some xenoliths suggest an igneous origin for the rocks. At graphite-stable conditions, diamond will dissolve in liquid while graphite may crystallise, so partially resorbed diamond crystals (ie. exhibiting dodecahedral surfaces) may indicate that diamond-stable conditions were followed by graphite-stable conditions. Such a change can be explained either by diminishing pressure or increasing temperature, so that more than one type of crystallisation path can be invoked to explain some types of carbon-bearing eclogite. Likely crystallisation paths are, however, illustrated in the accompanying figure.

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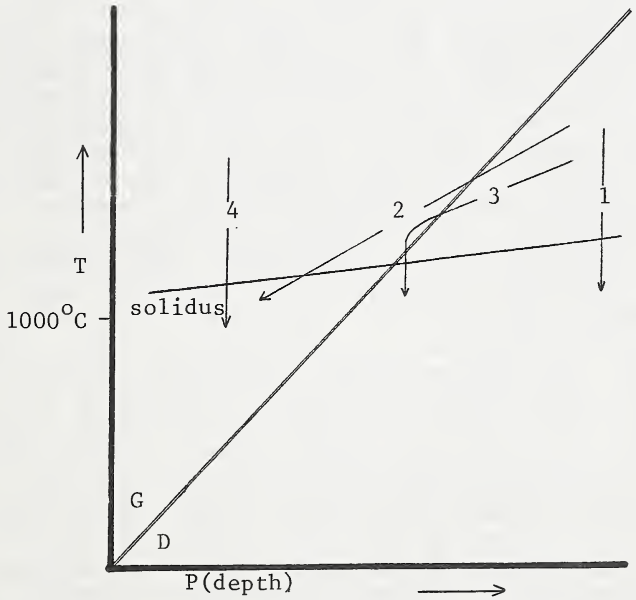

P(depth) - T paths for magma crystallising various types of carbon-bearing eclogite. 1. Diamond eclogite in which diamonds are sharp-edged octahedra. 2. Diamond eclogite in which diamonds are partly resorbed and graphite floated off to subsequently form graphite eclogite, or diamond-graphite eclogite in which carbon crystallisation either late or from very small volume of magma only and unresorbed diamond crystals were protected. 3. Diamond-graphite eclogite with more than one generation of diamond. 4. Graphite eclogite.