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The Reaction 3 Cordierite = 2 Garnet + 4 Sillimanite + 5 Quartz as a Geological Thermometer in the Opinicon Lake Region, Ontario

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Abstract. In equilibrated metamorphic rocks containing coexisting garnet, cordierite, quartz and sillimanite, the exchange of iron and magnesium between cordierite and garnet offers a highly favourable geological thermometer and barometer, because this exchange reaction is insensitive to pressure. Thermodynamic analysis shows that this thermometer may be calibrated from knowledge of the breakdown reactions for iron and magnesian cordierite end members to garnet. The thermometer was experimentally calibrated using cordierites of intermediate composition. When applied to rocks showing petrographic evidence of equilibrium, and chemical evidence of reaction between garnet and cordierite, the thermometer yielded temperatures of 600–750:C, and pressures of 5.7–6.7 kilobars. Similar conditions are indicated by other literature data on cordierite-garnet gneisses, and are believed to represent hornblende granulite grade of metamorphism.

One of the basic problems of metamorphic petrology is the determination of the peak pressure and temperature of metamorphism. If one assumes that the only relevant variables are temperature, total pressure and composition, this information can, in principle, be gained from the composition of appropriate coexisting mineral phases which are linked by a reaction relation dependent only on temperature and pressure. During a study of metamorphic rocks in southeastern Ontario, (Currie and Ermanovics, in press) petrographic evidence was discovered which makes it seem probable that garnet and cordierite are appropriate phases for this purpose.

The coexistence of cordierite and garnet in this region has been described in some detail by Wynne-Edwards and Hay (1963) and by Reinhardt (1968). In the Opinicon Lake region (Fig. 1) cordierite, together with quartz and potash feldspar, is present in the assemblages corierite-biotite, cordierite-sillimanite, cordierite-garnet-biotite-sillimanite, and cordierite-garnet-sillimanite. One specimen contains cordierite-sillimanite-andalusite (69–117). Garnet free assemblages occur in the southeastern part of the area only, whereas to the northwest, garnet is found as porphyroblasts containing sillimanite and quartz inclusions. The amount of cordierite steadily declines to the north-west, and no cordierite is found northwest of Opinicon Lake. Plagioclase (An 38–55) is rarely present in cordierite bearing rocks and opaque minerals are present only as alteration products of mafic minerals.

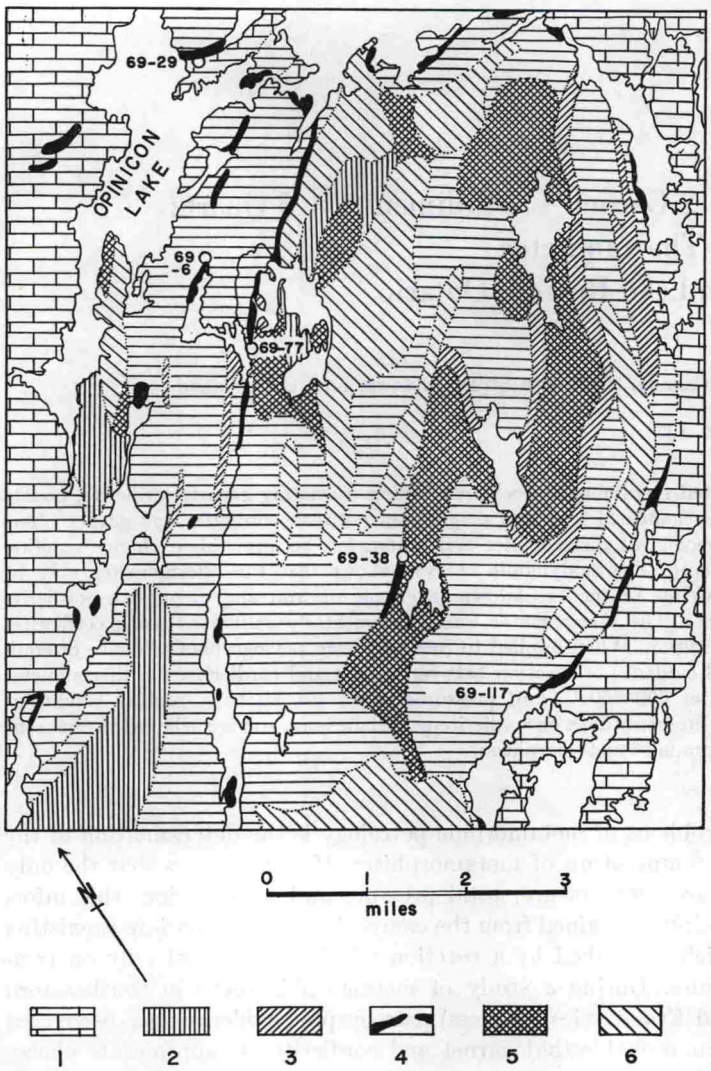

Fig. 1. Geological sketch of the Opinicon Lake region (geology from Currie and Ermanovics, in press). *1* marble and related rocks; *2* pyroxene granulites; *3* quartzite, including migmatite; *4* cordierite-bearing gneisses, garnet bearing except in southeast corner of area; *5* biotite gabbro, diorite, and mafic gneiss; *6* grantoid plutons. Horizontal ruling — stratiform quartz-feldspar-biotite gneisses. The centre of the map area lies near 44°30′ N, 76°20′W, about 28 miles north of the city of Kingston

An electron probe study of the partition of iron and magnesium among the coexisting phases (Table 1) showed that cordierite, in addition to decreasing in amount, became steadily more magnesian from southwest to northeast, while garnet increased in amount and magnesium content. The Fe/Fe + Mg ratio of biotite showed no very marked changes. These data strongly suggest that garnet