PERIDOTITES AND GARNET OLIVINE WEBSTERITES AT BULTFONTEIN MINE

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The great majority of mantle xenoliths at Bultfontein are peridotites which would fall within the modal proportions which define the common peridotites (C.P.) at Matsoku, N. Lesotho. (Cox et al 1973) (i.e. garnet 0-11%; clinopyroxene 0-5%; orthopyroxene 20-50%; olivine 45-75%; olivine > orthopyroxene). Rare xenoliths fall outside this range because they contain more garnet and clinopyroxene and less olivine. In such rocks orthopyroxene is the major mineral. They are referred to here as garnet olivine websterites. The following features have been recorded:

1. The textures shown by the C.P. at Bultfontein vary from coarse to laminated and disrupted mosaic porphyroclastic rocks. Variable degrees of deformation have been noted in single xenoliths. (Dawson et al 1975).
2. The garnet olivine websterites have coarse textures.
3. The temperatures and pressures of equilibration of the C.P. and the garnet olivine websterites is restricted to a narrow range on the basis of the Ca/Ca+Mg ratios of the pyroxenes and the Al_2O_3 content of the orthopyroxenes. (Dawson et al 1975).
4. There is no correlation between the temperature of equilibration and degree of deformation. (Dawson et al 1975).
5. No sub-calcic diopsides have been found in the xenoliths.
6. Some xenoliths have phlogopite or potassic richterite present. These minerals have been interpreted to be of primary metasomatic origin. (Erlank and Rickard 1977). The phlogopite may be associated with rutile, ilmenite and sulphides.
7. The minerals in the C.P. have high Mg/Mg+Fe ratios.
8. The minerals with the lowest Mg/Mg+Fe ratios are found in garnet olivine websterites.
9. The titanium content of the minerals in the coarse unmetasomatised rocks shows a positive correlation with iron whilst chromium has a negative correlation. This is best shown by the garnets, in which these two elements are concentrated.
10. The highest titanium contents are found in the minerals of the metasomatised rocks, as are the highest bulk rock titanium and potassium values.
11. The full range of the observed variations in bulk chemistry for magnesium, iron, aluminium, calcium, chromium, sodium, manganese and nickel are found in the coarse xenoliths.
12. As a consequence of the changes in modal proportions and mineral chemistry the C.P. have high whole rock $\frac{Mg}{Mg+\sum Fe}$ ratios compared to the iron rich garnet olivine websterites. The richterite bearing rocks and most of the phlogopitic rocks have intermediate values.

In respect of the features listed the xenoliths described are very similar to the suite at the Matsolku Pipe, N. Lesotho described by Cox et al (1973), Harte et al (1975), Gurney et al (1975) and Harte and Gurney (1975). The Bultfontein xenoliths do differ in some respects, however. We draw attention to the facts that:

(i) the most deformed rocks at Bultfontein are not found at Matsoku.
(ii) the metasomatised rocks at Matsoku are fine grained, whilst those at Bultfontein may be coarse.

(iii) potassic richterite is reported in metasomatised rocks at Bultfontein (Erlank and Rickard 1977) but has not been found at Matsoku.

(iv) the range in bulk chemistry and in Mg/Mg+Fe ratio for the minerals at Bultfontein, whilst greater than that reported by Boyd and Nixon (1973) for both deformed and undeformed rocks at several localities in N. Lesotho, is less than that found at Matsoku.

(v) some coarse garnet olivine websterites at Bultfontein do not show marked iron enrichment in the constituent minerals. At Matsoku the only pyroxenites which have similar chemistry are narrow pyroxene rich veins which are finer grained than the C.P. and appear to have re-equilibrated with adjacent peridotite. (Harte et al 1977).

Common Peridotites

The mineral and bulk rock compositions of the unmetasomatised C.P. at Bultfontein are very similar to the Matsoku coarse C.P. and for reasons advanced by Gurney et al (1975) are thought to most likely represent partly depleted mantle material. The trace elements Ba, Sr, Rb, Y, Zr, Nb, Zn, Cu and V are all very low in the unmetasomatised C.P. by comparison to the Stormberg volcanic rocks of Lesotho, whilst Ni and Cr and to a lesser extent Co are enriched, (Table 1) supporting this conclusion.

The most iron rich rock found at Bultfontein (JJG1417) is similar to those coarse xenoliths interpreted to most probably be of cumulate origin at Matsoku, except that it contains minor (1%) phlogopite in textural equilibrium with the major minerals. The rock is a coarse garnet olivine websterite, with an olivine composition of $Fo_{85.1}$ and an orthopyroxene of En_{87}. A similar rock is described by Williams (1932) (Wess 152). Wess 152 however has no olivine and is in that respect similar to LBM 18 (Cox et al 1973). O'Hara et al (1975) have described similar rocks from Matsoku (1031, 1032) and A17 from an unspecified locality in S. Africa. It has been suggested that the rocks represent either (i) Fertile mantle or (ii) Liquid compositions (komatiitic) or (iii) Cumulate minerals $\pm$ intercumulus. (e.g. O'Hara et al 1975, Gurney et al 1975). As argued for Matsoku, we consider the latter to be the most probable of the three.

References

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TABLE 1	3:1 Pyrolite II	Primary Lherzolite	HSS150	Stormberg Volcanics	PHN 1611	LBM 12	BD 2349	JJG 1417
SiO_2	43.95	45.0	44.9	49.7	43.70	44.1	44.4	50.3
TiO_2	0.57	0.36	0.28	1.00	0.25	0.11	0.01	0.11
Al_2O_3	3.88	4.1	3.12	14.9	2.75	3.60	1.46	2.98
Fe_2O_3	0.75		2.31		1.38	4.00	2.96	2.18
FeO	7.50	11.0*	11.53	11.4*	8.81	10.52	3.82	7.20
MnO	0.13	0.16	0.18	0.17	0.13	0.17	0.09	0.17
MgO	39.00	33.00	33.01	6.32	37.22	33.45	41.74	31.4
CaO	2.60	4.00	3.76	9.97	3.26	2.90	0.86	2.80
Na_2O	0.60	0.68	0.01	2.49	0.33	0.27	0.05	0.36
K_2O	0.22		0.01	1.11	0.14	0.03	0.03	0.09
P_2O_5			0.03	0.23	tr.	0.01	0.01	0.07
S			0.04	0.04		0.29	0.02	0.01
LOI				2.73		0.81	4.20	1.38
H_2O^+				1.00	1.94		0.32	0.23
Ba			36	247		120	8	73
Sr			7	195		49	34	107
Rb			< 1	19		3	< 3	3
Y			7	24		< 3	< 3	6
Zr			21	101		14	7	32
Nb			< 1	5		< 3	< 3	5
Zn			80	81		102	32	70
Cu			36	102		17	< 3	< 3
Co			145	46		188	116	116
Ni	3222	2122	1745	75		2390	2250	1530
V			83	232		76	26	68
Cr	2669	2395	4370	204		5500	2300	5100
(FeO*/MgO +FeO*) X 100	17.33	25.00	29.19	64.33	21.26	29.68	13.44	22.58

* Total iron as FeO

Table 1: Footnote

The pyrolite II composition is that of Green and Ringwood (1967). Primary lherzolite is P1 from Kuno and Aoki (1970). The Stormberg data is an average from a Kao Mine borehole and for rocks from the Witsieshoek area in Lesotho, provided by J. Bristow (unpublished data). The rock HSS 150 is an aphyric peridotitic komatiite, and is thought to represent a magnesian liquid composition. (H.S. Smith).