DISCRETE NODULE ASSEMBLAGES IN KIMBERLITE FROM NORTHERN COLORADO AND SOUTHERN WYOMING

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

Two compositionally distinct groups of discrete nodule megacrysts (more than 1 cm in diameter) occur in kimberlite of the Colorado-Wyoming State Line and Iron Mountain districts. The megacrysts are characterized by Cr-rich and Cr-poor assemblages and include garnet, clinopyroxene, orthopyroxene, olivine (rare), ilmenite and clinopyroxene-ilmenite intergrowths. The latter three types are essentially restricted to the Cr-poor group. Most Cr-rich nodules have relatively high Mg/Mg + Fe and CaO and are quite similar chemically to comparable minerals from peridotite nodules (Fig. 1). Some of the Cr-rich megacrysts could be peridotite disaggregation products; however, their coarse grain size is atypical of the peridotite fabric. The Cr-poor megacrysts differ from the Cr-rich discrete nodules in their relatively more subcalcic nature, higher TiO_2, and higher, more variable contents of iron, along with lower Cr_2O_3 (Fig. 2). Many megacrysts of both groups contain mineral inclusions of one or more members of that group. The megacryst assemblages are characterized by distinctive color variations between Cr-rich and Cr-poor members. Most Cr-rich garnet megacrysts (more than 6 percent Cr_2O_3) are lavender to deep purple whereas Cr-poor garnets (less than 4 percent Cr_2O_3) are typically reddish brown. Cr-rich vs. Cr-poor clinopyroxene (more than 1 percent vs. less than 1 percent Cr_2O_3) are emerald green and bluish gray to gray green respectively. Cr-rich orthopyroxene megacrysts (more than .4 percent Cr_2O_3) are bright to pale green; Cr-poor varieties (less than .3 percent Cr_2O_3) are gray green to gray brown.

Cr-poor megacrysts are quite similar to discrete nodules described by Nixon and Boyd (1973) and Boyd and Nixon (1975) from Lesotho and the Monastery Mine, South Africa (Fig. 1). However, the Colorado-Wyoming samples are more enriched in Cr_2O_3, have slightly higher Mg/Mg + Fe, and no high temperature (greater than 1300°C) orthopyroxene megacrysts have been found. Cr-rich megacrysts are not reported from the Lesotho and Monastery kimberlites.

Megacrysts from the Iron Mountain, Wyoming kimberlite district are almost exclusively of the Cr-poor assemblage, and show a prominent enrichment in iron relative to State Line district nodules. Chemical trends in ilmenite are especially pronounced. In addition to significantly higher average iron contents, a MgO vs. Cr_2O_3 plot (Fig. 3) shows a parabolic relationship similar to that reported by Haggarty (1975) for African ilmenites; most of the Iron Mountain samples fall on the bottom and left side (low MgO side) of the parabola. Chemical variations also occur in ilmenite from kimberlite within the State Line district. Megacrysts from the Schaffer, Ferris and Moen pipes are more enriched in iron than those from the Sloan and Nix pipes, but they do not show the degree of enrichment or extreme variation of iron as in the Iron Mountain ilmenite megacrysts. Similar chemical trends occur in garnet and clinopyroxene megacrysts. Clinopyroxene-ilmenite intergrowths are found primarily at Iron Mountain and contain the most magnesian ilmenite and Fe-rich clinopyroxene in that district. However, Mg concentrations in intergrowth ilmenites are appreciably lower than those in most State Line ilmenite megacrysts (Fig. 3).

Rare earth element concentrations determined for representative Cr-rich and Cr-poor diopside and garnet megacrysts suggest small but distinct differences in abundance and chondrite normalized fractionation patterns between the two groups. Cr-rich garnet and diopside are slightly enriched in the light and intermediate REE (La to Gd) and depleted in the heavy REE (Dy to Yb) relative to Cr-poor minerals. The patterns are strikingly similar to those of garnet and clinopyroxene mineral separates from Lesotho granular and sheared garnet lherzolite (Shimizu, 1974). REE fractionation patterns and abundances of the Cr-rich megacrysts correspond closely to granular (depleted) lherzolite minerals, whereas the Cr-poor megacrysts are more similar to the sheared lherzolite minerals studied by Shimizu (1974).

Pressure and temperature equilibration data for orthopyroxene megacrysts indicate depths of approximately 150-200 km and temperatures of 1110^{o}-1300^{o}C. Clinopyroxene megacrysts have a range of equilibration temperatures of approximately 1050^{o}-1350^{o}C; Cr-rich diopsides range to 1210^{o}C, whereas Cr-poor diopsides exceed 1210^{o}C. All diopsides may be considered to have been derived from depths of less than 200 km if pressure values for the higher temperature nodules are calculated from the inflected or disturbed portion of the geotherm established from State Line megacrysts (Eggler and McCallum, 1976). Equilibration temperatures for clinopyroxene-ilmenite intergrowths are confined to the narrow range of approximately 1220^{o}-1240^{o}C as determined from the diopside solvus after Davis and Boyd (1966), and would correspond to depths of about 170-175 km if pressures are determined from the inflected geotherm. Similar depth figures were established previously utilizing the uninflected geotherm and assuming that the intergrowths crystallized in equilibrium with ilmenite bearing orthopyroxene megacrysts at 1150^{o}-1160^{o}C (Smith et. al., 1976).

Chemical and physical properties suggest that both Cr-poor and Cr-rich suites crystallized in the presence of a liquid. Compositional trends of Cr-poor megacrysts, in particular ilmenite and garnet, are interpreted to reflect liquid fractionation trends. Most silicate phases crystallized before ilmenite; the clinopyroxene-ilmenite intergrowths represent a transition from silicate to oxide crystallization. Recent experimental work by Wyatt (1977) in which clinopyroxene-ilmenite intergrowths were formed at 38 kb pressure, strongly supports the contention that the megacryst suites crystallized in the presence of a melt. The liquid in which megacrysts crystallized may have been a primitive kimberlitic partial melt generated by the intrusion of mantle diapirs.

References

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

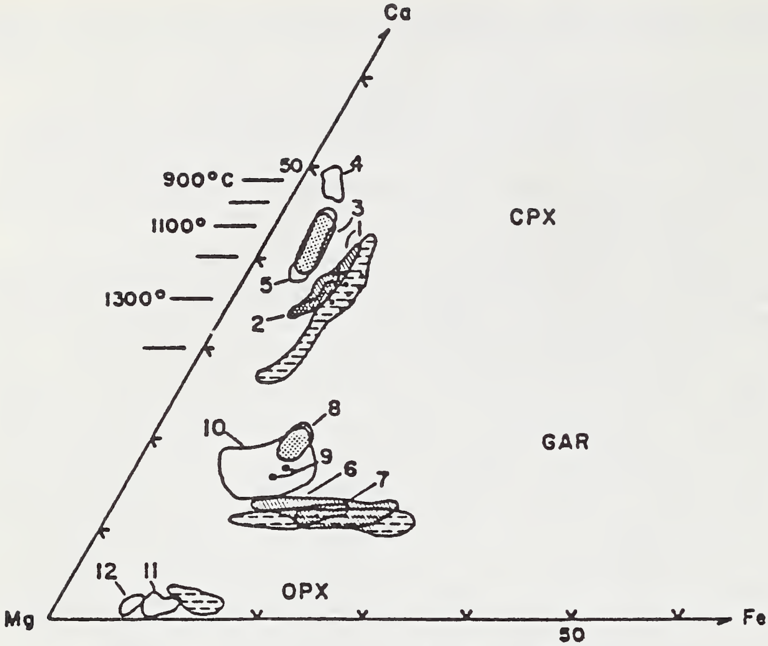

Figure 1. Compositions of megacryst minerals
1) Iron Mountain Cr-poor diops. 2) State line Cr-poor diops.
3) State Line Cr-rich diops. 4) depleted spinel peridotite diops.
5) depleted garnet peridotite diops. 6) Iron Mountain Cr-poor gar.
7) State Line Cr-poor gar. 8) State Line Cr-rich gar.
9) Iron Mountain Cr-rich gar. 10) depleted peridotite gar.
11) State Line Cr-poor enstatite 12) State Line Cr-rich enstatite
Fields with horizontal dashed lines define compositional ranges of megacrysts from South Africa and Lesotho. Cpx-ilmenite intergrowth diopsides are shown as cross (Iron Mountain) and points (South Africa). Cr-rich cpx and opx megacrysts have not been found at Iron Mountain.

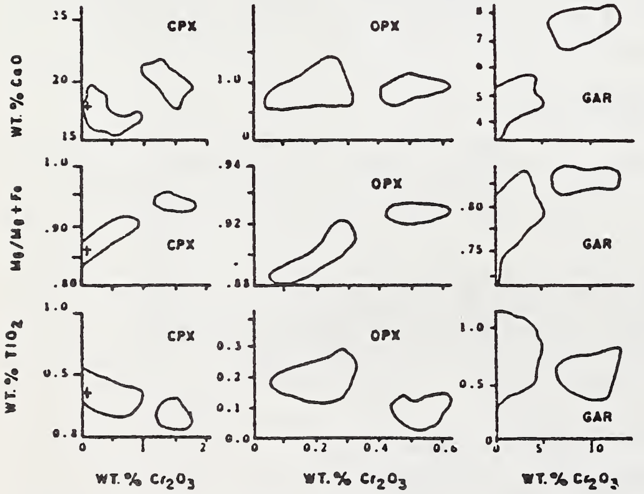

Figure 2. Compositional fields of Cr-rich and Cr-poor megacrysts. cross = cpx from cpx-ilm intergrowth.

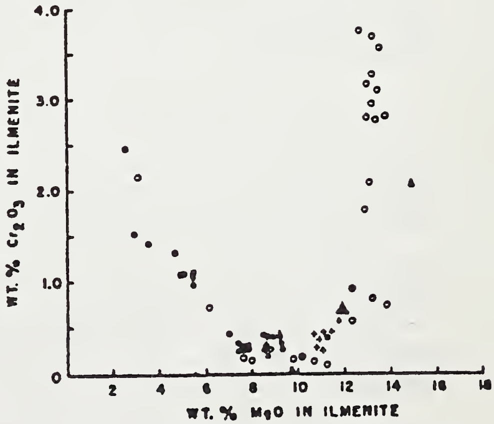

Figure 3. Ilmenite megacryst compositions. solid points = Iron Mountain; open points = State Line; crosses = cpx-ilm intergrowths; triangles = peridotite ilmenite.