NEW DATA ON KIMBERLITES AND LAMPROITES IN EASTERN KANSAS, U.S.A.

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A cluster of thirteen kimberlites occurs along the trace of the 1.10 Ga NNE-trending Midcontinent Rift System in Riley and Marshall counties in northeastern Kansas (Fig. 1). Three of these were discovered and drilled within the past three years utilizing donated aeromagnetic coverage of the area followed by detailed groundmagnetic surveys. Modeling of the magnetic anomalies shows that final emplacement of the kimberlite bodies is controlled by N40^{o}W trending structures, rather than NNE-trending structures and that the contacts between the sides of the kimberlite bodies and the Paleozoic country rock are steeply dipping. The kimberlites are Late Cretaceous (about 90 my) and range from crater and diatreme facies in Riley County to hypabyssal facies in Marshall County.

It is likely that as a result of Cretaceous tectonic activity, strike-slip movement was initiated along NW-SE-trending faults, thus opening pathways for the kimberlites to rise to the surface. Continuous core taken to a depth of 300 ft (91 m) was obtained from each of the three newly discovered kimberlites: Tuttle, Antioch, and Baldwin Creek. Thin-section examination of samples from the Tuttle and Antioch kimberlites show two textural types. The most usual type displays pseudo-detrital (pseudo-conglomeratic), inequigranular texture and contains abundant kimberlite xenoliths, various phenocrysts as well as country rock xenoliths. Kimberlite xenoliths are pelletal lapilli that represent magma droplets typically composed of a thin selvage of kimberlite material surrounding a cognate or exotic clast (Field and Scott-Smith, 1999). The rock can be referred to as an autholithic kimberlite (Dawson, 1980) and typically occurs in the diatreme facies.

The second type displays a more homogeneous, porphyritic texture and consists of a serpentine groundmass containing numerous small, highly altered microphenocrysts. This type does not contain country rock xenoliths and only a few kimberlite xenoliths. The rock is typical of the hypabyssal facies (Field and Scott-Smith, 1999) in the deeper parts of the diatreme.

Phlogopite is the abundant mica, serpentine pseudomorphs after olivine and minor amount of Cr-diopside are the main phenocrysts present. Abundant dark-colored lamprophyre-type (micaceous) xenoliths as well as less abundant perodotite/dunite (olivine-rich) kimberlite xenoliths are abundant. Preliminary microprobe analysis show garnet from the Tuttle Creek kimberlite to be pyrope, typically with kelyphitic rims consisting of phyllosilicates and spinel. An unknown (mica-like) mineral having a high barium content also has been identified. Many idiomorph crystals of opaque minerals have a composition typical of ilmenite.

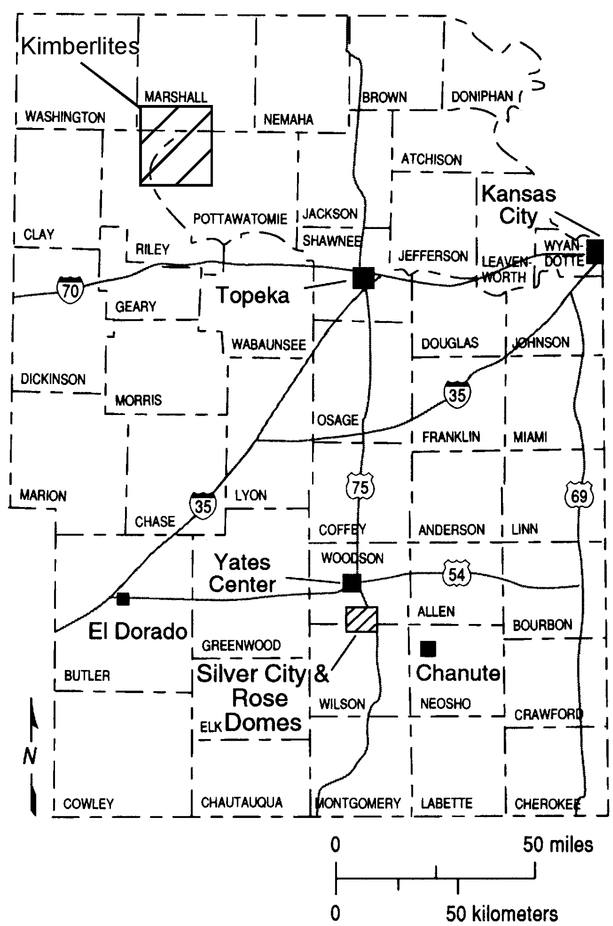

Figure 1. Index map

Lamproites occur in two locations, at Silver City Dome and Rose Dome, in Woodson and Wilson counties in southeastern Kansas. The name “dome” is actually a misnomer in that it implies a topographic high. Instead the domes are elliptical topographic depressions with their long axis aligned in a NE direction. Both domes are close to 3 mi (4.8 km) in the long direction, and about 2 mi (3.2 km) across, and show crater-like morphologies characterized by a central high surrounded by a “moat” having almost complete internal drainage. The domes are surrounded by low, hummocky hills. They are about 3 mi (4.8 km) apart with the area in between them showing a set of well-defined SW-NE-trending linear ridges. Lamproite is known to be present as a series of shallow dipping sills intruding between alternating layers of shale and limestone units of Middle and Late Pennsylvanian age. In one 800 ft (245 m) deep drillhole in the southern portion of Silver city Dome seven lamproite sills were encountered. As a result of exploration for oil in shale and sandstone of the Cherokee Group of rocks of Middle Pennsylvanian age in and around the domes several tens of drillholes penetrate the section to Mississippian carbonate rocks at about 1300 ft (400 m). No information about the presence and nature of lamproite below this depth is available. Seismic reflection studies at Silver City Dome failed to demonstrate the presence or absence of lamproite sills in the section, because the contrast in density between lamproite and the enclosing rocks is not sufficient to detect the sills. Gravity and magnetic studies also were unsuccessful. It was hoped that they might shed light on the possible presence of a feeder dike or an intrusive plug at some depth below the Pennsylvanian. The lamproite at Silver City Dome is non-magnetic, but recent drilling at Rose Dome revealed that the lamproite in two drillholes is magnetic. Drillhole information in the form of core, cuttings, and drillers logs show that lamproite is distributed widely throughout both domes, but the only surface exposures of lamproite are along the northern perimeter of Silver City Dome, where it is being mined commercially by Micro-Lite LLC.

The total thickness of the sedimentary rocks above the crystalline basement is 2,500 ft (760 m). The basement rocks in the area underlying the domes consist of 1,350-1,400 my old rhyolitic volcanic rocks and associated epizonal granitic plutons (Thomas, et al., 1984) belonging to a larger terrane of similar rocks stretching from eastern Missouri through Arkansas into Kansas and Oklahoma.

The Kansas Geological Survey with support and cooperation of Micro-Lite LLC, the owners of the mine and cooperation of landowners has drilled 54 coreholes ranging in depth from less than 30 ft (9 m) to about 960 ft (295 m). Most structural and chemical information is based upon closely spaced drilling in the section in which the mine is located. However, valuable information about the distribution and occurrence of sills in other parts of the domes comes from oil exploration drillholes. A well exposed, concentric, high angle fault marks the northern boundary of the dome at the Micro-Lite LLC property. No lamproite is known to occur north of this boundary. Our drilling results have shown that other concentric and radial faults are widespread. Further inspection shows also that most of these faults are reflected in the surface morphology. Using the approach that surface morphology can be used as an indicator of faulting, additional radial and concentric faults can be mapped on and between the two domes. A prominent set of SW-NE-trending linear ridges connecting the two domes probably reflects faulting in the subsurface. Except for the two core holes that we drilled recently at Rose Dome, little subsurface information is available for that area.

The lamproites are ultrapotassic, alkalic, and enriched in mantle-incompatible elements. The fresh rock is dark gray to black, but near the surface the rock weathers easily to a soft honey-brown. The lamproites are porphyritic, consisting of abundant zoned phenocrysts of phlogopite, serpentine pseudomorphs after olivine and less abundant microphenocrysts of potassic richterite, diopside, and chrome spinel set in a groundmass composed mostly of serpentine (Cullers, et al., 1985). No obvious trends are discernable within each sill, with the exception of minor interaction near the top and bottom of each sill. Representative analyses of a sill and the immediately surrounding country rock is given in Table 1. K_2O and Al_2O_3 concentrations are somewhat lower than in other lamproites and also differ between sills in other parts of the dome. The sills are enriched in mantle-incompatible elements.

Rose Dome and Silver City Dome are considered by many workers to be part of a set of eight cryptoexplosive structures closely associated with the 38th parallel (Snyder and Gerdeman, 1965). The age of the lamproite igneous occurrences generally is considered to be Late Cretaceous, which is coeval with the kimberlite igneous occurrences in Riley and Marshall counties in northeastern Kansas. For the last fifty or so years two different theories have been advanced for the formation of Rose and Silver City domes, but not for the kimberlites of the same age. The domes are thought to have been formed either by the impact of a string of bolides derived from the breakup of a larger bolide (Rampino, 1997) or else by explosive ultramafic volcanic activity at or near the intersection of major weak structural zones in the crust. Arguments for an impact include amongst others the presence of shock metamorphic features and breccias. At Rose Dome and Silver City Dome no shock metamorphic features have been recognized. Rounded granitic boulders, ranging in size up to 3-4 ft (0.9-1.2 m) in diameter occur at Rose Dome and are concentrated mainly in the area close to the central high of the dome. These granitic boulders have been studied by

Smith and Franks (1986); we consider them to be clasts ripped from the side of the vent, indicating the violent nature of the explosion. During their transport up the vent, they were subsequently rounded by tumbling action, much like materials that are rounded in a vortex.

Because of the nature of the rocks, the structure exhibited, the morphological characteristics, and the absence of clear indicators associated with impact structures we view the domes as being formed as a result of violent intrusion of volatile magma derived from a deep source and intruded along a crustal zone, or the intersection of zones, of weakness.

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TABLE 1

WHOLE ROCK MAJOR ELEMENT COMPOSITIONS, DRILLHOLE 92-5

Depth [ft.]	63.7	65.1	65.3	66.1	70.5	71.7	74.8	78.2	81.6	85.6	86.1	91.5	92.4	96.1	99.8	103.6	107.1	109.4
SiO_2	18.2	6.0	46.8	46.6	47.3	46.8	43.7	42.4	42.3	43.1	42.9	43.3	43.5	43.8	45.0	45.1	11.6	38.8
TiO_2	0.032	0.020	3.08	3.17	2.63	2.56	3.24	2.83	2.38	2.87	2.81	2.74	2.59	3.32	3.22	2.99	0.011	0.668
Al_2O_3	0.52	1.07	5.51	5.96	6.89	6.72	5.23	4.44	4.96	4.55	5.09	4.78	4.92	5.57	5.35	5.30	0.35	12.6
Fe_2O_3	2.75	3.94	7.43	7.81	6.65	6.48	8.06	7.88	7.28	8.04	7.58	7.43	7.46	6.80	7.79	7.35	4.22	4.71
MnO	0.168	0.139	0.147	0.109	0.088	0.087	0.130	0.115	0.109	0.113	0.095	0.099	0.097	0.119	0.100	0.128	0.197	0.084
MgO	2.26	3.88	13.9	15.8	15.1	15.7	17.4	19.5	19.5	21.4	19.0	18.5	20.4	11.7	18.4	17.0	3.82	7.04
CaO	30.4	34.1	4.07	4.01	4.78	5.10	4.96	4.35	3.16	3.63	3.35	3.70	3.38	9.63	4.46	3.49	31.0	12.3
Na_2O	2.74	0.201	2.56	1.97	1.82	1.70	1.41	1.84	1.69	1.89	1.83	1.63	1.61	2.59	1.85	1.69	0.93	1.29
K_2O	0.392	0.238	6.19	6.09	6.82	6.90	5.19	3.66	3.94	3.62	3.93	4.08	3.89	4.87	5.06	4.70	0.202	4.38

COMPATIBLE TRACE ELEMENT ABUNDANCES (PPM), DRILLHOLE 92-5

Depth	63.7	65.1	65.3	66.1	70.5	71.7	74.8	78.2	81.6	85.6	86.1	91.5	92.4	96.1	99.8	103.6	107.1	109.4
Sc ppm	4.07	3.36	15.7	14.9	52.6	13.3	14.5	13.5	11.7	14.0	29.3	15.2	13.6	15.0	14.3	13.5	2.43	12.8
V ppm	342	32.3	197	112	77.7	56.8	87.1	49.2	38.6	40.0	35.1	89.6	58.5	121	146	122	18.1	113
Cr ppm	5.76	11.76	195	236	351	430	460	395	294	259	293	353	442	216	147	128	6.02	111
Co ppm	2.89	5.01	42.2	44.4	46.1	42.8	49.2	52.2	53.5	52.1	47.6	50.8	53.1	37.3	44.6	46.0	2.39	14.7
Ni ppm	19.3	25.8	524	581	640	578	671	754	825	770	688	771	873	326	620	684	15.1	48.7
Cu ppm	6.73	10.7	58.5	63.3	52.4	36.6	58.7	56.5	49.6	51.8	55.9	56.3	51.4	65.7	64.8	42.5	2.30	15.0
Zn ppm	6.62	20.2	70.4	80.0	59.0	62.7	156	87.5	72.0	75.8	93.2	75.8	74.4	69.3	76.1	75.5	5.2	65.9