HYPERSTHENE AND CUMMINGTONITE FROM PAYNE BAY, NEW QUEBEC

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Abstract

Optical and chemical data are given for an iron-rich hypersthene (eulite) and for a cummingtonite (near grunerite) from metamorphosed iron formations located on the northern extension of the Labrador Trough, near Payne Bay, New Quebec.

The minerals described in this note occur in highly metamorphosed iron formations forming the northern extension of the Labrador Trough, in the vicinity of Payne Bay, New Quebec. The petrographic description of various phases of the iron formation forms the basis of a Master's thesis by the junior author. Most of the data here presented are taken from this thesis, supplemented by additional optical measurements by the senior author.

The material on which this study is based consists of sections of drill core. The iron formation in the core is thinly laminated, in some sections in even and parallel laminae, in others intensely contorted. The result is that a number of layers are visible in most thin sections. The associations recorded in the sections examined are classifiable into six groups:

(1) Hypersthene, with carbonate, magnetite, and in some sections quartz, grunerite or actinolite, and minor biotite. The hypersthene may show replacement by amphibole or antigorite. Where quartz and carbonate occur in the same section, the carbonate is usually calcite. In the absence of quartz, it is ferroan dolomite.

(2) Hedenbergite or diopside, with hornblende, magnetite, quartz or calcite, locally with biotite, and, in one section, with garnet.

(3) Cummingtonite or grunerite, with carbonate and/or quartz, magnetite, and locally biotite. Actinolite was associated in two thin sections, hornblende and garnet each in one section.

(4) Actinolite, carbonate, quartz, magnetite and/or hematite.

(5) Hornblende, carbonate, quartz, and magnetite, in some thin sections with biotite.

(6) Calcite, quartz, magnetite, and, in one section, hematite.

Hypersthene

The hypersthene which was analyzed and examined optically occurs in a laminated, contorted phase of the iron formation. The hypersthene is medium-grained, poikiloblastic, associated with a fine-grained mosaic of quartz, and abundant, fine-grained magnetite. Minor constituents include a little calcite, a few flakes of dark green biotite, a little amphibole, and a few grains of apatite.

The hypersthene is dark brown in colour, but in thin section it has a neutral, pinkish-brown colour, and is virtually non-pleochroic. It shows the typical prismatic cleavage, and also has well-developed pinacoidal cleavages parallel to the front and side pinacoids. The four cleavages are illustrated on the stereographic plot (Fig. 1). The prismatic and pinacoidal cleavages show equal development but are somewhat irregular so that accurate measurement on the universal stage is rarely attainable.

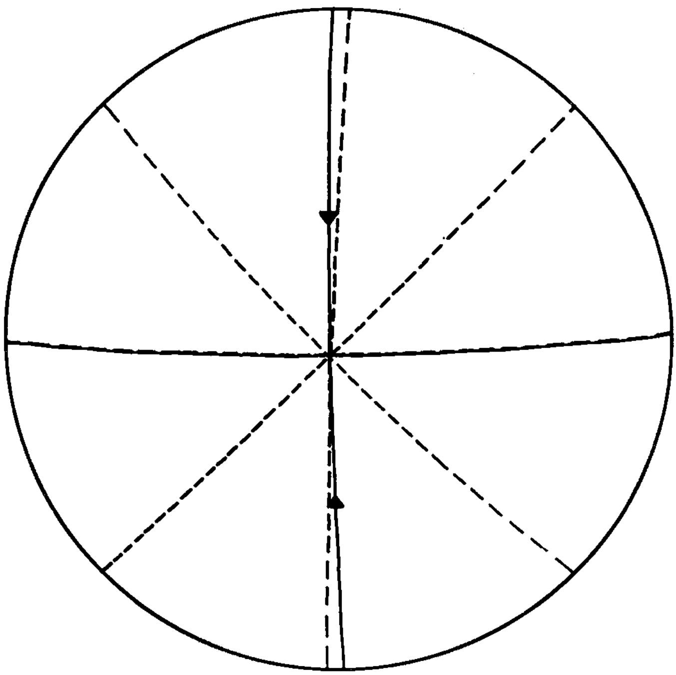

FIG. 1. Stereographic projection, as measured, of the XZ and YZ optic planes of the hypersthene. Cleavages (110, $1\bar{1}0$, 100, 010) are shown by pecked lines. The deviation of 3° of the 010 cleavage (Dana orientation) from the optic plane is due to imperfect development of this cleavage in the grain measured. The optic axes are indicated by small triangles.

Observed between crossed nicols, the hypersthene generally shows sharp extinction, strictly parallel in prismatic sections. There is no indication of exsolution textures characteristic of many igneous hypersthenes. Due to the high dispersion, some sections normal, or nearly normal, to the optic axes, give imperfect extinction and anomalous blue or yellow interference colours in white light.

The refractive indices were determined using Shillaber index oils. Matches were obtained by mixing the oils, the index of the mixture being checked with a refractometer for each determination. All measurements were made in sodium light. The optic angle was measured on the universal stage for six different grains in the thin section, using sodium light. Because the optic angle is near 90°, accurate direct measurement of the angle was impossible. Determinations by stereographic construction show a considerable range in values of $2V_\gamma$, from 88° to 98°, with an average of 93°. Measurements on each grain were repeated 5 or 6 times, and averaged. It is possible that this range in the angle reflects variations in composition from one cluster of grains to another. If this is a real variation, it may account for the rather wide limits of accuracy assigned to the index determinations (Table 1).

TABLE 1. HYPERSTHENE

n_α	$1.752 \pm .002$	$2V_\gamma$	= 93° Sign −
n_β	$1.762 \pm .002$	$\gamma \wedge c$	= 0°
n_γ	$1.772 \pm .002$	Dispersion: strong $v > \rho$	
$n_\gamma - n_\alpha = 0.020$			

Calculation of the optic angle from the refractive indices gives $2V_\gamma =$ 90°. The birefringence was checked using the Berek compensator, by which a value of $n_\gamma - n_\alpha$ of 0.018 was obtained.

A sample of the pyroxene was separated from the associated minerals, chiefly magnetite and quartz, with a hand magnet and the Frantz isodynamic separator. From the resulting concentrate, grains as pure as possible were picked under the binocular microscope, and were submitted to Mr. E. J. Brooker of *X*-Ray Assay Laboratories Limited for partial analysis. Magnesia was determined with the arc spectrograph, iron and manganese were measured on the *x*-ray fluorescence spectrometer. The results are shown in Table 2.

TABLE 2. HYPERSTHENE

	1		2
MgO	4.70%	MgO	4.70%
Fe	34.6	FeO	44.5%
Mn	1–2%(est.)	MnO	1.9%

1. Analysis, as received; Mn estimated only, taken as 1.5%.
2. Analysis, Fe and Mn recalculated as FeO, MnO respectively.

The partial analysis gives for this mineral 90.7 per cent $(Fe,Mn)SiO_3$ and 9.3 per cent $MgSiO_3$ by weight, or 84.6 per cent and 15.4 per cent respectively, in molecular proportions. This places the mineral in the group termed eulite by Poldervaart (1950). The composition and optics of the hypersthene are very close to those given by Henry (1935) for a hypersthene from Mansjö Mountain, Sweden. This hypersthene occurs in a eulysite, believed to be a metamorphosed iron-rich sediment (von Eckermann, 1936), therefore, similar in origin to the rocks from which the mineral under discussion was obtained.

Amphibole

Three types of amphiboles occur in the metamorphosed iron formations of the Payne Bay area, *viz.* members of the cummingtonite-grunerite series, the actinolite-tremolite series, and the hornblende series. The amphibole selected for optical determination and analysis is one of the cummingtonite-grunerites, the amphibole most frequently encountered in the thin sections examined. It occurs as acicular crystals, radiating aggregates of acicular crystals, and poikilitic grains. It is invariably twinned, either a simple twin or, more commonly, polysynthetically twinned. The indices of refraction were determined in sodium light as was done for the hypersthene. The indices for n_α and n_β had to be determined on the universal stage. The optic angle was also determined on the universal stage, by construction because of the large $2V$. Ten determinations were made, on 5 separate grains. The range in values was large, from 74° to 94°, with an average of 83° for $2V_\gamma$ (Fig. 2). The positive sign obtained by universal stage measurements is inconsistent with the indices, which by calculation give a negative angle $2V_\gamma = 92°$. Variations within the limits of error assumed for the indices would fit the observed value.

Table 3. Cummingtonite

n_α 1.655 ± .002	$2V_\gamma = 83°$
n_β 1.671 ± .002	$\gamma\Lambda c = 15°$
n_γ 1.686 ± .001	Dispersion weak $\nu > \rho$
$n_\gamma - n_\alpha = 0.031$	

The amphibole was isolated from the associated carbonate and magnetite by the use of the hand magnet, Frantz isodynamic separator, and by hand-picking. The sample, about ¾ gram was analyzed by H. B. Wiik. (Table 4, column 1). Due to an error in labelling, he was advised that the sample was the hypersthene, hence because of the small amount of

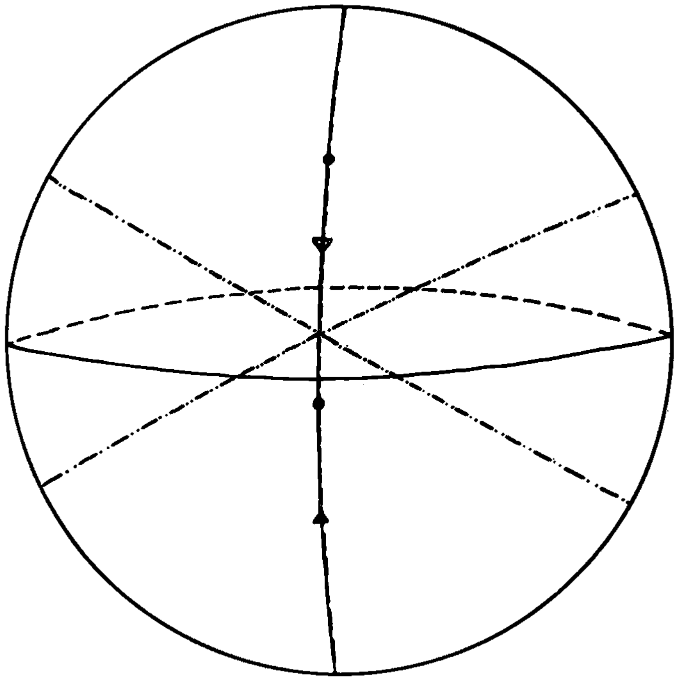

FIG. 2. Stereographic projection, as measured, of *XZ* and *YZ* optic planes of a twinned grain of cummingtonite. One element of the twin is shown with solid lines, and its optic axes are represented as small triangles, the other by pecked lines, and its optic axes by small circles. The cleavages are indicated by alternately dashed and dotted lines.

material H_2O was not determined. In Table 4, column 2, the analysis has been recalculated on the assumption that it contains 2.0 per cent H_2O.

Thus the cummingtonite contains (in molecular proportions) 58.1 per cent of the iron, 3.2 per cent of the manganese, and 38.7 per cent of the magnesium components respectively. In composition and optical properties this mineral very closely resembles the grunerite from the Bijiki schist, Michagamme, Marquette district, whose analyses and optics are given by Sundius (1931). The indices also are identical (within the limits of error) with the grunerite from Uttersvik, also reported by Sundius (1931), which however, has 4 times as much MnO and correspondingly less FeO and MgO, and has a negative optic angle of 83°. Because of its positive sign, the mineral here described has been called cummingtonite rather than grunerite. Negative members of the series occur in other thin sections from the Payne Bay iron formations.

TABLE 4. CUMMINGTONITE

	1	2
SiO_2	52.68	51.96
TiO_2	0.18	0.18
Al_2O_3	0.57	0.56
Fe_2O_3	0.57	0.56
FeO	31.39	30.94
MnO	1.67	1.65
MgO	11.76	11.59
CaO	0.40	0.40
Na_2O	0.08	0.08
K_2O	0.00	0.00
P_2O_5	0.05	0.05
CO_2	n.d.	—
H_2O	n.d.	1.97
H_2O	0.04	0.04
	99.39	99.98

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