

Guillemin) showed all these minerals to be perfectly identical, although the latter specimen was not pure, the two stronger lines of mimetite being present on the photograph.

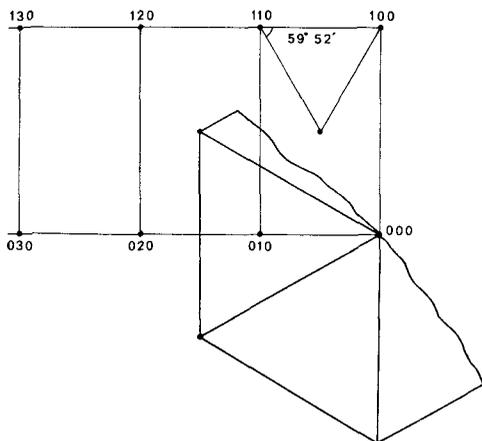


FIG. 1. Trilling of bayldonite, in relation to the reciprocal lattice.

The crystals present sector twinning in thin sections perpendicular to the pseudo-threefold axis; the orientation of one of these sectors in the (001) plane is shown in fig. 1.

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REFERENCES

- CLARINGBULL (G. F.), 1951. *Min. Mag.* **29**, 609–14.
GUILLEMIN (C.), 1956. *Bull. Soc. franç. Min. Crist.* **79**, 7–95.

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Nickel hydroxides from Unst, Shetland

THE first natural occurrence of nickel hydroxide $\text{Ni}(\text{OH})_2$, blue-green in colour, was reported by Williams (1960). Jambor and Boyle (1964) demonstrated that natural

nickel hydroxide could deviate from that found by Williams, and showed that their yellow nickel hydroxide¹ was interlayered and very close in composition to $4\text{Ni}(\text{OH})_2 \cdot \text{NiOOH}$ (as adduced from X-ray data) and probably contained a low content of inter-layered NiOOH . A similar nickel hydroxide to that featured by Jambor and Boyle, though green, was described by Durozoy *et al.* (1966).

TABLE I. X-ray powder data for nickel hydroxides

Yellow mineral		$4\text{Ni}(\text{OH})_2 \cdot \text{NiOOH}^*$		Yellow mineral		$4\text{Ni}(\text{OH})_2 \cdot \text{NiOOH}^*$	
<i>d</i> (meas.)	<i>I</i> (est.)	<i>d</i> (meas.)	<i>I</i> (est.)	<i>d</i> (meas.)	<i>I</i> (est.)	<i>d</i> (meas.)	<i>I</i> (est.)
11·03	vs	—	—	1·982	vw	2·03	s
7·68	vs	7·7	vs	1·945	m	—	—
5·53	m-w	—	—	1·827	vw	—	—
3·786	m	3·85	s	1·730	vw	1·75	w
2·644	vw	2·63	w	1·632	vw	1·66	w
2·592	m	2·56	s	1·540	m	1·53	s
2·505	vw	—	—	1·506	m	1·50	s
2·396	vw	—	—	1·460	vw	—	—
2·307	m	2·31	s	1·424	vw	1·42	w
2·199	vw	—	—	1·389	vw	1·32	w
2·060	vw	2·09	vw				

* Synthetic compound (Glemser and Einerhand, *op. cit.*).

In Heddle's *The Mineralogy of Scotland* (1901) is noted 'emerald nickel' and zaratite, on chromitite, from Hagdale Quarry, Unst. A suite of specimens from this locality, in the Heddle collection, are invested with clear gel-like, and 'opaque' blue-green material identified by Heddle as zaratite, together with a citron-yellow encrustation, which Heddle called chrome ochre, doubtless in allusion to its colour and association. The gel-like and blue-green phases occur as scaly fracture-filling or mammillary coatings. Occasionally, incipient rosette texture and shrinkage cracks are evident.

Only one refractive index for each phase could be ascertained with n 1·613, 1·66, and 1·635 being obtained for the gel-like, blue-green and yellow phases respectively; pleochroism was not detected and all are obscurely fibrous. The blue-green phase value is in good agreement with that obtained by Williams (1·68).

X-ray powder patterns of the gel-like and blue-green coatings are simply the lower nickel hydroxide $\text{Ni}(\text{OH})_2$ with *d*-spacings in very close agreement with those of synthetic $\text{Ni}(\text{OH})_2$. Only limited two-dimensional development is shown, in contrast to the $\text{Ni}(\text{OH})_2$ featured by Klug and Alexander (1962). Powder data are presented in Table I for the yellow phase and compared with that of the synthetic nickel hydroxide $4\text{Ni}(\text{OH})_2 \cdot \text{NiOOH}$ (Glemser and Einerhand, 1950). Apart from the 11·03 and 5·53 Å lines (*00l* reflections?) there is a remarkable resemblance to the $4\text{Ni}(\text{OH})_2 \cdot \text{NiOOH}$ data, and to the data given by Jambor and Boyle (*op. cit.*). However, numerous small

¹ Compare jaborite (N. Morandi and G. Dalrio, *Amer. Min.* 1973, **58**, 835).

fragments from various portions of the same sample, and different samples, consistently produce the same pattern.

Under isothermal conditions and thirty-minute ignition period, both the blue-green and yellow phases break down to NiO at approximately 375 °C.

Spot micro-chemical tests on the gel-like, blue-green, yellow, and synthetic Ni(OH)₂ phases, with dilute HCl, reveal that only the gel-like material effervesces, and in the yellow phase Ni³⁺ is present.

Infra-red studies of the gel-like material produce a spectrum identical to that published by Huang and Kerr (1960) for zaraitite, but with indications of a low Ni(OH)₂ content. The blue-green Ni(OH)₂ I.R. data is similar to that of laboratory grade Ni(OH)₂ (also carbonate-bearing) but lacks the 460 cm⁻¹ band and exhibits a much higher OH stretching frequency than laboratory grade Ni(OH)₂, or the material used by Nyquist and Kagel (1971), being 3662 cm⁻¹ compared with 3650 and 3635 cm⁻¹ respectively. Indications of a possible disordered carbonate-bearing phase were found in the blue-green Ni(OH)₂ spectrum. The yellow mineral contains hydrogen bonded OH, with no free OH, and again an admixed carbonate phase was detected.

In summary, from X-ray and infra-red investigations the gel-like and blue-green materials contain Ni(OH)₂ with differing concentrations of an X-ray-amorphous admixed carbonate, possibly the doubtful mineral zaraitite (Isaacs, 1963) and the yellow mineral is probably a higher nickel hydroxide with an admixed carbonate.

The presence of the X-ray-amorphous admixed carbonate phase unfortunately precludes quantitative analysis of the natural Ni(OH)₂ material. However, the occurrence of the two unnamed nickel hydroxides, hitherto unrecorded from the U.K., seems worthy of note.

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REFERENCES

- DUROZOY (G.), HAUTE (H.), and JACOB (C.), 1966. *Compt. Rend. Acad. Sci., Paris*, **263**, sér. D, 625-6 [M.A. 69-586].
- GLEMSEY (O.) and EINERHAND (J.), 1950. *Zeits. anorg. Chem.* **261**, 43-51.
- HEDDLE (M. F.), 1901. *The Mineralogy of Scotland*. Edinburgh.
- HUANG (C. K.) and KERR (P. F.), 1960. *Amer. Min.* **45**, 311-24.
- ISAACS (T.), 1963. *Min. Mag.* **33**, 663-78.
- JAMBOR (J. L.) and BOYLE (R. W.), 1964. *Canad. Min.* **8**, 116-20.
- KLUG (H. P.) and ALEXANDER (L. E.), 1962. *X-Ray diffraction procedures*. 3rd edn, New York and London (J. Wiley & Sons).
- NYQUIST (R. P.) and KAGEL (R. O.), 1971. *Infrared spectra of inorganic compounds (3800-45 cm⁻¹)*. New York (Academic Press).
- WILLIAMS (K. L.), 1960. *Amer. Min.* **45**, 1109-10.

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