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# HELLYERITE, A NEW NICKEL CARBONATE FROM HEAZLEWOOD, TASMANIA

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## Abstract

Hellyerite, $NiCO_3 \cdot 6H_2O$, has been identified in samples from the old Lord Brassey nickel mine, at Heazlewood, Tasmania. It occurs as thin, pale blue coatings, associated with zaratite, on shear planes within a body of serpentinite. In transmitted light it is pale greenish blue in color and weakly pleochroic; its refractive indices are $\alpha = 1.455$, $\beta = 1.503$ and $\gamma = 1.549$. It is biaxial negative, with a 2V of approximately 85°. Its measured specific gravity is 1.97, and its hardness $2\frac{1}{2}$.

The $x$-ray powder diffraction pattern of hellyerite is similar to that of synthetic nickel carbonate hexahydrate, prepared by the method of Rossetti-François (1952). The powder diffraction pattern of the zaratite, however, cannot be indexed on the basis of published unit cell measurements.

## Introduction

During a visit by one of us (K.L.W.) to the old Lord Brassey Mine, near Heazlewood in north-western Tasmania, specimens were collected from a body of serpentinite containing small amounts of a pale blue mineral and an emerald green mineral, occurring together as coatings on shear planes. Primary sulphide mineralization within the serpentinite consists of veins and segregations of heazlewoodite with a little pentlandite, intergrown with magnetite (Williams, 1958). The heazlewoodite in places is altered to millerite, and the pentlandite to violarite.

The green mineral has been described as zaratite by Petterd (1910) and Reid (1921), but the presence of the blue mineral does not appear to have been recorded. A study of this mineral shows that it is a new species, which it is proposed to name *hellyerite*, after Henry Hellyer, who was the first Surveyor-General of the Van Diemen's Land Company and who conducted surveys and exploration in north-western Tasmania in the period 1826–1830.

Hellyerite is the naturally occurring equivalent of the compound $NiCO_3 \cdot 6H_2O$, which has been prepared and described by Rossetti-François (1952). No natural occurrence of a mineral of this composition has been recorded in any of the standard sources published up to the time of writing.

## Physical Properties

Hellyerite is a pale blue mineral of vitreous lustre occurring as extremely fine-grained coatings up to 1.0 mm. thick, in part coating zaratite, along shear planes in serpentinite. It has one perfect cleavage, and two good, but less perfect cleavages. The weaker cleavages are inclined at 112° to each other and are both approximately perpendicular to the strong cleavage (Figs. 1, 2). Rare crystal fragments have been observed microscopically, but none has been sufficiently large for morphological study.

The specific gravity of hellyerite, measured on a Berman microbalance, is 1.97, and its hardness is $2\frac{1}{2}$.

Hellyerite is biaxial negative, with 2V approximately 85°, and is pleochroic with X very pale greenish blue, Y very pale greenish blue and Z pale greenish blue. The refractive indices were measured in immersion oils as $\alpha = 1.455$, $\beta = 1.503$ and $\gamma = 1.549$, each $\pm 0.002$.

The orientation of the optical directions relative to the cleavages is shown in Figs. 1 and 2. The trace of the optic plane makes an angle of 3° with the strongest cleavage on a section parallel to one of the weaker

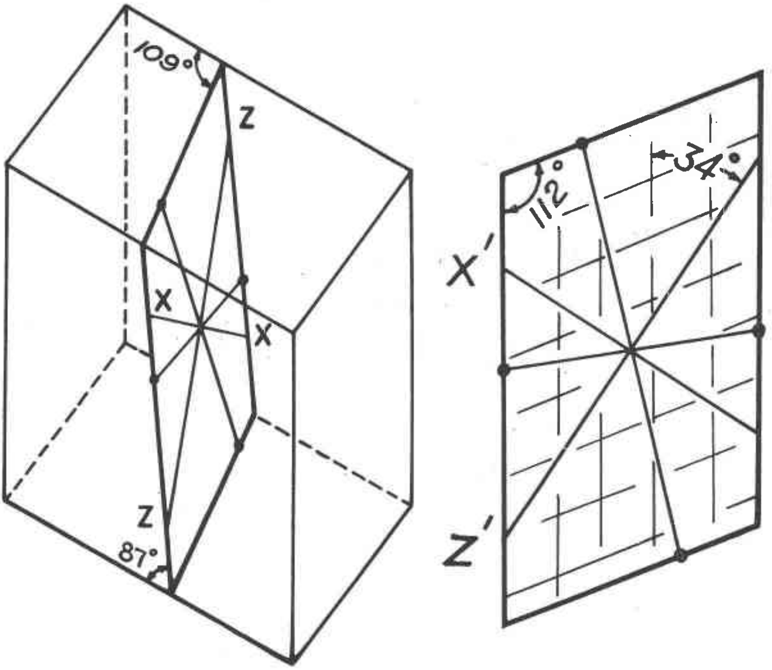

FIG. 1

FIG. 2

FIGS. 1, 2. Optical orientation of hellyerite, relative to the cleavages. Fig. 1. Isometric projection showing the orientation of the optic plane relative to the cleavages. The strongest cleavage is that cleavage almost parallel to the optic plane. Fig. 2. Position of the optic elements in a section parallel to the strong cleavage. X'X' and Z'Z' are the apparent positions of X and Z respectively.

cleavages; the corresponding angle on a section parallel to the other less perfect cleavage is 19° (Fig. 1). These angles were determined by extinction measurements on cleavage fragments. Each optic axis is approximately normal to one of the less perfect cleavages (Fig. 2).

Fine lamellar twinning occurs parallel to the perfect cleavage, individual twin lamellae ranging from 0.002 mm. to 0.03 mm. in width. Where the minute crystal faces are developed they commonly have a striated appearance resulting from this twinning; the effect resembles that produced by albite-type twinning of plagioclase felspars.

## *X*-RAY POWDER PATTERN

The *x*-ray powder diffraction data for hellyerite are listed in Table 1, together with corresponding data for synthetic $NiCO_3 \cdot 6H_2O$ prepared by one of us (A.W.H.), using the method of Rossetti-François (1952), and with the *x*-ray data given by Rossetti-François for this compound. The table shows the close correspondence between the data for hellyerite and for our synthetic preparation. The only differences between these and the data of Rossetti-François are in two lines, given by her as 3.72 Å (in place of 3.11 Å) and 6.53 Å (in place of 6.06 Å), both errors undoubtedly arising from misprints.

## CHEMICAL ANALYSIS

An 80 mgm. hand-picked sample of hellyerite was analyzed as follows: $CO_2$ was determined as loss on ignition after subtraction of water determined by the Penfield method. NiO was determined as ignition residue and independently by precipitation with dimethyl-glyoxime. Spectrographic analysis showed the presence of strong traces of Ca and Mg and a weak trace of Fe.

The results of the analysis (Table 2) show a composition close to $NiCO_3 \cdot 6H_2O$, which is in accordance with the agreement of *x*-ray powder diffraction data for hellyerite and synthetic $NiCO_3 \cdot 6H_2O$.

The analysis of the synthetic nickel carbonate hexahydrate prepared by the method described by Rossetti-François (1952) shows a nickel oxide content of 35.7 per cent (Table 2), exceeding the amount in $NiCO_3 \cdot 6H_2O$ by 2.7 per cent. This discrepancy is probably due to the presence of a proportion of a "basic" nickel carbonate which, as Rossetti-François has shown, readily forms in small amounts during the preparation of nickel carbonate hexahydrate unless very careful control of temperature and concentrations is maintained. Moreover, some decomposition may have taken place after precipitation, since Rossetti-François noted that the hexahydrate which she had synthesized was unstable, decomposing to a poorly crystalline carbonate whose composi-

TABLE 1. HELLYERITE $NiCO_3 \cdot 6H_2O$—X-RAY POWDER PATTERN (Cu/Ni radiation)

| Artificial $NiCO_3 \cdot 6H_2O$ (Rossetti-François, 1952) | | Hellyerite, Lord Brassey Mine, Heazlewood, Tas. $CuK\alpha_1$; $\lambda = 1.5405$ Å Camera diam. 114.6 mm. | | Artificial $NiCO_3 \cdot 6H_2O$ (prep. A. W. Hounslow) $CuK\alpha_1$; $\lambda = 1.5405$ Å Camera diam. 114.6 mm. | |
|---|---|---|---|---|---|
| d (Å) | I | d (Å)* | I (est.) | d (Å)* | I (est.) |
| 9.33 | 10 | 9.4 | 10 | 9.4 | 9 |
| 6.53† | 10 | 6.06 | 10 | 6.06 | 10 |
| | | 5.69 | 0.2 | 5.71 | 0.2 |
| 5.33 | 3 | 5.38 | 2 | 5.40 | 2 |
| 5.12 | 2.5 | 5.17 | 2 | 5.19 | 2 |
| | | 4.99 | 1 | 5.01 | 1 |
| | | 4.81 | 0.5 | 4.83 | 0.5 |
| | | 4.66 | 0.5 | 4.68 | 0.5 |
| | | | | 4.05 | <0.2 |
| 3.72 | 2 | 3.76 | 2 | 3.78 | 1.5 |
| 3.61 | 8 | 3.65 | 7 | 3.66 | 7 |
| 3.37 | 6 | 3.40 | 6 | 3.42 | 5 |
| 3.19 | 3 | 3.21 | 1.5 | 3.23 | 1.5 |
| 3.72† | 4 | 3.11 | 4 | 3.12 | 4 |
| | | | | 3.03 | <0.2 |
| 2.95 | 2 | 2.98 | 1 | 3.00 | 1 |
| | | 2.92 | 0.2 | 2.92 | 0.2 |
| | | 2.84 | 0.2 | 2.85 | 0.2 |
| 2.75 | 4 | 2.78 | 4 | 2.79 | 4 |
| | | 2.73 | 0.2 | 2.74 | 0.2 |
| | | 2.69 | 1 | 2.70 | 1 |
| 2.65 | 2 | 2.62 b | 2 | 2.64 | 0.5 |
| | | | | 2.62 | 1.5 |
| 2.60 | 2 | 2.57 | 1 | 2.58 | 1 |
| 2.54 | 1 | 2.54 | 0.2 | 2.54 | 0.2 |
| 2.35 | 5 | 2.38 | 5 | 2.38 | 5 |
| 2.28 | 3 | 2.31 | 4 | 2.32 | 4 |
| 2.23 | 1 | 2.26 | 1.5 | 2.27 | 1.5 |
| | | 2.21 | 0.5 | 2.21 | 0.5 |
| | | 2.17 | 3 | 2.18 | 3.5 |
| | | 2.11 | 1.5 | 2.11 | 1.5 |
| | | 2.08 | 0.2 | 2.09 | 0.2 |
| | | 2.01 | 1 | 2.02 | 1 |
| | | 1.986 | 0.5 | 1.992 | 0.7 |
| | | 1.965 | 1.5 | 1.973 | 1.5 |
| | | 1.949 | 1.5 | 1.953 | 1.5 |
| | | 1.900 | 0.2 | 1.907 | 0.5 |
| | | 1.872 | 0.2 | 1.877 | 0.5 |
| | | 1.845 | 0.2 | 1.847 | 0.2 |
| | | 1.824 | 3.5 | 1.831 | 3.5 |
| | | 1.790 | 1.5 | 1.797 | 1.5 |
| | | 1.724 b | 3 | 1.729 b | 3 |
| | | 1.700 | 0.2 | 1.704 | 0.2 |
| | | 1.660 | 1 | 1.667 | 1.5 |
| | | 1.634 | 0.5 | 1.638 | 0.7 |
| | | 1.604 | 1 | 1.609 | 1.5 |
| | | 1.577 | 0.2 | 1.580 | 0.2 |
| | | 1.553 | 2 | 1.560 | 2 |
| | | 1.521 | 0.5 | 1.528 | 0.7 |
| | | 1.499 | 2 | 1.503 | 2 |

* Interplanar spacings uncorrected for film shrinkage.
† Misprint? See text.
b Denotes broad line.

Table 2. Chemical Analyses

| | 1 | 2 | 3 | | 4 | |
|---|---|---|---|---|---|---|
| NiO | 33.0 | 33.1 | 32.9 | — | 35.7 | — |
| $CO_2$ | 19.4 | 19.8 | 22.8 | — | 20.0 | — |
| $H_2O$ | 47.6 | 47.3 | 45.0 | — | 44.3 | — |
| Ignition loss to 110° C. | — | — | — | 39.0 | — | 40.7 |
| Ignition loss 100° to 500° C. | — | — | — | 23.2 | — | 22.2 |
| Ignition loss 500° C. to 1000° C. | — | — | — | 5.5 | — | 1.4 |
| Ignition residue (NiO) | — | — | — | 32.3 | — | 35.7 |
| | 100.0 | 100.2 | 100.7 | 100.0 | 100.0 | 100.0 |

1. Theoretical $NiCO_3\cdot 6H_2O$.
2. Artificial $NiCO_3\cdot 6H_2O$; Rossetti-François, 1952.
3. Hellyerite, anal. A. W. Hounslow.
4. Artificial $NiCO_3\cdot 6H_2O$; prep. and anal. A. W. Hounslow.

tion approximated to that of a basic carbonate. A re-analysis of our synthetic product six months after preparation showed it to contain 40.3 per cent nickel oxide, an increase of 4.6 per cent over the freshly prepared material. Although clearly some further decomposition had thus occurred, an $x$-ray powder photograph did not show evidence of any additional phases. It appears most likely that this is due to the development of a highly disordered structure in the decomposition product. Rossetti-François, referring to the decomposition of the synthetic hexahydrate at 38° C., states that it consists in part of " . . . a continuous disorganization from the crystalline state, terminating after 188 hours . . . in a completely disorganized state. . . ." The authors observed a similar effect when hellyerite was held at 50° C. for one week.

The apparent rarity of hellyerite is in accordance with the instability of the synthetic preparation under atmospheric conditions, although it is possible that the instability of the synthetic material may have been unduly accentuated by the fact that it was obtained only in very finely divided form. The larger surface area thus obtained would aid relatively rapid dehydration. It may be expected that the more coarsely crystalline natural material would be more stable; in fact a re-analysis of hellyerite six months after the initial examination showed no change in its chemical composition.

## ZARATITE

The emerald green mineral associated with the hellyerite has a chemical composition, determined by analysis, similar to zaratite from Texas, Pennsylvania (Silliman, 1848). However, it was found that the $x$-ray powder pattern of the Heazlewood mineral could not be indexed on the basis of the simple cubic cell, having $a_o = 6.15$ kX, attributed to zaratite by Fenoglio (1934, quoted by Palache, Berman and Frondel, 1951, p. 245).

Specimens of zaratite from Heazlewood and Trial Harbour, Tasmania, and from Texas, Pennsylvania, were obtained from several museums for comparison, and these all gave *x*-ray powder patterns similar to that of the Heazlewood mineral.

The reasons for this discrepancy are not yet known, since the authors have not had access to a copy of Fenoglio's original paper or to samples of the European material with which he evidently worked. Steps are being taken to obtain both and to institute a more complete examination of the mineral.

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## References

Fenoglio, M. (1934): Nuove ricerche sulla zaratite: zaratite sintetica—*Per. Min.*, 5, 265 (seen only in abstract form—*Min. Abstr.*, **6**, 55 (1935)).

Palache, C., Berman, H. and Frondel, C. (1951): Dana's System of Mineralogy—ed. 7—New York.

Petterd, W. F. (1910): Catalogue of the minerals of Tasmania—Dept. of Mines, Tasmania.

Reid, A. M. (1921): Osmiridium in Tasmania—*Geol. Surv. Tas., Bull. 32.*

Rossetti-François, J. (1952): Etude du carbonate nickel hexahydrate—*Comptes Rendus de l'Académie des Sciences*, **234**, 840.

Silliman, B. (1848): On Emerald Nickel from Texas, Lancaster Co., Pa.—*Am. J. Sci.*, **6**, 248.

Williams, K. L. (1958): Nickel mineralization in western Tasmania—*Proc. Aus. Inst. Min. Met.*, Stillwell Anniversary Volume (in press).

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