PETROLOGY AND GEOCHEMISTRY OF ULTRAMAFIC XENOLITHS FROM THE JAGERSFONTEIN MINE, O.F.S., SOUTH AFRICA. Judith L. Johnston, Dept. of Geology, University of California, Davis, California, U.S.A.

A suite of seventy-seven ultramafic xenoliths from the Jagersfontein Mine has been studied and divided into two distinct groups, the granular harzburgites and the sheared xenoliths, on the basis of mineralogy, textural differences and mineral chemistry.

1) <u>The harzburgite group</u> consists of rocks in which olivine and enstatite are the principal minerals; sixty-six rocks fall into this category. These rocks have a granular texture and contain large subhedral grains of olivine and enstatite. Small grains of anhedral diopside, garnet and chrome-spinel occur between the olivine and enstatite grains. These minor phases, plus amphibole, which may be either a major or a minor constituent, serve to further subdivide this group into spinel, garnet and amphibole harzburgites.

Diopside in the harzburgites often occurs in only trace amounts and usually comprises $<$5.0% of the rock. In many cases it appears to have exsolved from enstatite. Garnet has also exsolved from enstatite althogh in some samples-garnet harzburgites containing 6.0% garnet-it may represent a primary phase. Spinel occurs in two different forms; as small ($<$2mm.)euhedral crystals or as the oxide phase in oxide-silicate symplektites. The euhedral spinels arethought to be primary and the symplektites the result of subsolidus reactions. All of the symplektites contain chrome-spinel as the oxide phase; the silicate phase is usually diopside, although enstatite-spinel, amphibole-spinel and garnet-spinel symplektites are also present.

Amphibole occurs as a minor phase ($<$ 2.0%) in seven harzburgite samples; in three other harzburgites it is a major component (15.0 to 27.3%). It occurs as large single crystals poikilitically enclosing olivine and enstatite. In these amphibole harzburgites garnet is present as small round grains embedded in the amphibole.

2) <u>The sheared xenoliths</u> contain olivine, enstatite, diopside and garnet except for one sample which is a pure dunite. Spinel and amphibole are absent, as are syplektites. These samples are not granular as were the harzburgites, but have been sheared. The degree of shearing varies from sample to sample: some are definitely foliated while others show granulation with no obvious foliation. Olivine has been most completely granulated and have been fractured into a mosaic of small grains. Enstatite has been elongated parallel to the foliation (if the rock is obviously foliated) and is partially granulated. Diopside is anhedral or subrounded, with very little granulation. It does not appear to be oriented with respect to foliation. Garnet occurs as large round grains with kelyphitic rims; although the rounde shapes may be due to shearing stress, no pressure shadows or granulation was observed.

Electron microprobe analyses were made of the constituent phases from all samples except when adequate separates of minor minerals could not be obtained. Olivines were analyzed for Mg, Al, Si, Ca, Ti, Cr, Mn, Fe and Ni. Enstatites, diopsides, garnets and amphiboles were analyzed for Na, Mg, Al, Si, K, Ca, Ti, Cr, Mn and Fe. Spinels were analyzed for Mg, Al, Ti, Cr, Mn and Fe.

The forsterite content of olivines was found to be an accurate means of distinguishing between the two groups. Olivines from harzburgites had Fo-Fa ratios of $Fo_{95.3}$ to $Fo_{91.8}$ while the olivines from sheared xenoliths ranged from $Fo_{91.6}$ to $Fo_{86.4}$. In addition the olivines from sheared xenoliths have higher Al_2O_3 contents than do those from harzburgites.

Enstatites from sheares xenoliths have higher En-Fs ratios than enstatites from harzburgites. When enstatite data, in terms of mole per cent, are plotted onto the pyroxene quadrilateral the harzburgite enstatites fall on the enstatite-ferrosilite join, except for eight samples which contain a high proportion of euhedral spinels. Enstatites from these spinel harzburgites are more calcium-rich, and may be interpreted as having equilibrated at higher temperatures than other harzburgite enstatites. Enstatites from sheared xenoliths are richer in both calcium and iron than enstatites from harzburgites, and are also assumed to represent higher equilibration temperatures.

Diopside chemistry, when displayed on the pyroxene quadrilateral also shows the same separation of harzburgites and sheared xenoliths: the diopsides from sheared xenoliths are more magnesian and therefore represent a higher temperature of equilibration than the diopsides from harzburgites. Diopsides from symplektites are the most calcic, falling on the diopside-hedenbergite join, and show the lowest equilibration temperatures of the entire suite. This is to be expected, as these symplektites represent subsolidus reactions.

Garnets, when considered in terms of pyrope, almandine and grossular end members, are very pyrope-rich. Pyrope variation is greater in the harzburgite group, from $Py_{87.5}$ to $Py_{64.5}$ although most are $< Py_{75.0}$. Garnets from sheared xenoliths tend to show little pyrope variation-all are between Py_{75} and Py_{78}. In general, Cr_2O_3, TiO_2, K_2O and Na_2O are higher in garnets from sheared xenoliths than in garnets from harzburgites.

Both symplektite and euhedral spinels are closest to magnesiochromite ($MgCrO_4$) in composition, with some substitution of Fe^{+2} for Mg and of Al for Cr. The symplektite spinels are more aluminous , and the euhedral spinels are more chrome-rich.

The amphiboles are all varieties of hornblende. If the calcic amphibole classification scheme of Leake (1969) is applied to these amphiboles, two types are recognized: 1) amphiboles which occur as minor constituents are magnesiohornblendes 2) those which are found in amphibole harzburgites are edenites.

An attempt was made to determine pressures and temperatures of equilibration for this suite of xenoliths. Temperatures were estimated for rocks with coexisting enstatite and diopside using the 30 kilobar diopside solvus from the join $Mg_2Si_2O_6$-$CaMgSi_2O_6$(Davis and Boyd, 1966). These temperatures, together with Al_2O_3 contents of enstatites, were used to determine pressures of equilibration using MacGregor's isopleths in the system MgO-Al_2O_3-SiO_2 (1973). The resulting plot (Fig.1) shows that the granular harzburgites and the sheared xenoliths were equilibrated under very different conditions of temperature and pressure: the harzburgites at $\approx 900^{\circ}C$ and 36 to 52 kilobars, and the sheared xenoliths at 1150 to 1280$^{\circ}C$ and $\approx$ 60 kilobars.These differences, together with the mineralogical and textural differences already noted, would suggest different processes to account for the evolution, and perhaps genesis of these two groups.

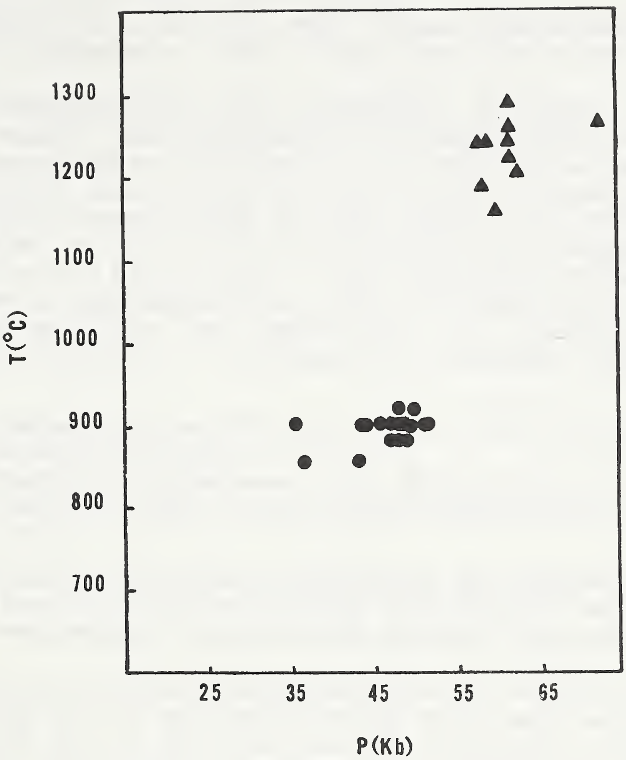

Figure 1. Pressure-temperature plot of Jagersfontein xenoliths. Triangles are sheared xenoliths, circles are granular harzburgites.

REFERENCES

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