SILICA-BEARING ECLOGITES FROM THE ROBERTS-VICTOR KIMBERLITE

J. R. Smyth (Geological Research Group, Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87545)

Recently, Smyth and Hatton (1977) described a coesite-bearing kyanite eclogite from the Roberts-Victor Kimberlite, South Africa. Since that description, two additional silica-bearing kyanite eclogites from the same locality have been found to contain quartz, apparently pseudomorphic after coesite (Smyth, 1977a). Based on several independent lines of evidence, the mineral assemblages of these specimens appear to have equilibrated near 900°C and 3.0 GPa (30 Kb). Based on bulk major element chemistry obtained from microprobe and modal analyses, these specimens appear to form a chemically distinct group of mantle-derived rocks. They are rich in both SiO_2 (52-54 wt %) and Al_2O_3 (18-23 wt %), and CIPW norm calculations yield gabbroic anorthosites with 65 to 80 percent feldspar. This set of unique mineral assemblages has provided constraint on the depth of origin and magma migration velocities of the kimberlite (Smyth and Hatton, 1977), additional insight into high pressure pyroxene crystal chemistry, and may possibly be subducted samples of a plagioclase-rich primordial crust of the earth.

The mineralogy of the specimens can be used to infer temperatures and pressures of equilibration. The disordered state of the sanidine sets a minimum temperature of 900°C, and the pesence of coesite a minimum pressure of 3.0 GPa. Based on thermodynamic equilibrium of the four simplified reactions:

$$\text{Ky} + \text{Cpx} \rightleftharpoons \text{Coes} + \text{Gt} = \text{En}$$
$$\text{Cs} + \text{Phl} \rightleftharpoons \text{Sn} + \text{En} + H_2O$$
$$\text{Ky} + \text{Cpx} + \text{Phl} \rightleftharpoons \text{Sn} + \text{Gt} + \text{En} + H_2O$$
$$\text{Cs} + \text{Gt} + \text{Phl} \rightleftharpoons \text{Sn} + \text{Ky} + \text{Cpx} + H_2O$$

Wohletz (personal communication) has obtained an invariant point at 1186°K (913°C) and 3.2 GPa. Further, based on the experimental study of Råheim and Green (1974), the Fe-Mg distribution between coexisting garnet and clinopyroxene indicates a temperature of approximately 850°C, assuming the 3.0 GPa pressure minimum of the quartz-coesite transition.

The pyroxenes in these eclogites may be described as peraluminous omphacites, that is, the Al^{VI} exceeds the Al^{IV} + Na + K. In hand specimen, the clinopyroxene appears characteristically milky-white due to the exsolution of Ca-Tschermaks pyroxene and quartz according to the reaction:

$$Ca\square Al_2Si_4O_{12} \longrightarrow CaAl_2SiO_6 + 2\ SiO_2$$

(Smyth, 1977b).

The bulk chemistry may provide some insight into the ultimate origin of these rocks. The major element chemistry and CIPW norms based on microprobe and modal analyses are given in Table I. Lappin and Dawson (1975), Harte and Gurney (1975), and Gurney (1975 personal communication) have proposed a high pressure igneous cumulate origin for many of the eclogites from Roberts-Victor. It is difficult to imagine how the silica-bearing eclogite rocks could be related to the more normal bimineralic eclogites by a simple fractionation process at depth, because it is difficult to enrich a liquid in Si, Al, and Ca by the subtraction of either a clinopyroxene or garnet phase. The low-pressure equivalent of these rocks is a gabbroic anorthosite (Table I), and samples SRV-1 and SRV-6 contain 78 wt % feldspar in the norm. Rocks of this composition are common in low pressure basic cumulate igneous complexes but are exceedingly rare as primary liquids. It therefore seems likely that these silica-bearing eclogites represent subducted bits of low-pressure cumulate rocks. The whole-rock $^{16}O/^{18}O$ of sample SRV-1 was determined by K. Muehlenbachs (University of Alberta) as +8.0^{o}/oo relative to SMOW. This value is somewhat higher than typical of mantle-derived eclogites, and would be more consistent with an origin in the lower crust. The whole-rock $^{86}Sr/^{87}Sr$ determined by J. Wooden (NASA/JSC) is 0.7074 which is also consistent with a low pressure origin of these rocks. If these silica eclogites do indeed represent subducted bits of crustal material, in order for them to have been erupted from under the stable craton of Africa, it is possible that they originated very early in the history of the earth.

REFERENCES

Harte, D. , and J. J. Gurney, (1975), "Evolution of Clinopyroxene and Garnet in an Eclogite Nodule from the Roberts-Victor Kimberlite Pipe, South Africa," Phys. Chem. Earth 9, p. 367-387.

Lappin, M. A., and J. B. Dawson, (1975), "Two Roberts-Victor Cumulate Eclogites and Their Re-equilibration," Phys. Chem. Earth 9, p. 351-365.

Råheim, A., and D. H. Green, (1974), "Experimental Determination of the Temperature and Pressure Dependence of the Fe-Mg Partition Co-efficient for Coexisting Garnet and Clinopyroxene," Contrib. Mineral. Petrol. 48, p. 179-203.

Smyth, J. R., (1977a), "Quartz Pseudomorphs After Coesite," Amer. Mineral. 62, (July-August issue).

Smyth, J. R., (1977b), "Peraluminous Omphacite: Cation Vacancies in Upper Mantle Pyroxenes," (abstract), Trans. Amer. Geophys. Union 58, p. 523.

Smyth, J. R., and C. J. Hatton, (1977), "A Coesite-Sanidine Grospydite from the Roberts-Victor Kimberlite," Earth Plant. Sci. Lett. 34, p. 284-290.

TABLE I. ESTIMATED BULK COMPOSITIONS AND COMPUTED NORMS OF THREE SILICA-BEARING ECLOGITES

	SRV-1	SRV-6	SRV-7
SiO_2	52.4	52.5	53.5
TiO_2	.1	.3	.2
Al_2O_3	22.8	22.7	18.3
Cr_2O_3	.1	.0	.1
FeO	3.8	4.2	4.6
MgO	5.5	4.8	8.6
CaO	11.1	11.2	11.2
MnO	.1	.0	.1
Na_2O	3.7	4.3	3.2
K_2O	.2	.1	.1
P_2O_5	.01	-	-
Total	99.8	100.1	99.9
CIPW Norm (wt %)			
OR	1.4	.7	.5
PL	76.2	76.6	62.5
(AB)	(31.1)	(34.4)	(27.0)
(AN)	(45.0)	(42.2)	(35.5)
NE		1.2	
DI	8.1	11.0	16.2
(WO)	(4.2)	(5.7)	(8.4)
(EN)	(2.6)	(3.4)	(5.6)
(FS)	(1.3)	(2.0)	(2.2)
HY	6.5		16.2
(EN)	(4.3)		(11.7)
(FS)	(2.2)		(4.5)
OL	7.3	10.2	4.1
(FO)	(4.7)	(6.1)	(2.9)
(FA)	(2.6)	(4.1)	(1.2)
CM	.1	.1	.1
IL	.2	.6	.4
AP	.02	.6	.4