MIARGYRITE CRYSTALS FROM RANDSBURG, CALIFORNIA

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ABSTRACT

A study of recently collected miargyrite from Randsburg, California, has shown crystals richer in forms than from any other locality except Bräunsdorf, Saxony. Forty-seven forms in all have been observed by the writer, of which T (313) and Σ (322) are new, and α ($\bar{2}33$) and Z (205) confirm forms which have been reported as doubtful by earlier workers. A few of the crystals are as much as one centimeter across, but most of them are considerably smaller.

The mineral miargyrite is noted for its richness in crystal forms and complex crystals. Fifty-nine forms have been accepted up to the present as established, another 25 or so have been noted as probable or uncertain, and 17 more have been observed as untypical or vicinal.

The crystallography of miargyrite has been studied by many authors,[1] notably in recent years by Rosický, who has made an exhaustive investigation of the known forms.

Various orientations of this species have been suggested: Naumann followed the modern orientation, but with the a-axis $\frac{1}{3}$ of its present length: $a : b : c$ 0.9977:1:2.91, $\beta=81°36'$. In the orientation of Weisbach the base corresponds to present c, but o ($10\bar{1}$) was taken as the orthopinacoid (100), (100) as (101), and ($31\bar{3}$) as the prism (110). This orientation appears in an early edition of Dana's *Textbook* (1868), and was accepted by Friedlander, Vrba and G. vom Rath. This gave an axial ratio of:

$$a : b : c \quad 1.0136:1:1.3026, \beta=48°38'.$$

Miller and Lewis used the present orientation, which has been followed

[1] Miller, W. H., In *Phillips Elementary Introduction to Mineralogy*, 1837.
Naumann, C., Ueber die Krystallformen des Miargyrits: *Pogg. Ann. Physik und Chemie*, **XVII**, 142 (1829).
Weisbach, A., Beitrag zur Kentniss des Miargyrits: *Pogg. Ann. Physik und Chemie*, **CXXV**, 441 (1865).
Weisbach, A., Beitrag zur Kentniss des Miargyrits: *Zeits. Kryst.*, **II**, 55 (1877).
Vom Rath, G., Ein Beitrag zur Kentniss der Krystallform des Miargyrits: *Zeits. Kryst.*, **VIII**, 25 (1884).
Lewis, W. J., Ueber die Krystallform des Miargyrit: *Zeits. Kryst.*, **VIII**, 545–567 (1884).
Eakle, A. S., Miargyrit von Zacatecas, Mexico: *Zeits. Kryst.*, **XXXI**, 209–215 (1899).
Spencer, L. J., Notes on some Bolivian minerals: *Mineral. Mag.*, **XIV**, 339–340 (1907).
Rosický, V., Ein Beitrag zur Morphologie des Miargyrits: *Bull. Inter. de l'Acad. des Science de Boheme*, **XVII**, 1912.
Shannon, E. V., Miargyrite silver ore from the Randsburg District, California: *U. S. Nat. Mus. Proc.*, **LXXIV**, Art. 21 (1929).

by observers since that time. Lewis calculated the elements from 32 measured angles. Dana, recalculated many observed angles, modified Lewis' values slightly, and obtained: $a : b : c = 2.99449:1:2.90951$, $\beta = 81°22'35''$.

These are the present accepted values, and have been used in this paper.

Lewis grouped the crystal habits in seven types, as follows:

1. Bräunsdorf type: *a o c* large, *d s t* small, the latter intersecting an analogous zone in the rear octants to form a sharp angle on the *b*-axis.
2. ξ strongly developed, also faces in the symmetry zone [*a o c*].
3. *a o c* large, *d, g* almost as large, producing orthorhombic development.
4. [*d s t*] and [β *z k t*] zones equally developed, with either β or *x*, or both, present.
5. Tabular, with large *c*. [*o p g*] zone more strongly developed than [*d s t*].
6. Kenngottite type—base large, all other faces small, and belonging to [*o p g*] or [*d s t*] zones.
7. Minute crystals with *o* and *b* well developed, *g* large, *a* triangular, *c* lacking, [*d s t*] zone subordinate.

Rosický has discussed at length the zones and dominant combinations from all the prominent localities (Bräunsdorf, Felsöbanya, Príbram, Zacatecas, Potosi) and has grouped them into three types.

1. Isometric habit: equidimensional crystals with the orthodiagonal zone ordinarily prominent. *c a o* the largest faces. *A* and *g* fairly large. This is the commonest habit in crystals which have been illustrated.
2. Tabular habit—base largest face, or less commonly *a* or *o*.
3. Columnar habit. Generally the zone [*o g A*] is developed, which determines the columnar form. He did not observe this type, personally, but noted it in the literature.

Rosický also has listed all known forms up to the time of writing, 59 certain, 16 doubtful, and 16 vicinal or untypical. Since then Shannon[2] has observed three probable new forms from Randsburg, (722), (733), (433), although the observed readings of ϕ vary by over 1° from the calculated values.

It has been the writer's good fortune recently to obtain crystallized material from Randsburg, much of it quite different in character from Shannon's, and the present paper is the result of a study of these crystals. The geologic occurrence has been described by Hulin[3] and by Shannon.[2] The crystals range in size from about a millimeter across up

[2] Shannon, E. V., *loc. cit.*

[3] Hulin, C. D., Geology and ore deposits of the Randsburg Quadrangle, California: *Calif. State Min. Bur., Bull.* XCV, 97–102 (1925).

to a maximum of one centimeter, although the larger crystals, usually, are not complete. Some of them are quite complex, one crystal showing 27 forms, with 48 faces, another 25 forms with 39 faces.

In habit they fall into three classifications:

1. Small crystals like those described by Shannon, with few distinct faces. The *a* pinacoid keystone shaped, the base large, and the [*d s t*] zone represented by a heavily striated band, with one or two definite facets. Any number of observations may be made in this zone, but only a few places give a definite signal. This corresponds to Rosický's No. 1 type. Little evidence appeared of the fracturing and recementing of crystals noted by Shannon, except that here and there a zone of signals is offset a trifle.

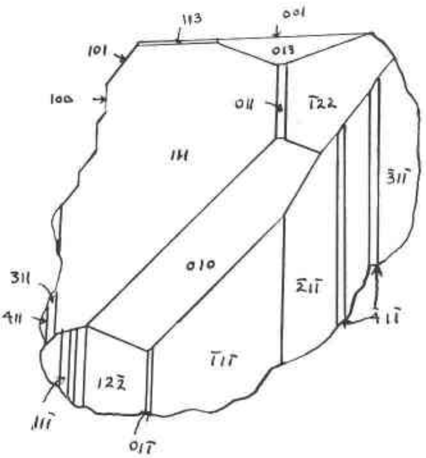

Fig. 1

2. Large crystals, beautifully formed, but incomplete, planted approximately on one end of the symmetry axis. These do not show the maximum number of forms, but there are no heavily striated zones as in type 1. The face *b* is often heavily lined, and some of the other faces may be somewhat curved and striated. The [*d s t*] zone is prominently developed, commonly in characteristic panels, although some of the faces are dull or corroded by etching, and the junction between faces is often marked by a series of narrow lines, or vicinal faces, giving no separate reflections. This type is shown in Fig. 1, which is a projection of one of the large crystals on *b*. This type occurs in a rather vuggy matrix of massive miargyrite and quartz, the latter being bluish, transparent, and forming a drusy coating on the cavity walls. The miargyrite crystals rest on the quartz, and are in general later. This material, with glistening

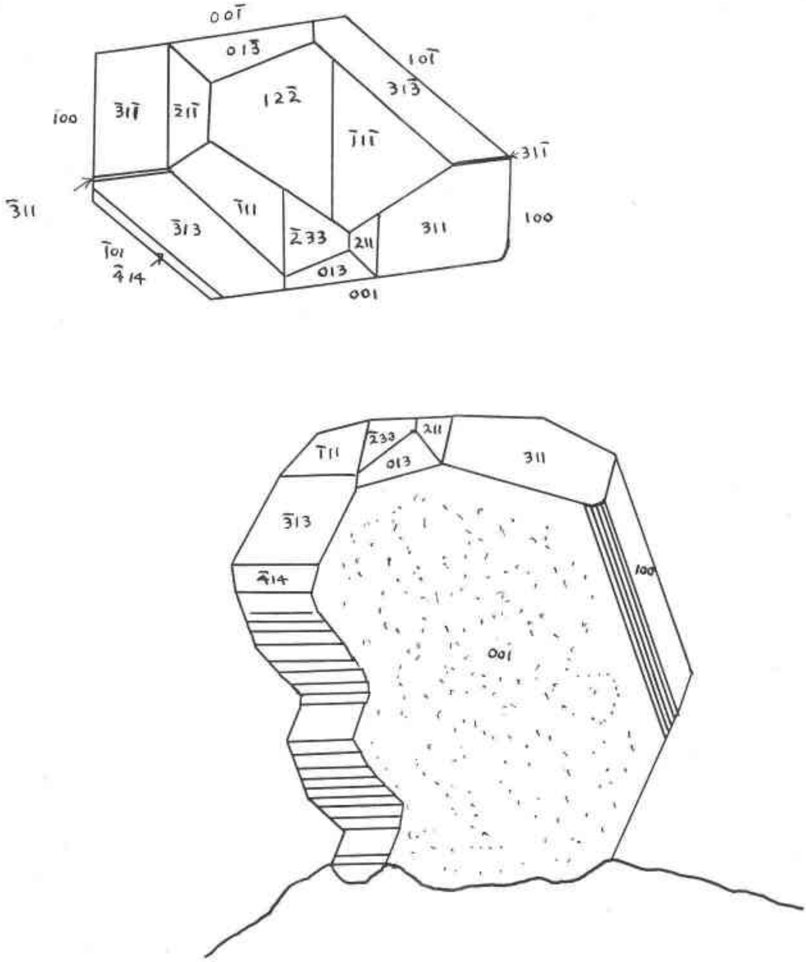

FIG. 2

miargyrite and sparkling quartz, makes very showy specimens. This type is not represented in Rosický's classification, but may approach Lewis' No. 4.

3. Small crystals, tabular, parallel to *c*. They correspond to Rosický's type 2, but are somewhat elongated and are perched on the matrix by an extreme end of the symmetry axis, so that they stand up like posts on the surface. One end is perfectly terminated and many faces are visible on the other. Only two crystals of this type were found, and proved to be very complex, one of them having the greatest number of forms (26)

observed from the region. Another crystal had 24. The *c* face is ordinarily roughened, dull or studded with minute crystals, with other faces in the orthodome zone (except perhaps *a* or *o*) poorly developed or represented by a series of striations. One of these crystals is shown in Fig. 2.

No difficulty was experienced in orientating crystals of types 1 and 3 although type 3 is more easily set in the second inversion position.[4]

Crystals of type No. 2 are very difficult to adjust, particularly those in in which *b* is absent, or as is often the case when present, deeply grooved, so that it cannot be used as a pole face. Under such conditions it was found easiest to place the [*d s t*] zone in a prism position, make a stereographic projection from the readings, and by rotation match these points with a series of known pole positions similarly plotted. Then the projection is tilted, by means of stereographic protractors, into a normal position, or second inversion position, whichever is more convenient. From this readjusted projection, the faces can be identified. In many instances the preliminary orientation will enable a normal setting to be made, so that the ϕ and ρ angles may be plotted directly and more accurately.

Measurements on 14 crystals showed 42 forms, two of which are new. If we add to this number two known and three new forms observed by Shannon, but not by the writer, we have a total of 47 forms for miargyrite from this locality.

New Forms

T (313)—occurs as three faces on a single crystal. The reflections are rather poor, but reasonably consistent. Calculations from the average of observed angles give a value of 3.02 instead of 3 for the indices.

Σ (322)—a single face, with good signal and fair agreement with the calculated position. This form occurs also on crystals from Ungemach's collection, measured by Palache[5] and is considered by him as established.

Confirmed Forms

In addition to these new forms, several were observed which confirm doubtful forms noted by Rosický and others, or add to the evidence in favor of some he calls untypical or vicinal.

α ($\bar{2}33$)—present as two faces on one crystal and one on another, confirming the identity of this form. This is accepted by Palache, and earlier had been noted by Rosický as a doubtful form.

Z (205)—a single very narrow face, with a poor signal. This is listed by Rosický as untypical, but has been found on Ungemach's material by Palache, and may be considered as established.

[4] Peacock, M. A., A suggested form of crystallographic presentation: *Am. Jour. Sci.*, **XXVIII**, 244 (1934).

[5] Charles Palache, personal communication.

Doubtful Forms

δ (13.4.4)—present as two faces on one crystal and one on another. This has been listed by Rosický as untypical and vicinal, and is probably to be so considered.

W (1.0.12)—present as a single very narrow face. It is noted by Rosický as untypical, and cannot as yet be considered as an established form.

$\bar{7}$.10.10—faces with these indices were observed in three instances, but never in the same quadrant as α ($\bar{2}$33). The values are so close to those of α that probably they could not be separated, and should all be grouped under the accepted form.

144—a single face in this position. Probably should be taken as (133).

524—a single face with good signal, and fair agreement with calculated position. Since this occurs only once, it would be better to consider it as a possible but not established form.

A number of other faces occur only once, poorly developed, narrow, and with very unreliable readings. They are ($\overline{10}$.1.3), (623), ($\bar{5}$44), ($\bar{6}$12), and (315). They should be considered as very doubtful forms.

In Table 1 are given the measured and calculated values for these forms.

Table 1

Letter	Symbol		*Measured* ϕ	*Measured* ρ	*Calculated* ϕ	*Calculated* ρ
T	(313)		49°48′	56°12′		
			49 40	56 16		
			48 44	57 10		
		Average	49 24	56 35	49°10′	55°05′
Σ	(322)		31 50	73 30	29 11½	73 18
α	($\bar{2}$33)		−10 34	71 14		
			− 9 28	71 16		
			− 8 42	71 30		
		Average	− 9 35	71 20	− 9 49	71 17½
			ϕ_2	ρ_2	ϕ_2	ρ_2
	(In 2ᵈ inversion)		114 50	20 16	116 42½	21 02
Z	(205)		60 29	90 00	61 25	90 00

			Measured		Calculated	
			ϕ	ρ	ϕ	ρ
δ	(13.4.4)		49 16	77 16		
			49 00	77 32		
		Average	49 08	77 24	48 59	77 17
W	(1.0.12)		90 00	13 00	90 00	13 09
	(524)		42 30	63 49	43 31	63 29½
	($\overline{10}$.1.3)		−72 48	73 00	−72 44	72 59
	(623)		47 00	70 00	47 29½	70 47½
	($\overline{5}$44)		−20 00	72 16	−20 19	72 08
	($\overline{6}$12)		−63 28	73 07	−63 03½	72 42
	(315)		50 08	44 09	51 52	43 18½
	($\overline{7}$.10.10)		−11 10	71 36		
			−11 08	71 36		
			−11 30	70 44		
			−10 46	69 48		
		Average	−11 08½	70 56	−10°40′	71°20½′
	(144)		7 46	70 53	7 46	71 11½

In Table 2 are given the calculated crystallographic data for the new and confirmed forms according to the presentation method suggested by Peacock.[6]

TABLE 2

Letter	Symbol	ϕ	ρ	ϕ_2	$\rho_2 = B$	C	A
T	(313)	49°10′	55°05′	41°23½′	57°34½′	81°23′	51°39′
Σ	(322)	29 11½	73 18	31 35	33 15	69 15	62 09
α	($\overline{2}$33)	−9 49	71 17½	116 42½	21 03	72 58	99 17½
Z	(205)	90 00	28 35	61 25	90 00	19 57½	61 25

In Table 3 are listed the observed forms from Randsburg, with the number of faces of each form and on each crystal.

[6] Peacock, M. A., *loc. cit.*

TABLE 3

Letter	Form	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total faces	Number of crystals
c	(001)	1	1	1	1	2	1	1	1	2		1	1	1	1	15	13
b	(010)		1		1	1	1	1		1					1	7	7
a	(100)	2	1	2	1	2	1	1	1	2	1	2	2	1	1	20	14
β	(013)	2	1	1	1		1		1				1			8	7
ω	(011)		2	1		2	1						1			7	5
W	(1.0.12)	1														1	1
G	(105)(S)																
Z	(205)														1	1	1
m	(101)	1	1	1	1	1	1	1							1	8	8
o	$(\bar{1}01)$	2		2	2	1	1	1	1	2	1	1	1		1	16	12
h	(113)		1			1		1	1							4	4
t	(111)		3	1		2	1						1	1	1	10	7
ρ	$(\bar{1}13)$								1							1	1
A	$(\bar{1}11)$	2	1	2	2			3	1					1		12	7
z	(137)						1									1	1
k	(124)					1							1		1	3	3
Γ	(133)					1		1								. 2	2
X	(122)					1										1	1
x	$(\bar{1}22)$	2	2	2		3	1		1			1				12	7
ζ	$(\bar{2}15)$														1	1	1
α	$(\bar{2}33)$	1		4	2								1			8	4
p	$(\bar{6}16)$			2		1	1	2	1							7	5
π	$(\bar{5}15)$	1		1							1					3	3
γ	$(\bar{4}14)$	2		3	1	2	2	1			1		1			13	8
T	(313)					3										3	1
g	$(\bar{3}13)$	3		1	2	3	1	2		1	1	1			1	16	10
χ	$(\bar{2}12)$			1		1	1									3	3
	(524)					1										1	1
ψ	$(\bar{4}13)$			1		1										2	2
Σ	(322)													1		1	1
	(433)(S)																
s	(211)	2	1	3		2	2		1	1		1	1	1		15	10
σ	$(\bar{2}11)$					3		1	1							5	3
Y	(11.5.5)			1		2										3	2
Q	(733)(S)																

Letter	Form	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total faces	Number of crystals
ϵ	(522)											1				1	1
d	(311)	3	2	3	1	3	2	1	1	2	1	1				20	11
i	($\bar{3}$11)	1		1		3		1	1	1	1	1			1	11	9
δ	13.4.4					1								1	1	3	3
	(722)(S)																
ϕ	(411)	2	2	2		3	1			1	1			1		13	8
H	($\bar{4}$11)							1								1	1
f	(922)													1		1	1
F	(511)	2		1						1						4	3
η	(611)			1							1		1			3	3
D	(711)										1	1				2	2
	(15.1.1)(S)																
Total forms		15	14	24	12	26	17	16	13	11	10	9	12	9	12		

47 = total for district. (S) indicates form observed by Shannon but not by the writer. *a, c, o, d, g, s* appear on practically all crystals, but there are 12 forms each of which appear only on one crystal, showing the highly variable character of these combinations. These odd faces are, however, in general small or unimportant, so that they do not notably affect the crystal types.

Comparison of the total number of forms from various localities shows that Randsburg, with 47 forms is second in the list, exceeded by Bräunsdorf with 70 (including doubtful forms), and followed by Zacatecas with 40, Příbram with 28, Potosi with 13, and Parenos, Mexico, with 13.

Table 4

Analyses

	1	2	3	4	5	6
S	21.96	21.54	19.27	21.68	21.95	21.9
Sb	41.07	41.73	42.46	41.15	39.14	40.5
Ag	36.97	36.57	36.20	36.71	36.40	33.9
Cu		0.07	0.02	—	1.06	2.6
Fe		(tr)	0.56	tr	0.62	1.0
Pb		—	0.95	—	—	0.6
As		—	—	—	—	—

(1) Theory; (2) Randsburg, F. A. Gonyer; (3) Randsburg, E. V. Shannon; (4) Příbram, R. Andreasch; (5) Bräunsdorf, H. Rose; (6) Potosi, Bolivia, L. J. Spencer.

The analysis made for the writer by Gonyer was on selected crystals, mostly of type 2. A spectroscopic analysis confirmed the chemical tests but showed a very slight trace of iron.

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