Breunnerite from the Tarr albite complex, Sinai

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Abstract

Conspicuously coarse grained breunnerite occurs together with dolomite associated with albrite 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 albites, 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 MgCO₃ and FeCO₃ as end members. The term breunnerite was first used by Haidinger (1825, in Palache et al., 1951) to describe a magnesite containing between 8 to 17% FeCO₃. Dana and Ford (1932) proposed the following classification: breunnerite (up to 30% FeCO₃), mesitite (between 30 and 50% FeCO₃), pistomesite (between 50 and 70% FeCO₃) and sideroplesite (between 70 and 95% FeCO₃). However, only breunnerite is commonly reported in the literature, and Deer et al. (1962) expand its definition to include from 5 to 50% FeCO₃.

Petrographically two main varieties of magnesite occur: a crystalline or "spathic" type generally believed to be derived from hydrothermal or metamorphic 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 calcite (Wells, 1977); and related to phosphorites (Siegal, 1969). Syngenetic low temperature finely crystalline breunnerite occurring in veinlets in association with halite and anhydrite was described by Fijal and Stanczyk (1970).

The breunnerite reported in this paper is perhaps unique in its extremely coarse crystallinity and in its geological association with albites. 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 km²) and numerous small albite bodies consisting mainly of albite and of some quartz (0–15%), actinolite (0–10%), rutile (0–2%), and accessoryapatite and zircon. Locally, biotite (up to 1%), pyrite (up to 15%) and magnetite (up to 2%) occur.

Spatially associated with the albites are breccias of country rock and albite, in places containing breunnerite and dolomite. The breunnerite is typically very coarsely crystalline.

Field description

The breunnerite 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 subhorizontal "sheets" (Fig. 2) up to 10 m thick, associated with albite-actinolite ± country rock breccias. It occurs without dolomite only in two locations: as a cement in an albite breccia, and as discrete rhombs aligned parallel to S₀ and S₁ 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),
but also forms a fine grained variety. Dolomite is the dominant carbonate in this association (≈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 (0118) as the twinning plane. It is colorless, but secondary iron oxide staining gives a dark brown color around rhomb boundaries and along the excellent (1011) cleavage.

Impurities in single rhombs are common, but generally form less than ≈2% of any given surface. These consist of minute “inclusions” of dolomite, 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 (ε < ω). Refractive indices measured by the oil immersion method with a sodium light source gave ε = 1.521 ± 0.001; ω = 1.719 ± 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 CO2) are subtracted from the analysis and these are recalculated for breunnerite in Table 2.
Table 1. Chemical analyses* of Sinai Breunnerite

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>W-102 B</th>
<th>W-105 C</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>3.6</td>
<td>4.0</td>
</tr>
<tr>
<td>MgO</td>
<td>35.9</td>
<td>36.6</td>
</tr>
<tr>
<td>FeO</td>
<td>7.2</td>
<td>5.6</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>5.3</td>
<td>6.2</td>
</tr>
<tr>
<td>MnO</td>
<td>0.22</td>
<td>0.28</td>
</tr>
<tr>
<td>CO₂</td>
<td>46.0</td>
<td>45.8</td>
</tr>
<tr>
<td>H₂O</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>I.R.</td>
<td>0.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Total</td>
<td>98.82</td>
<td>99.28</td>
</tr>
</tbody>
</table>

* CaO, total Fe, MnO by atomic absorption; MgO by difference between CaO and FeO by two independent methods, titration with K₂Cr₂O₇ and by Mossbauer effect; CO₂ by volumetric determination; I.R. by Perkin-Elmer method; Inosoluble 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: CuKα radiation with a Ni filter (Fe and Cr tubes were not available); 55 kV, 10 mA; diffractometer ½2θ/min., recorder ½cm/min.; time constant 4 sec.; slit system 1° - 1° - 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

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

(modified after Klug and Alexander, 1954).

The a unit cell dimension was found to be 4.642±0.005 Å, and the c dimension 15.055±0.015 Å (for sample W-102 B). Only very slight differences were detected for different samples. Fijal and Stanczyk (1970) found a = 4.61 and c = 15.08 Å for a breunnerite with 5.12% FeO. The values we found are similar to those reported by Shaikh and Brusewitz (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 cm⁻¹ and the well defined bands at 880 cm⁻¹ and 745 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 albrites 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 albite 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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References


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