GEOCHEMISTRY OF THE MURFREESBORO KIMBERLITE AND ITS RELATIONSHIP WITH OTHER IGNEOUS ROCKS OF ARKANSAS

K.F. Steele (Department of Geology, University of Arkansas, Fayetteville, Arkansas 72701)
G.H. Wagner (Department of Geology, University of Arkansas, Fayetteville, Arkansas 72701)

Kimberlite, lamprophyre, carbonatite and syenite are all exposed in west-central Arkansas. Samples of these rocks have been analyzed for most major and selected trace elements by atomic absorption spectrometry in order to characterize them chemically and to determine any geochemical relationships. Although these rock types are often associated, the kimberlite and some of the carbonatite exposures in Arkansas are not in close proximity to other types of igneous rocks. For example, the kimberlite at Murfreesboro in Pike County Arkansas is about 56 km southwest of tinguaite and monchiquite dikes in Garland County, the nearest igneous outcrops. The few radiometric dates for Arkansas lamprophyre and syenite indicate that their intrusion took place during the Cretaceous.

Unlike most North American kimberlite and most of the igneous rocks of Arkansas, the Murfreesboro kimberlite does not intrude Paleozoic sediments. The Murfreesboro kimberlite is located in Pike County in the Gulf Coastal Plains at the southern edge of the Ouachita Mountain Region. The Murfreesboro kimberlite is narrowly dated geologically because it intrudes Lower Cretaceous sediments and some kimberlite is found in the lower part of an Upper Cretaceous formation (Miser and Purdue, 1929). There are four distinct occurrences of kimberlite near Murfreesboro. The Prairie Creek intrusion covering 73 acres is the major intrusion. The other three outcrops are located a few miles to the northeast and are of limited extent. The following discussion and interpretations are based on data from the Prairie Creek intrusion. Three varieties of peridotite are associated with these intrusions: 1) massive porphyritic peridotite, 2) breccia, and 3) tuff. The massive peridotite is composed primarily of olivine phenocrysts (many serpentized) in a phlogopite groundmass. Pyroxene is also present, and perovskite and magnetite are present in minor amounts. Xenoliths of local sedimentary rocks (mostly shale) are present as well as rare fragments of igneous rocks. The mineralogy of the breccia and tuff is similar to that of the massive peridotite (Lewis et al., 1976, Miser and Ross, 1923b). Weathered breccia have produced most of the diamonds at Prairie Creek (Thoenen et al., 1949).

The three varieties of kimberlite are similar chemically; however, the tuff contains less Fe, Mg, Ni and Ba than the other two and more Na and K. The massive peridotite has the highest Cr values and the lowest Li, V, and Zn values. Differences in Ba content are difficult to ascertain because barite veins are present in the breccia. The variation of Co, Ni and V appears to be controlled by iron content. Plots of Cr, Al, K and Rb versus mafic index yield smooth trends suggestive of some differentiation. Based on chemical data (Table 1) the massive peridotite is slightly more mafic or primative than the breccia and the tuff is least mafic. This suggests that the massive peridotite was emplaced first followed by the breccia and lastly the tuff. However, considering field, petrographic and geophysical data Bolivar et al (1976) have suggested the sequence of intrusion to be breccia, massive peridotite tuff. Meyer (1975) suggests that the scatter of points for Kimberlite from Norris Lake on an AFC diagram parallel to the CF side is a reflection of the

extensive alteration of the samples. It is of interest to note that the Murfreesboro samples exhibit a similar trend. It is also interesting that the gradual increase in Ca content corresponds with increase in felsic character.

The Murfreesboro kimberlite exhibits the general chemical characteristics of other kimberlites when compared to other peridotites, namely higher K/Na and lower Mg/Fe ratios, and relatively high Ti, Al, Fe, Cr, K, Li, Sr and Ba. However, the Murfreesboro samples contain less Ca than most other kimberlites.

A small 2 m wide peridotite sill resembling the kimberlite at Murfreesboro is exposed along Freedom Creek in Scott County. This peridotite contains phenocrysts of phlogopite and serpentinized olivine in a groundmass of phlogopite, calcite and magnetite. The Scott County peridotite differs from the Murfreesboro samples in that no diamonds have been found and there is little brecciation at this site (Miser and Ross, 1923a). The chemical composition of the Scott County peridotite reported here for the first time is similar to other kimberlite (Table 1). The greatest chemical difference between the Scott County and Murfreesboro rocks is that the Scott County peridotite contains about twice as much Ca. Slight differences in other element concentrations are also present, e.g. the Scott County peridotite also contains more Mn and V, but less Ti than the Murfreesboro samples.

A large majority of igneous rock outcrops in Arkansas are in the eastern end of the Ouachita Mountain Region or near its boundaries. Numerous tinguaite and lamprophyre (mostly monchiquite and ouachitite) dikes and sills are located in Garland, Hot Springs and Pulaski Counties. The largest igneous intrusion in the state is located at Granite Mountain about 153 km northeast of Murfreesboro in Pulaski County. The rock is predominantly pulaskite. Twenty-four kilometers southwest of Granite Mountain in Saline County near Bauxite nepheline syenite outcrops. About 48 km west of these two large syenite intrusions are the Magnet Cove, Potash Sulfur Springs and the "V" Intrusive igneous complexes. These complexes consist chiefly of varieties of nepheline syenite and related mafic rock such as jacupiranguite.

Arkansas carbonatites can be divided into two groups, small massive bodies associated with the syenite complexes at Magnet Cove and Potash Sulfur Springs and small brecciated intrusions often occurring as dikes or sills. The later group is located in Conway and Perry Counties with no other igenous rocks exposed within 19 km. The xenoliths present are usually shale; however, igneous rock fragments are abundant at one locality.

Many of the kimberlite, lamprophyre, syenite and carbonatite samples exhibit similar chemical affinities, e.g. high K/Na ratios. All of the rocks follow the alkali-olivine basalt trend on an AFM diagram. Although, the various lamprophyre types exhibit considerable chemical overlap, the lamprophyre that has intruded the syenite complexes is characterized by both lower mafic indices and higher alkali content (K>Na) than the lamprophyre samples. These lamprophyre samples which intrude the syenite complexes are most similar to the kimberlite. Although the kimberlite and other igneous rocks of Arkansas are not closely related in space, they do appear to be related chemically and in time which indicates a genetic relationship of these rocks.

Table 1. Composition of Arkansas kimberlite and "average" kimberlites. Oxides are in weight percent and trace elements are in ppm by weight.

	1	2	3	4	5+	6+
TiO_2	2.26	2.24	2.22	1.20	2.32	2.03
Al_2O_3	2.94	3.92	4.60	2.46	4.4	4.9
Cr_2O_3	0.37	0.16	0.04	0.11	0.26+	0.22+
Fe_2O_3*	9.16	9.52	6.11	10.02	10.89	11.67
MnO	0.15	0.15	0.16	0.24	0.11	0.10
MgO	20.89	19.49	10.38	18.61	27.9	23.9
CaO	5.84	5.32	5.49	11.60	7.6	10.6
NiO	0.14	0.17	0.04	0.10	0.17+	0.14+
Na_2O	0.48	0.35	1.72	0.19	0.32	0.31
K_2O	2.72	3.40	5.04	3.93	0.98	2.1
BaO	0.34	0.37	0.16	0.30	0.13+	0.23+
Sr	1272	1295	653	950	675	1100
Rb	-	-	-	-	35	80
Li	11	52	51	46	4	24
V	38	115	83	205	120	120
Co	58	92	39	70	65	70
Zn	38	66	61	62	-	-

1. Massive peridotite, Murfreesboro
2. Breccia, Murfreesboro
3. Tuff, Murfreesboro
4. Peridotite, Scott County
5. Basaltic kimberlite (Dawson, 1967)
6. Micaceous kimberlite (Dawson, 1967)

* Total iron as ferric iron

\+ Trace elements and oxides indicated from Dawson (1962)