

NOTES ON CORDIERITE: (A) CORDIERITE CRYSTALS
FROM A GLASS FURNACE; (B) CORDIERITE
FROM HORNS NEK, TRANSVAAL

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(A) CORDIERITE CRYSTALS FROM A GLASS FURNACE

A group of cordierite crystals, recovered from the wall of a tank in which glass is manufactured, was given to me lately by a friend who requested that the name of the factory be withheld from publication. I am only permitted to state that the tank in which the charge is melted is composed of aluminum silicate, having nearly the composition of mullite; that the glass is a borosilicate variety containing magnesium; that the tank is heated by oil burners from above; and that the temperature at the hottest point may reach 1600°C. Under these conditions a crust of cordierite crystals was formed on the wall of the tank, a little distance above the top of the melt. I am assured that the glass never stood at such a high level as the crust, and creeping of the melt up the walls of the tank seems to be excluded because the wall is rather deeply undercut between the crust and the top of the melt. The suggestion has therefore been made that the magnesia required to convert mullite into cordierite may have been volatilized from the melt. (But the late Professor Peck, of Ann Arbor, offers the simpler suggestion that dust from the charge, settling on the wall of the tank, was the cause of the reaction.)

Cordierite has been synthesized, intentionally or accidentally, by several experimenters. The most recent synthesis was described by Dittler and Köhler in 1938.¹ Mixtures of magnesia, alumina, and silica in the proportions of 1:1:3, 2:2:5, and 3:3:8 were melted in magnesite crucibles, in a gas furnace at 1400°. The 2:2:5 mixture was found to give the best yield of cordierite, the others being contaminated with sillimanite and spinel. The pseudo-hexagonal crystals had the following properties:

$$\alpha = 1.524$$
$$2V(\alpha) = 50^\circ - 57^\circ, \text{ mean } 53.5^\circ.$$

Crystals from the 1:1:3 melt had slightly different properties, namely

$$\alpha = 1.526$$
$$2V(\alpha) = 65^\circ - 78^\circ, \text{ mean } 74^\circ.$$

An earlier synthesis of pure magnesia-cordierite was made by Rankin and Merwin² in 1918. The crystals gave interference figures which were

¹ *Centralblatt Min., Abt. A*, 149 (1938).

² *Am. Jour. Sci.*, 45, 301 (1918).

“nearly or quite uniaxial negative.” Those formed from melts containing 66 per cent of silica had the following refractive indices:

$$\alpha=1.519, \beta=\gamma=1.522.$$

Crystals from melts containing about 50 per cent of silica showed

$$\alpha=1.524, \beta=\gamma=1.528 \pm .002.$$

Rankin and Merwin thought there was a possibility of solid solution, the crystals ranging in composition from 1:1:3 to 2:2:5.



FIG. 1. Transverse section of a hexagonal prism of cordierite, between crossed nicols. Magnification 14 diameters. The prism is seen to be composed of six smaller prisms in contact, each of them showing sector twinning and complex intergrowth.

In view of the prevailing uncertainty regarding the composition of cordierite, and the relation between composition and optical properties, it seemed desirable to make a study of the crystals from the glass furnace. The specimen, measuring about $4 \times 2\frac{1}{2}$ inches, consists of an aggregate of water-clear crystals from 2 to 5 millimeters long, resting upon and growing out of a thin plate of scale from the wall of the tank. The crystals have the shape of hexagonal prisms, but each crystal is actually a group of similar prisms in nearly parallel position. A thin section made from

one of these groups proved, when examined between crossed nicols, to be a very complex aggregate in which the familiar sector twinning of cordierite is combined with quite irregular intergrowth (Fig. 1).

The optic axial angle was measured on the universal stage, using various sectors of the twinned crystal. The sign was always negative.

Refractive index of hemispheres, 1.554

$2V=82^\circ, 83^\circ, 82^\circ.$

Refractive index of hemispheres, 1.516

$2V=83^\circ, 82^\circ.$

I am indebted to Dr. E. N. Cameron for measuring the refractive indices of the cordierite, using the immersion method with variable temperature. He found

$\gamma=1.5270 \pm .0003$

$\alpha=1.5223 \pm .0003$

To determine the specific gravity, about 2 grams of broken crystals were weighed in a pycnometer. The result was 2.520 at $19^\circ\text{C}.$, which is equivalent to 2.516 at $4^\circ\text{C}.$

The crystals were now analyzed with the following result:

| | % | <i>mol. no.</i> |
|--------------------------------|--------|-----------------|
| SiO ₂ | 50.77 | .846 |
| Al ₂ O ₃ | 35.26 | .345 |
| CaO | 1.24 | .022 |
| MgO | 12.72 | .318 |
| H ₂ O | .25 | |
| | 100.24 | |

Iron is absent, the alumina precipitate being pure white after ignition. A flame test for boric acid, made with potassium bisulphate and calcium fluoride, gave no coloration. This test is said by Hillebrand to be sensitive to 0.2%. Considering the high temperature at which the crystals were formed, the water must be regarded as "moisture."

From the molecular numbers given in the second column it appears that the ratio of MgO+CaO:Al₂O₃:SiO₂ is almost exactly 2:2:5.

B. CORDIERITE FROM HORNS NEK, TRANSVAAL

In the year 1905, H. Kynaston³ described a curious rock from Horns Nek, a pass over the Magaliesberg range near Pretoria, and named it "nepheline granophyre." About a mile north of the Nek the norite of the Bushveld complex comes into contact with the slates and quartzites of the Magaliesberg series; and Kynaston described the gradual passage of normal norite into a marginal diabasic facies which contains some in-

³ *Trans. Geol. Soc. S. Africa*, 8, 60 (1905).

terstitial quartz and micropegmatite. The supposed nepheline granophyre was found in this passage zone. It is a dark, fine-grained rock consisting of quartz, feldspar, hypersthene, biotite, and rounded areas of fine, feathery micropegmatite. The mineral which was described as nepheline forms tiny idiomorphic prisms within the micropegmatite. Kynaston noted that this mineral shows quadratic and hexagonal cross-sections, a faint yellowish color, and "a lamellation suggesting a quadruple twinning." The identification of this mineral as nepheline, in spite of these unfamiliar characters, was based on a staining test which appeared to show that the mineral was gelatinized by acid.

When I read this description, some 20 years later, I was convinced that the identification of nepheline must be erroneous for the reason that nepheline is chemically incompatible, under magmatic conditions, not only with quartz but also with hypersthene. Dr. A. L. Hall kindly permitted me to borrow the original rock specimen from the museum of the Geological Survey, in Pretoria, and to cut a new thin section from it. In this preparation the little hexagonal grains, which average 0.5 millimeter in diameter, all show sector twinning between crossed nicols. There are commonly 4 to 6 roughly triangular sectors, each of which is optically biaxial. When the slide was treated with hydrochloric acid and malachite green this mineral was not affected at all, proving that it is not nepheline.

When studying the synthetic cordierite described in the preceding note I was reminded of the Horns Nek rock, and I re-examined the thin section on the universal stage. Several measurements of the optic axial angle in different sectors of the twinned crystals gave the following results:

$$2V(X) = 70^\circ, 68^\circ, 70^\circ, 72^\circ, 70^\circ; \text{average } 70^\circ.$$

The plane of the optic axes, in each sector, is perpendicular to the prism face which forms the base of that sector. If any doubt remains that this mineral is actually cordierite it should be dispelled by the observation that the grains show progressive alteration to a green chloritic substance.

Further study of this thin section leads me to believe that even the name "granophyre" was wrongly applied to this rock. Instead of being a marginal facies of the norite, as Kynaston assumed from its occurrence in the marginal zone, I judge it to be a cordierite-hypersthene hornstone formed by thermal metamorphism of a siliceous slate. The feldspar in the micropegmatite is orthoclase; that in the darker part of the rock sometimes shows faint twinning lamellae, but wherever the relief could be observed it was less than that of Canada balsam. Quartz occurs in interlocking grains. The distinctly pleochroic hypersthene is mostly in shapeless grains which are moulded on feldspar and quartz. Biotite has been formed at the expense of hypersthene. Of all the minerals present, cor-

dierite alone is idiomorphic. It is difficult to identify this mineral in the dark part of the rock, among the little grains of quartz, feldspar, hypersthene, and ore. No sector twinning could be detected in this part of the rock, so it is likely that cordierite is confined to the micropegmatite patches.

It is not often that one finds such abundant micropegmatite in a metamorphic rock, but I may refer to Harker's drawing of a recrystallized feldspathic sandstone from the island of Rum⁴ for an illustration of such a rock.

⁴ Metamorphism, p. 68, Fig. 21 B.