CRYSTALLOGRAPHIC NOTES: CRISTOBALITE, STEPHANITE, NATROLITE

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ABSTRACT

Cristobalite crystals with cubic habit are reported from Two Rivers, California.

A study of doubly terminated crystals of stephanite shows pronounced diversity in the forms on opposite ends of crystals, and further confirms the hemimorphic character of this mineral. One probable new form, {17.8.17}, was noted as occurring three times on the measured crystals.

Natrolite crystals in which the square prismatic habit is due to the *a* and *b* pinacoids rather than the prism, and which are rather complexly terminated, are described. The typical assemblage of forms is: *a,b,m,p,z,y,o,β,α*. The new form *t*{351}, appeared on one crystal.

CRISTOBALITE

Through the courtesy of Dr. Cordell Durrell, of the University of California, Los Angeles, the writer received a specimen of olivine basalt carrying cristobalite crystals on its fracture surfaces. The material was collected by Dr. Durrell near Two Rivers, Plumas County, California.

The normal habit of cristobalite is octahedral, and usually the octahedron is the only form present, although other forms have been reported, both on natural and on synthetic crystals. Rosicky[1] describes cristobalite from Bohemia in clear or cloudy octahedra with small modifying faces of {100}, {110}, and {331}. Weil[2] synthesized cristobalite in cubo-octahedra, never as simple octahedra.

The crystals from Two Rivers occur thickly distributed on fracture surfaces of the basalt, as small individuals or groups; none of the crystals are over 0.5 mm. in size. Most of them appear as clusters of individuals, showing well-developed cubic faces. In these clusters the crystals are sometimes interpenetration twins according to the spinel law, and at other times they occur as radiating or sub-parallel groups. Twinning has been reported by Gaubert[3] on cristobalite from Mayen, in the Eifel district. One single crystal was found in the Two Rivers specimen, which showed a balanced development of cube and octahedron. Its faces were sufficiently smooth so that the forms could be checked on the reflection

[1] Rosicky, V., Die drusen Minerale des Andesites von Nezdenice in Mähren: *Festschrift, V. Goldschmidt*, Heidelberg, 229–242 (1928).

[2] Weil, R., Synthèse de la cristobalite par voie humide: *Compt. Rendus Acad. Sci.* (Paris), **181,** 423–424 (1925).

[3] Gaubert, P., Sur la cristobalite de Mayen: *Bull. Soc. Min. de France*, **27,** 242–245 (1904).

goniometer. Descriptions of occurrences of cristobalite other than those noted above, mention only the octahedron, so that the cubic habit is clearly quite uncommon, and on that account worth recording.

Stephanite

Some time ago a collection of unlabelled specimens was received at the University of California, Los Angeles, among which was one ore specimen showing numerous well developed crystals of a metallic mineral. These were examined carefully in the hope of obtaining material suitable for a crystallographic collection. Chemical tests and crystal measurements identified the mineral as stephanite, and it was further noted that a number of the crystals were doubly terminated. This offered an opportunity of checking further the hemimorphic character of this mineral, and accordingly fifteen crystals were carefully measured on the goniometer, with the results detailed below.

Five of the measured crystals are sufficiently developed so that measurements could be made on both terminations. Almost invariably the

Table 1

Crystal #15

Form		Number of faces	Measured (average)				Calculated	
			ϕ	var.	ρ	Var.	ϕ	ρ
b	010	1	0°00′		90°00′		0°00′	90°00′
π	130	1	27 56		90 00		27 55	90 00
u	350	1	44 54		90 00		43 38	90 00
o	110	3	57 47	(13′)	90 00		57 49	90 00
t	023	2	0 00		24 24½	(04½′)	0 00	24 33
k	011	2	0 00		34 27	(03′)	0 00	34 25
d	021	2	0 00		54 13	(27′)	0 00	53 52
β	101	1	90 08		47 28		90 00	47 26
m′	113	3	57 47½	(13½′)	23 19	(03′)	57 49	23 13
h′	112	3	57 47	(11′)	32 51	(15′)	57 49	32 45
l′	223	1	57 57		40 36		57 49	40 37
P′	111	3	57 47½	(13′)	52 08	(04′)	57 49	52 08
r′	221	2	57 53	(04′)	68 34	(24′)	57 49	68 46
A′	313	1	78 02		48 04		78 09	48 03
C′	17.8.17*	2	73 23	(03′)	48 37	(01′)	73 30½	48 38
w′	131	1	27 56		66 39		27 55	66 44
ρ''	241	1	38 32		74 18		38 28	74 03

* New form.

crystals are multiple, being composed of two or three individuals as interpenetration twins on the usual twinning plane {110}, but in most cases it was possible to distinguish the individuals readily, and compare terminations directly. No evidence of twinning on {001} was seen, and any striations on prism faces were either vertical or horizontal. The quality of the reflections was for the most part excellent, so that very accurate readings could be made, and there is no reason to suppose that observational errors have any effect on the conclusions which were reached. The quality of the readings is shown in the example given below, which is typical of many other crystals measured.

New Form

A form was observed twice on this crystal and once on the crystal in twinned position to this, the angular position of which is given below, with calculated angles for neighboring indices. The signals fall in the zone between {101} and {111}.

	Observed			Calculated	
Quality	ϕ	ρ	Form	ϕ	ρ
D	73°20′	48°38′	212	72°32½′	48°47′
B	73 26	48 36	17.8.17	73 30½	48 38
D	73 52	48 48	13.6.13	73 48½	48 36
average	73 33	48 41	11.5.11	74 02½	48 33½
			949	74 23	48 31
			525	75 53	48 20

From an inspection of these values it is difficult to pick an appropriate symbol for the form. As is seen above, the calculated values for {212} and {949} differ about equally from the measured figures, and the values most closely in agreement are for forms with complex indices. In view of the good quality of the faces, the accuracy of setting of the crystal, and the fact that many recorded stephanite forms have complex indices, the writer is inclined to choose {17.8.17} for this form, rather than the much simpler {212}, or even {949}.

Hemimorphism

The hemimorphism of stephanite was observed first by Miers,[4] who noted the polarity of prism faces as revealed by the striations parallel to

[4] Miers, H., The hemimorphism of stephanite: *Mineral. Mag.*, **9,** 1–4 (1889).

the edge 110∧731, and the presence of twinning on {001}. D'Achiardi[5] observed differences in size between {001} and {00$\bar{1}$}, and noted that the upper termination carried many 0*kl* faces, but that only {02$\bar{1}$} appeared on the lower end. He also observed {13$\bar{2}$} on the bottom only. Soriano[6] also observed a difference in forms on opposite ends of a well developed crystal, and lists the following forms as appearing only on one end: {122}, {133}, {114}, {155}, {152}, {134}. Further evidence of hemimorphism has been supplied by Taylor[7] in *x*-ray studies, and in morphological analysis according to Donnay's method. These studies rule out on theoretical grounds the possibility of structure class 222, even when the horizontal plane is not a plane of morphological symmetry.

The writer observed the distribution of faces on opposite terminations of seven distinct crystals, in most cases noting faces occurring above and below identical prisms or brachydomes, so that direct comparison was possible. These observations showed that a considerable number of faces appear on only one termination of a given crystal. There seem, however, to be few forms which do not at one time or another appear on both ends of the same crystal. There is apparently no criterion by which the upper and lower ends may be distinguished, as there seems to be no consistent variation in size or quality of faces on the two ends. The omissions are in general certainly not due to imperfect crystal development, because their positions are nearly always flanked on either side by faces of the same zone.

{223} appears to be the only form never observed on both ends of any crystal or group, occurring four times, only on what the writer has oriented as the lower termination. {133} occurs four times also, but twice above and twice below (one pair in the same group although not on the same crystal). The faces of the zone [101–111] appear only above, with the sole exception of {101}, which appears below in one instance. {134} occurs four times above and twice below. In the brachydome zone, {023}, {011} and {021} appear consistently both above and below, and other faces occur indiscriminately in either position. These results do not correspond with those reported by Soriano and D'Achiardi, as several brachydomes do occur on both ends, and further, there is no noticeable

[5] D'Achiardi, G., Emimorphismo e geminazione della stephanite del Sarrabus: Abstr. in *Neues Jahrb. Min., etc.*, **II,** 338 (1902).

[6] Soriano, V., Los Cristales de Estefanita de Hiendelaencino (Guadalajara): *Bol. Soc. Esp. de Hist. Nat.*, **31,** 1, 49–67 (1931).

[7] Taylor, E. D., Stephanite morphology: *Am. Mineral.*, **25,** 327–337 (1940).

difference in size of the faces on opposite ends. The form {132} was not observed on any of the writer's crystals, and so cannot be compared with their results.

In spite of the inconsistency of these observations, the general inequality of terminations helps to confirm the observed hemimorphism of stephanite.

Natrolite

Several specimens of natrolite from the headwaters of the San Benito River, San Benito County, California, near the famous benitoite locality, carry large crystals showing a rather unusual complexity of habit. The crystals occur in open vugs in a vein of massive natrolite in what is apparently serpentine, although not enough of the wall rock was preserved on the specimens to make this determination certain. The crystals are long prismatic, square or rectangular in cross-section, reaching a maximum length of 3 cm., with a thickness of 0.2–0.3 cm. Many of the crystals are terminated by a group of shiny faces. A considerable number of crystals were examined, and a dozen measured on the goniometer. The signals were, generally, of high quality, and the resulting readings very accurate. The measurements on a typical crystal, and the calculated values for the angles, are given in Table 2.

Table 2

Form		Number of faces	Measured				Calculated	
			ϕ average	var.	ρ average	var.	ϕ	ρ
a	100	2	89°59′		90°00′		90°00′	90°00′
b	010	2	0 03	(02′)	90 00		0 00	90 00
m	110	2	45 31	(02′)	90 00		45 32	90 00
	110 (very poor face)	1	46 17		90 00			
p	111	4	45 34½	(05½′)	26 46	(02′)	45 32	26 42
z	331	3	45 28	(03½′)	56 35	(01′)	45 32	56 28
y	131	3	18 45	(04′)	48 16	(01′)	18 26	48 06
o	151	1	11 31		61 34		11 31	60 56
β	311	2	71 58½	(04½′)	48 43½	(04½′)	71 53	48 34
α	511	2	78 57	(02′)	61 30	(01′)	78 54	61 20

The square cross-section of these crystals is due to the strong development of the pinacoids {100} and {010}, while the prism faces are always

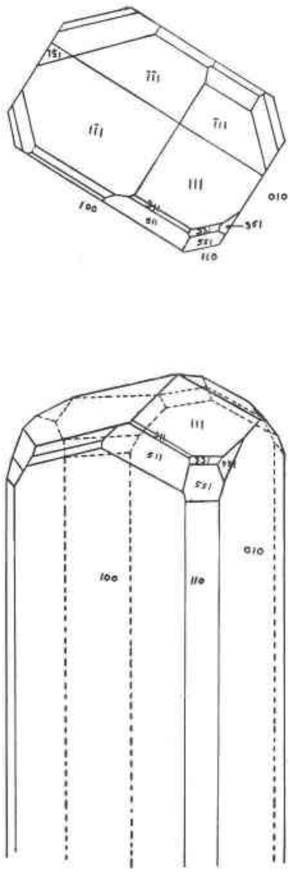

FIG. 1. Natrolite.

narrow, and occasionally missing. The most prominent terminal faces are those of {111}, which are modified by narrow faces of several other pyramids. The usual habit of crystals from this locality is shown in Fig. 1. The relatively uncommon form *o*{151}, found by Phillips,[8] was observed on three crystals, in each case as a very narrow face.

NEW FORM

A small face, occurring only once on the measured crystals, but smooth and giving a good signal, lies in excellent position for {351}, which thus

[8] Phillips, A. H., Some new forms of natrolite: *Am. Jour. Sci.*, (4) **42,** 472 (1916).

far has not been recorded for natrolite. Since this face has been reliably measured, and lies near no other face with simple indices, it may be considered as reasonably established. It has been given the designation *t*. The observed and calculated angles for this new form are given below:

	Measured		Calculated	
	ϕ	ρ	ϕ	ρ
t 351	31°29′	64°20′	31°26′	64°10′

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