MINERAL GEOCHEMISTRY OF THE ELLIOTT COUNTY KIMBERLITE, KENTUCKY

PREJEANT-DICKERSON, K.[1], PEREZ, M.[1], WHITE, John C.[1], LIERMAN, Robert T.[1], and REN, Minghua[2]

(1)Department of Geography & Geology, Eastern Kentucky University, 521 Lancaster Ave, Roark 103, Richmond, KY 40475, kathryn_dickerson6@mymail.eku.edu

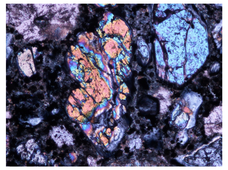
(2) Department of Geological Sciences, University of Texas at El Paso, 500 W. University Ave, El Paso, TX 79968

Abstract

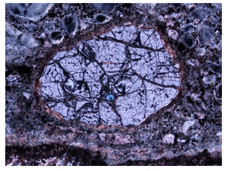
Several kimberlite bodies crop out in Elliott County, a remote and hilly area in eastern Kentucky. The presence of these kimberlites have been known since 1886 and have been prospected for diamonds several times since then, although none have yet been found. The kimberlite dikes intrude into Pennsylvanian sandstones and have been dated at approximately 257-279 Ma (Early Permian). The kimberlites include phenocrysts of olivine, garnet, phlogopite, calcite, and ilmenite, and are also host to abundant upper crustal xenoliths of limestone. We present whole rock and mineral geochemical analyses of the kimberlite and its phenocrysts obtained through electron-probe microanalysis of thin sections, and from bulk analysis following mineral separation via magnetic, heavy liquid, and hand-picking techniques. We also present mineral/melt partition coefficients derived from these analyses.

Microscopic Images with Cross Polarized Light

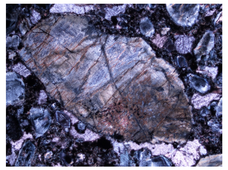
Sample 2, Phlogopite, 10x



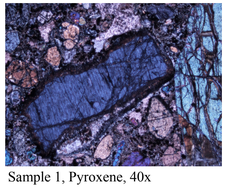
Sample 1, Olivine and specks of Il-



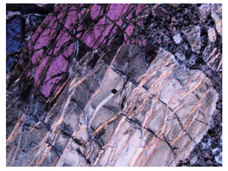
Sample 2, Garnet with Olivine



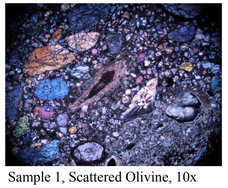
Sample 2, Serpentinized Olivine,



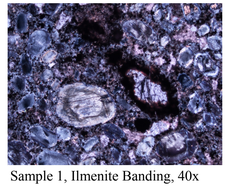
Sample 1, Pyroxene, 40x



Sample 1, Serpentinized olivine

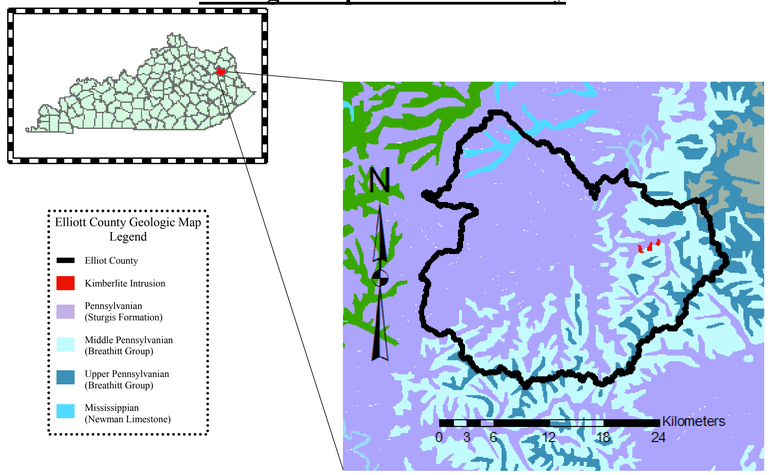


Sample 1, Scattered Olivine, 10x



Sample 1, Ilmenite Banding, 40x

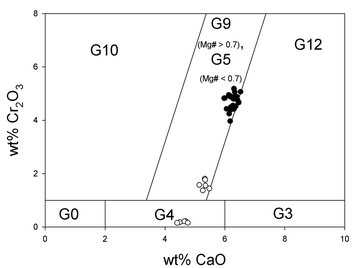
Geologic Map Of Elliott County



Petrographic Summary

The kimberlite found in Elliott County, Kentucky includes a wide variety of minerals often altered by secondary processes and highly fractured. The samples we collected consist mainly of xenocrysts of forsteritic (88-91 mol% Fo) olivine, Cr-pyrope garnet, phlogopite, enstatite (~90 mol% En), perovskite, calcite, ilmenite-geikielite, and sulfides. Olivine is the most abundant mineral in the kimberlite and usually found completely or partially replaced by serpentine or chlorite. The garnet crystals are frequently rimmed due to a possible reaction with the kimberlitic melt. The Cr-pyrope garnets are characterized by high CaO and Mg# (= mol Mg/(Mg+Fe)), and thus classify as G9, or lherzolitic, garnets, which are only rarely (<15%) found associated with diamond deposits. Garnets also have a low Cr/(Cr+Al) ratio, which strongly suggests that they equilibrated with the mantle at relative lower pressures (<30 kbar), well within the field of graphite stability.

Garnet Classification Chart



Geochemistry

Table 1. Average values of electron probe microanalyses of Kimberlite minerals.

Mineral	Olivine		Olivine		Pyroxene		Pyroxene		Garnet (high -Cr)		Garnet (low-Cr)		Garnet (high-Cr)		Garnet (low-Cr)		Ilmenite		Ilmenite		Ilmenite		Perovskite		Perovskite		Phlogopite		Apatite		Calcite	
Sample	Loc 1		Loc 2		Loc2		Loc2		Loc 1		Loc 1		Loc 2		Loc 2		Loc1		Loc2		Loc2		Loc1		Loc2		Loc2		Loc2		Loc2	
n =	33		35		12		16		25		11		9		8		6		11		6		16		5		5		3		19	
	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std	Avg	Std
SiO2, wt%	41.05	0.25	40.77	0.34	56.99	0.58	56.27	0.27	41.88	0.23	41.79	0.32	41.35	0.15	41.63	0.09	0.01	0.01	0.00	0.00	0.00	0.00	0.07	0.26	0.01	0.01	40.92	0.24	1.88	0.27	0.02	0.07
TiO2	0.01	0.02	0.04	0.02	0.21	0.11	0.22	0.02	0.07	0.04	0.99	0.17	0.25	0.07	0.85	0.03	51.50	0.86	50.74	2.51	49.82	2.67	54.22	1.28	55.53	0.36	0.90	0.02	0.08	0.01	0.06	0.01
Al2O3	0.00	0.00	0.03	0.02	0.85	0.26	0.88	0.02	19.36	0.44	21.63	1.00	20.07	0.53	22.70	0.13	0.55	0.17	0.54	0.20	0.54	0.06	0.18	0.04	0.29	0.08	11.80	0.07	0.06	0.01	0.05	0.01
Cr2O3	0.00	0.01	0.04	0.03	0.14	0.03	0.00	0.00	4.69	0.29	0.95	0.74	3.83	0.66	0.14	0.02	0.90	1.61	0.73	0.67	0.36	0.11	0.22	0.03	0.23	0.05	0.16	0.01	0.12	0.01	0.06	0.01
NiO	0.31	0.11	0.32	0.09	0.05	0.03	0.08	0.02	0.01	0.01	0.02	0.03	0.01	0.01	0.00	0.01	0.22	0.05	0.26	0.05	0.17	0.03	0.14	0.04	0.13	0.05	0.05	0.03	0.04	0.06	0.03	0.02
FeO	9.27	0.94	10.02	1.04	6.76	0.91	7.74	0.15	6.52	0.15	9.73	0.25	8.16	0.32	10.49	0.16	31.01	3.17	33.28	5.23	31.89	3.25	1.18	0.14	1.14	0.09	6.04	0.16	0.26	0.02	0.13	0.06
MnO	0.00	0.00	0.11	0.05	0.12	0.02	0.12	0.03	0.06	0.03	0.10	0.05	0.40	0.03	0.36	0.05	0.15	0.06	0.38	0.16	0.42	0.12	0.00	0.00	0.09	0.05	0.03	0.01	0.03	0.03	0.02	0.02
MgO	51.05	0.73	50.51	0.84	34.79	1.29	33.57	0.17	20.96	0.18	20.46	0.22	20.37	0.12	20.29	0.10	13.02	1.38	12.35	2.39	12.49	1.77	0.05	0.20	0.00	0.00	24.41	0.10	0.00	0.00	0.00	0.00
CaO	0.05	0.03	0.08	0.05	0.84	0.45	0.99	0.03	6.26	0.14	4.99	0.39	5.37	0.16	4.83	0.11	0.29	0.36	0.19	0.14	0.12	0.08	36.76	2.15	40.40	0.80	0.02	0.01	54.13	1.76	60.59	2.65
Na2O	0.02	0.01	0.03	0.01	0.17	0.08	0.17	0.02	0.01	0.01	0.08	0.01	0.04	0.01	0.08	0.01	0.03	0.01	0.04	0.01	0.03	0.01	0.43	0.12	0.27	0.06	0.06	0.01	0.20	0.03	0.05	0.07
K2O	0.00	0.01	0.00	0.01	0.01	0.03	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.01	0.04	0.02	0.00	0.00	0.07	0.02	0.05	0.01	10.73	0.05	0.03	0.01	0.01	0.01
P2O5	0.00	0.00	0.01	0.02	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.04	0.03	0.06	0.03	0.02	0.02	0.02	0.02	0.06	0.02	0.04	0.02	0.04	0.02	0.02	0.02	35.90	0.67	0.02	0.02
ZrO2	0.01	0.01	0.02	0.02	0.04	0.02	0.03	0.02	0.03	0.02	0.04	0.03	0.11	0.02	0.11	0.03	0.39	0.05	0.43	0.08	0.44	0.02	0.48	0.04	0.49	0.07	0.06	0.02	1.03	0.05	0.17	0.02
HfO2	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.04	0.66	0.10	0.64	0.05	0.73	0.06	0.79	0.13	0.04	0.04	0.18	0.02	0.10	0.02
Y2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.06	0.02	0.02	0.02	0.12	0.02	0.13	0.02	0.00	0.00	0.09	0.03	0.01	0.01
La2O3	0.01	0.02	0.04	0.05	0.03	0.03	0.01	0.04	0.01	0.04	0.00	0.00	0.04	0.04	0.02	0.02	0.12	0.07	0.20	0.09	0.23	0.07	0.65	0.20	0.46	0.07	0.05	0.06	0.10	0.07	0.06	0.05
Ce2O3	0.03	0.03	0.08	0.07	0.15	0.06	0.00	0.00	0.05	0.06	0.06	0.06	0.12	0.08	0.18	0.08	0.25	0.09	0.30	0.14	0.41	0.09	1.83	0.73	1.07	0.32	0.07	0.05	0.09	0.07	0.12	0.08
Subtotal	101.81		102.09		101.16		100.10		99.92		100.86		100.16		101.75		99.20		100.21		97.65		97.15		101.13		95.34		94.24		61.49	
F	--		--		--		--		--		--		--		--		--		--		--		--		--		0.26	0.04	1.96	0.29	0.03	0.04
Cl	--		--		--		--		--		--		--		--		--		--		--		--		--		0.05	0.00	0.01	0.01	0.00	0.00
O=F-Cl	--		--		--		--		--		--		--		--		--		--		--		--		--		0.12		0.83		0.01	
Total	101.81		101.81		101.81		101.81		101.81		101.81		101.81		101.81		101.81		101.81		101.81		101.81		101.81		95.22		93.41		61.47	
Mg#	0.91		0.90		0.90		0.89		0.85		0.79		0.82		0.78		0.43		0.40		0.41		0.08		0.00		0.88		0.00		0.00	
Formula																																
Si, apfu	0.99		0.98		1.96		1.96		3.01		2.97		2.98		2.94		0.00		0.00		0.00		0.00		0.00		5.90		0.17		--	
Ti	0.00		0.00		0.01		0.01		0.00		0.05		0.01		0.05		0.91		0.89		0.89		0.97		0.96		0.10		0.01		--	
Al	0.00		0.00		0.03		0.04		1.64		1.81		1.70		1.89		0.02		0.01		0.02		0.00		0.01		2.01		0.01		--	
Cr	0.00		0.00		0.00		0.00		0.27		0.05		0.22		0.01		0.02		0.01		0.01		0.00		0.00		0.00		0.01		--	
Fe3+	--		--		--		--		--		--		--		--		0.16		0.20		0.20		--		--		--		--		--		--	
Fe2+	0.19		0.20		0.19		0.23		0.39		0.58		0.49		0.62		0.45		0.46		0.44		0.02		0.02		0.73		0.02		--	
Mn	0.00		0.00		0.00		0.00		0.00		0.01		0.02		0.02		0.00		0.01		0.01		0.00		0.00		0.00		0.00		--	
Mg	1.83		1.82		1.78		1.74		2.24		2.17		2.19		2.14		0.46		0.43		0.44		0.00		0.00		5.25		0.00		--	
Ca	0.00		0.00		0.03		0.04		0.48		0.38		0.41		0.37		0.00		0.00		0.00		0.94		0.99		0.00		5.39		--	
Na	--		--		0.01		0.01		0.00		0.01		0.00		0.01		0.00		0.00		0.00		0.01		0.01		0.02		0.02		--	
K	--		--		--		--		--		--		--		--		--		--		--		--		--		--		1.97		0.00		--	
P	--		--		--		--		--		--		--		--		--		--		--		--		--		--		0.00		2.82		--	
F	--		--		--		--		--		--		--		--		--		--		--		--		--		--		0.01		0.00		--	
Cl	--		--		--		--		--		--		--		--		--		--		--		--		--		--		0.12		0.59		--	
Cations:	3.01		3.01		4.01		4.01		8.03		8.03		8.03		8.04		2.02		2.01		2.01		1.95		1.99		15.98		8.45		--	
Anions:	4		4		6		6		12		12		12		12		3		3		3		3		3		22		5		--	
Classification:																																
	Fo	0.91	Fo	0.90	En	0.89	En	0.87	Py	0.85	Py	0.79	Py	0.81	Py	0.77	Ilm	0.46	Ilm	0.46	Ilm	0.45										
	Fa	0.09	Fa	0.10	Fs	0.10	Fs	0.11	Al	0.15	Al	0.21	Al	0.18	Al	0.22	Hem	0.07	Hem	0.10	Hem	0.10										
					Wo	0.02	Wo	0.02	Sp	0.00	Sp	0.00	Sp	0.01	Sp	0.01	Gk	0.46	Gk	0.43	Gk	0.44										
																	Py	0.00	Py	0.01	Py	0.01										

Summary

Over the last 100+ years the kimberlite in Elliott county has been prospected in search of diamonds to no avail. Garnets, typically a good indicator of the possible formation of diamonds in kimberlite, mean nothing in Elliott county because the overall chemistry proves the impossibility of diamond crystallization. In conjunction with chemistry, the situation at which the kimberlite formed also supports the anti-diamond theory, because it mineralized at a shallow depth and low temperature; this environment is extremely nonconductive to the formation of a tightly packed carbon configuration. With these factors in mind it has been determined that further exploration of the kimberlite in Elliott county for diamonds would be futile.

-Special thanks to the GSA website for the Geologic map of Kentucky and the legend labels.