Scorodite from Kiura mine, Japan.[1]

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SCORODITE from Kiura mine, Bungo, Japan, has been known for many years. However, owing to its diversity in crystallographical and optical properties as well as chemical composition from those of other localities there appears to be some doubts as to the identity of the mineral.[2] It has even been suggested to be possibly a new mineral having a composition akin to that of scorodite.[3] Some time ago a number of fine crystals were placed at our disposal by the courtesy of Dr. Kô, in addition to the recent acquisition by our Institute of a few rarely found beautiful druses of the mineral. It will therefore be worth while to describe some of its main features in detail.

The mineral occurs in druses associated with vivianite, fluorite, quartz, &c., forming a part of mispickel veins intruded into limestone. The druses are mainly composed of tiny dark-brown opaque crystals not exceeding 2 mm. in length. Some greenish-brown transparent crystals of larger dimensions (up to 5 mm. in length) were included in those recently found. The latter show a brilliant lustre, and are the crystals that we are now concerned with.

Chemical.—Utmost care was taken in sampling material for chemical analysis. As a microscopical investigation has revealed, the mineral contains many enclosures, probably hydrous iron oxides of doubtful nature. This suggests that the excess of iron and water reported by the earlier analysis may be presumably attributable to these impurities. For the purpose of chemical analysis, therefore, transparent crystals were used, after crushing and subjecting them to

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[1] See Journ. Geol. Soc. Tokyo 1931, vol. 38, p. 309 [an abstract in Japanese].

[2] J. Sasamoto, Journ. Geol. Soc. Tokyo, 1898, vol. 5, p. 31 [in Japanese]. K. Yamada, ibid., p. 302 [in Japanese]. S. Kô, ibid., 1903, vol. 10, p. 573 [in Japanese].

[3] T. Wada, Minerals of Japan, 1916, p. 321 [in Japanese]. N. Fukuchi, Journ. Geol. Soc. Tokyo, 1916, vol. 23, p. 137 [in Japanese].

a close scrutiny under the microscope.   Ordinary chemical methods were followed in the course of estimating Fe_2O_3 and As_2O_5, the difference being taken as H_2O.   The result (I) is as follows (T. Shiga, analyst) :

		I.		II.
As_2O_5 ...	...	49·85 %	... ...	49·80 %
Fe_2O_3 ...	...	34·33	... ...	34·59
H_2O ...	...	15·82	... ...	15·61
		100·00		100·00

This corresponds with a considerable degree of accuracy to the formula of scorodite, $FeAsO_4.2H_2O$, as shown by the calculated percentages (II).

We have further studied the behaviour of the water on heating, using a thermo-balance devised by Dr. Honda of Tohoku Imperial University.   The result is that no appreciable amount of water is lost until the temperature reaches 220°.   Between 220° and 250° the crystals give up all their water content, making 15·84 % in all.   No discontinuity was observed in the course of dehydration.   This agrees well with the result of the chemical analysis.

Morphological.—The crystals are pyramidal and equi-dimensional, tending to be 'octahedral' in habit.   Table I is the result of measurement with a Goldschmidt two-circle reflection-goniometer.

TABLE I.   *Goniometric measurements.*

		Measured.		Calculated.		No. of
		ρ.	ϕ.	ρ.	ϕ.	faces.
$c(001)$	...	0° 0′	—	0° 0′	—	11
$a(100)$	...	90 0	90° 0′	90 4	90° 0′	9
$g(011)$	...	*44 12	0 0	*44 12	0 0	23
$d(120)$	...	90 0	*30 1	90 5	*30 1	27
$p(111)$	...	56 4	49 8	56 0	49 7	28
$n(201)$	...	66 1	90 0	66 2	89 50	19
$i(211)$	...	67 47	66 36	67 38	66 26	10
$-(322)$	...	62 48	60 1	62 44	60 18	7

The calculated values [1] are based on the measurements of the faces (011) and (120) and give the axial ratios :

$$a : b : c = 0.865 : 1 : 0.972.$$

The faces (111), (120), and (011) are the most persistent, (111) usually predominating ; (001), (100), and (201) are less persistent, and are sometimes completely or partly absent.

[1] T. Ito, Zeits. Krist., 1929, vol. 71, p. 536. [Min. Abstr., vol. 4, p. 299.]

An interesting morphological feature of the crystals is the configuration of faces around (100). Fig. 1 illustrates a serial development of these faces, tending from unsymmetrical to symmetrical arrangement. Fig. 2 is drawn more or less idealized.

FIG. 1. Scorodite from Kiura mine, Bungo, Japan. Actual development of the crystals.

FIG. 2. Scorodite from Kiura mine, Japan.
Ideal development.

There are abundant vicinal faces on (111), the boundaries of which present to the unaided eye many striations parallel to the edges [(111) : (011)]. On the reflection-goniometer their images are often continuous in certain directions, forming bright ribbon-shaped bands. Recording several points on the ribbon-shaped images and noting at the same time the many bright separate images, we could trace two

principal zones, [01$\bar{1}$] and [10$\bar{1}$], in which most of the vicinal faces are located (figs. 3 and 4). In the zone [01$\bar{1}$] their development ranges from (111) over (322) to (211), while in the zone [10$\bar{1}$] it is limited in the proximity of (111) (fig. 5). The zone [01$\bar{1}$] itself sometimes separates into two or three vicinal zones (fig. 3). Table II gives an example of the measurements on these vicinal faces (fig. 3).

TABLE II. *Goniometric measurement of vicinal faces.*

	Observed.			Calculated Indices.	
	ρ.		φ.		
0°	0′	0°	0′	(100)	
23	53	90	0	(20$\bar{1}$)	
23	22	99	57	(23.$\bar{10}$.$\bar{16}$)	
23	49	−89	55	(201)	
86	37	−90	23	(1.20.20)	
32	18	−45	44	211	⎫
38	37	−45	41	(38.25.25)	⎪ (111) group
50	1	−46	5	(26.25.25)	⎬
53	14	−48	42	(49.50.55)	⎭
32	17	45	53	(21$\bar{1}$)	
33	46	46	58	(47.25.$\bar{26}$)	⎫
39	9	45	17	(85.50.$\bar{49}$)	⎪
39	25	45	55	(32$\bar{2}$)	⎪
37	48	46	25	(75.50.$\bar{51}$)	⎬ (11$\bar{1}$) group
43	31	47	0	(39.25.$\bar{26}$)	⎪
⎧ 42	18	44	22	(133.100.$\bar{95}$)	⎪
⎩ 46	26	45	6	(58.50.$\bar{49}$)	⎭
⎧ 40	36	134	6	(73.$\bar{50}$.$\bar{50}$)	⎫
⎩ 46	39	134	17	(29.$\bar{25}$.$\bar{25}$)	⎪
⎧ 41	56	132	46	(71.$\bar{50}$.$\bar{52}$)	⎪
⎩ 49	9	131	48	(28.$\bar{25}$.$\bar{27}$)	⎬ (1$\bar{1}\bar{1}$) group
⎧ 38	33	145	59	(13.$\bar{10}$.$\bar{7}$)	⎪
⎩ 47	51	145	4	(29.$\bar{25}$.$\bar{17}$)	⎭
39	15	−139	4	(6$\bar{5}$4)	⎫
⎧ 43	33	−141	4	(59.$\bar{50}$.39)	⎪
⎩ 48	44	−141	53	(23.$\bar{25}$.19)	⎬ (1$\bar{1}$1) group
40	49	−136	57	(73.$\bar{50}$.45)	⎪
⎧ 48	14	−137	31	(52.$\bar{50}$.45)	⎪
⎩ 53	3	−137	38	(70.$\bar{25}$.22)	⎭

⎧ indicates continuous images.

Fig. 6 shows the combination of faces and vicinal faces of the fourteen crystals investigated, each representing a distinct type. Crosses denote the existence of faces, full lines that of vicinal faces showing continuous images, and broken lines that of vicinal faces showing distinct single images.
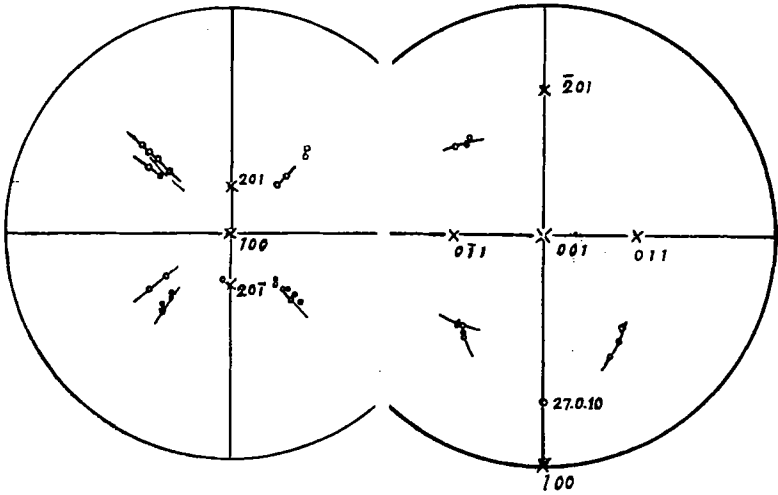
FIG. 3.   FIG. 4.

FIG. 3.   Scorodite, crystal no. 10.   Stereographic projection on (100) of
the vicinal faces.

FIG. 4.   Scorodite, crystal no. 5.   Stereographic projection on (001) of
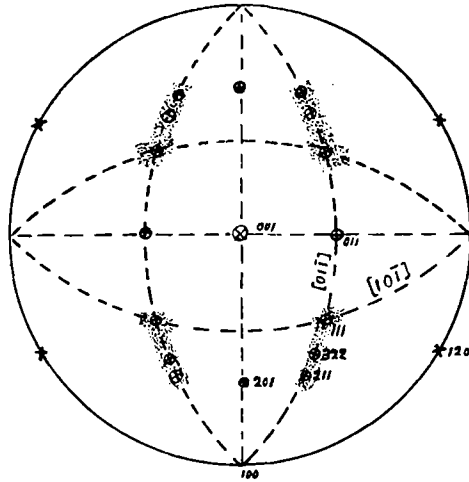the vicinal faces.

FIG. 5.   Stereographic projection of scorodite
from Japan.

It appears that the existence of (211) has contributed to the development of vicinal faces in the zone [01$\bar{1}$], as indicated in Table III.

FIG. 6. Combination of faces and vicinal faces on crystals of scorodite from Japan.

TABLE III. *Typical Combinations.*

1.	2.	3.	4.
111	111	111	111
120	120	120	120
011	011	011	011
100	100	—	100
—	201	201	201
211	211	—	—

vicinal faces in the zone [01$\bar{1}$] more conspicuous. vicinal faces in the zone [01$\bar{1}$] less conspicuous.

The refractive indices of scorodite from the ' Kuira ' [i.e. Kiura] mine, Bungo, Japan, have been determined by E. S. Larsen,[1] who

[1] E. S. Larsen, The microscopic determination of the nonopaque minerals. Bull. U.S. Geol. Survey, 1921, no. 679, p. 132.

gave the values α 1·888, β 1·895, γ 1·915 all $\pm 0·003$, and 2V 65°$\pm$ 5°, positive, $\rho > v$ strong. Since these values for the refractive indices are considerably higher than those for scorodite from other localities, he suggested there was here probably a different mineral, and this view has also been expressed by some other authors.[1] This view is, however, not confirmed by the determinations made by T. Shiga on the crystals now described. With a prism cut in a random direction he found for sodium-light α' 1·776 and γ' 1·810 ; and determinations by the immersion method, also in sodium-light, gave the values :

$$\alpha\ 1·771 \pm 0·003,\ \beta\ 1·805 \pm 0·005,\ \gamma\ 1·820 \pm 0·003.$$

[1] W. F. Foshag, H. Berman, and R. A. Doggett, Amer. Min., 1930, vol. 15, p. 390. [M.A. 5–43.]

Note.—Prof. T. Ito has generously presented to the British Museum collection of minerals four of the scorodite crystals from Japan that he here describes. These show a sub-parallel grouping of sub-individuals, and it is possible that some of the vicinal faces noted by him may really be due to this imperfection of the crystals.—L. J. S.