CRYSTALS OF NATIVE TELLURIUM FROM JAPAN.

By

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With 1 Plate and 8 Text-figures.

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INTRODUCTION.

Recently tellurium minerals have often been noted from several epithermal gold-silver deposits in Japan. In our country native tellurium was first recorded by Dr. M. WATANABE, Professor of Tôhoku Imperial University, in 1932 from the Teine[(1)] Mine, Hokkaidô, where it occurs as slender needles in gold-silver veins mainly composed of barite and quartz. Though several new localities of tellurium minerals have been reported, especially, by Professors T. KATO and M. WATANABE, crystallographic data on these minerals are very scarce, because of the non-discovery of suitable crystals for goniometrical work except very excellent tellurite crystals from the Kawazu[(2)] Mine (4).

In the course of the microscopic study of gold ores from the Kawazu mine, Sizuoka Prefecture, and from the Teine mine, the writer found some beautiful fine crystals of native tellurium in some cavities of the gold ores from both mines. The materials from the former mine were collected by the writer, and those from the latter have come into his hand by the courtesy of Mr. K. URABE, an official of the Teine mine.

On account of the minuteness of those crystals the writer devised a simple method for measuring the facial angles of such fine crystals. The method is also explained in this report.

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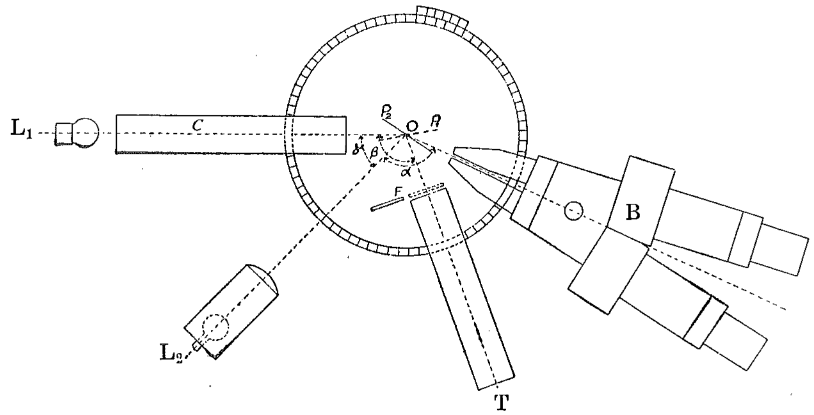
(1) 手稲 (Te-iné)

(2) 河津

A METHOD FOR MEASURING FACIAL ANGLES OF MINUTE CRYSTALS ON A SINGLE-CIRCLE GONIOMETER WITH THE AID OF A BINOCULAR MICROSCOPE.

As has been well-known, smaller crystals are suitable for goniometrical measurement because their crystal faces are usually smooth and undistorted. But when minute crystals are less than 0.5 mm in size, some difficulty may arise in discriminating images from narrow faces or from vicinal faces of those crystals, which cannot be observed by the ordinary low-power microlens attached in front of the telescope of the ordinary single-circle goniometer. In order to overcome this difficulty and to make easy the manupilation of such fine crystals on the goniometer, the writer devised a conventional and simple method, especially, for adjusting and checking tiny crystals during the measurements, using the single-circle goniometer(1) with the aid of a binocular microscope and an auxiliary light source.

The method of arrangement of these instruments will be rendered clear by the illustration (Text-fig. 1).



Text-fig. 1. Principle of single-circle goniometer with auxiliary equipment suited for measurements of very minute crystals.

L_1 : Light source. C : Collimator. T : Telescope. F : Front lens of telescope. L_2 : Auxiliary light source. B : Binocular microscope.

(1) The single-circle goniometer of Fuess Model (II b) type was used by the writer.

As shown in Text-fig. 1, a binocular microscope[1] (B) is set up horizontally on a suitable vertical stand so that the optic center-line of the objective of the microscope is in a horizontal plane containing the axes of collimator (C) and telescope (T) of the goniometer. Then the binocular microscope (B) should be focused sharply on the image of an object (a slender sharp pin is preferable in this preliminary adjustment) attached on the crystal holder of the goniometer.

Next an auxiliary light sourse (L_2), has to be installed so as to fulfil the following conditions: [1] Its position is nearly half between the collimator (C) and the telescope (T). [2] The angle (α) between the axes of the auxiliary light source and the binocular microscope is equal to that (β) between the axes of the collimator and the telescope. [3] The optical center line of the light source (L_2) is in the same horizontal plane above stated.

Thus the preliminary setting up of the instruments may easily be carried out.

In order to measure facial angles of a very minute crystal, the crystal should be first attached on the point of a fine needle by means of Canada balsam. After the setting up of the auxiliary instruments as explained the needle holding the crystal must be mounted upon the crystal holder of the goniometer with the use of wax, in such a position that the crystals is centered to the common intersection of the axes of C, T, B and the goniometer circle, and that its edge or its zone axis is approximately parallel to the goniometer-axis. This adjustment may be easily done by the aid of the binocular microscope, even if the size of the crystal is less than 0.2 mm.

Then, the goniometer-circle carrying the crystal (O) is rotated in such a position (P_1), that the brilliant illumination of a face itself lighted by the auxiliary light source, may be seen through the binocular microscope.

If the inner axis of the goniometer is again rotated in clockwise direction through the angle ($\gamma = \angle L_1OL_2$), the brilliant illumination of this face lighted by the light source (L_1), may be seen again through the micro-telescope of the goniometer. While in this position (P_2) it may be expected that an image of the Websky signal-slit of the collimator would be also visible in the telescope.

After finishing the adjustments of one face, the next thing to do is the adjustments of other faces on the zone to be measured, in the same way.

(1) A Leitz's binocular microscope may be suitable for this purpose.

If these preliminary operations are performed, further precise adjustments of the position of the signal images can be made by using the tangent screws of two sliding cylinder-segments of the goniometer after the ordinary method for adjusting and centering. Next clamp the inner axis to the axis of goniometer and measure the facial angles of this zone without the aid of the auxiliary instruments. (See A. E. H. TUTTON: Crystallography and Practical Crystal Measurement, Vol. I, Chapter IV).

In these operations the measurements of facial angles may be carried out on the goniometer itself and thus its accuracy is not effected by the auxiliary system, that is to say, the inherent accuracy of the goniometer is maintained.

In short, the binocular microscope plays merely the part of the microlens of the telescope, but this simple device for goniometrical measurement has the following advantageous features:

(1) By means of this auxiliary equipment the goniometric measurements of crystals smaller than those measurable on an ordinary goniometer, may be carried out without diminishing the accuracy of the goniometer, provided that their faces are smooth enough and bright enough to yield good reflections of signals.

(2) In regard to etched figures, vicinal faces and other minute characters of crystal-faces, the more detailed examination may be easily achieved with the binocular microscope, which is characterized by its stereoscopic upright vision in higher magnification.

(3) The long working distance of the binocular microscope is also very favourable for centering and adjusting the crystal when adapted to the Fuess goniometer.

MODE OF OCCURRENCE.

1) Native tellurium from the Kawazu mine.

The Kawazu mine, better known as the Rendaizi mine, is situated in the southern portion of the Izu peninsula, Sizuoka Prefecture, 2 kilometers north of the famous port of Simoda. The general rocks in the vicinity of the mine are pyroclasts and propylitic andesite of late Tertiary age. In this region a large number of productive gold-silver veins of epithermal type are massed together, usually in association with abundant manganiferous gangue minerals. It is one of the characteristic features of the Tertiary gold-silver veins in Izu peninsula as noted by Prof. T. KATO (2, 3, 4) that the manganese minerals such as rhodochrosite, inesite, etc. are banded in crustification together with chalcedonic quartz. But the Hinokizawa vein (4, 5), one of the gold veins in the Kawazu mine, exceptionally lacking in these manganiferous minerals, is interestingly rich in tellurium minerals. A large amount of beautiful crystals of tellurite were recently found in this vein. A detailed description of them and their associated minerals was already given by T. KATO, H. SHIBATA and A. NAKAMOTO (4, 5). Besides, a rare mineral, rickardite (Cu_4Te_3) was discovered in one part of this vein; the result of its microscopic examination has also been published by M. WATANABE (12). Later, the present writer could collect some excellent crystals of native tellurium from small vugs of this vein. The quartz- filling of this vein is usually very fine grained, chalcedonic and porcellaneous and shows sometimes brecciated structure.

2) Native tellurium from the Teine mine.

The Teine mine is situated in the northern foot hills of Mt. Teine, the dissected old-volcanic mountain, about 10 kilometers northwest of Sapporo, Hokkaidô. The ore deposits of the mine are of special interest because of the association of gold and tetrahedrite in a quartz-barite vein with some tellurium minerals. From the geological point of view, the veins of Teine are also typically epithermal. Though the microscopic and chemical studies of native tellurium and its associated minerals has been already done by M. WATANABE (9, 10, 11), little crystallographic data on tellurium have been available in his reports. In the course of the recent prospecting of this mine minute tellurium crystals have been discovered from the Takinosawa vein, some of which have come into the hand of the writer and are described hereafter.

A brief summary of the geology of the Teine mine (6) follows: the country rocks of the mine are mainly composed of pyroclastic sediments, dacite and andesite of late Tertiary age in which the strong effect of the propylitization is usually traced. Abundant quartz-barite veins accompanying gold, tellurium and copper minerals lie within these rocks. The characteristic feature of the veins is that the content of tellurium is always a good indication for gold, even if no tellurium mineral is macroscopically observed in them. However, occurrences of fairly large crysals of native tellurium are rather common in some veins such as the Mitsuyama Tellurium-vein (No. 3 Level) and the Takinosawa vein. The handspecimens of the gold ores from the latter vein are massive aggregates of acicular native tellurium, platy barite and microcrystalline quartz. Where they are drusy, minute crystals of native tellurium showing brilliant metallic lustre are occasionally seen in association with slender yellowish needles of tellurite.

GEOMETRICAL CRYSTALLOGRAPHY.

About fifteen crystals detached from the wall of small vugs of ores (Pl. I, figs. 1 and 3) from the Kawazu mine and ten, from the Teine mine, were examined under the binocular microscope. The average size of the crystals from the former is about 0.3 mm., and the latter 0.7 mm. As tellurium belongs to the trigonal system and its crystal habits somewhat resemble those of quartz. Three types of crystals showing the form R{$10\bar{1}1$}, r{$01\bar{1}1$} and m{$10\bar{1}0$}, were observed, which are tabular and prismatic to the c-axis, the former being rarely present (Text-figs. 2–7). Doubly terminated crystals are not rare. It is often observed that prism faces are equally developed in the terminated crystals as shown in Pl. I, figs. 1 and 2. Perfect cleavage parallel to m($10\bar{1}0$) and imperfect cleavage parallel to c(0001) are often observed (Text-fig. 6), when destroying the crystals under the microscope.

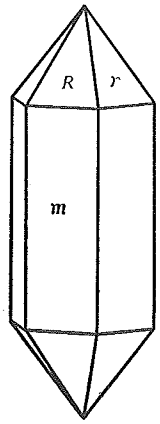


Fig. 2.

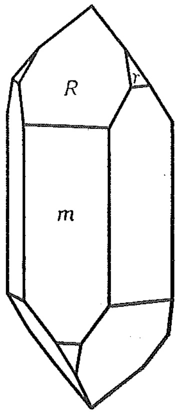


Fig. 3.

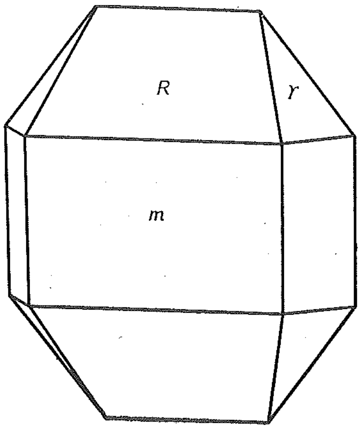


Fig. 4.

Text-figs. 2–4. Crystals of of native tellurium from the Kawazu mine, showing the forms : R{$10\bar{1}1$}, r{$01\bar{1}1$}, and m{$10\bar{1}0$}.

Six crystals from the Hinokizawa vein, Kawazu mine, were selected for measurement. In spite of the minuteness very good reflections were obtained on the Fuess goniometer, because the examined materials are free from distortion and striation on their faces, and partly because of high reflectivity of tellurium.

The results of these measurements are given in Table I.

TABLE I.

Angle Table for Native Tellurium from the Kawazu Mine.

Angle measured	No. of Measurement	Range	Mean observed	Calculated	Difference
R$(10\bar{1}1)$: m$(10\bar{1}0)$ r$(01\bar{1}1)$: m$(01\bar{1}1)$	30	12′	33°03′*		
R$(10\bar{1}1)$: m$(1\bar{1}00)$ r$(01\bar{1}1)$: m$(\bar{1}100)$	5	5′	65°37′	65°13′	24′
R$(10\bar{1}1)$: r$(01\bar{1}1)$	5	2′	49°38′	49°33′	5′
R$(10\bar{1}1)$: r$(\bar{1}011)$	5	3′	113°52′	113°54′	2′
R$(10\bar{1}1)$: R$(\bar{1}101)$ r$(01\bar{1}1)$: r$(\bar{1}011)$	5	14′	93°16′	93°05′	11′
m$(10\bar{1}0)$: m$(01\bar{1}0)$ m$(01\bar{1}0)$: m$(\bar{1}100)$	20	7′	60°02′	60°00′	2′

From the fundamental angle, marked with an asterisk in Table I, the following axial ratio was calculated: $a:c = 1:1.3310$

All tellurium crystals from the Takinosawa vein, Teine mine, are prismatic in habit, and are often doubly terminated (Figs. 5–7). Unlike those from the Kawazu mine, crystals from this locality are not so beautiful in their form and their faces are more or less rough and curved due to corrosion and oscillatory repetition of faces (Text-fig. 7, and Pl. I, fig. 4). After the examination of ten crystals, three were selected for measurements whose prismatic faces always gave good reflections. On the other hand, on account of the scarcity of good terminated crystals suitable for goniometrical work, the only one crystal giving excellent reflection from pyramidal faces was selected for measurements of facial angles between R and m. The angles measured are as follows:

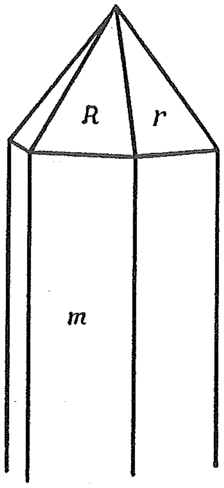


Fig. 5.

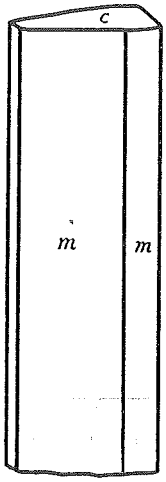


Fig. 6.

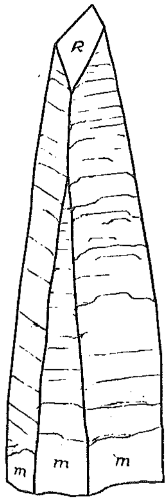


Fig. 7.

Text-figs. 5–7. Crystals of native tellurium from the Teine mine.

Fig. 5: Typical crystal showing the forms: R{$10\bar{1}1$}, r{$01\bar{1}1$}, and m{$10\bar{1}0$}.
Fig. 6: Acicular crystal with the form m, showing the cleavage parallel to c(0001).
Fig. 7: Crystal having a tapering termination due to the oscillatory repetition of pyramidal and prismatic faces.

Table II.

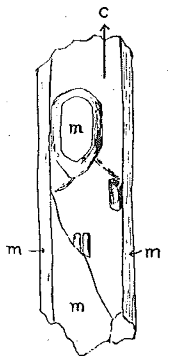
Angle Table for Native Tellurium from the Teine Mine.

Angle measured	No. of Measurement	Range	Mean observed	Calculated (Cited from Table I.)	Difference
R($10\bar{1}1$) : m($10\bar{1}0$) r($01\bar{1}1$) : m($01\bar{1}0$)	6	4′	33°04′	33°03′	1′
R($10\bar{1}1$) : r($01\bar{1}1$)	3	2′	113°52′	113°54′	2′
m($10\bar{1}0$) : m($01\bar{1}0$) m($01\bar{1}0$) : m($\bar{1}100$)	24	13′	60°00′	60°00′	0′

The fundamental angle ($R\hat{}m$, $r\hat{}m$) leads to the axial ratio: a:c = 1:1.3302. For comparison the previously published ratios are given in Table III.

TABLE III.

Authors		$R\hat{}m$, $r\hat{}m$	a : c	References
G. ROSE	Facebaja Artificial	33°04′.5	1:1.3298	Abhandl. Akad. Berlin, (1849) Vol. LXXXIV, pp. 14–18.
H. FOULLON	Facebaja	33°05′.8	1:1.3283	Verh. d. k. k. geol. Reichsanst, (1884) pp. 269–275.
M. K. SLATTERY (1923)		(By powder method)	1:1.33	Phys. Rev. (1923) Vol. XXI, pp. 378–379, (1925) Vol. XXV, pp. 333–337.
A. J. BRADLEY (1924)		(By powder method)	1:1.33	Phil. Mag., (1924) Vol. XLVIII, pp. 477–496.
T. WATANABE	Kawazu	33°03′	1:1.3310	
T. WATANABE	Teine	33°04′	1:1.3302	



Text-fig. 8. Natural etched hill on m(10$\bar{1}$0). (Native tellurium, Teine.) ca.×70.

According to Bradley X-ray study by powder method showed that tellurium belongs to the rhombohedral trapezohedral class (D_3). The writer's attempt to produce etch-figures by H_2SO_4 on the prismatic faces and to determine whether the crystals are left-handed or right-handed, was unsuccessful because of the minuteness of the crystals, though, under the microscope, some natural etched hills were observed on those faces of some of the Teine crystals (Text-fig. 8).

CHEMICAL PROPERTIES.

Qualitative chemical tests were made on small detached single crystals under the microscope: several pieces of terminated crystals were completely soluble in warm conc.H_2SO_4, leaving no residue and forming the characteristic carmine-red solution; on addition of excess water black powders are deposited:

$$\underset{\text{(Black)}}{Te} + H_2SO_4 \rightleftarrows \underset{\text{(Carmine-red)}}{TeSO_3} + H_2O$$

ACKNOWLEDGEMENTS.

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SUMMARY.

Native telluriums from the Kawazu and Teine, were found in Tertiary gold-silver veins of epithermal type. They occur as very minute crystals of prismatic or tabular habit with the forms: R $\{10\bar{1}1\}$, r $\{01\bar{1}1\}$ and m $\{10\bar{1}0\}$. Axial ratios are as follows: a:c = 1:1.3310 (Kawazu crystals), a:c = 1:1.3302 (Teine crystals).

A simple, rapid and accurate method for measuring facial angles of very minute crystals on the ordinary single-circle goniometer was devised by the writer. All goniometrical work was done by this method.

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PLATE IX (I)

PLATE IX (I)

Fig. 1. Native tellurium (T) on quartz (Q) from the Kawazu mine. Enlargement of a part of the small vug (V) of Fig. 3. Magnified 30 diameters.

Fig. 2. Prismatic terminated crystals of native tellurium (T). Kawazu. Magnified 60 diameters.

Fig. 3. A specimen of the telluriferous gold ore with the small vug (V) containing minute crystals of native tellurium. Kawazu. Natural size.

Fig. 4. Photomicrograph of a slender prismatic crystal of native tellurium (T) from the Takinosawa vein, Teine, attached to sharp point of a needle (N). Magnified 65 diameters.

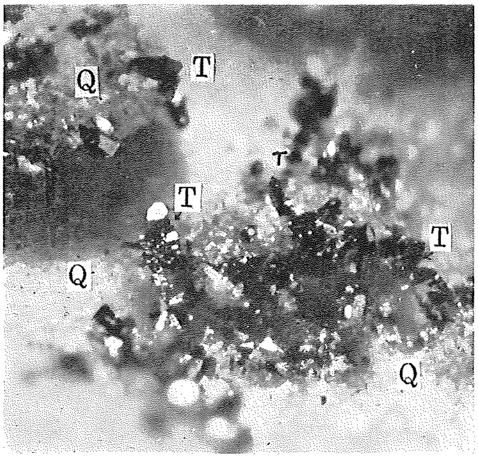

Fig. 1.

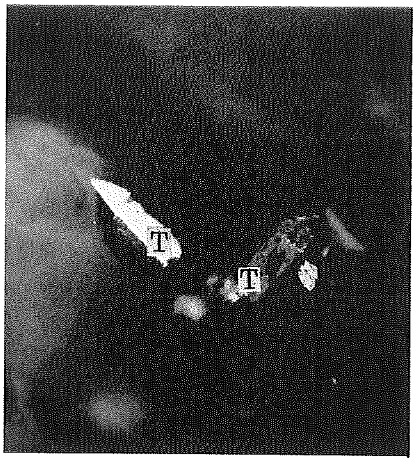

Fig. 2.

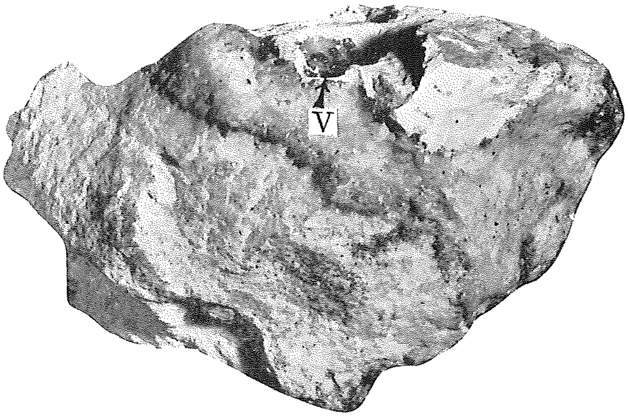

Fig. 3.

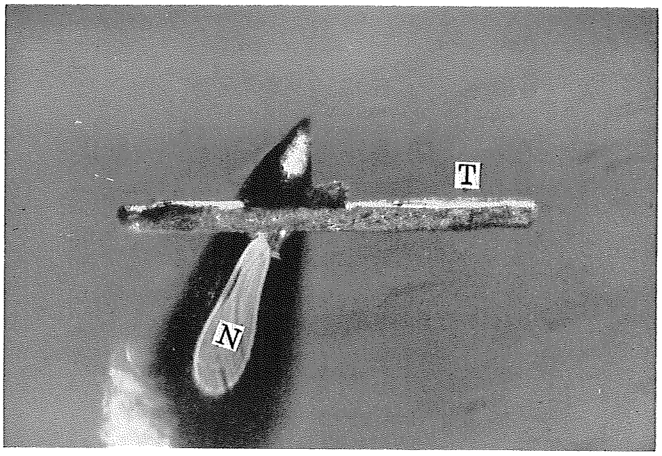

Fig. 4.

T. Watanabe: Crystals of Native Tellurium.