THE HILLS POND PERIDOTITE, WOODSON COUNTY, KANSAS: A RICHTERITE-BEARING CRETACEOUS INTRUSIVE WITH KIMBERLITIC AFFINITIES

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Geologic Relationships

The Hills Pond Peridotite (e.g. Wagner, 1954) is the larger of two micaceous peridotites exposed in Woodson County, Kansas (Fig. 1); others are known from drilling. The body is located on the Hill farm in southern Belmont township, and intrudes sedimentary rocks of Pennsylvanian Age. The age of the body is about 90 m.y., as determined by K-Ar and Rb-Sr measurements on phlogopite (Zartman *et al.*, 1967). The Hills Pond Peridotite and the nearby peridotite intrusive at Rose Dome (Franks *et al.*, 1971) are on the westward extension of the Thirty-eighth Parallel Lineament of Heyl (1968).

Surface mapping and drilling have established that the peridotite body is an elongate, plug-like mass about 1.7 km long and about 300 m wide, with several sill-like extensions to the south. The emplacement of the igneous material has caused gentle doming of the sedimentary rocks, forming the Silver City Dome. A contact metamorphic aureole extends outward from the main plug for about 300 m; principal metamorphic effects are the conversion of sandstone to quartzite and the development of chlorite, but local development of epidote, tremolite-actinolite, hornblende, and chert is observed in limestone and calcareous shale (Wagner, 1954).

The exposed rock is deeply weathered to a mass of clay still containing abundant phlogopite. Fortunately, the body has been drilled extensively. The following petrographic and chemical data are based upon 18 samples from a core that penetrated the main plug to a depth of about 180 m.

Petrography

The peridotite is strikingly porphyritic. The phenocrysts include titanphlogopite, serpentine pseudomorphous after olivine, potassic richterite, and titanaugite, all in a fine-grained groundmass of serpentine. Accessory minerals include perovskite, apatite, and chrome spinel. Olivine pseudomorphs are large (about 1.5 mm ave. dia.), typically rounded, and are characterized by curved veins of chrysotile in more homogeneous lizardite or antigorite that is commonly coarser than the serpentine of the matrix. Phlogopite phenocrysts are also large (1.5 mm ave. dia.), are only slightly pleochroic, and many are subhedral, but most are intergrown ophitically with earlier olivine and titanaugite; much phlogopite is bent and deformed. Richterite occurs in fan-shaped bladed aggregates and less commonly as bladed crystals about 0.5 mm long. It is colorless in plane light and faintly pleochroic in shades of pale pink. Optically, richterite is negative with 2V of about 60°, and typically is zoned showing undulose extinction with angles increasing from edges of grains inward.

Apatite occurs typically as tiny, prismatic crystals enclosed in phlogopite. Perovskite occurs as brownish opaque crystals with square outlines or as irregular masses. Chrome spinel occurs as crystals of square to rounded and irregular outlines. It is reddish in both transmitted and reflected light, and is not completely isotropic.

Modal data for three samples are given in Table 1. The ratio of phenocrysts to matrix decreases with increasing depth, while richterite increases and titanaugite decreases in abundance relative to other phenocryst species.

Chemistry

Major element analyses of the peridotite are listed in Table 2. REE and other trace element contents are reported in Table 3. In general, the chemical characteristics of this peridotite are very similar to those of "typical" kimberlite (*cf* Dawson, 1967), but potassium content is significantly higher. The chondrite-normalized REE plot (Fig. 2) shows that La abundance is 500 times chondrites and that La/Yb = 111, suggesting that the peridotite equilibrated with garnet at some point in its history.

Major element mineral analyses also are listed in Table 2. The titanaugites (Ca/Ca + Mg = 0.51) are similar chemically to groundmass pyroxenes in some kimberlites, and except for unusually high TiO_2 fall within Group 3 of Stephens and Dawson (1977). The titanphlogopite is similar in composition to specimens which coexist with richterite in nodules from South African kimberlites (Aoki, 1974) but is richer in TiO_2 and lower in Al_2O_3 than most kimberlite phlogopites thought to be "primary". The potassic richterite is very rich in TiO_2 relative to richterites in South African kimberlites, which implies that the Kansas richterites have equilibrated at shallower depths. This is consistent with the absence of garnet from the Hills Pond phenocryst assemblage.

Comparison with Kimberlites

Although the chemical data suggest kimberlitic affinities, in some respects the Hills Pond Peridotite is quite different from "typical" kimberlite and also differs from the mica peridotites of western Kentucky and southern Illinois (Watson, 1967). These differences are summarized below:

1. The Hills Pond Peridotite contains no garnet, whereas kimberlites characteristically contain pyrope-almandine.
2. No inclusions of eclogite or of garnet peridotite have been found in the Hills Pond body, although these commonly are found in kimberlite. The similar peridotite at Rose Dome, about 8 km to the northeast, contains large inclusions of Precambrian granite, but these are not present in the Hills Pond body.
3. Typical kimberlites contain Mg-bearing ilmenite. The Hills Pond body contains only perovskite and chrome spinel as oxide phases.
4. Clinopyroxene is relatively abundant in the Hills Pond body, but is rare in the micaceous peridotites of western Kentucky and southern Illinois.
5. Petrographic relations (ophitically intergrown phlogopite) and the occurrence of peridotite as thin sills suggest that the Hills Pond body was emplaced primarily as a liquid and not explosively. Kimberlites commonly are microbreccias and appear to have been emplaced explosively.

Six kimberlites are known in Riley County, Kansas (Fig. 1; Meyer, 1976). These are believed to be Cretaceous in age, but their relation to the Woodson County bodies is unknown. Marked differences in mode of emplacement and in major element chemistries suggest that any connection is remote. The Hills Pond and Rose Dome Peridotites are more similar to the bodies in western Kentucky, southern Illinois, and Missouri, suggesting a relationship with the Cretaceous rifting in the Mississippi Embayment region.

Conclusions

Field relations suggest that the Hills Pond Peridotite was emplaced as a largely-liquid magma. REE evidence indicates that this magma equilibrated with garnet at some time in its history, presumably within a mantle source region. We infer that the magma was a partial melt of primitive material or the result of limited crystal fractionation. The exceptionally high potassium content may not be a primary feature, but rather a result of crustal contamination.

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TABLE 1 -- MODAL DATA

Sample	Depth (meters)	Phlog-opite	Serp. Psdmph. Olivine	Titan-augite	Rich-terite	Perov-skite	Chrome Spinel	Apatite	Serp. Matrix
SCP70	23	24.9	14.1	4.8	3.9	0.5	0.2	0.2	51.4
SCP290	97	21.8	11.2	2.6	5.9	0.5	0.2	0.1	57.7
SCP427	142	19.7	11.0	0.3	7.6	1.0	0.6	Trace	59.7

TABLE 2 Major element data for peridotites (by XRF, except * by INAA) and constituent minerals (by microprobe).

	Peridotites				Minerals		
	1	2	3	4	5	6	7
SiO_2	44.62	45.55	47.34	45.76	53.3	41.2	51.1
TiO_2	2.68	2.85	2.97	2.45	1.4	5.0	5.5
Al_2O_3	5.00	4.96	5.06	6.31	0.0	5.7	0.1
Cr_2O_3*	0.19	0.18	0.17		0.3	0.1	0.1
ΣFeO	6.82	6.74	6.78	7.49	2.6	8.8	3.3
MnO	0.10	0.14	0.16				
MgO	20.40	18.65	17.29	22.31	17.1	22.9	20.7
NiO*	0.11	0.10	0.09				
CaO	3.51	3.67	2.88	1.56	24.4	0.0	6.3
Na_2O*	0.340	0.49	0.66	1.52	0.5	0.1	3.4
K_2O	4.31	5.18	5.71	6.30	0.0	10.1	5.6
P_2O_5	0.72	0.78	1.00	0.28			
S	0.31	0.24	0.10	0.04			
Loss				4.38			
SUM	89.11	89.53	90.21	98.40	99.6	93.9	96.1
$\frac{100\ Mg}{Mg+\Sigma Fe}$	84.2	83.1	82.0	84.1	92.1	82.3	91.8

1. SCP60; 2. SCP270; 3. SCP510; 4. Material from depth of 59.3 feet. Analysis from Franks *et al.*,(1971); 5. Titanaugite in SCP70; 6. Titanphlogopite in SCP70; 7. Potassic richterite in SCP70.

Table 3. Trace element data (ppm)

	SCP60	SCP270	SCP510
La	167	172	184
Ce	341	356	374
Sm	14.1	14.6	15.5
Eu	3.93	4.20	4.36
Tb	1.15	1.35	1.17
Yb	1.50	1.52	1.60
Lu	0.21	0.19	0.23
Hf	17.2	18.6	18.8
Th	10.5	11.2	12.6
Ta	4.1	4.3	4.5
Sc	12.2	13.6	13.3
Co	56	53	51
Cr	1290	1260	1170
Ni	870	770	730

INAA

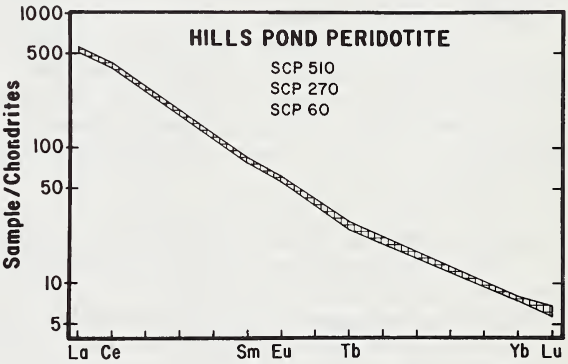

Fig. 2. Chondrite-normalized plot of REE data from Table 3.

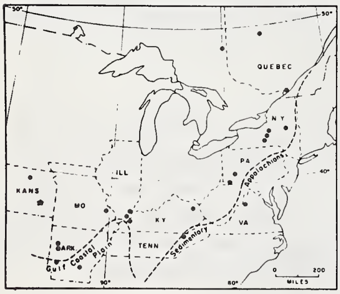

Fig. 1. Distribution of kimberlites and alnöite in eastern North America (from Watson, 1967). Star marks Hills Pond Peridotite.