SHORT COMMUNICATIONS

Mcguinnessite from New Zealand; a new occurrence

MCGUINNESSITE was originally described from Red Mountain, Mendocino county, California, by Erd *et al.* (1981). There the mineral occurs as spherules on joint and vein surfaces with goethite, malachite, azurite, chrysocolla, copper sulphides, chlorite, and vuagnatite in a rodingite assemblage derived from metagabbro dykes in a serpentinized peridotite of Mesozoic age. A similar material from Kraubath, Austria, was reported by Postl (1978). More recently, Schmetzer and Tremmel (1981) reported an occurrence of mcguinnessite on massive dolomite from Bou Azzer, Morocco.

Early in 1981 the author visited the Champion mine [grid reference New Zealand Map Series 1, S20, 638168] which is situated on the south side of Champion Creek, a tributary of the Roding River in the upper Aniseed valley and about 25 km from Nelson, New Zealand. This mine is at the site of one of a number of small copper deposits found in the serpentinized mafic and ultramafic rocks of the Dun Mountain, in a mineralized belt. The extent of this belt is indicated by the sparse vegetation at the surface which contrasts with the bush of the surrounding countryside. In this area the copper ores occurred as sporadic small lenses which abruptly pinch out to be replaced entirely by serpentine. Above the water table the ore consisted of a thick capping of oxidized ore and included malachite, chrysocolla, native copper, and cuprite. Below the water table the main ores consisted of cupriferous pyrrhotite and native copper (Bell *et al.*, 1911). Two specimens of a bluish-green mineral which was noticeably more blue than either brochantite or malachite, which are also present, were collected from the mine dump. This material was subsequently confirmed to be mcguinnessite from the data published by Erd *et al.* (1981). The mcguinnessite occurs as bluish-green crusts and spherulitic aggregates on a serpentine matrix. The crystals forming the crust are rather small averaging about 3.0 μm in length by about 0.4 μm in wide (see fig. 1). The colour of the crust varies from bluish green to very pale bluish green. Scattered throughout the crust are tiny opaque grains of an iron-rich phase, which, on the basis of a qualitative microprobe analysis, are tentatively identified as magnetite or hematite.

Chemistry. Mcguinnessite has the formula $(Mg,Cu)_2CO_3(OH)_2$ with $Mg > Cu$. Atomic absorption (AA) spectrophotometric analyses on minute samples of the mcguinnessite crust indicated $Mg > Cu$ but the $Mg:Cu$ ratios varied from 1.65 to 2.04. Traces of Zn and Ni were also found but Co was not detected. In view of the difficulty in avoiding contamination by the matrix when removing samples for analysis, the variation in $Mg:Cu$ ratios was considered likely to be due to contamination by varying amounts of Mg-rich minerals from the matrix. The matrix was found to contain 40.4% SiO_2, 35.8% MgO. Qualitative energy dispersive analysis showed mcguinnessite to contain major Mg,Cu ($Mg > Cu$) with minor Fe,Si. Subsequently, the mcguinnessite was chemically analysed using a Jeol Superprobe 733 with an accelerating voltage of 15 kV with a beam current of 0.012 μA. Elements found included Mg, Cu, Fe, and Si. Elements sought but shown to be absent or present in insignificant amounts were Zn, Ni, Co, As, P, and Al.

Significant amounts of silica (2.3-2.9%), Fe_2O_3 (1.0-1.8%), and SO_3 (0.1-0.9%) were found. Although Erd *et al.* (1981) noted that mcguinnessite
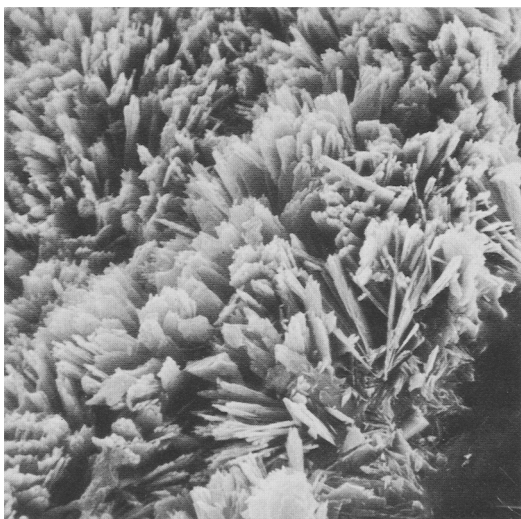

FIG. 1. Electron-scanning micrograph of mcguinnessite, 1300 × .

is occasionally found coated with or replaced by chrysocolla, the analyses in Table I have been corrected on the basis that the SiO_2 represents contamination by serpentine minerals using the matrix analysis given above. This correction ranges from 2.2 to 2.6 % as MgO and the Mg:Cu ratios obtained after this correction clearly represent minimum values and are compared with ratios from previous occurrences in Table I. The Fe_2O_3 and SO_3 contents were treated as impurities for these calculations. A similar problem of silicon contamination was found by Nickel and Berry (1981) in their analysis of nullaginite, Ni_2CO_3 $(OH)_2$. In this case the silicon was considered an impurity and due to the presence of pecoraite.

TABLE I. *Electron microprobe results for mcguinnessite*

	Wt. %	Number of ions†	Mg/Cu	Wt. %‡	Occurrence
1. MgO*	27.5	1.25	1.67	29.4	Nelson
CuO	32.3	0.75		34.6	
2. MgO*	26.6	1.21	1.53	28.1	Nelson
CuO	34.3	0.79		36.2	
3. MgO*	27.4	1.19	1.47	27.4	Nelson
CuO	36.9	0.81		37.1	
4. MgO		1.08	1.17	24.4§	Red Mountain
CuO		0.92		41.0	
5. MgO		1.08	1.21		Bou Azzer
CuO		0.92¶			

* Values corrected for c. 2.5% MgO (see text).
† Normalized to Mg+Cu = 2.00 corresponding to $(Mg,Cu)_2CO_3(OH)_2$.
‡ Idealized composition based on figures in column 3.
§ Average composition (Erd et al., 1981).
¶ This is ΣM (Schmetzer and Tremmel, 1981).

Strictly, mcguinnessite is characterized by Mg:ΣM > 1 where ΣM represents the sum of all cations other than Mg which are present in the structure (Schmetzer and Tremmel, 1981). Here, Zn, Ni, and Co were below the detection limits for microprobe analysis and the Fe is present as a separate unidentified phase. Even if the Fe is considered an essential constituent of the mcguinnessite structure the ratios of Mg:ΣM would be lowered by less than 6 %. As the trace levels of Zn and Ni found by AA analysis were minor and imprecisely determined, no correction has been applied to the ratios in Table I.

X-ray crystallography. The unit cell data summarized by Erd et al. (1981) clearly show that mcguinnessite is closely related to the rosasite series of minerals. These authors analysed the X-ray pattern on the basis of a monoclinic unit cell with space group $P2_1/a$. However, as these authors noted, the weak reflections at 12.0 and 9.4 Å are

excluded by this space group. A summary of the present incomplete understanding of the crystal structure of the rosasite series of minerals is shown in Table I of Nickel and Berry (1981). For example, whereas Deliens and Piret (1980) described the Co analogue, kolwezite, with Cu:Co = 2 and proposed kolwezite, glaucosphaerite, and rosasite to be triclinic, Nickel and Berry (1981) have reported rosasite and glaucosphaerite to be monoclinic. In the absence of unambiguous information on the crystal structure the treatment here follows that of Erd et al., i.e. mcguinnessite is regarded as monoclinic with space group $P2_1/a$. The X-ray data for mcguinnessite from Nelson were obtained with a Gandolfi camera using Cu-$K\alpha$ radiation with exposures up to 40 hours. The agreement with the data of Erd et al. (1981) and Schmetzer and Tremmel (1981) is good, but owing to the presence of Fe in the sample it was not possible to measure the reflection at 7.4 Å due to the darkening of the film by iron fluorescence. The presence of the weak lines at 11.98 and 9.39 Å observed by Erd et al. (1981) could not be confirmed for the same reason. Weak lines were recorded at 2.80 and 1.75 Å which are excluded by the space group $P2_1/a$ and may be due to the presence of siderite. That Schmetzer and Tremmel also recorded reflections at 2.80 and 1.75 Å in their investigations and also determined Fe to be present (see their Table I) may be cited as supporting evidence. The unit cell parameters obtained by least-squares refinement (Appleman and Evans, 1973) of the X-ray data indexed on the basis of a monoclinic cell with space group $P2_1/a$ (Jambor, 1976a, b), are compared with literature values in Table II.

TABLE II. *Unit cell parameters for mcguinnessite*

	Nelson	Red Mountain	Bou Azzer
a A°	9.384	9.398	9.35
b	12.047	12.011	12.08
c	3.374	3.379	3.09
β	93.27°	93.28°	91°
Vol. ($Å^3$)	380.8	380.8	[349.0]

In the absence of single crystal X-ray structure determinations, or precise X-ray powder diffraction data, the distinction between the monoclinic and triclinic propositions may, in principle, be achieved from accurate density measurements (Deliens and Piret, 1980). However, the accuracy required may not be reliably attained with this type of material. At present the X-ray data do not enable either a

clear distinction between triclinic or monoclinic crystal systems or for the space group to be unambiguously determined.

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Oriented enstatite inclusions in natural diamond

THE sample studied, a twinned diamond, composed of at least four distinct crystals, was collected in the Tibagi River diamond deposits near Telêmaco Borba, Paraná State, Brazil. Under an optical microscope a group of six crystal inclusions was observed; their size ranged between 0.05 and 0.2 mm. All the inclusions were colourless and euhedral, showing different crystal habits, and were identified as forsterite (prismatic and equidimensional crystals) and enstatite (tabular crystals, with $a_0 = 18.17 \pm 0.02$; $b_0 = 8.81 \pm 0.01$, and $c_0 = 5.17 \pm 0.01$ Å). The prismatic forsterite inclusions are oriented along the $\langle 110 \rangle$ directions of the host diamond; the main direction of the tabular enstatite crystals are in the same orientation. The identification of the included material, as well as the establishment of the orientation of the inclusions, was obtained by a precession camera using unfiltered Mo radiation. The setting of a selected inclusion under the X-ray beam was achieved by the microradiography technique described by Henriques (1969), and the interpretation of the precession diagrams was by a technique described in an earlier paper (Leite, 1972).

Orientated precession photographs, obtained with the X-ray beam focused on the enstatite inclusions, are shown in figs. 1 (inclusion A) and 3 (inclusion B). In fig. 1 may be seen the $(hk0)^*$ reciprocal plane of enstatite A, represented by a circular area limited by very weak Laue streaks (dotted circle), and a misaligned $(hhl)^*$ reciprocal plane of the host crystal (dashed line limiting the diamond strong reflections). The picture also shows both reciprocal planes mutually tilted at about 10° around the [111] diamond axis. The coincidence of the $\bar{4}20$ and $1\bar{1}\bar{1}$ reflection trails of enstatite and diamond, respectively, is, however, nearly perfect, with a misfit smaller than 3°. That coincidence indicates that the (210) enstatite face is set in near parallel orientation in relation to the octahedral layer of the host crystal, as may be seen in the stereogram in fig. 2. If an exact coincidence could be verified, the mutual orientation of diamond and enstatite should be interpreted as an epitaxic