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

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McSween and Nystrom (1979) have presented a detailed account of field, petrographic, and mineral chemical characteristics of the Dutchmans Creek gabbroic intrusion, which shows a strong resemblance to Permo–Triassic gabbroic intrusions in eastern Queensland, Australia. Recently, Ambler and Ashley (1977) described spectacular vermicular orthopyroxene–magnetite intergrowths from the Wateranga layered mafic intrusion from southeast Queensland and presented petrographic and mineral chemical data for specimens containing the symplectites.

The intergrowths described by Ambler and Ashley (1977; Figs. 1–4) appear identical to those described by McSween and Nystrom from the Dutchmans Creek gabbro; however, the conclusions drawn regarding the genesis of the two symplectite occurrences are somewhat different. We concluded that the orthopyroxene–magnetite intergrowths represent eutectic-like textures resulting from simultaneous coprecipitation of orthopyroxene and magnetite at dispersed locations in a crystal mush, where olivine (Fo_{63-69}) was reacting with late-stage magmatic liquids. McSween and Nystrom stated that the vermicular orthopyroxene–magnetite intergrowths developed as a result of a reaction between orthopyroxene and residual melt. They stated also that the olivine compositional range in the Dutchmans Creek gabbro, Fo_{71} to Fo_{75}, is similar to that reported by Goode (1974) (Fo_{63-75}), who observed similar symplectites and attributed their origin to subsolidus oxidation of the olivine.

We cited the following as evidence for an olivine–residual melt origin for orthopyroxene–magnetite symplectites in the Wateranga gabbro: (a) the ratio of volume of orthopyroxene to volume of magnetite within simplectites is relatively constant; (b) ilmenite exsolution lamellae occur in magnetite vermicules within symplectites in similar amounts to that in intercumulus magnetite; (c) orthopyroxene and magnetite compositions are very similar to compositions of cumulus and intercumulus orthopyroxene and magnetite within individual specimens; and (d) compositions of brown hornblende surrounding symplectites in the Wateranga intrusion are typical of late-magmatic hornblende from other layered mafic intrusions.

Figures 9D and 9F of McSween and Nystrom are very similar to our Figures 4 and 9 respectively (Ambler and Ashley, 1977, p. 166, 167). Figures 3 to 10 of our article demonstrated that the orthopyroxene–magnetite intergrowths occur as embryonic symplectites to complete pseudomorphous replacements. These photomicrographs also demonstrated that symplectites occur between grains of olivine and several other minerals including clinopyroxene, plagioclase, hornblende, and cumulus magnetite/ilmenite. We include here four photomicrographs (Figs. 1–4) which illustrate the range in stages of development and occurrence.

We concluded that the location of symplectites was determined by the accessibility of residual melt to olivine in a crystal mush consisting of less than 20 volume % residual melt. This conclusion was based on observation, within individual thin sections, of a range from unaltered olivines, to incipiently developed symplectites at olivine grain margins, to partial olivine replacement by symplectite and complete pseudomorphous replacement of olivine by an orthopyroxene–magnetite intergrowth. The compositions of resulting orthopyroxene and magnetite would be determined by the compositions of the residual melt

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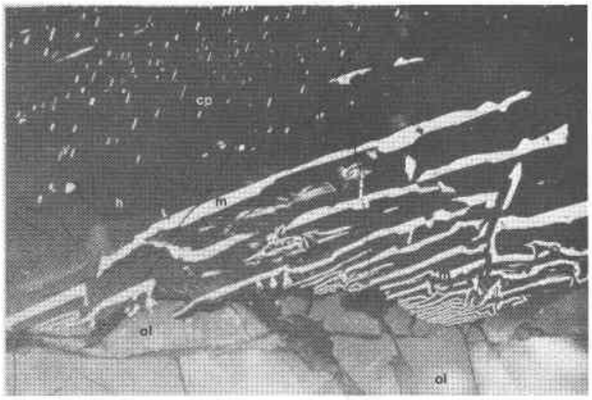

Fig. 1. Incipient development of magnetite (m)–orthopyroxene (o) symplectite replacing olivine (ol), separated from clinopyroxene (cp) by hornblende (h). Clinopyroxene exhibits magnetite exsolution lamellae. (Plane-polarized reflected light, oil immersion, photomicrograph dimensions 0.3 × 0.45 mm.)

Fig. 3. Olivine (ol) partially replaced by orthopyroxene (o)–magnetite (m) symplectite. The symplectite orthopyroxene is in optical continuity with surrounding magnetite-free intercumulus orthopyroxene (io). The magnetite rim appears to represent the original olivine grain boundary. (Transmitted light, crossed polars, photomicrograph dimensions 0.6 × 0.9 mm.)

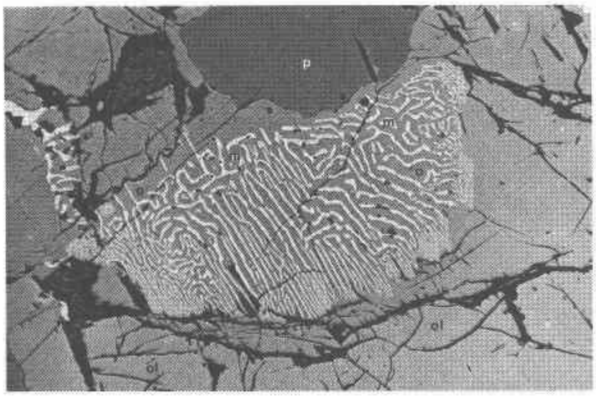

Fig. 2. Orthopyroxene (o)–magnetite (m) symplectite partially replacing olivine (ol) and abutting plagioclase (p). Note the finer-grained and more complex nature of symplectite approaching the olivine. (Plane-polarized reflected light, photomicrograph dimensions 0.75 × 1.5 mm.)

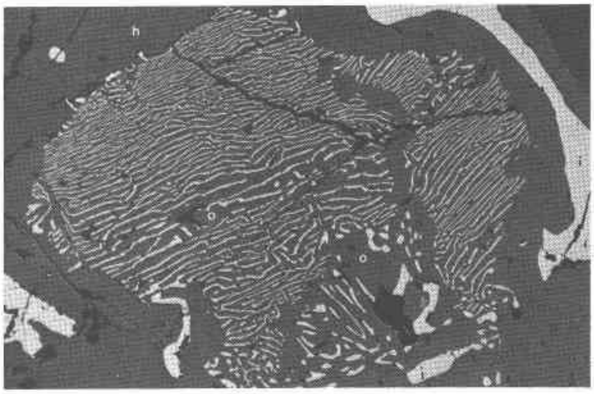

Fig. 4. Spectacular orthopyroxene (o)–magnetite (m) symplectite pseudomorphous after olivine surrounded by intercumulus hornblende (h) and ilmenite (i). (Plane-polarized reflected light, photomicrograph dimensions 0.75 × 1.15 mm.)

and the cumulus olivine, olivine-to-melt ratio, and oxygen fugacity, and would be similar in composition to intercumulus orthopyroxene and magnetite precipitating from this residual melt, independent of olivine–melt reaction.

Conclusion

In summary, the volume, texture, composition, and location of orthopyroxene–magnetite symplectites in gabbroic rocks depend upon the volumetric and chemical relationships between olivine and residual melt. It is possible to explain compositional differences in symplectite and cumulus and/or intercumulus, orthopyroxene and/or magnetite in terms of melt inaccessibility to reaction sites.

Acknowledgment

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References

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