# BRAUNITE FROM SNOWMASS, PITKIN COUNTY, COLORADO*

Austin F. Rogers, *Stanford University, California.*


## Abstract

Braunite, tetragonal, with the probable composition $3Mn_2O_3 \cdot MnSiO_3$, a comparatively rare mineral in this country, is recorded from a new locality in Pitkin County, Colorado.

It is a massive, somewhat granular, black metallic mineral which shows in cavities the pseudo-octahedral crystals highly characteristic of it.

Associated minerals are calcite, barite, a pleochroic mica [probably manganophyll (manganian biotite)], muscovite, quartz, microcline, and plagioclase. The three latter and probably the muscovite are detrital.

Calcite and barite are "persistent minerals" and thus give no clue to the type of deposit, but the presence of manganophyll points to a hydrothermal origin.

Attention is called to the importance of plane angles of crystal faces in the determination of minerals. Plane angles may be expressed as interzonal angles since edges of crystal faces are parallel to the corresponding zone-axes.


## Introduction

Braunite, a characteristic mineral of the manganese ores of India, Sweden, and Brazil, is usually considered to be a rather rare mineral in the United States, although at least eleven American localities have been recorded to date. These are: Cartersville, Ga. (1); Batesville, Ark. (2); Mason County, Tex. (3); Iron County, Mo. (4); Shannon County, Mo. (4); Humboldt County, Calif. (5), Plumas County, Calif. (5), Stanislaus County, Calif. (6), Bisbee, Ariz. (6), Aroostook County, Me. (6), and Golconda, Nev. (6).

The purpose of this article is to put on record braunite from another American locality. I am indebted to Mr. L. P. Teas, consulting geologist, of Houston, Texas, for the specimens herein described.

According to Mr. Teas, the manganese ores were collected from a prospect on a hill one-half mile northwest of Snowmass Post Office, which is about fifteen miles northwest of Aspen, in Pitkin County, Colorado. The prospect is located about 250 feet above the Roaring Fork River. The ore occurs in the Maroon Formation (chiefly Pennsylvanian) in an irregular vein-like deposit from one to five feet thick which transgresses the bedding plane at a small angle. Basalt flows occur a few miles distant.

The information contained in the preceding paragraph was supplied by Mr. Teas in August, 1940; what progress has been made in the development of the deposit I have yet to learn.

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In the map of structural trends in northwestern Colorado drawn by Macquown (7), Snowmass Post Office must lie on or near the Castle Creek Fault Zone.

Dr. Tom S. Lovering† informs me that there are many occurrences of manganese ore at the base of the basalt flows to the northwest of the locality under discussion.

## Description of the Braunite

The specimens submitted to me consist of a massive, somewhat granular, iron-gray to black mineral of rather high specific gravity. The streak is brownish black and the mineral is slightly harder than a knife blade. It is very slightly magnetic.

Minute (*ca.* $\frac{1}{4}$ mm.) euhedral crystals are present in cavities. The octahedral appearance of these crystals, together with the slightly magnetic character, suggested braunite, and such they proved to be. The importance of geometrical crystallography in the sight determination of minerals is sometimes overlooked.

A broken surface shows numerous cleavages and since some of these have more or less the shape of equilateral triangles, the cleavage is evidently parallel to the common tetragonal dipyramid.

Thin slices of the massive braunite show euhedral to subhedral crystals with sections that remind one of magnetite (see Fig. 1). Chains of subhedral crystals are frequently prominent. The mineral is opaque; this fact distinguishes it from hausmannite, which is decidedly red-brown in thin sections, especially when examined in direct sunlight between crossed nicols (8).

## Chemical and Pyrognostic Tests

The powdered mineral is soluble in hot dilute hydrochloric acid with the evolution of chlorine which is recognized by its pungent odor and bleaching action of litmus paper, and it also leaves a residue of gelatinous silica.

It gives a good amethyst-colored borax bead in O.F. which becomes almost colorless in R.F.

## Associated Minerals

Judging from the thin sections, not more than 60 to 70 per cent or so of the specimens by volume is braunite (see Fig. 1). Hausmannite is a common associate of braunite, as at Långban, Sweden (9), but none could be detected in the Snowmass specimens. The interstitial minerals are mainly calcite and barite; the latter is recognized by its rather weak

† Personal communication, February 2, 1946.

birefringence, fairly high relief in balsam, and an index of refraction of about 1.64, which was determined in fragments by means of immersion liquids.

Several detrital minerals also are present, among them microcline, plagioclase, and quartz. Tabular crystals of muscovite, often curved and bent, are detrital for the most part, but some may be authigenic.

The sedimentary rock containing the braunite may be classified as arkose.

Since both calcite and barite are "persistent minerals" with a wide temperature range, these give no certain clue to the type of deposit. Lindgren (10) does not include barite in his list of "persistent minerals"

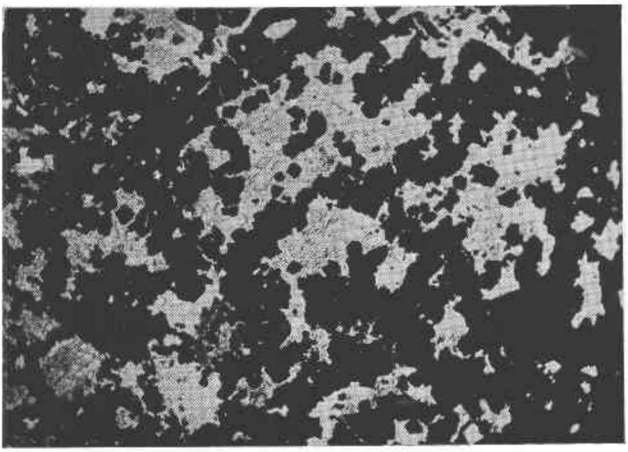

FIG. 1. (×27). Mineralized arkose with braunite (opaque), interstitial barite and calcite, and muscovite shred (n.w. of center).

but the presence of barite in the rocks of the gondite series of India, as reported by Fermor (11) is, in my opinion, sufficient warrant for extending the temperature range of barite to include hypothermal deposits, since gondite is a metamorphic rock consisting of varying amounts of quartz and spessartite (garnet). According to Butler and Burbank (12), barite reaches its maximum development in mesothermal deposits. Braunite itself has an appreciable temperature range; it is considered to have been formed under conditions varying from metamorphic through hydrothermal to weathering.

The presence of muscovite might be used as an argument in favor of the hydrothermal origin of the deposit, but it is not certain that any of the muscovite is authigenic.

Manganophyll is a characteristic mineral of the Långban manganese deposits (9, pp. 46–48) and occurs there in association with braunite.

A brown pleochroic mica which resembles manganophyll* (manganian biotite) occurs sparingly through the thin sections (see Fig. 2); this is evidence that the braunite is a hydrothermal mineral.

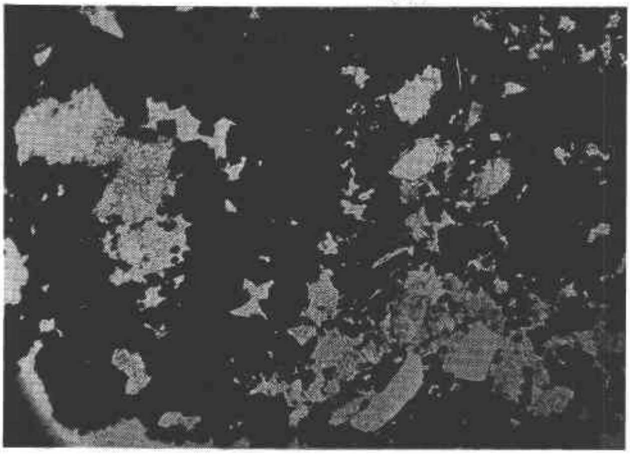

FIG. 2 (×37). Mineralized arkose with braunite (opaque), interstitial barite and calcite (gray), several detrital grains, muscovite shred (near center), and manganophyll (dark gray, bottom center).

## GEOMETRICAL CRYSTALLOGRAPY

The euhedral braunite crystals of the Snowmass occurrence are minute (about $\frac{1}{4}$ mm.), but distinct enough to be recognized with a hand lens as octahedral or pseudo-octahedral. The crystals are simple tetragonal dipyramids occasionally modified by the pinakoid {001}. In the original orientation of Haidinger this dipyramid was taken to be *p* {111} as shown in Fig. 3; down to the end of the nineteenth century this was generally accepted.

The change of orientation of the first order dipyramid {111} (Fig. 3) to the second order dipyramid {101} (Fig. 4) is credited to Goldschmidt (13) by Hewett and Schaller (3), but Brooke and Miller (14) were the first to make this change. Figure 5 is a copy of Brooke and Miller's drawing, which is a plan view with the forms *e* {101}, *s* {201}, and *c* {001}. This drawing was overlooked by Goldschmidt in his *Atlas der Krystallformen der Mineralien.*

* The original name manganophyll of Igelström is more euphonious than its equivalent, manganophyllite. It also seems a more suitable name since the mineral has no relation to the rock phyllite.

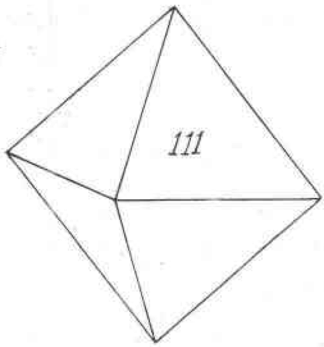


FIG. 3.

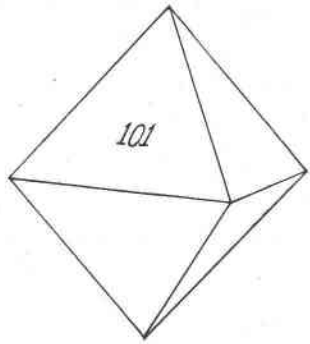


FIG. 4.

FIG. 3. Usual habit of braunite {111}. Haidinger-Dana orientation.
FIG. 4. Usual habit of braunite {101}. Brooke and Miller—Goldschmidt orientation.

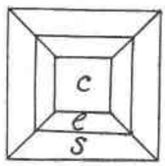


FIG. 5. Plan view of braunite crystal with the forms: *c*{001}, *e*{101}, and *s*{201}. (After Brooke and Miller.)

The transformation scheme of the original Haidinger setting (*hkl*) to the Brooke and Miller setting (*pqr*) is as follows:

(Haidinger) $hkl \rightarrow h-k \cdot h+k \cdot 2l$
$p+q \cdot q-p \cdot r \leftarrow pqr$ (Brooke and Miller).

This change of one setting to the other is the equivalent of a rotation of 45° and modification of the unit on the *c*-axis by $\sqrt{2}$.

Expressed in the linear form of Barker the transformation scheme is $110/\bar{1}10/002$ (D. to G.) and $1\bar{1}0/110/001$ (G. to D.) as given by Switzer (15), who designates the two settings as Dana (D.) and Goldschmidt (G.).

Three kinds of angles are recognized in solid geometry:

(1) Plane angles of the faces.
(2) Dihedral or angles over the edges.
(3) Polyhedral or solid angles at the vertices.

Polyhedral angles may be resolved into a combination of plane angles and dihedral angles. In crystallography dihedral angles are called interfacial angles. Donnay and O'Brien (16) designate plane angles of crystal faces as interedge angles.

Plane angles were formerly recorded in books on geometrical crystallography; because of the difficulty of accurate measurement of these angles the custom fell into disuse. It is my contention (17) that plane angles are used unconsciously in the sight-determination of crystallized minerals more than interfacial angles. For example, we probably recognize small quartz crystals by the shape of the triangular *r* faces rather than by interfacial angles such as *mr*. The plane angle of the *r* face at the apex of the usual *rzm* combination is 41°51′. See Fig. 1, p. 8, reference (18).

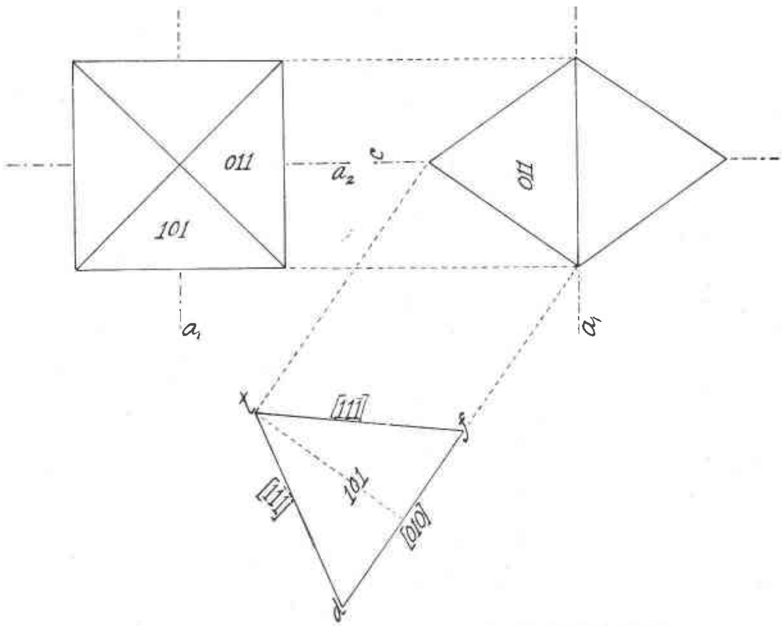


FIG. 6. Graphic determination of plane angle $dtf=[1\bar{1}\bar{1}]\wedge[11\bar{1}]$ on a braunite crystal with the {101} form.

The graphic determination of plane angles is accomplished by constructing a projection (19) so that the face appears in its true shape (19). For braunite we first construct (Fig. 6) a plan view on the left, then the side elevation from the interfacial angle $(101\wedge10\bar{1}=70°48')$. To show the (101) face in its true shape we construct a supplementary projection with folding-line parallel to the [101:011] edge by making the edge *df* [010] equal to the corresponding edge in the plan. In the triangle *dtf* the angle *dtf* is very close to 60°. This plane angle may be expressed as the interzonal angle $[1\bar{1}\bar{1}]\wedge[11\bar{1}]$. The calculated value of this angle is

60°10′,* if we use the $\rho$ angle of (011) = 54°36′ determined by Switzer (15). The other plane angles $[1\bar{1}\bar{1}] \wedge [010]$ and $[11\bar{1}] \wedge [010]$ are each 59°55′. So the common form {101} of braunite is decidedly pseudo-octahedral. The plane angle at the apex of the usual hausmannite crystal with the unit dipyramid {111} is 54°34′, which is the same as the interzonal angle $[10\bar{1}] \wedge [01\bar{1}]$.

## The Chemical Composition of Braunite

Perhaps the most interesting, and certainly the most puzzling, feature of braunite is its chemical composition. This was formerly given as $Mn_2O_3$, but to account for the silica, which is present to the amount of about ten per cent, the formula is usually given as $3Mn_2O_3 \cdot MnSiO_3$. Rammelsberg (20) was the first to suggest this formula. An analysis of the Långban braunite by Flink (21) furnished confirmation of this formula. Niggli (22), however, expresses the composition as $nMn_2O_3 \cdot mMnSiO_3$ because of the supposed variability in the silica content. Ford (23) writes the formula $3MnMnO_3 \cdot MnSiO_3$. Palache, Berman, and Frondel (24) suggest the possibility of the replacement of manganese by silicon as expressed by the formula $(Mn,Si)_2O_3$.

Another variation in the chemical composition is the presence of ferric iron replacing the trivalent manganese which gives the formula $3(Mn,Fe)_2O_3 \cdot MnSiO_3$ proposed by Hewett and Schaller (3). The ferrian braunite of Mason County, Texas, contains as much as 15 per cent $Fe_2O_3$ (3), but analyses of braunite from other localities show less than one per cent $Fe_2O_3$. Strunz (25) places braunite in a group with bixbyite $(Mn,Fe)_2O_3$.

Mason and Byström (27) call attention to an analysis of braunite from Kájlidongri, India, mentioned in the paper of Fermor (11, p. 68) which furnishes the formula $3Mn_2O_3 \cdot (Mg,Ca)SiO_3$. This is confirmation of the formula of Rammelsberg.

The synthesis of braunite from $Mn_2O_3$ and $MnSiO_3$ by Mason and Byström is additional confirmation of the formula $3Mn_2O_3 \cdot MnSiO_3$.

The probable space-group of braunite was determined by Aminoff (26) to be $D_{4h}^{20}$. Mason and Byström (28), however, give arguments in favor of the space-group $D_{2d}^{10}$, which means that the crystal class is tetragonal-scalenohedral. But since none of the figured braunite crystals show any sign of merosymmetry their conclusion is open to question.

The complete structure of braunite has not yet been solved, which is not surprising in view of Aminoff's statement that 160 atoms are present in the unit cell.

* The equation is: $[1\bar{1}\bar{1}] \wedge [11\bar{1}] = 2 \text{ arc cot } \{\sec (001 \wedge 011)\}$.

## Acknowledgments

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