PETROGRAPHY AND GEOLOGICAL HISTORY OF UPPER MANTLE XENOLITHS FROM THE MATSOKU KIMBERLITE

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Xenoliths of garnet peridotite facies origin (Group 1 of Cox, Gurney and Harte, 1973) usually consist only of varying proportions of the minerals: olivine, orthopyroxene, clinopyroxene (chrome-diopside), and garnet (ignoring late-stage alteration products). The majority of the xenoliths (common peridotites - CP) consist predominantly of olivine and orthopyroxene (ol. > opx.) with < 5% of chrome-diopside and < 11% of garnet. Dunites, garnet orthopyroxenites (with subordinate olivine ± chrome-diopside), and garnet websterite also occur in small amount, as well as rare unbanded garnet lherzholites enriched in chrome-diopside and/or garnet.

BANDING

A banded distribution of minerals is seen in 10 specimens, with bands corresponding to modal varieties listed above, but also including types considerably enriched in chrome-diopside (and garnet). The transitional nature of most band contacts and absence of sharp distinctions in modal proportions (excepting LBM 40; Cox, Gurney & Harte 1973), together with a lack of intrusive relationships or metasomatic features (excepting LBM 38; op. cit.), suggests a cumulate origin for much of the banding. Such an origin is supported by the constant mineral chemistry of adjacent bands (Gurney, Harte & Cox 1973), and the presence in LBM 31 of a dunite band between harzburgite bands.

TEXTURAL TYPES

Texturally the following principal types of xenolith (both banded and unbanded) may be recognised:

(a) Coarse-granular (Fig.1a) This is the commonest type and shows a predominantly coarse grain size of anhedral crystals. Grain boundaries are usually quite wavy and irregular, but vary towards smoothly curving. Slight undulose extinctions and some broad deformation bands are not uncommon within large olivine and orthopyroxene grains, but crystals are not strongly deformed. Preferred dimensional elongation of minerals is not usually visible, but weak crystallographic fabrics may be present.

(b) Coarse-granular with slight recrystallisation Similar to (a) but with more pronounced deformation of minerals, accompanied by polygonisation within large olivine and orthopyroxene crystals, and thin zones of recrystallisation along grain boundaries.

(c) Flaser (Fig.1b) Showing prophyroclasts and lenticles of coarse grain size (especially of orthopyroxene), with large garnets frequently drawn out into schlieren. Between the relics or original minerals the rock shows recrystallisation to a fine grained aggregate. (Although flaser, the structure and fabric of these rocks is not nearly so pronounced as that figured in Williams (1932, plate 145), or described by Boyd (1973, and personal communication).

(d) Fully recrystallised (even textured) (Figs. 1c & 1d). These rocks show varying grain size depending on the amount of grain growth following recrystallisation. Within individual specimens the grain size is usually quite uniform, and grain boundaries are characteristically regular and smoothly curving. The latter features with regular triple junctions

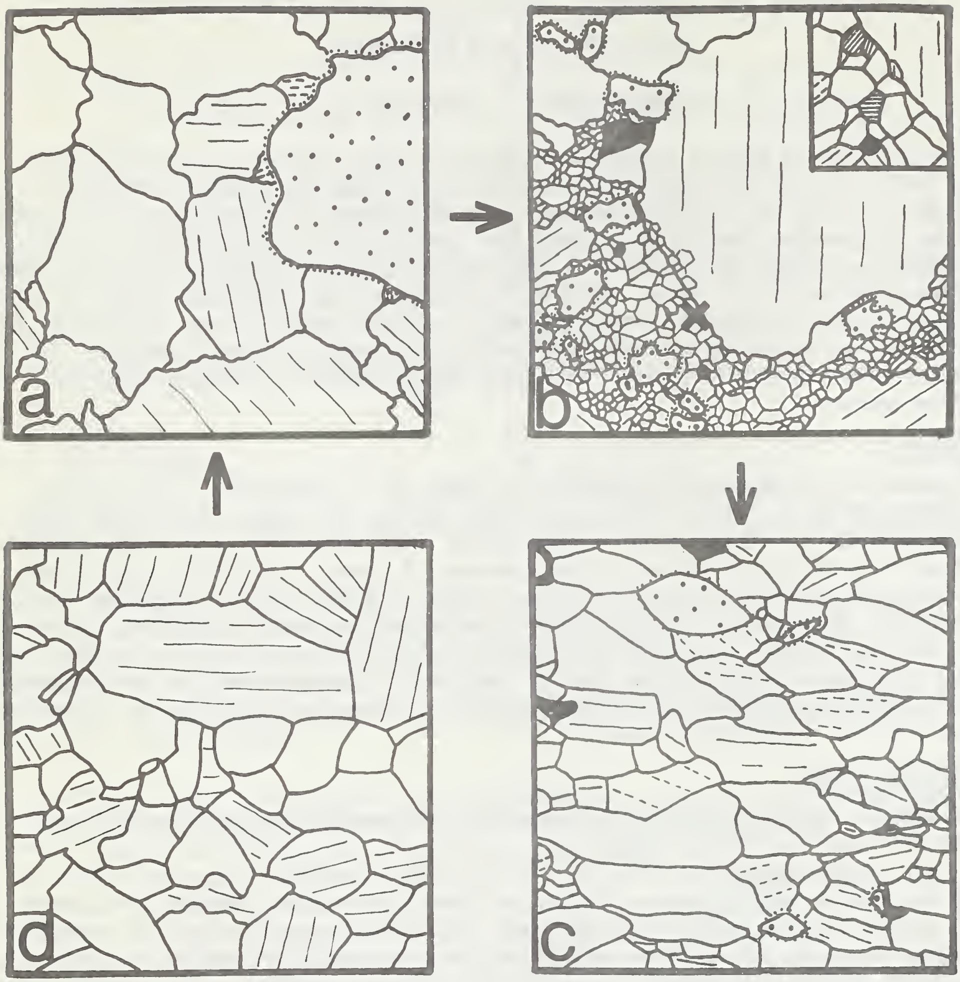

FIG. 1 Diagrams illustrating different textures in Matsoku rocks - see text. All traced from photographs and with constant magnification (x 12.5) except inset in 1b (x 25).

(a) Coarse-granular
(b) Flaser - showing very fine grained recrystallised areas and large prophyro-clasts.
(c) & (d) Fully recrystallised.

ORNAMENTATION (not shown in recrystallised areas of main part of b):

olivine
orthopyroxene
clinopyroxene
garnet
phlogopite
ore mineral

distinguish medium to coarse grained rocks of this category from those of category (a) - compare Figs. la & ld. In some fully recrystallised rocks there is a distinct dimensional elongation of mineral grains (Fig.lc) producing schistosity, and strong fabrics may be present.

All gradations are seen between each of the above types and those listed immediately above and below it . Subsequent deformation leading to undulose extinction and broad deformation bands may be seen to have affected occasional grains in some type (d) rocks, and more irregular grain boundaries are often associated with such grains (contrast the centre left with the right handside of Fig. ld). Thus one may envisage type (d) rocks (Fig.ld) passing into type (a) rocks (Fig. la) with continued grain growth and slight deformation. A continuous 'cycle' of deformation, recovery, recrystallisation and grain growth is thus generated as shown on P.4; although there is no specific evidence in the case of the Matsoku nodules for any rock having undergone more than one complete cycle. The textural changes seen, and the gradual and progressive nature of the reconstitution coupled with its occurrence under constant conditions of high T. and P. (Gurney, Harte & Cox 1973) suggests an origin by mantle creep (Ave'lallement & Carter 1970; Raleigh & Kirby, 1970).

METASOMATISM AND THE FORMATION OF PHLOGOPITE AND ORE MINERALS

In the recrystallised areas of some flaser rocks, and in some fully recrystallised rocks small amounts of phlogopite and ore minerals (ilmenite, rutile, chalcopyrite, pyrrhotite, and pentlandite) are seen. These additional minerals show smooth grain boundary contacts with recrystallised olivine, orthopyroxene, and clinopyroxene, and thus appear texturally primary (Fig. lb inset). Such relations contrast with those of phlogopite and ore mineral seen in all xenoliths, where these minerals are associated with kelyphite and serpentine and are clearly related to very late-stage alteration (within the kimberlite?). The general absence of other than the latter phlogopite and ore mineral in coarse-granular xenoliths, suggests that the texturally primary material has been introduced metasomatically during the coarse of recrystallisation. The introduction of metasomatic fluid may have promoted the recrystallisation in some instances.

Specific evidence of infiltration metasomatism is shown by a vein enriched in phlogopite and ore mineral in LBM 22. The vein truncates a flaser structure present in this rock, and within the vein all minerals appear fully recrystallised.

Minerals in metasomatised areas of rocks (including the LBM 22 vein) show only slight departures in chemical composition from minerals outside metasomatised areas (Gurney, Harte & Cox, 1973), and the metasomatism is therefore believed to have occurred under the common T. & P. conditions indicated by all xenoliths. The metasomatic fluid may be derived from the low velocity zone (Boyd, 1973). Since the metasomatism (and associated recrystallisation) are the last definite events seen in the nodules prior to their eruption in kimberlite, it is possible that the metasomatic fluid was derived from the developing kimberlite 'magma'.

References:

Ave'lallement, & Carter, 1970 Bull. Geol. Soc. Amer.

Boyd, F.R. & Nixon, P.H., 1973. Origin of Ilmenites-Silicate Nodules in Lesotho Kimberlites, edited P.H. Nixon.

Boyd, F.R., 1973. Geochem et Cosmoschem. Acta (in press).

Cox, K.G., Gurney J.J., & Harte, B., 1973.in Lesotho Kimberlites edited P.H. Nixon./ Gurney, J.J., Harte B., & Cox, K.G., 1973. This Volume.

Raleigh C.B., & Kirby, S.H., 1970. Miner Soc. Amer. Spec. Pap.3,113-121.

Williams, A.F., 1932. The Genesis of the Diamond.

Harte, Cox & Gurney.

SUMMARY OF GEOLOGICAL HISTORY OF UPPER MANTLE XENOLITHS FROM MATSOKU PIPE