

- portion of the systems $\text{SiO}_2\text{-NaAlSi}_3\text{O}_8$ and $\text{SiO}_2\text{-LiAlSi}_3\text{O}_8$, and their bearing on the tridymite problem. *Bull. Geol. Soc. Amer.* **68**, 1789.
- ROY, D. M. AND R. ROY (1964) Tridymite-cristobalite relations and stable solid solutions. *Amer. Mineral.* **49**, 952-962.
- SHAFFER, E. C. AND R. ROY (1956) Studies of silica-structure phases: I. GaPO_4 , GaAsO_4 and GaSbO_4 . *J. Amer. Ceram. Soc.* **39**, 330-336.
- AND ——— (1957) Studies of silica-structure phases: III. New data on the system AlPO_4 . *Z. Phys. Chem.* **11**, 30-40.
- WAHL, F. M., R. E. GRIM, AND R. B. GRAF (1961) Phase transformations in silica, as examined by continuous x-ray diffraction. *Amer. Mineral.* **46**, 196-208.
- WOLLAST, R. (1961) Proposition de quelques modifications du diagramme des phases des systèmes silice-oxydes alcalins. *Silicate Ind.* **26**, 89-92.

THE AMERICAN MINERALOGIST, VOL. 52, JULY-AUGUST, 1967

AN OCCURRENCE OF CORDIERITE-GARNET GNEISS
IN GEORGIA

CHARLES A. SALOTTI, *Department of Geology, University of Georgia, Athens, Georgia* AND JAMES A. FOUTS, *Department of Geology, University of New Mexico, Albuquerque, New Mexico.*

Cordierite occurs in regionally metamorphosed rocks in Lincoln County near the Georgia-South Carolina boundary. Well-exposed outcrops are along Curry Creek and along Georgia Highway 79, three miles north of Lincolnton, Georgia (Fig. 1). The presence of cordierite is noteworthy because it is a rare regional mineral within the Appalachian province (Conant, 1935; Heald, 1950; Hurst, 1956; Barker, 1961; Barker, 1962) and because garnet is a common associate mineral.

The cordierite-bearing rock is fine-grained, generally contorted biotite gneiss. All outcrops show some weathering, and where weathering has been intense a dark red-brown soil has developed. This soil is readily identified by its distinctive color and very high content of fine-grained quartz and micas.

The area south of the cordierite-bearing rocks is underlain by the lower Paleozoic Little River series. The nature of the contact between the two units is not directly observable; however, the contact is delineated by the sharp contrast in soil types overlying each rock. The Little River series is the southwestern extension into Georgia of what in South Carolina is referred to as the Carolina slate belt. In Lincoln County, Georgia, this unit consists of a thick sequence of interbedded fine-grained metavolcanic and metasedimentary rocks. Most of the Little River series has a well-developed foliation that strikes about N45E and dips nearly vertical. North of the cordierite-bearing gneiss is a sequence of generally

coarser-grained schists and gneisses, some of which contain abundant fibrolitic sillimanite. Several small bodies of post-early-Paleozoic—pre-Triassic granite and adamellite have intruded these rocks and a larger body of prophyritic granite crops out six miles north of the cordierite gneiss. Cordierite was not found in the thin sections prepared from the coarser-grained gneisses north of the area. If the contact between the gneissic rocks and the finer-grained more schistose rocks of the Little River series is extended to the east it coincides with the contact between the upper Precambrian and Cambrian Charlotte belt (gneiss) and the lower Paleozoic Carolina slate belt (schist) in South Carolina (Overstreet

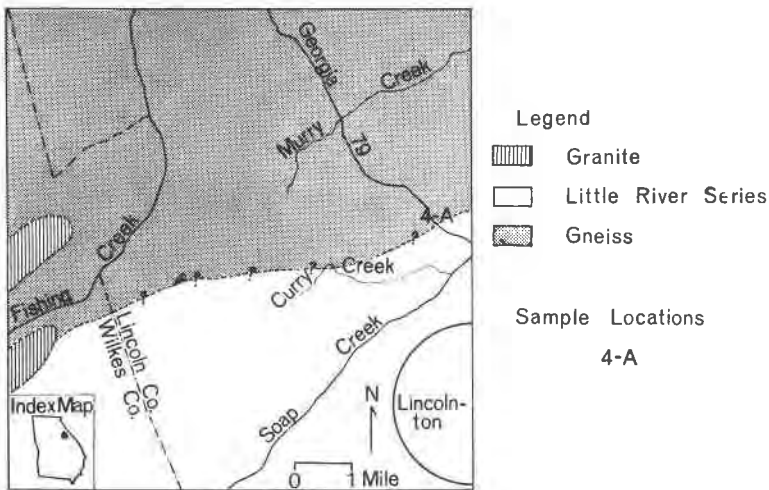


FIG. 1. Geologic map of Lincolnton, Georgia, showing the location of cordierite-garnet gneiss.

and Bell, 1965). Cordierite has not been reported from the Charlotte belt in South Carolina.

In thin section 4A, cut from a sample of cordierite-rich gneiss, cordierite or its decomposition product compose 21% of the rock by volume. An X-ray diffraction pattern of the mineral confirmed that it is cordierite. Other minerals, as determined by 1250 point counts, are: biotite 26, plagioclase (An_{36}) 22, quartz 25, muscovite 2.8, garnet (Pyralspite) 1.8, chlorite (after biotite) 0.5, magnetite 0.2, and secondary ferric oxides, 0.2 volume percent.

This rock in hand specimen is dark gray with alternating layers several millimeters thick of light (quartz-feldspar) and dark (biotite) minerals. The leucocratic layers are slightly more coarse-grained. Microscopically

the rock is mostly fine-grained composed of equant grains of plagioclase, quartz, and cordierite with elongate biotite and minor muscovite. The micas have a weakly developed parallel orientation. Larger (up to 25 mm) poikiloblastic garnets are common. The feldspar appears to be entirely plagioclase, about An_{36} (Michel-Levy method). It is slightly sericitized locally, but generally is unaltered. Many grains show well-developed albite twinning. Staining showed that the untwinned feldspar is also plagioclase. Quartz occurs in interlocking generally equant grains with minor undulose extinction. Garnet is present as poikilitic, 2–25 mm, porphyroblasts.

Cordierite appears as equant to ellipsoidal grains generally less than 0.5 mm. Most grains have an alteration envelope of a yellow tan to pale orange amorphous substance whose index of refraction is lower than that of quartz. Some smaller grains have been completely altered. A few grains show what appears as simple polysynthetic twinning, but most grains are untwinned. Both biaxial (+) and (–) cordierite occur in the same section. Inclusions are no more numerous in cordierite than in quartz and feldspar, and although pleochroic haloes surrounding radioactive zircon grains are common in biotite, they were not found in cordierite.

The indices of refraction are $\alpha = 1.540$ and $\gamma = 1.554$, which according to Winchell (1956) suggest a Mg/Fe ratio of about 2:1. The small grain size and the intimately associated alteration product precluded using Iiyama's (1956) method for determining the composition. The absence of detectable pleochroism and the straw-yellow to pale orange color of the alteration product suggest a relatively low iron content.

From a paragenetic standpoint the occurrence of cordierite in the gneissic rocks near Lincolnton is highly interesting. The tectonic history, structural relations, and chemical petrology of the area are poorly known. Post-metamorphic igneous rocks are absent in the immediate area of the cordierite gneiss. In thin section no superimposed thermal effects are evident—cordierite has every appearance of having formed simultaneously with the other primary mineral components. This recording of cordierite in the Southern Appalachians affords no selective support for any of the various theories of origin, *i.e.*: regional metamorphism under deficient shearing stress (Harker, 1939); a low or medium hydrostatic pressure environment (Schreyer and Yoder, 1959); or an abnormal chemical composition (Eskola, 1915, Chinner, 1959, Wynne-Edwards and Hay, 1963).

This occurrence of cordierite-garnet rock differs from previously reported examples (Wynne-Edwards and Hay, 1963, p. 456) in that both optically (+) and (–) cordierite occur, K-feldspar is absent to very subordinate, and no aluminous spinels are present.

REFERENCES

- BARKER, F. (1961) Phase relations in cordierite-garnet-bearing Kinsman quartz monzonite and enclosing schist, New Hampshire. *Amer. Mineral.* **46**, 1166-1176.
- (1962) Cordierite-garnet gneiss and associated microcline-rich pegmatite at Sturbridge, Mass., and Union, Connecticut. *Amer. Mineral.*, **47**, 907-918.
- CHINNER, G. A. (1959) Garnet-cordierite parageneses, *Carnegie Inst. Wash. Yearb.*, **58**, 112-114.
- CONANT, L. D. (1935) Optically positive cordierite from New Hampshire. *Amer. Mineral.*, **20**, 310-311.
- ESKOLA, P. (1915) On the relation between the chemical and mineralogical composition in the metamorphic rocks of the Orijarvi region. *Bull. Comm. Geol. Finlande*, **44**, 109-143.
- HARKER, A. (1939) *Metamorphism*. 2nd ed., London, Methuen and Co.
- HEALD, M. T. (1950) Structure and petrology of the Lovewell Mountain Quadrangle, New Hampshire. *Geol. Soc. Amer. Bull.*, **61**, 43-89.
- HURST, V. J. (1956) Mineralogic Notes (on a cordierite-garnet occurrence in Georgia). *Georgia Miner. Newsletter*, **9**, No. 2, 73; and No. 3, 90.
- IYAMA, T. (1956) Optical properties and unit-cell dimensions of cordierite and indialite. *Mineral. J. (Tokyo)* **1**, 372.
- OVERSTREET, W. C. AND BELL, H. (1965) The crystalline rocks of South Carolina. *U. S. Geol. Surv. Bull.* **1183**, 1-126.
- SCHREYER W. AND YODER H. S., JR. (1959) Cordierite-water system. *Carnegie Inst. Wash. Yearb.*, **58**, 100-104.
- WINCHELL, A. N. (1956) *Elements of Optical Mineralogy*. 4th Ed., John Wiley and Sons Inc., New York.
- WYNNE-EDWARDS, H. R. AND HAY, P. W. (1963) Coexisting cordierite and garnet in regionally metamorphosed rocks from the Westport area, Ontario. *Can. Mineral.*, **7**, 453-478.

THE AMERICAN MINERALOGIST, VOL. 52, JULY-AUGUST, 1967

REDUCING PREFERRED ORIENTATION IN DIFFRACTOMETER SAMPLES

F. DONALD BLOSS, *Department of Geology, Southern Illinois University, Carbondale, Illinois*, GERHARD FRENZEL, *Mineralogisch-Petrographisches Institut, Universität Heidelberg, Heidelberg, Germany*, AND PAUL D. ROBINSON, *Department of Geology, Southern Illinois University, Carbondale, Illinois*.

INTRODUCTION

The problem of eliminating preferred orientation in powdered samples for diffractometer study was solved by Flörke and Saalfeld (1955) who suspended one gram of powdered material (<60 microns diameter) in 10 ml of a solution consisting of cellulose acetate dissolved and properly thinned in acetone. For clay minerals, which exhibited swelling in the