PETROGRAPHY, PETROLOGY AND CHEMISTRY OF KIMBERLITE FROM THE COLORADO-WYOMING STATE LINE AND IRON MOUNTAIN, WYOMING DISTRICTS

C. B. Smith, M. E. McCallum,* and H. G. Coopersmith (Colorado State University, Fort Collins, Colorado 80523)
D. H. Eggler (Geophysical Laboratory, 2801 Upton St., N. W., Washington, D. C. 20008)

Kimberlite of probable Devonian age is intrusive into Precambrian granitic rocks along the Front Range of northern Colorado and southern Wyoming (McCallum et al., 1975). Known occurrences are confined predominantly to two areas that have been designated as the State Line district and the Iron Mountain, Wyoming district 70 km to the north. Kimberlite occurs in a variety of intrusive forms including dikes, sills, small plugs, blind diatremes and diatremes. Emplacement was localized along fault and joint planes, and at various intersections thereof.

The kimberlite is compositionally and texturally heterogeneous and four transitional varieties have been recognized: massive to porphyritic, carbonate-rich massive to porphyritic, breccia and carbonate-rich breccia. Massive to porphyritic kimberlite occurs in dikes, sills and small plugs and, as such, reflects more deeply eroded levels of the intrusive systems. Brecciated kimberlite is restricted to diatremes and blows. Carbonate-rich phases appear to be closely related to pipe structures, the massive to porphyritic varieties occurring in associated dikes and sills.

Massive to porphyritic kimberlite consists essentially of phenocrysts and/or xenocrysts of rounded olivine and enstatite (both usually serpentinized), Cr-rich and Cr-poor diopside and pyrope, magnesian ilmenite, phlogopite and chromite set in a fine grained groundmass of serpentine, calcite, dolomite, phlogopite, magnetite, perovskite, apatite, rutile, hematite, zircon, and locally, chlorite and talc. Diamond is present in several of the State Line pipes but has not been found at Iron Mountain. Most kimberlite is distinctly porphyritic, but where phenocrysts or xenocrysts are absent or sparce a massive texture is imparted to the rock. Serpentine occurs as fibrous pseudomorphs after olivine and enstatite, and as very fine grained, nearly isotropic patches (serpophite) within the matrix. The latter variety is interpreted as being a primary crystallization product of the kimberlite magma. Carbonate (mostly calcite) comprises up to 30 percent of the matrix, and in some samples is distributed with serpophite in an emulsion-like texture. Contacts between serpophite and calcite patches are generally sharp and irregular, and calcite may be poikilitic. The textural relationships indicate that, at least locally, carbonate and silicate fluid phases were immiscible during the final stages of emplacement.

Massive to porphyritic carbonate-rich kimberlite is texturally similar to the more serpentine-rich variety described above but contains greater amounts of calcite and dolomite. Phenocrysts and xenocrysts may be suspended in a matrix composed primarily of carbonate with minor amounts of chaotically distributed serpentine, phlogopite, apatite and secondary hematite and leucoxene after magnetite and perovskite. In some phases phenocrysts, xenocrysts and serpentinous matrix material may be completely carbonatized, resulting in a rock that may contain as much as 80 percent carbonate (abundant only at Iron Mountain).

Kimberlite breccia and carbonate-rich breccia are similar in composition to the massive to porphyritic varieties except that matrix serpentine and

carbonate contents are more widely variable within any one exposure, and greater amounts of xenolithic material are present. Rock clasts include Lower Paleozoic sedimentary rocks, upper and lower crustal Precambrian crystalline rocks (granite, gneiss, schist, basalt, pyroxenite and granulite), and upper mantle nodules of spinel and garnet peridotite, garnet clinopyroxenite and websterite, dunite, eclogite and carbonatite. Kimberlite breccia fragments and/or autoliths are locally abundant. Breccia phases are generally structureless; flow structures defined by alignment, layering and/or size sorting of phenocrysts that are locally present in massive to porphyritic kimberlite dike facies are absent in the breccias.

Preliminary chemical analyses reveal no pronounced differences in major or trace element chemistry relative to kimberlite in other parts of the world (Fig. 1, Table 1). Most low carbonate rocks have high MgO and relatively low Al_2O_3 , K_2O, CaO and CO_2 contents which, coupled with low phlogopite and calcite contents, indicate a "basaltic" affinity (Dawson, 1967). High rare earth element (REE) abundances and highly fractionated chondrite normalized patterns (La/Yb = 75 to 377) are similar to other kimberlites (Fig. 2). Major variations in chemistry of the Colorado-Wyoming kimberlite appear to be directly related to the highly variable carbonate content; carbonatized samples have the highest CaO, CO_2, La, Ce, Nd, Cs, Ba, Be, Pb, Sr and Zn contents. However, even the most carbonate-rich samples that petrographically display intense carbonatization do not differ markedly in chemistry from average kimberlite. This similarity apparently results from the presence of dolomite and the tendency for high carbonate kimberlite to contain greater amounts of foreign SiO_2 in the form of granitic fragments and silicified groundmass constituents. The carbonate-rich kimberlite is chemically dissimilar to carbonatitic-kimberlite dikes reported from the Saguenay River valley, Quebec, Canada (Gittins et. al., 1975) in having substantially higher SiO_2 and MgO contents.

Petrographic and field evidence in the Colorado-Wyoming districts indicates that kimberlite magma containing immiscible silicate and carbonate fluid phases in various degrees of segregation was emplaced into hypabyssal dike systems. Diatreme formation by fluidization and explosive boring, and attendant carbonatization, apparently was initiated in portions of the dike systems where the carbonate-rich fluid phase was most concentrated, and where fluid pressures exceeded load pressures.

References

Cornelissen, A. K., and Verwoerd, W. J., 1975, Phys, Chem. Earth, 9, p. 71-94.

Dawson, J. B., 1967, in Ultramafic and Related Rocks, P. J. Wyllie, ed., John Wiley & Sons, Inc., New York, p. 269-278.

Gittins, J., Hewins, Roger H., and Laurin, Andre F., 1975, Phys. Chem. Earth, 9, p. 137-148.

McCallum, M. E., Eggler, D. H., and Burns, L. K., 1975, Phys. Chem. Earth 9, p. 149-161.

*Also with U.S. Geological Survey, Denver, Colorado

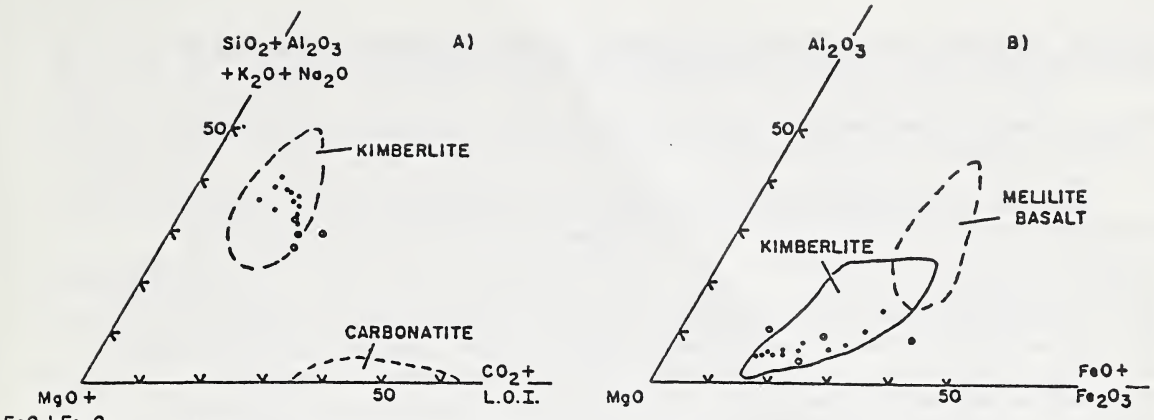

Figure 1. Composition of Colorado-Wyoming kimberlite. A) after Dawson (1967), B) after Cornelissen and Verwoerd (1975). L.O.I. = loss on ignition at 1000°C. solid points = kimberlite, open points = carbonate rich kimberlite.

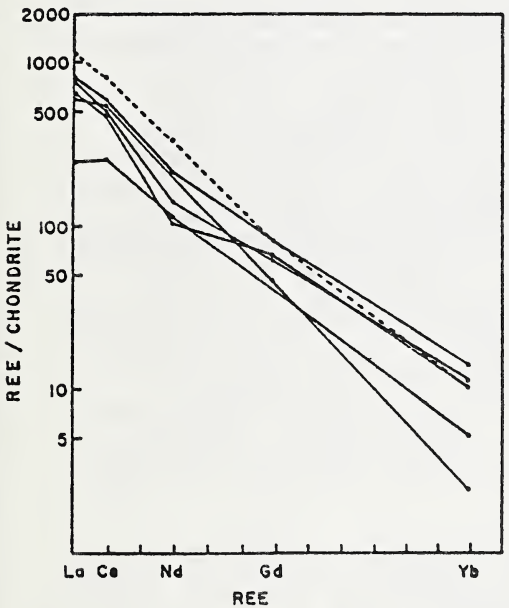

Figure 2. Rare earth normalized patterns for Colorado-Wyoming kimberlite
solid curves = kimberlite
dashed curve = carbonate rich kimberlite

Table 1. Chemical analyses of representative samples

	SD1-86	IM16-5	NX4-10	NX3s-1	IM1-8
SiO_2	30.4	33.6	34.2	24.8	25.7
Al_2O_3	1.9	2.8	2.4	3.1	2.1
Fe_2O_3	4.0	7.7	4.7	7.0	8.7
FeO	2.0	3.8	2.1	1.3	0.87
MgO	25.9	28.4	31.2	22.2	12.6
CaO	14.8	5.1	7.9	16.2	19.9
Na_2O	0.04	0.05	0.07	0.07	0.05
K_2O	0.29	1.4	1.1	0.16	1.0
TiO_2	0.90	3.0	0.75	1.4	2.6
MnO	0.13	0.18	0.13	0.15	0.16
P_2O_5	0.35	0.35	0.15	1.4	0.35
CO_2	8.9	1.7	3.5	10.5	20
L.O.I.	10.2	11.2	12.0	10.0	5
total	99.81	99.20	100.2	98.20	99.03

SD1-86 = kimberlite breccia; IM16-5, NX4-10 = porphyritic kimberlite; NX3s-1, IM1-8 = carbonate rich porphyritic kimberlite.
L.O.I. = loss on ignition at 1000°C