OCCURRENCE OF METASOMATIC HYPERSTHENE, AND ITS PETROGENETIC SIGNIFICANCE

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ABSTRACT

Hystersthene pseudomorphs augite where a dolerite is cut by an alumina-rich granitic rheomorphic vein. The control of alumina in the formation of hypersthene is not confined to basic melts, but is also effective in the solid state.

INTRODUCTION

A zone of intense metamorphism extends for six feet on both sides of an olivine dolerite dyke (nearly vertical and fifteen feet thick). The emplacement of the dolerites is the last manifestation of igneous activity which affected an Archaean complex in the Kulgera Hills about 160 miles S.S.W. of Alice Springs in Central Australia.

Granitic rocks have been converted in situ to rocks resembling quartz porphyries, and a case of mobilization of cordierite gneiss was found. A description of these unusual contact effects is given elsewhere (Wilson 1952). Metasomatic hypersthene occurs pseudomorphing augite where the rheomorphic vein (the result of mobilization on the metamorphism of the cordierite gneiss) cuts the dolerite. The dolerite is normally devoid of hypersthene.

PETROGRAPHY

The rheomorphic vein

No. 30104* is representative of the vein resulting from the mobilization of granitic cordierite-bearing gneisses which comprise the bulk of the oldest rocks of the Kulgera Hills.

The dark gray vein is straight, several yards long and nearly one inch thick. It has clean walls, and transgresses both the dolerite and the gneisses in which it appears to arise. Microxenoliths are roughly parallel to the walls of the vein.

The vein consists of a fine-grained groundmass of plagioclase, strongly zoned from andesine to albite, and potash feldspar-quartz micrograno-phyre, abundant flakes of pale green sericite, numerous granules of dull

* Catalogue number in the collection of University of Western Australia, but duplicates are housed in the University of Adelaide. Field work was in part financed by a Commonwealth Research Grant administered by the University of Adelaide, and this assistance is here acknowledged.

black iron ore, wisps of graphite, and ragged plates of biotite (X = colorless, Y = Z = khaki green). The average grain size of the groundmass minerals is 0.04 mm.

There are no true phenocrysts, but xenocrysts and microxenoliths of all sizes are so abundant that it is difficult to decide the nature and origin of many mineral clusters in the groundmass. The most conspicuous foreign bodies are large, very deeply embayed masses of quartz, many of which are 3 or 4 mm. long. Several microxenoliths were noted comprising large bundles of sillimanite needles (largest observed is 8 mm. × 2 mm.). A few strongly pinitized cordierite anhedra (some enclosing sillimanite needles) are present, and are in several places associated with irregular patches of dull black octahedra of magnetite (or some other ferriferous spinellid). Also observed were some irregular kaolinized xenocrysts of plagioclase. Occasional zircon and (?) monazite occur. Relict ophitic texture is readily seen in a "hydrated" xenolith of dolerite (2.5 mm. × 2 mm.). Pyroxene is pseudomorphed by yellowish-green serpentine which is studded with tiny octahedra of magnetite. Plagioclase is almost completely kaolinized and carbonated.

Contact Phenomena

The walls of the rheomorphic vein are well defined, and augite is pseudomorphed by hypersthene in a zone extending up to 0.4 mm. from both contacts (see Fig. 1).

Owing to the granular nature of the hypersthene its identity is not obvious. Indeed, it was suspected that the metasomatic masses may well be microintergrowths of clino- and ortho-pyroxene. Grains were removed from an uncovered slide, and it was found that the masses are monomineralic. Some of the properties of this mineral are: $\gamma = 1.698$ (approx.); $2V = (-)\ 70°$ to $75°$; weakly pleochroic with X = very pale pinkish gray, Z = very pale greenish gray; good {110} cleavages (nearly at right angles), good {010} parting, and poor {100} parting; optic plane parallel to {010} with Z parallel to *c*. These properties indicate the mineral to be hypersthene (approx. 25 mol. % Of).

Within the contact zone plagioclase shows no alteration. But olivine (perfectly fresh elsewhere in the normal dolerite) is completely serpentinized near the vein, and it was the writer's first impression that the formation of the hypersthene and serpentine took place at the same time. More careful study, however, shows that in almost every case a tiny serpentinized crack can be found emanating, apparently, from the vein and traversing the normal olivine dolerite for a few mm., and serpentinizing any olivine with which it comes in contact.

Discussion

Although the serpentinization of the olivine may only indicate the activity of "late magmatic waters" from the rheomorphic vein, it seems strange that the "dry" mineral hypersthene should form under the influence of a magma (or crystal mush) in which the "wet" mineral biotite

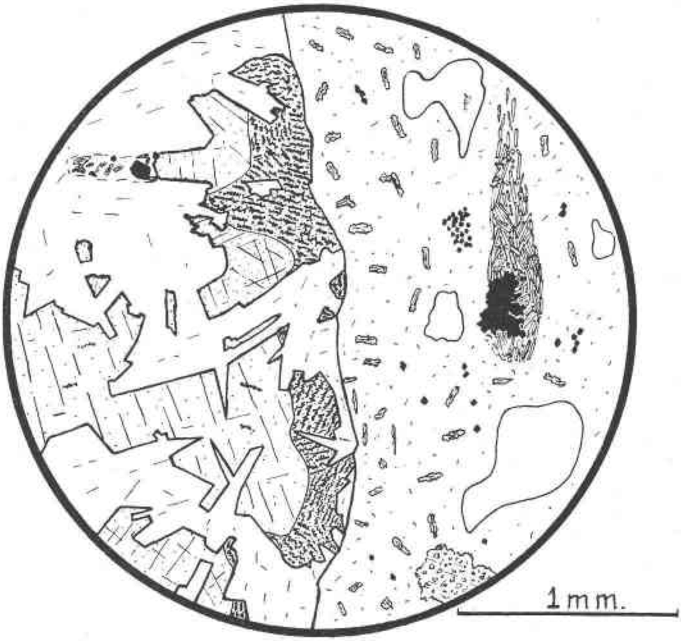

FIG. 1. *Metasomatic hypersthene* at the junction of rheomorphic vein (right) and olivine dolerite (left).

The rheomorphic vein is made up of xenocrysts of quartz (white) and antiperthitic andesine (poorly cleaved mass with irregular patches of potash feldspar), and a xenolith of sillimanite needles set in a groundmass of plagioclase, potash feldspar-quartz micrographophyre, and ragged flakes of biotite (cleaved). The dolerite is made up of large ophitic flakes of augite and late pigeonite (cleaved and lightly stippled), and plagioclase (white). A little end-phase alkali feldspar, magnetite, and biotite is shown in the upper left portion of the field. Hypersthene (heavily stippled) replaces all clinopyroxene within about $\frac{1}{3}$ mm. from the contact.

was stable. Further, there seems to be no dearth of alkali in the vein, and under such conditions one could reasonably expect to find either an amphibole or biotite in the contact zone.

A remarkable feature is that the hypersthene is *metasomatic* (see Fig. 1). The formation of hypersthene in a basic *magma* which has assimilated aluminous material is a well known process (Read (1935), Kuno (1950), etc.). In a crystallizing basic magma so much CaO is needed to combine with xenolithic Al_2O_3 to form anorthite that hypersthene (a calcium-free pyroxene) takes the place of the clinopyroxene, diopsidic augite. In the case of the metasomatic hypersthene here described, however, it seems that this process, known to take place in basic melts, can also take place in the solid state.

The formation of the hypersthene seems to have been conditioned by the high Al_2O_3 content of the vein (as shown by xenolithic sillimanite schist). CaO was taken from augite in the wall rocks and formed plagioclase with excess Al_2O_3, Na_2O, and SiO_2 in the vein. The CaO of the augite seems to have been replaced by FeO from the vein to form hypersthene. (Small quantities of FeO are to be expected in the vein in view of the tendency for conversion of Fe_2O_3 to FeO, and expulsion of some FeO during the metamorphism which culminated in the formation of the rheomorphic vein (Wilson, 1952).)

Petrogenetic applications of these phenomena are, doubtless, very limited, otherwise they would have been described before. However, one is tempted to speculate whether mobilization of certain lime-deficient pelitic sediments during intense metamorphism, and subsequent lit-par-lit injection into basic rocks, may be factors in the formation of certain diopside-hypersthene-biotite-bearing migmatites with charnockitic affinities. This may preclude the necessity felt by some to postulate an assimilation of alumina by basic magma to give hypersthene-diopside-bearing rocks prior to their injection by granitic liquors and formation of biotite at the expense of the pyroxenes.

Whether this be true, or not, there are at least three features which are clear, viz.,

(1) Hypersthene may form metasomatically.
(2) Although a "dry" mineral, hypersthene can form under "wet" conditions.
(3) Contamination of magma by alumina may give rise to hypersthene in either the magma, or the wall rocks.

References

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