

## Brunnerite from the Tarr albitite complex, Sinai

RON BOGOCH, LUDWIG HALICZ AND YA'ACOV NATHAN

*Geological Survey of Israel*  
*Jerusalem, Israel 95 501*

### Abstract

Conspicuously coarse grained brunnerite occurs together with dolomite associated with albitite bodies in Wadi Tarr, Southeastern Sinai. From the chemical analyses, it is seen to contain about 8% FeO. The *a* cell dimension was found to be 4.64 and the *c* dimension 15.06Å. It exhibits rare pressure twins. Infra-red absorption spectra fall within those of magnesite and siderite.

The carbonates are clearly related in origin to the albitites, and it is suggested that they could be derived from a buried ophiolite complex.

### Introduction

Naturally occurring ferrous magnesites appear to form a complete solid solution series with pure  $MgCO_3$  and  $FeCO_3$  as end members. The term brunnerite was first used by Haidinger (1825, in Palache *et al.*, 1951) to describe a magnesite containing between 8 to 17%  $FeCO_3$ . Dana and Ford (1932) proposed the following classification: brunnerite (up to 30%  $FeCO_3$ ), mesitite (between 30 and 50%  $FeCO_3$ ), pistomesite (between 50 and 70%  $FeCO_3$ ) and sideroplesite (between 70 and 95%  $FeCO_3$ ). However, only brunnerite is commonly reported in the literature, and Deer *et al.* (1962) expand its definition to include from 5 to 50%  $FeCO_3$ .

Petrographically two main varieties of magnesite occur: a crystalline or "spathic" type generally believed to be derived from hydrothermal or metasomatic alteration of pre-existing dolomites (rarely limestone), and a cryptocrystalline variety, generally associated with the alteration of serpentinites (Wicken and Duncan, 1975). Hydrothermal magnesite in pegmatites has also been noted (Nemec, 1977) as well as magmatic magnesite (Deer *et al.*, 1962). It is rare in carbonatites (Heinrich, 1966). Other modes of origin include diagenetic nodular magnesite (Eisbacher, 1969); associated with calcrete (Wells, 1977); and related to phosphorites (Siegal, 1969). Syngenetic low temperature finely crystalline brunnerite occurring in veinlets in association with halite and anhydrite was described by Fijal and Stanczyk (1970).

The brunnerite reported in this paper is perhaps unique in its extremely coarse crystallinity and in its

geological association with albitites. Its geology, chemistry and crystallography are described below.

### Geological setting

The Tarr area of southeastern Sinai consists of polyphase metamorphosed sediments (mainly greywacke, slate and lesser marble), pyroclastics (mainly dacitic to andesitic) and conglomerate, in greenschist to lower amphibolite facies. Within these metamorphic rocks are two large (about 2 km<sup>2</sup>) and numerous small albitite bodies consisting mainly of albite and of some quartz (0–15%), actinolite (0–10%), rutile (0–2%), and accessory apatite and zircon. Locally, biotite (up to 10%), pyrite (up to 15%) and magnetite (up to 2%) occur.

Spatially associated with the albitites are breccias of country rock and albitite, in places containing brunnerite and dolomite. The brunnerite is typically very coarsely crystalline.

### Field description

The brunnerite which is medium brown in color, occurs together with dolomite in vein and dike-like bodies 5 to 100 cm wide (Fig. 1), and as sub-horizontal "sheets" (Fig. 2) up to 10 m thick, associated with albitite-actinolite ± country rock breccias. It occurs without dolomite only in two locations: as a cement in an albitite breccia, and as discrete rhombs alligned parallel to  $S_0$  and  $S_1$  in a calcitic marble. The crystal size generally varies from 0.5 to 10 cm, and averages in most occurrences, 2–4 cm, and is equant. The dolomite is also commonly coarsely crystalline (rarely up to 30 cm),

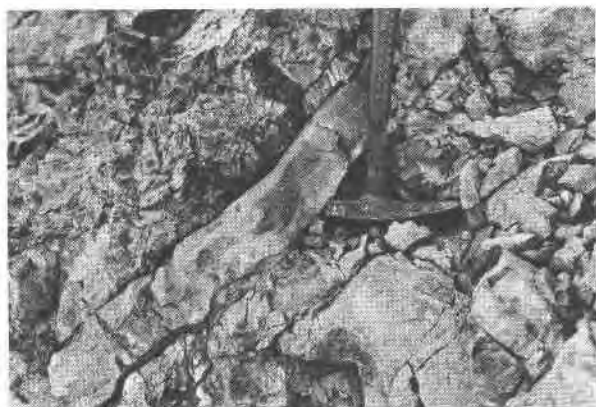


Fig. 1. Dike-like occurrence of breunnerite + dolomite in albitite-actinolite breccia.

but also forms a fine grained variety. Dolomite is the dominant carbonate in this association ( $\approx 70\%$ ).

Certain of the veins exhibit zoning, with dolomite along the walls and breunnerite in the center. Contacts between the breunnerite and dolomite are sharp. In places, the breunnerite appears to be replacing the dolomite as indicated by corrosion features.

### Petrography

In thin section, the breunnerite exhibits straight to undulatory extinction and rarely, pressure twins with  $(01\bar{1}8)$  as the twinning plane. It is colorless, but secondary iron oxide staining gives a dark brown color around rhomb boundaries and along the excellent  $(10\bar{1}1)$  cleavage.

Impurities in single rhombs are common, but generally form less than  $\approx 2\%$  of any given surface. These consist of minute "inclusions" of dolomite,



Fig. 2. Sub-horizontal "sheet" of breunnerite + dolomite in albitite-actinolite-greywacke breccia. Maximum thickness of this body is 10 m. It consists of two fault-separated sections totalling approximately 1000 m<sup>2</sup> in area.



Fig. 3. SEM micrographs of breunnerite with dolomite filling cleavage cracks (left) and Ca distribution (right).

very rarely calcite, and magnetite, which are either irregularly dispersed or are concentrated along cleavage cracks. Magnetite also occurs in dolomite, but in lesser amounts.

The breunnerite is pleochroic ( $\epsilon < \omega$ ). Refractive indices measured by the oil immersion method with a sodium light source gave  $\epsilon = 1.521 \pm 0.001$ ;  $\omega = 1.719 \pm 0.001$ . Electron-probe investigation confirms the close association of breunnerite and dolomite. Figure 3 shows dolomite occurring in cleavage cracks of breunnerite. The breunnerite itself is not homogeneous and the differences in Fe content are most conspicuous in the X-ray pictures. Quartz as well as talc (Fig. 4) were identified as inclusions within the breunnerite.

### Chemistry

Results of chemical analyses for breunnerite-rich samples are given in Table 1. Assuming that the ferric oxide occurs as free iron oxide (probably hydrous) and that all the CaO occurs as dolomite, both (together with the corresponding MgO and CO<sub>2</sub>) are subtracted from the analysis and these are recalculated for breunnerite in Table 2.

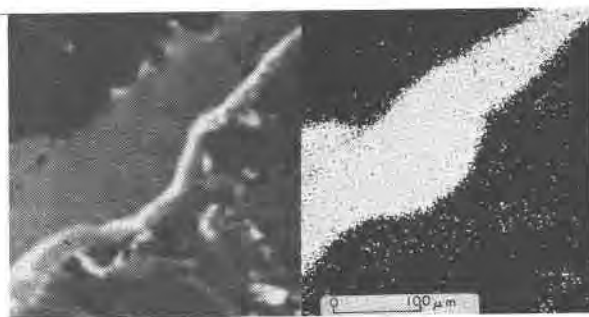


Fig. 4. SEM micrographs showing talc veinlet (medium grey) edged by dolomite (white) in breunnerite (left) and Si distribution (right).

Table 1. Chemical analyses\* of Sinai Breunnerite

Sample No.	W-102 B	W-105 C
CaO	3.6	4.0
MgO	35.9	36.6
FeO	7.2	5.6
Fe <sub>2</sub> O <sub>3</sub>	5.3	6.2
MnO	0.22	0.28
CO <sub>2</sub>	46.0	45.8
H <sub>2</sub> O	0.3	0.2
I.R.	0.3	0.6
Total	98.82	99.28

\* CaO, total Fe, MnO by atomic absorption; MgO by difference between CaO + MgO by E.D.T.A. titration and CaO by atomic absorption; FeO by two independent methods, titration with K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> and by Mossbauer effect; CO<sub>2</sub> volumetric determination; H<sub>2</sub>O by Penfield method; Insoluble residue, gravimetric.

### X-ray diffraction

Samples of powdered single rhombs were measured on a Philips PW 1050/70 vertical goniometer. Quartz was used as an internal standard with the following run conditions: CuK $\alpha$  radiation with a Ni filter (Fe and Cr tubes were not available); 55 kV, 10 mA; diffractometer  $\frac{1}{2}^{\circ}2\theta/\text{min.}$ , recorder  $\frac{1}{2}\text{cm}/\text{min.}$ ; time constant 4 sec.; slit system  $1^{\circ} - 1^{\circ} - 0.2$  mm. Most reflections (Table 3) are similar to standard magnesite. Primitive cell parameters were calculated by the least square method using the formula

$$\frac{1}{d^2} = \frac{4}{3a^2} (h^2 + hk + k^2) + \frac{1}{c^2}$$

(modified after Klug and Alexander, 1954).

The  $a$  unit cell dimension was found to be  $4.642 \pm 0.005 \text{ \AA}$ , and the  $c$  dimension  $15.055 \pm 0.015 \text{ \AA}$  (for sample W-102 B). Only very slight differences were detected for different samples. Fijal and

Table 2. Recalculated analyses

Sample No.	W-102 B	W-105 C
MgO	41.2	42.7
FeO	8.9	7.1
MnO	0.3	0.4
CO <sub>2</sub>	49.7	49.9

Number of ions on the basis of 6 (O)

Mg	1.796	} 2.03	1.852
Fe	0.217		0.173
Mn	0.007		0.010
C	1.990		1.983

Table 3. X-ray powder data for sample W-102 B

d	hkl	I/I <sub>0</sub>	d	hkl	I/I <sub>0</sub>
3.548	012	3	1.705	116	36
2.747	104	100	1.511	211	3
2.510	006	15	1.490	122	5
2.322	110	6	1.409	214	5
2.108	113	52	1.357	119	4
1.942	022	13	1.341	300	7
1.733	024	5	1.255	0012	4

Stanczyk (1970) found  $a = 4.61$  and  $c = 15.08 \text{ \AA}$  for a breunnerite with 5.12% FeO. The values we found are similar to those reported by Shaikh and Bruswitz (1975) for breunnerites with similar FeO contents. These authors studied the dependence of the cell parameters of magnesite on FeO content and showed that up to 8.55% FeO, the cell parameters of magnesite are only slightly dependent on the FeO content. Our results confirm their findings.

### Infra-red

The infra-red absorption spectra is somewhat affected by the presence of dolomite, however the broad absorption band at  $1400 \text{ cm}^{-1}$  and the well defined bands at  $880 \text{ cm}^{-1}$  and  $745 \text{ cm}^{-1}$  are all assigned to carbonate (from breunnerite) and fall within those reported for magnesite and siderite (White, 1974).

### Conclusion

The chemistry and X-ray crystallographic properties of the Sinai breunnerite are comparable with those of other low Fe breunnerites reported in the literature. The pressure twinning, which is relatively rare in magnesites, is similar to that in calcites but is apparently restricted to one plane.

The origin of the breunnerite-dolomite association is clearly related to the albitites with which it is intimately associated. Shimron (1975) suggested that the carbonates are "atypical" carbonatites, resulting from a liquid immiscible fraction separated from an already differentiated albitite melt. Detailed petrochemical studies of the complex are now in progress. However, the very equant coarse crystallinity of the breunnerite, even in veins several centimeters across, is not suggestive of crystallization from a "normal" viscous magma. Carbonatites in general show normal chilled zones in narrow dikes and even in the more massive intrusives, are rarely more coarsely crystalline than 1 cm for

calcite, and even less for dolomite (W. J. Voerwoerd, 1979, personal communication).

The occurrences of magnesite (and breunnerite) in the neighboring Eastern Desert (Egypt) related to serpentine in the so-called Barramiya rocks (Attia, 1948; Rittman, 1958) suggest the possibility that the Sinai breunnerite also is somewhat related to a serpentine (ophiolite) occurrence at depth. At the present stage of knowledge the question is open.

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