American Mineralogist, Volume 65, pages 1304–1306, 1980

Mineralogy and petrology of the Dutchmans Creek gabbroic intrusion, South Carolina: reply

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In our petrologic study of the Dutchmans Creek gabbro (McSween and Nystrom, 1979), we stated that one of the features of late-magmatic crystallization in these rocks was reaction of orthopyroxene with residual liquid to form symplectic intergrowths (Fig. 1a,b). Ambler and Ashley (1980) argue that this intergrowth was produced by late-magmatic reaction of olivine with liquid, and that the reaction was limited by the accessibility of residual melt to olivine crystals. Reexamination of Dutchmans Creek sections indicates several textural features which appear to corroborate their suggestion.

Ambler and Ashley's (1977) observation that symplectite boundaries approximate the margins of the original olivine grains is especially cogent evidence for their model, and several examples of this have been found in Dutchmans Creek samples. Symplectic intergrowths only occur in Dutchmans Creek rocks which contain cumulus olivine, although not all olivine-bearing rocks contain symplectites. Where olivine is in contact with hornblende (a late-magmatic phase), symplectite is often developed, but not where olivine is in contact with other cumulus phases. Isolated patches of symplectic orthopyroxene and magnetite/ilmenite are sometimes not directly associated with olivine, but it is possible that these may be completely pseudomorphed olivine (Ambler and Ashley, 1977). Vermicules of oxides are thicker towards the original olivine grain boundary and tend to thin out towards the interior of the olivine grain, as if the reaction was initiated at the olivine grain margin and proceeded inward.

Although I concur with Ambler and Ashley's model for the origin of these symplectites, I do not agree with one line of evidence cited by them. Similarities of the compositions of primary cumulus and intercumulus orthopyroxene and magnetite to those in symplectites do not necessarily indicate that both are products of magmatic crystallization, but rather reflect the subsolidus reequilibration characteristic of plutonic rocks.

In addition to symplectites, another type of intergrowth between orthopyroxene and magnetite occurs in Dutchmans Creek gabbro samples. Large orthopyroxene oikocrysts contain abundant rodlets (often platelets in three dimensions) of magnetite oriented in one crystallographic direction (Fig. 1c,d). These inclusions tend to be concentrated in the interior of pyroxene grains. Clinopyroxene crystals exhibit similar intergrowths, and commonly contain two sets of magnetite rodlets oriented in different crystallographic directions (Fig. 1e,f).

Fleet *et al.* (1980) recently described very similar magnetite inclusions in orthopyroxene and clinopyroxene from the Umfraville gabbro, Ontario, and from the Renzy Lake ultramafic complex, Quebec. They noted that although the magnetite inclusions do not transect pyroxene exsolution lamellae, the restriction of inclusions to interlamellar areas clearly indicates that the pyroxene exsolution lamellae formed first. Hence these magnetite inclusions must be subsolidus reaction products. As both the Umfraville and Renzy Lake host rocks show metamorphic effects, Fleet *et al.* suggested that the magnetite inclusions were a breakdown or reaction product of pyroxenes, formed during metamorphic reheating. The Dutchmans Creek gabbro is post-metamorphic as evidenced by absence of internal metamorphic features and by the development of pyroxene hornfels adjacent to the pluton (McSween and Nystrom, 1979); therefore, metamorphic reheating does not appear to be necessary to produce these intergrowths, and they may have formed by subsolidus breakdown or reaction under plutonic conditions.

Ambler and Ashley's (1980) suggestion that pyroxene–magnetite symplectites formed by late-magmatic reaction of olivine with residual liquid appears to explain the origin of these intergrowths in the Dutchmans Creek gabbro. Other types of crystallographically controlled pyroxene–magnetite intergrowths also occur in the same rocks, and these require a different mechanism of formation involving subsolidus

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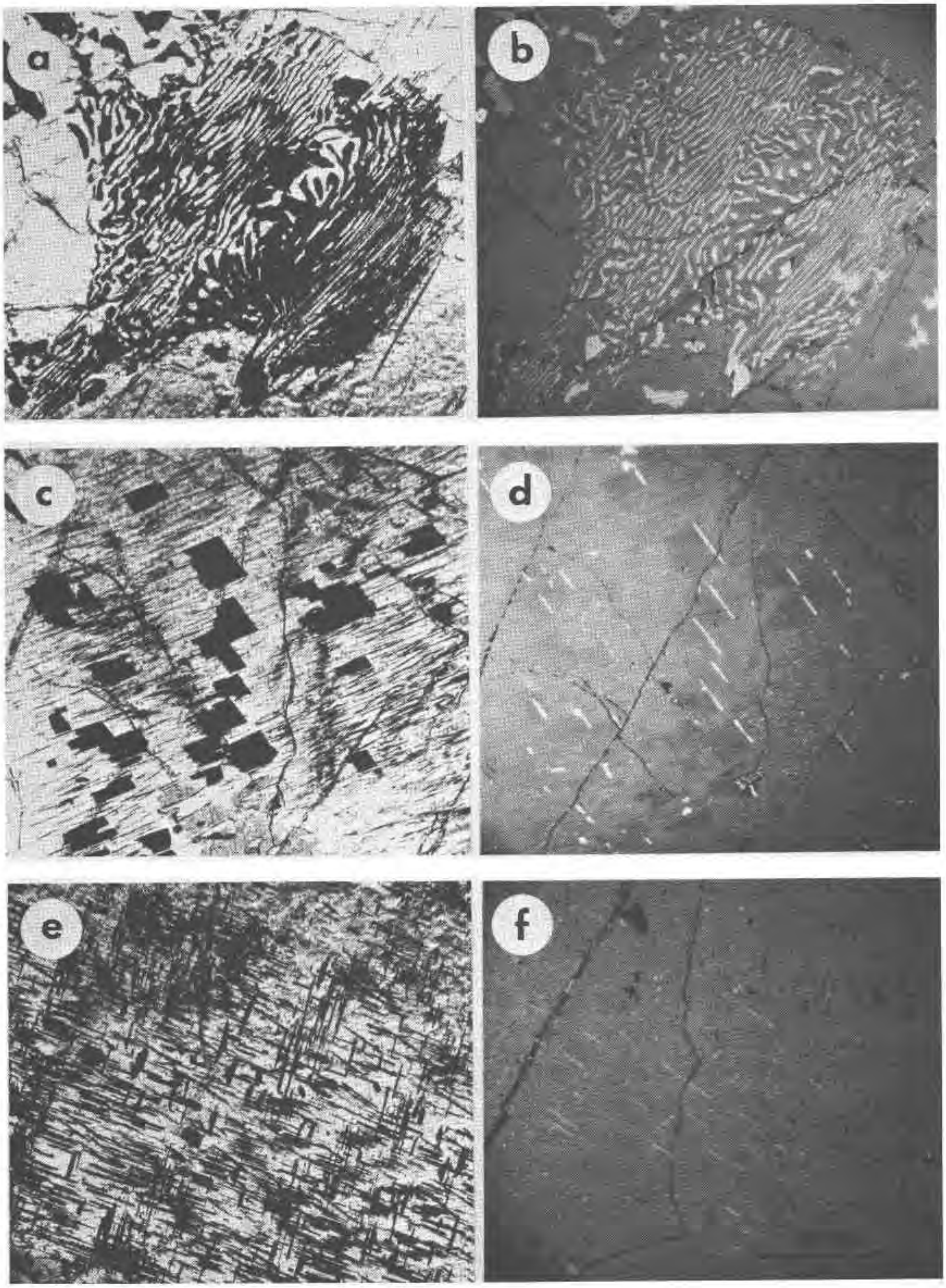

Fig. 1. Pyroxene–magnetite intergrowths in Dutchmans Creek gabbro samples, in plane polarized (left) and reflected (right) light. All photomicrographs to the same scale, as in (f). (a) and (b) Orthopyroxene–magnetite symplectite. (c) and (d) Oriented platelets of magnetite in orthopyroxene. These platelets intersect the polished surface at an angle (d), forming linear rodlets. (e) and (f) Rodlets of magnetite in clinopyroxene oriented in two directions.

reactions. Late-magmatic and post-crystallization reactions in gabbroic rocks are exceedingly complex and offer a fruitful area for further study.

Acknowledgment

Some ideas expressed here were formulated through discussions with J.R. Garrison, S.F. Deetz, and J.B. Higgins.

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Manuscript received, May 8, 1980;
accepted for publication, May 9, 1980.