

## Notes on the Minerals of Japan.

BY

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Through the kindness of Mr. Tsunashirō Wada, I have been allowed to study his collection of Japanese minerals, which surpasses all others of the kind both in magnitude and completeness. Moreover, he has given me much necessary assistance and advice in writing the present notes, which consist of short accounts of the characters and occurrence of minerals in Japan, with special reference to his collection. I wish therefore to express here my most cordial thanks to him.

Next to Mr. Wada's collection, are to be mentioned that of the Science College of the Imperial University of Tōkyō, that of the Imperial Museum in Ueno, Tōkyō; and those of Messrs. Kō, Sasamoto and others; as being the most important collections of Japanese minerals. Papers connected with these specimens are scattered through the Journal of the Geographical Society of Japan, begun in 1889; the Journal of the Geological Society of Tōkyō, begun in 1893; the Journal of the Science College, Tōkyō, begun in 1888; and other Japanese periodicals; besides well-known foreign publications containing mineralogical descriptions.

In the present notes, all crystal faces are treated according to Dana's System of Mineralogy; and all Japanese names are transliterated according to the rules made by the Society for romanising the writing of Japanese. Thus, all vowels are pronounced as in Italian, and all consonants as in usual English spelling. Special care must be taken to distinguish long vowels marked with  $\bar{\phantom{a}}$ , as in *Ōta* and *Ota*, which are two fundamentally different names in Japanese.

The statement of mineral-localities has usually been restricted to the names of the village and province; for more exact and detailed statements, the reader is referred to the catalogues of Japanese minerals, &c., in the Imperial Museum, of those exhibited in the Chicago Exhibition, or of those sent to the International Geological Congress of 1897.

Authorities are mentioned in the case of many minerals; but references to periodicals published in Japanese have been omitted.

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## A. Elements.

### 1. Graphite.

Province HIDA contains many localities of graphite and is known as the principal source of this mineral in Japan. According to Ishiwará it forms impregnations in biotite-gneiss. A peculiar occurrence of graphite in the shape of round masses in a dioritic rock is found in the Piboro river in Tokachi Province. Suzuki has given a list of graphite localities in Japan.

### 2. Sulphur.

SHIRANE Volcano in Kōzuke.—Iwāsaki has described sharp-

pointed pyramidal crystals of sulphur from a solfatara of Manza on the western flank of the volcano. The individuals attain a length of 1.5 cm. along the *c* axis, show the faces,  $\circ P$ ,  $P$ ,  $\frac{1}{3}P$ ,  $\infty P$  and a brachydome, and carry terraced depressions on  $P$ , which are due to imperfect development of crystals. Numerous minute elliptic depressions on this face may be due to etching.

In 1898, I found, at the same place, less numerous but more perfect crystals showing a short-columnar habit. Their size is smaller than one fourth of the above mentioned specimens; the faces are, however, more numerous.

KOBUI in Oshima Province.—On the western side of the volcano Esan, a brownish-grey compact sulphur is found forming thin layers in a grey tuff, in which we find, besides the stratified specimen, quite irregular aggregates of ordinary yellow sulphur (Jimbo's observation 1889).

YONAGO in Shinano Province gives orange-red tellurium-sulphur, while TATEYAMA-JIGOKU in Etchū Province and the island IWŌJIMA near the province of Ōsumi are localities of selenium-sulphur.

The KOSAKA mines in Rikuchū.—Small crystals of sulphur with numerous faces are found in the metallic veins containing copper, silver, &c.

### 3. Arsenic.

AKATANI in Echizen.—As described by Beck in Tschermak's *Mittheilungen*, 1897, and previously mentioned in the *Zeitschrift der deutschen Geologischen Gesellschaft*, 1895, the native arsenic of this place is found in the shape of globular as well as quite irregular groups of numerous rhombohedral crystals showing their poles outside. Their edges are usually rounded and their surfaces roughened and tarnished. The centre of the aggregate

consists of concentric spherical shells of arsenic. The separate rhombohedra are about 0.4 cm. long, and the diameter of the aggregate is usually less than 4 cm.

#### 4. Bismuth.

At KANAGASE in Ikuno in Tajima Province we find bismuth filling up interstices of botryoidal quartz-aggregates found in silver ores.

At ŌKURADANI in Obira in Bungo Province, thin lamellæ of bismuth are found in the cleavage of a light rosy-coloured fluorite.

#### 5. Platinum.

The occurrence of minute black grains of platinum was reported by Ishikawa, &c. from the wash-gold of TUNAKBETS, a tributary of the Sorachi river in Ishikari Province; and also from that of the upper course of the Yūbari river in Iburi Province.

#### 6. Iridosmium.

This metal was mentioned by Ishikawa, &c., in the form of flattened minute grains, found with the above mentioned platinum. Another locality for iridosmium is the gold placers of the river YOSHINOAWA in Shikoku.

#### 7. Copper.

Beautiful crystal groups of copper with numerous but hardly determinable faces occur in the mines of OSARUZAWA and KOSAKA in Rikuchū, of ARAKAWA in Ugo Province, &c., where irregular, platy, moss-like and other aggregates are also observed with associated cuprite.

### 8. Silver.

Minutely platy and other forms of silver are found in the gold mines of YAMAGANO in Ōsumi Province and of KAGO in Satsuma Province, besides at KOSAKA in Rikuchū, &c., (according to Kō).

Wada possesses a specimen of long hairy silver from TASEI in Ikuno in Tajima Province.

### 9. Mercury.

Mercury occurs, according to Harada and Ōtsuka, in the two provinces HYŪGA and AWA (Honshū).

### 10. Gold.

ASAHI near Ikuno in Tajima.—Beautiful groups of minute crystals, as well as feather-like aggregates are found in the gold mines.

YAMAGANO in Ōsumi.—In the mines of Yamagano, there was found a minute hexagonal plate of gold about 0.4 cm. in length, now in Wada's collection. It carries a few straightly truncated triangular pyramids on its hexagonal face.

Scaly, platy, hair-like and other forms of gold aggregates are often found in some Japanese gold mines.

### 11. Meteorites.

The meteorite of OGI in Hizen was described by Divers in 1882, that of TAJIMA treated by Korschelt in 1881, and that of KESENGŌRI in Rikuzen by Ward in 1893. (See Wenckstern's Bibliography, 1895, for the literature of Japanese minerals written in European languages). A few notes on Japanese meteorites are found in the Journal of the Geographical Society and in that of the Geological Society of Tōkyō, both published in Japanese. The specimens accessible to me are : two from FUKUTOMI in Hizen, two

from MAEME and another place in Ōsumi Province, one from ŌSHIMAMURA in Satsuma Province, and one from SAKARI in Kesengōri (all these specimens are preserved in the Imperial Museum), besides two others fallen in 1897 in the neighbourhood of the town of Yamaguchi in Suwō Province.

## B. Sulphides, &c.

### 12. Realgar and Orpiment.

Beautiful minute crystals of realgar are found at MONJI in Rikuzen Province; from this locality Wada obtained a good crystal of this mineral about 2 cm. in length but already broken to pieces by exposure to sun-light.

Massive realgar and coarse platy orpiment were collected in a tuff near the hot springs of JŌZANKEI in Ishikari Province.

### 13. Stibnite.

ICHINOKAWA in Iyo Province.—The large well-known crystals of stibnite, formerly found at the mines of Ichinokawa, are often more than 50 cm. in length; but such good specimens are now very rare. As described by Ogawa, Iwasaki, &c., the stibnite veins are found there in a conglomerate as well as in the crystalline schists of Kotō's Sambagawa Series (Journal of the College of Science, Tōkyō, 1888), attaining a thickness of 25 cm. Associated with this mineral we find quartz and calcite crystals. The stibnite is often in fine needle-like aggregates, but good measurable crystals give very numerous crystal faces enumerated by Dana, who has given all details of characters of this mineral as it occurs in Iyo.

Other occurrences of stibnite are the provinces HYŪGA, KII, &c.

#### 14. Bismuthinite (?).

A fine needle-shaped aggregate of grey colour, rarely found with bismuth, fahlore, &c. in the silver veins of IKUNO in Tajima is probably of this mineral.

#### 15. Molybdenite.

Six-sided platy crystals as well as irregular plates (sometimes attaining 6 cm. in length) of this mineral are found in the provinces IZUMO, ECHIGO, HIDA, &c. The small plates about 0.5 cm. in diameter, found in the crystalline limestone of Kamioka in Hida, are very pretty.

#### 16. Zinc-blende.

Kō mentioned the occurrence of beautiful and large crystals (sometimes more than 7 cm. in diameter) of zinc-blende in the mines of KURATANI in Kaga Province, of ANI and ARAKAWA in Ugo Province, of OSARUZAWA in Rikuchū Province, of ADAKAI in Izumo Province, &c. The crystal faces are usually only  $\pm \frac{O}{2}$  and  $\infty O$ , but specimens from Ani, which sometimes exceed 4 cm. in diameter, also often shows  $\infty O \infty$ , &c. Polysynthetic twins on O are quite numerous at Ani and Kuratani, while similar twins of usually two or three individuals occur at the UCHINOKUCHI mines in Bungo Province. Wada possesses a druse of tetrahedral zinc-blende crystals, about 1 cm. in diameter and brought from the DAIRA mines in Ugo Province. The edges of the tetrahedra are beveled with  $\infty O \infty$ , and the solid angles with very small faces of negative tetrahedra.

All the above-mentioned localities of zinc-blende usually give the dark-brown to brownish-yellow varieties.

A parallel growth of minute copper-pyrite crystals, on dark-brown zinc-blende individuals, is found at KAYAKUSA in the mining district of Ani. From this region, we found optically anomalous specimens of zinc-blende, showing dark brown stripes in yellow-coloured cleavage-pieces, beside numerous thin lamellæ with double refraction under the microscope.

Thick deposits of the mineral are found in the mines of KAMIOKA in Hida Province.

Manganese-bearing zinc-blende found in the SAIMYŌJI mines in Ugo Province is massive, dark-brown coloured and nearly opaque. It is associated with rhodocrosite besides a little pyrrhotite, &c.

### 17. Pyrrhotite.

BIZEN and other provinces in the western part of HONSHŪ, besides the province of ECHIGO, &c. are the localities of massive pyrrhotite in metallic ore deposits.

### 18. Pyrite.

Beautiful crystals which are usually not rich in faces are found according to Kō, in the mines of UDO, ADE and ADAKAI in Izumo Province, of OSARUZAWA in Rikuchū Province, of ANI and ARAKAWA in Ugo Province, of OGOYA in Kaga Province and of FUTTO in Mikawa Province, besides in OGASAWARAJIMA (the "Bonin Islands" of foreign maps) and other places. The crystals sometimes attain 6 cm. in diameter.

UDO (according to Hiki's description).—Beautifully shining crystals of pyrite, often about 3 cm. in diameter, are here found mostly in the combination  $O. \infty O \infty$ , but sometimes in  $O. \infty O \infty. \left[ \frac{\infty O 2}{2} \right]$ .



We find also the faces  $\infty O$  and  $[\frac{mO_n}{2}]$ . Simple octahedra are seldom met with. Striations on  $O$  and  $\infty O \infty$  are due to oscillatory combinations of these faces with  $\infty O$  and  $[\frac{mO_n}{2}]$ , as in the specimens from Ogasawarajima, Osaruzawa, Ani and Arakawa. Striations on  $[\frac{\infty O_2}{2}]$  are mostly parallel to its regular edges, but in rare cases perpendicular to them. Besides there are striations on  $\infty O \infty$ , running parallel to  $[\frac{\infty O_2}{2}]$  and  $2O_2$ . Each crystal is developed usually on all sides, for it is found in a clay vein.

OGOYA.—Pyrite crystals which are here found with copper-pyrite, &c. show  $O$ ,  $\infty O \infty$ ,  $[\frac{\infty O_2}{2}]$ ,  $2O_2$  and  $[\frac{mO_n}{2}]$ ; and have an octahedral habit usually with very subordinate  $[\frac{\infty O_2}{2}]$ , &c. The individuals of pyrite attain 2 cm. in diameter.

TŌHIRA in Rikuchū Province.—The specimens of pyrite from Tōhira, described by Hiki, show a peculiar rhombohedral habit on account of the development of only six of the dodecahedral faces. The crystal-form is nothing but  $[\frac{\infty O_2}{2}]$ .  $\infty O \infty$ . The size of individuals is sometimes more than 2 cm. in length.

Quite a similar form of pyrite is seen at AKADANI in Echigo Province, where the largest individual is about 4 cm. in length and the crystal developed on all sides, as at Tōhira.

Good specimens of supplementary twins of dodecahedra were found in OGASAWARAJIMA and at ANI(?).

The face of  $\frac{3}{2}O$  was only observed in a specimen from ŌHINATA in Shinano.

### 19. Marcasite.

Botryoidal aggregates and crystal groups of marcasite were collected in the AIKAWA mines in Sado. Small spherical or

irregular rounded aggregates in the clay of KAMISHINA in Shinano are either pyrite or marcasite.

### 20. Arsenopyrite.

Kō mentioned the occurrence of nearly perfect crystals of arsenopyrite ( $\infty P$ .  $\frac{1}{4}P\infty$ ) in the mines of KURATANI in Kaga, FUTTO in Mikawa, KAMIOKA in Hida, SASAGATANI in Nagato, and KOHAGI and BANDŌ in Echizen. Twins are quite numerous at Kuratani and Futto.

Among the small perfect crystals of arsenopyrite from AWASHIRO in Mikawa, Fukuchi found many twins on  $\infty P$  and those on  $P\infty$ , besides simple individuals ( $\infty P$ .  $\frac{1}{4}P\infty$ ). There are also found trillings on  $P\infty$ .

### 21. Galena.

Pretty crystals with bright faces, usually showing only O,  $\infty O\infty$  and  $\infty O$  are found in the mines of KURATANI in Kaga and of ANI in Ugo. The crystals from the former locality with prevailing O and subordinate  $\infty O\infty$  are often rounded on edges, holed on O, and covered with microscopic etching figures. A peculiarly zonal appearance is observable on account of this natural etching, which had produced indistinct terraces on the almost smoothly rounded crystal edges.

### 22. Argentite.

Wada possesses octahedral (?) crystals of this mineral from the mines of AIKAWA in Sado and of INNAI in Ugo. Their faces are really very hard to determine. KANAGASE in the Ikuno mining district in Tajima gives, though rarely, imperfect crystals of argentite.

### 23. Chalcosite.

Massive chalcosite is found at OSARUZAWA in Rikuchū, &c.

### 24. Cinnabar.

The principal localities for cinnabar in Japan are KOMAGAESHI in the Yamato Province, HIRADO in Hizen Province, ISE Province, AWA Province (in Shikoku), TSUKIYOSHI in Iyo Province, &c. Very minute crystals are sometimes observed with the help of a lens.

### 25. Bornite.

This mineral is found in massive state in many copper mines of Japan, especially in those of OMODANI in Echizen Province.

### 26. Chalcopyrite.

Chalcopyrite is worked in most Japanese copper mines, among which those of ANI, ARAKAWA, OSARUZAWA, OGOYA, ADE, &c., give good crystals, usually showing only  $\frac{P}{2}$ , but sometimes  $\frac{P}{2}$  and  $\frac{mP_n}{2}$ .

A small flattened crystal of this mineral from the ASHIO mines in Shimotsuke Province, a curious triangular wedge-shaped crystal from Arakawa (Wada's collection), and numerous complicated twin-like forms (somewhat resembling Fahlore twins on O, with a projecting part on some of the tetrahedral faces) found at Ogoya, Ani and Osaruzawa, are still unsolved problems in the determination of crystals of Japanese chalcopyrite.

### 27. Matildite.

A nearly compact aggregate of this mineral was found with native gold in a mine of KURIYAMA near Nikkō in Shimotsuke

Province. The matildite is here associated with argentiferous galena in a quartz vein.

### 28. Jamesonite.

This mineral is found as feather-ore in association with galena and rhodocrosite of KURATANI in Kaga, and with arsenopyrite, &c., of TSUGU in Mikawa. In the HOSOKURA mines in Rikuzen Province, there are found loose botryoidal aggregates of short fine needles, of a purple-grey velvety appearance. They were determined as jamesonite.

### 29. Pyrargyrite,

Pyrargyrite is found in the mines of IKUNO in Tajima, as well as in the INNAI mines in Ugo, &c. Small prismatic and other crystals are found rarely in KANAGASE, &c., belonging to the Ikuno mining district.

### 30. Fahlore.

Copper-fahlore is found in the AIKAWA, KURATANI and KANAGASE mines. Crystal faces observed in these fahlore specimens are  $\frac{0}{2}$ ,  $\infty O$ ,  $\frac{mOm}{2}$ , &c. The size of individuals is always small.

### 31. Stephanite.

Massive specimens as well as small hexagonal plates and short prisms of this mineral are found in the mines of INNAI in Ugo, IKUNO in Tajima and HANDA in Iwashiro Province.

### 32. Stannite (?).

Kochibe mentioned the occurrence of this mineral in the mines of SAKURA in Harima Province, KANAGASE in Tajima, TANIYAMA in Satsuma Province and Obira in Bungo.

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## C. Oxides.

### 33. Quartz.

The principal localities of quartz crystals in Japan are as follows:—

(1.) Several places near Kōfu (as MITAKE, OTOMEZAKA, KAMIKANE; TAKEMORI, KAWAHAKE &c.),—rock-crystals, often containing liquid cavities and various mineral enclosures.

(2.) Several localities at and near TAKAYAMA in Mino Province,—smoky quartz.

(3.) TANOKAMIYAMA in Ōmi Province,—smoky quartz.

(4.) The mines of AIKAWA in Sado Province,—rock-crystals with numerous negative crystals and liquid cavities.

(5.) OHARA in Iwaki Province,—amethyst.

(6.) KURODAKE in Etchū Province,—rock-crystal.

(7.) FUJIYA, &c., in Hōki Province,—amethyst and smoky quartz.

At the localities mentioned under (1) quartz crystals are mostly found in granitic regions, but their paragenesis is not well known.

At (2) and (3), quartz crystals are found in pegmatite masses in granite, in association with micas, albite, potash-felspars, topaz, beryl, tourmaline, &c. Cassiterite, sapphire, rutile (?), wolframite, magnetite, fluorite and fergusonite are found in rivers at (3), while secondary minerals as manganese oxide are quite frequently found at both of these localities. Our material is not sufficient for the discussion of mineral successions in these occurrences; though, as mentioned later on, we have already some knowledge of the age of different micas and of the two generations of topaz crystals in Tanokamiyama.

In the tertiary tuffs of the Aikawa mines (locality 4), rock-crystal is found in veins of sulphuretted ores; and in the garnet-rock of Kurodake, the same mineral is found together with various garnet-crystals, magnetite, pyroxene, &c. At Ohara, amethyst occurs in coarse-grained rhyolite; while at Fujiya the mineral is found with smoky quartz in mountains of granite and other rocks.

Japanese quartz is often found as Dauphiné twins, as for instance the smoky quartzes of the provinces of Ōmi, Hōki and Mino, and the rock-crystals of the provinces Kai and Etchū.

Twins of rock-crystals on  $P_2$  are not very rare at Otomezaka, Takemori, Kawahake, &c. near Kōfu; and on the island NARUSHIMA belonging to the Gotō group, lying off the coast of Hizen. Those of Narushima usually attain a length of 2 cm., while those from the environs of Kōfu are much larger. Two largest specimens from the latter, one in the science college and the other in Wada's collection, are nearly 25 cm. long. In the specimens from the region near Kōfu, we find clefths parallel to the  $c$  axis and perpendicular to the broadest faces of individuals. Two individuals united on  $P_2$  are in very rare cases normally developed, instead of being flattened as usual. The small twins of Narushima are quite simple in combination, there being rarely found any trapezohedral face on them.

The Brazilian twins are quite frequently observed in rock-crystals collected near Kōfu, in the Aikawa and Innai mines, at Kurodake in Etchū, at Amagisan in Izu Province and at Katsudo in Tosa Province, also in the light-grey quartz from Tanokamiyama, in the smoky quartz of Mino and of Moraiyama in Shinano Province, and lastly in the amethysts of Ohara and Fujiya.

Double twins have been observed in two pretty regularly developed, dark-smoky quartz crystals from Mino, and in many rock-crystals found near Kōfu which are twins on  $P_2$ . The former two specimens are Dauphiné twins, which show Airy's spirals in cross sections; Fukuchi recognised in them, a complicated distribution of electric poles after an experiment with pyro-electricity. In the specimens taken near Kōfu, there are very often found Dauphiné twins, again united on  $P_2$ .

In the Brazilian twins above enumerated, the twin-structure was always observed in interference-figures and not in the characteristic distribution of trapezohedral faces.

Ordinary rock-crystals of Kai are sometimes more than 15 cm. in the diameter of basal sections; but individuals large enough to yield a perfectly clear colourless sphere of as much as 13 cm. diameter, such as are sometimes to be found in private collections, are no longer now to be had.

Quartz crystals showing  $\pm R$ ,  $\infty P$ ,  $4P$ ,  $2P_2$ ,  $6P_3$ ,  $4P_3$ , &c. occur in larger crystals at the localities 1, 2, 3, 6 and 7. Many specimens from these localities show straight prismatic edges and nearly equal-sized rhombohedral faces. Crystals with rhombohedral terminations and curved prismatic faces are found in the amethyst of Ohara, and in rock-crystals of Aikawa and other metal mines. Trapezohedral faces are usually found on larger individuals, sometimes however on smaller ones; they are very seldom met with on the small twins on  $P_2$  from Narushima. Corrosion-faces were numerous on a naturally etched smoky quartz from Kamikane in Kai, which will be treated of later on.

Parallel growth is frequently found in the quartz of Tanokamiyama, where smoky quartz is often surrounded by a zone of white or colourless quartz in the form of a complete cover.

On this outer shell there are often attached dark-purple or grey, simple but regularly formed, small individuals ( $\pm R. \infty R$ ), which are all nearly parallel in orientation to the main crystal. In Wada's collection, there is found a large smoky quartz from Fujiya, about 20 cm. in diameter of basal section and surrounded by small individuals of amethyst, which are all nearly equal in thickness and whose rhombohedral faces are parallel to those of the main crystal. These amethyst crystals may form a perfect shell over it, when their interstices are filled up with amethyst substance.

Zonal structures, already mentioned in connection with Tanokamiyama, are also quite frequent in the crystals from Aikawa, Fujiya, &c. At Aikawa, the structure is produced by an unequal distribution of liquid enclosures; at Fujiya, &c., by different colourations and optical characters of different zones. Such zonally composed quartz crystals from Tanokamiyama, Aikawa, Kai, Fujiya, &c. frequently show biaxial interference-figures; moreover, right-handed and left-handed as well as spiral interference-figures are sometimes found in different zones of one crystal.

Enclosures of liquid, often with gas bubbles, are quite numerous in the rock-crystals of Aikawa and Kai, which often show biaxial interference figures. The smoky quartz of Tanokamiyama contains liquid enclosures, in which Kō has observed certain mineral crystals. The smoky quartz of Tanokamiyama, Takayama, &c. rarely enclose minerals; tourmaline and, in one or two cases, garnet also were found in the specimens from Tanokamiyama. Liquid enclosures are also found in the amethysts of Ohara and Fujiya, and in the rock-crystals of Innai, Kurodake, &c. Specimens from Ohara sometimes



show in basal sections a peculiar distribution of liquid cavities, by which white and purple sectors with edges parallel to the hexagonal sides are produced. Mineral enclosures are very numerous in the rock-crystal from Kai and consist of tourmaline, actinolite(?), pyrite, epidote(?), &c.; sulphur was found in one or two specimens. Grey-coloured minute spheres are enclosed in the rock-crystal of Kurodake and in the amethyst of Ohara.

Natural etching figures on a smoky quartz crystal from Kamikane in Kai Province, are essentially similar to those described by Molengraaf in Groth's Zeitschrift, 1888. The triangular depressions on  $\pm R$  measure about 0.07 cm. along their longest side (larger holes of this kind were discovered by Kō in the smoky quartz of Mino Province). The depressions on  $\infty P$  are not so distinct as in Molengraaf's descriptions; long triangular scratches and rectangular hillocks on  $\frac{mP_n}{4}$  seem not to have been found in his specimens; besides there are found on some crystal edges irregular grooves, which are not at all mentioned by him.

A smoky quartz from TENJINBARU in Obira in Bungo Province bears triangular etching figures on  $\pm R$  as in the specimen from Kamikane.

The rock-crystal of KURODAKE shows a kind of etched depressions on  $\infty P$ , not like those in Molengraaf's description. Polygonal (mostly four-sided) depressions on the rhombohedral faces of quartz from Kawahake in Shinano Province, collected by Hoshina, &c., are also most probably referable to etching. Minute flat hillocks, whose triangular bases are bounded by slightly curved lines, are very numerous on the roughened part of rhombohedral faces in the smoky quartz of Hōki. These hillocks are more pointed in outline, than those produced by

ordinary vicinal faces on  $\pm R$  and are conjectured to be due to etching.

Chalcedony and agate are chiefly found in the provinces KAGA, ETCHŪ, IZUMO, &c. Dark-green to green compact quartz is found in the provinces of IZUMO, ECHIGO, &c. All these occurrences of quartz varieties have been described by Ōtsuka, Hiki, &c.

Pseudomorphs of quartz after calcite in  $\infty P. \circ P$  were found at OSAWA near Nikkō in Shimotsuke Province; those after sharp-pointed rhombohedra of calcite were found in MINO Province. Top-shaped chalcedonies from the provinces of UZEN, ECHIGO, &c., seem to be pseudomorphs after broken pieces of some spherical mineral-aggregate with radial-fibrous structure and consist of two flat cones united at bases. They have a diameter of about 1 to 1.5 cm. The apex of the cones is provided either with a rounded prominence or a depression. For the pseudomorphs of quartz after barite, see under Barite.

### 34. Tridymite.

In the stone-quarry of Gōroyama close by the town of NAGANO in Shinano Province and in that of SHIMAZAKI on the west of Kumamoto in Higo Province, there exist andesite exposures with loose enclosures and segregations. In these rocks tridymite is abundantly found as irregular scales and tabular crystals. Associated with it are found a few breislakite(?) needles in some of the specimens from these localities. At Gōroyama, Yamasaki has observed a very pretty trichroic cordierite crystal of very minute size. Tridymite from Shimazaki is usually more transparent than that from Gōroyama, although the characteristic optical anomaly, as well as twinning crystal-

forms, is equally well observable in specimens from both places.

The occurrence of Tridymite at Maekakeyama, a part of ASAMA Volcano, is rather rare.

### 35. Rutile.

Of this mineral a single bad specimen of prismatic form, and another small crystal, both from TAKAYAMA in Mino Province, are found in Wada's collection. They are of a dark brown colour.

### 36. Cassiterite.

TAKAYAMA, &c., in Mino.—The tin placers of this granitic region, which are now nearly exhausted, gave wolframite, sapphire, fergusonite, magnetic iron sand, topaz crystals with rounded edges, &c. Many of the larger specimens of cassiterite are about 1 cm. in diameter, but mostly smaller. They have sometimes quite well preserved edges and show the usual cyclical twins on  $P\infty$ .

TANIYAMA in Satsuma Province.—In the tin mines of this locality cassiterite is found in massive form and associated with wolframite.

KIURA in Bungo Province.—Here, cassiterite crystals are found in a brown-coloured detritus filling up cavities in crystalline limestone; massive specimens of cassiterite are also found along with arsenopyrite, &c., in veins through limestone, hornfels, &c.

HITACHI Province.—Wada possesses a beautiful druse of crystals of cassiterite, each about 1 cm. in diameter; it is said to have been obtained at TAKANO in this province.

**37. Pyrolusite.**

See Psilomelane.

**38. Corundum.**

TAKAYAMA in Mino Province.—From tin placers of this locality were formerly collected flat hexagonal pieces and more columnar grains of blue to bluish-white corundum. Their diameter is less than 1 cm. The parting parallel to  $\rho$ P shows concentric zones and radial stripes of white colour. The different zones are sometimes distinguished by uniaxial and biaxial characters of interference figures.

**39. Hematite.**

The principal hematite localities of Japan have been studied by Ōtsuka, &c., who determined the extent of the specular iron deposit at SENNIN in Rikuchū, AKATANI in Echigo, &c. The mineral is found either in massive forms, or as small, flat crystals with rhombohedral and prismatic faces.

The occurrence of titaniferous iron, which accompanies magnetic iron sand from different provinces in Japan, has not yet been specially studied.

**40. Cuprite.**

Small cubical, dodecahedral and other simple crystals, less than 0.15 cm. in diameter, are found in cuprite masses, associated with native copper at KOSAKA in Rikuchū, ARAKAWA in Ugo, &c.

**41. Tenorite.**

Kō mentioned small dark-blue six-sided plates, on the black coloured ore ("Kuromono") of KOSAKA in Rikuchū, as being identical with tenorite.

#### 42. Opal.

The most important occurrences of opal in Japan are BODAI in Kaga, the province of IWASHIRO, &c. Some of the specimens show irregular double-refracting bands in thin sections.

Pretty Hyalite spheres of TATEYAMA in Etchū, about 0.2 cm. in diameter, either loose as sand or cemented together into aggregates, were formerly obtainable on the northern shore of a small round lake of hot water, lying about 4 km. to the east of hot-spring hotels. In 1898, I have found only dirty-grey hyalite grains in an ash-like decomposition-product of volcanic rock.

Silicified wood, usually of coniferous species, is found in tertiary as well as cretaceous deposits of several parts of HOKKAIDŌ, (see Jimbō's General Geological Sketch of Hokkaidō, 1892) and also at a number of localities in other parts of Japan.

Diatom-earth forms thick beds in the Tertiaries of HOKKAIDŌ (see the above mentioned work); it is also found in BUNGO Province, &c.

#### 43. Manganite.

Rectangular platy crystals (about 1 cm. long) of manganite, from ASHIO in Shimotsuke province, were found associated with copper-pyrite crystals and drusy quartz. Prismatic crystals (about 1 cm. long) of the same mineral came from the ŌWANI mines in Mutsu Province.

#### 44. Limonite.

Massive limonite is found to some extent at YANABARA in Mimasaka Province. Limonite in the form of roots of plant has been described by Kotō from TAKASHI in Mikawa Province, and occurs also in several other places. Limonite after pyrite,

found in the tuff of TAKESHI in Shinano Province, (shows  $\infty$  O  $\infty$  and  $[\frac{\infty O_2}{2}]$ , and seldom O besides.

#### 45. Asbolane.

This mineral is found in gravels in OWARI Province, whence it is taken for use in porcelain works.

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### D. Haloid Salts.

#### 46. Cerargyrite.

Wada possesses a crust-like specimen from NUKUMI in Satsuma Province, resembling common cerargyrite in appearance.

#### 47. Fluorite.

The principal localities of fluorite in Japan are ŌKURADANI in Obira in Bungo Province, ISHIGURE in Ise Province, OMODANI mines in Echizen Province, HŌDATSUSAN in Noto Province, &c. The fluorite of Obira is colourless to light rose-coloured, contains bismuth on its cleavage cracks, and forms part of copper veins. That of Ishigure is green or dark-purple coloured and forms veins in granite; here good crystals, with O alone or with  $\infty$  O  $\infty$ , O and  $\infty$  O, are sometimes found. Octahedral crystals have also been found in the mines of Ashio, &c., while cubical crystals are more common in other localities. The face  $\infty$ O was observed in a single colourless crystal from Obira measuring about 1 cm. in diameter and showing an octahedral habit.

#### 48. Thomsenolite (?) and Ralstonite (?).

Wada possesses a single small specimen said to be from TANO-

KAMIYAMA in Ōmi, showing druses of minute crystals of a white colour. The crystal-forms agree with those of thomsenolite and ralstonite.

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## E. Carbonates, &c.

### 49. Calcite.

Good crystals of calcite are found in the metallic veins of ANI, KAMIOKA and of other places. We find, for instance, rhombohedral crystals looking like cubes, at the zeolite-locality of MAZE in Echigo Province, acute and obtuse rhombohedra at ISHIGURE in Ise, and scalenohedral crystals ( $R_3$ ) in the copper mines of MAZE, ANI, &c.

Calcite containing a little manganese is found in massive state in the INNAI and AIKAWA mines. In the latter place, the mineral sometimes occurs in the form of more or less rhombic plates, covered with minute scalenohedral crystals of the same substance with rounded edges. The thickness of the plate, together with the drusy crystals on both faces, reaches about 0.8 cm. The whole structure resembles scalenohedral crystals, joined together on their lateral edges and arranged in parallel orientation. Kō first described this structure and ascribed it to a simple parallel growth of minute supplementary twins of scalenohedral crystals with a twinning suture at their middle.

Some crystals from KAMIOKA are in the combination  $\frac{2}{3}R_2$ .  $R_3$ .  $\infty R$  and enclose a simple rhombohedron  $R$  as the main crystal. (Kō's collection).

Supplementary twins of  $R_3$  are found in the mines of ANI, and FUKOKURA near Osaruzawa; in both of these localities.  $R_3$  is also found as simple individuals.

Some crystals from the HANDA mines in Iwashiro are, according to Sakurai, in the form of  $R_2$  (instead of  $R_3$ ) with peculiarly rounded crystal edges.

Scalenohedral calcite with numerous faces was brought by Saitō, from the zeolite locality of OSAWA near Nikkō.

Prismatic sub-individuals are found upon calcite crystals with  $-\frac{1}{2}R$ .  $\infty R$  from the zeolite locality of MAZE. In the KOSAKA mines in Rikuchū, the crystals in  $-2R$  are covered by sub-individuals in  $-\frac{1}{2}R$ .  $-2R$ . A reddish-white sharp-pointed rhombohedron of calcite from CHIKUGO Province (in the University collection in Tōkyō) is covered with prismatic sub-individuals in  $\infty R$ .  $-\frac{1}{2}R$ .

Peculiar brownish-grey pseudomorphs of calcite found in the tertiary shale of AOKI in Shinano Province, are of special interest. The shale is well stratified, and in it we have found remains of vertebræ, a skull (about 18 cm. long) and other bones of an animal belonging to Delphinidæ (?), which are all deformed by pressure. The pseudomorphs vary in length from 3 to 13 cm., and their forms are of at least four different types. Hiki has referred two of these to Gay-Lüssite. As chief characteristics of these pseudomorphs, we may mention rough transverse striations like those of oscillatory combinations, the arrangement of individuals parallel to the stratification of the shale with their imperfectly developed edges below, and their frequent grouping in an irregularly branched finger-like figure. Acute pyramidal forms resembling a monoclinic form are most numerous; flattened pyramids with sharp polar edges, very short pyramids with nearly



rounded outlines produced by numerous striations, and prismatic forms with blunt terminations are less frequently found. The number of these pseudomorphs enclosed in the shale is very great; ten or twenty samples of them are easily collected in a few minutes.

Similar specimens occur in marly nodules in the tertiary shale of the PORONAI and other coal-fields in Hokkaidō; also in another state at Ōkōzu in Echigo Province.

Beautiful limestone-caves with stalactites are found at KIURA in Bungo, KAGEMORI in Musashi, &c.

#### 50. Dolomite.

Crystals of dolomite occur rarely in the Aikawa mines; dolomite-nodules and beds are found in the tufaceous shale of NAKAYAMATŌGE near Aikawa. Rhombohedral crystals of the mineral, white to yellowish-grey in colour, are found in the ANI and INNAI mines.

#### 51. Magnesite.

At Yoshinomura in Tosa, magnesite crystals of brown colour were found imbedded in a white talc-like mass.

#### 52. Smithsonite.

In the HOSOKURA mines in Rikuzen Province, there is found massive smithsonite derived from zinc-blende and forming botryoidal aggregates. Drusy crystals are sometimes found on these aggregates. In the KURATANI mines grey-coloured spherical as well as botryoidal aggregates of smithsonite are found, with attached and enclosed individuals of pyrite and zinc-blende. A pseudomorph of smithsonite after calcite ( $-\frac{1}{2}R. \infty R$ ) was brought from the KAMIOKA mines in Hida, where massive smithsonite is found in other forms together with calamine.

**53. Rhodocrosite.**

Pretty rhombohedral crystals of this mineral, about 1 cm. in diameter, are found in the silver mines of PONSIIKARIBETS in Shiribeshi Province. Flattened forms of rhombohedra as well as peculiar saddle-shaped specimens are found in the KURATANI mines.

**54. Siderite.**

Good crystals of siderite are found in the Ōmori mines in IWAMI Province, while saddle-shaped small individuals of it are collected at the Uchinokuchi mines in Bungo Province.

Siderite in the form of dark brownish-grey cylindrical bodies is found in the gravel deposit of SHIBUYA near Tōkyō, and was described by Ogawa as a pseudomorph of decayed plant-roots.

**55. Aragonite.**

TAIRA in Shinano Province.—On a tributary of the upper part of the river Takasegawa flowing through the village of Taira, there are numerous small pits from which hot sulphurous water issues. On the sides of these solfataras, there are remains of huge sinter-cones still preserving central and secondary openings of former hot springs. In some of the now active pits of sulphurous water, are sometimes collected beautiful white-coloured small balls and irregular lumps of aragonite. These balls are also found in the shape of aggregates on parts of old sinter cones, where they usually have dirty-grey colour.

A complete series of transition could be traced from nearly perfect spheres to curious dodecahedral grains of the aragonite, through such spheres as are supplied with one or more depres-

sions. These dodecahedra resemble  $\left[\frac{\infty O_2}{2}\right]$  of the regular system and have rounded edges and slightly depressed faces. How such a remarkable form was produced is still a question.

The structure of each ball is concentric and radial-fibrous, with a nucleus of some decomposed rock-fragment. The size varies from that of very minute sand-grain up to that of a hen's egg (about 4 cm. in length).

MUTSUREJIMA near Nagasaki.—Kō has mentioned the occurrence of white and grey-yellow hemispherical aggregates of aragonite on a dark rock of this island.

The same author has also described the same mineral as being found in the ICHINOKAWA mines in Iyo.

#### 56. Witherite.

Kō has mentioned radial aggregates of white-coloured witherite in metallic veins at TSUBAKI in Ugo, where crystals are also found with  $\infty P$ ,  $2P\infty$ ,  ${}_0P$  and  $P$ .

#### 57. Cerussite.

Kō has described stellar trillings of this mineral from the mines of KAMIOKA and KOSAKA (in Rikuchū). In the former locality  $P$ ,  $\infty P$ ,  $P\infty$  and  $\infty P\infty$  were observed. Saitō has brought from Kosaka, trillings showing a combination of  $P$ ,  $\infty P\infty$ ,  $\infty P$ ,  $P\infty$ ; and from ARAKAWA in Ugo, small pyramidal crystals of white cerussite. They are about 1.5 cm. in length and apparently in the form of hexagonal pyramids, which are all trillings with faces  $P$  and  $\infty P\infty$ . Besides, columnar aggregates of the same mineral occur in this locality.

#### 58. Malachite.

In the mines of ANI and ARAKAWA, there occur, besides

the usual botryoidal aggregates, short minute needles of malachite, which sometimes show the ordinary crystalline habit under the microscope.

### 59. Azurite.

Small crystals of this mineral are found in the KOSAKA (Rikuchū) and ARAKAWA mines. They are less than 1.5 cm. in length. They must not be confused with barite plates coloured deep-blue with azurite substance, which are found in the same localities.

### 60. Psilomelane.

Manganese oxides (pyrolusite and psilomelane) of NUMADATE in Ugo, NISEUMBETS in Shiribeshi Province, &c., are mostly botryoidal, but sometimes also in more or less fibrous groups. Nasa has given a list of these oxides in different provinces of Japan.

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## F. Sulphates, Molybdates, &c.

### 61. Barite.

KURATANI in Kaga.—There are found in these mines white rhombic plates of barite with  $\circ P$ ,  $\infty P$ ,  $P\bar{\infty}$ ,  $\frac{1}{2}P\bar{\infty}$ , &c. They enclose minute particles of jamesonite, in such distribution as to produce a zonal structure. The largest diameter of the crystals sometimes measures 9 cm.

NAKAYAMATŌGE and AIKAWA in Sado.—Besides nodules of radial-fibrous structure, there are found prismatic as well as rectangular-platy crystals, sometimes 8 cm. in length. Yamada has observed  $\infty P\bar{\infty}$ ,  $\infty P\bar{\infty}$ ,  $\circ P$ ,  $\infty P$ ,  $\infty P\bar{2}$ ,  $P\bar{\infty}$ ,  $\frac{1}{2}P\bar{\infty}$ ,  $\frac{1}{4}P\bar{\infty}$ ,  $P\bar{\infty}$ ,

$P\bar{2}$ , &c. The colour is brownish to bluish or quite colourless. A beautiful tabular crystal of colourless barite from Aikawa, (Watanabe's collection) measuring about 6 cm. in length and showing the combination  ${}^0P$ .  $\infty P$ .  $\infty P\bar{\infty}$ .  $P\bar{\infty}$ .  $P\bar{\infty}$ .  $\frac{1}{2}P\bar{\infty}$ , is marked on  ${}^0P$  with fine striations parallel to the  $a$  and  $b$  axis, as well as to the edges of combination of  ${}^0P$  with  $\infty P$ .

KOSAKA in Rikuchū.—Small tabular colourless crystals, ( ${}^0P$ .  $P\bar{\infty}$ .  $\frac{1}{2}P\bar{\infty}$ .  $\infty P\bar{\infty}$ .  $P\bar{\infty}$ .  $\frac{1}{2}P\bar{\infty}$ .  $\infty P\bar{\infty}$ ) are here found in metallic veins.

Besides, we find, according to Kō, good crystals of barite from Tsubaki, Daira and Yatsumori in Ugo, Karuizawa in Fukushima-ken and Ponsnikaribets in Shiribeshi Province.

Pseudomorphs of the Aikawa and Arakawa mines.—The curious quartz aggregates of the former locality, occurring in the shape of thick rhombic tables with rounded edges, are found to be probably a pseudomorph.

Those of the Arakawa mines are of five different habits. The first kind is in the form of nearly rhombic tubes with drusy quartz on their inner as well as outer walls. These are most probably quartz-envelopes, on prismatic barite crystals, which were dissolved away afterwards. The quartz individuals on the surface are of course later accretions. The second kind of the pseudomorph is a compact quartz-mass with cavities left after the dissolution of barite crystals. Its walls are casts of prismatic faces of two different indices, and show minute striations. The bottom is perpendicular to these walls. While the tubular pseudomorphs sometimes measure 18 cm. in length, the above mentioned cavities are much smaller in dimension. The third kind is represented by casts of rhombic tables of barite.

The fourth kind in the form of numerous smaller rhombic plates laid one over the other. The fifth is that of separate rhombic tables. The two last kinds are peculiarly hollow inside in many cases.

#### 62. Anglesite.

Small white crystals, with brown coating, about  $\frac{1}{2}$  cm. in length and showing mostly  $P\infty$  and  $\infty P$  only; were found in the KOSAKA mines in Rikuchū.

#### 63. Wulfenite.

Kō mentions small beautiful, orange-red crystals, of this mineral with  $\circ P$ ,  $\infty P$  and  $\frac{1}{16}P(?)$ , from the SENNŌ mines in Echizen Province.

#### 64. Scheelite.

Wada possesses a large yellowish-grey crystal of scheelite from SANNOTAKE in Buzen, with faces of  $P\infty$  and  $P$  and nearly 5 cm. in length. This specimen is covered with a black coating.

In the province KAI, there are sometimes found brownish-coloured imperfect crystals and crystal fragments of the same mineral. One of the largest specimens measures about 4 cm. in diameter.

#### 65. Wolframite.

Massive wolframite occurs in the TANIYAMA tin-mines in Satsuma Province, while crystals, sometimes 4 cm. long, were found in the tin placers of Takayama, &c. in Mino. The specimen from the latter locality, belonging to Wada, shows  $\infty P$ ,  $\infty P\bar{\infty}$ ,  $P(?)$  and  $P\bar{\infty} (?)$ .

#### 66. Linarite.

Ogawa has ascertained the presence of this mineral in nearly compact aggregates in the KAMIOKA mines in Hida.

**67. Gypsum.**

YOGOSAWA in Kai Province.—Good crystals with  $\infty P$ ,  $\infty P \bar{\infty}$ , and  $-P$ , developed on all sides and sometimes measuring 3 cm. in length, are here collected. Besides simple crystals, there are also to be found twins on either  $\infty P \bar{\infty}$  or  $-P \bar{\infty}$ .

According to Kō, good crystals are also found at MIYAZAKI in Iwate-ken; they occur, besides, at KUWABARA in Shinano Province, in OGASAWARAJIMA, at KWANKAIJI in Bungo, at KOSAKA in Rikuchū, &c. A beautiful fibrous aggregate of white gypsum has been found at YUDA in Rikuchū.

**68. Melantherite.**

OSARUZAWA in Rikuchū gives beautiful crystals and fibrous aggregates of this mineral, in association with copper ore. The crystals are flattened on  $\infty P \bar{\infty}$  and elongated in the direction of the  $c$  axis. The length attains 2.5 cm. There are observed  $\infty P \bar{\infty}$ ,  $\infty P$ ,  ${}_0P$ ,  $P \bar{\infty}$ ,  $-\frac{1}{3}P \bar{\infty}$ ,  $\frac{2}{3}P \bar{\infty}$ , &c. The colour of crystals is greenish-blue, with a yellow tinge on the edges, which is due to oxidation. The aggregate shows a silky lustre, and resembles fine asbestos in white-coloured long fibres. The crystals contain some copper, while the aggregates, which are said to be derived from the decomposed crystals, are quite free from it.

**69. Alunite.**

At TOCHIHARA in Harima, there has been found a compact specimen of this mineral, which Kochibe believes to be derived

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No specimens of Reinite (See Neues Jahrbuch für Mineralogie &c., 1879.) were found in collections accessible to me.

from decomposed liparite. The specimen was analyzed in the laboratory of the Imperial Geological Survey.

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## G. Aluminates, Ferrates, &c.

### 70. Chromite.

Small octahedral crystals and aggregates are found, together with k ammererite, in the serpentine of WASHIDANI, &c., in Bungo. In the MUKAWA river in Iburi Province, Ishikawa observed another case of the occurrence of this mineral in common serpentine.

### 71. Magnetite.

Dodecahedral crystals of this mineral about 2 cm. in diameter are found as druses in the magnetite aggregate found with garnet rock at ŌHASHI, &c., near Kamaishi in Rikuch . Minute octahedra of magnetite are enclosed in the chlorite schist of NOGAMI in Musashi, SONOKIG RI in Hizen, &c. Minute crystals in ∞ Ō are found in the massive magnetite of KURODAKE in Etch , associated with rock crystal, &c., in a garnet rock. The magnetite of NAKAKOSAKA in K zuke Province is fine granular, and found as huge masses in a pale-coloured dioritic rock. Yamashita and Ōtsuka have studied the magnetic iron sand in the western part of HONSH , &c.

### 72. Chrysoberyl.

A minute trilling of chrysoberyl, said to have been found at TAKAYAMA in Mino, is found in the collection of the Imperial Geological Survey.



## H. Phosphates, Arseniates, Niobates, &c.

### 73. Fergusonite.

Irregular columnar individuals of fergusonite with fibrous surface occur in the tin placers of TAKAYAMA. According to Takimoto, there are occasionally found crystals about 0.7 cm. in length, terminating in pyramids.

### 74. Monazite.

Red-brown crystals, more than 0.5 cm. in diameter, with curved faces, and found enclosed in the topaz crystals from TANOKAMIYAMA in Ōmi, were determined by Ogawa as monazite after a qualitative analysis made by a chemist of the Geological Survey.

### 75. Apatite.

Good crystals of this mineral are very rare in Japan. We find, in old collections, a few yellowish crystals from Miyamoto (?) in Kai Province with  $\infty P$ ,  $\infty P$ ,  $\infty P_2$ , &c. Their rough faces are covered with a white powder. The specimens are sometimes 8 cm. in diameter; there are partings parallel to  $\infty P$  and  $\infty P$ .

A semi-transparent glassy crystal, about 5 cm. in diameter of basal sections, and showing  $\infty P$ ,  $\infty P$ ,  $\infty P_2$ ,  $\frac{3}{2}P$ ,  $\frac{3}{4}P$ , and  $\infty P_2$ , is found in Wada's collection and is said to have come from MIYAMOTO. This specimen, which differs from the above only in having smooth shining faces, is the best specimen of macroscopic apatite crystals thus far discovered in Japan!

Massive apatite with clayey and sandy admixtures, found in the shale on the coast of HYŪGA Province, has been treated in detail by Ōtsuka and Tsunetō from geological and agronomical points of view.

#### 76. Pyromorphite.

Minute crystals ( $\infty P$ ,  $\circ P$ ) of green pyromorphite are found in the metallic veins of MOZUMI in Hida, ARAKAWA in Ugo, and KOSAKA in Rikuchū.

#### 77. Adamine (?)

Wada possesses a specimen of adamine (?) forming crystals on a brown ferruginous mass. It is said to have been sent from KIURA in Bungo.

#### 78. Olivenite (?).

A specimen in Wada's collection, in the form of minute prismatic crystals, said to have been found in Settsu Province.

#### 79. Vivianite.

From KODAKI in the Ashio mining district in Shimotsuke Province, there were once obtained in one of the veins, many perfect crystals of vivianite, which were nearly colourless, with only a slight blue tinge. They are 1.5 cm. in maximum length. Hiki has distinguished in them, the faces of  $\infty P \bar{\infty}$ ,  $\infty P$ ,  $\infty P \bar{\infty}$ ,  $P$  and  $P \bar{\infty}$ .

Earthy vivianite forms fossils of plant leaves in the grey tuff of KIMPŌZAN in Higo Province, and irregular patches in a similar tuff of OGASHIMA in Ugo.

**80. Erythrine.**

This mineral is found only in the form of thin encrustations on the silver ores of KANAGASE in Tajima, which contain argentite, fahlore, native bismuth, &c.

**81. Scorodite (?).**

At INUNAGARE in the mining district of Kiura in Bungo, dark-green octahedral crystals with curved faces have been collected. The diameter of the crystals is about 0.3 cm. Sasamoto, Yamada, &c., who first mentioned the occurrence of this mineral at Inunagare, made its qualitative analysis; but the faces have not yet been fully determined. Yamada has found the same mineral also at DATSUGATAO in Kiura.

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**I. Silicates, Titanates, &c.****82. Staurolite.**

According to Kochibe, etc., this mineral occurs at KUSHIGI in Hizen.

**83. Hemimorphite.**

Wada possesses a beautiful druse of colourless hemimorphite, said to have been found at KURANARI in Bungo.

**84. Andalusite.**

Microscopic individuals showing distinct pleochroism were found in the mica-clay slate of NIYAMAHAMA in Rikuzen Province. KIKUCHI has found similar specimens at MATSUDA, &c., in

Shimotsuke, also at a place near Tsukuba in Hitachi, &c. Pebbles of biotite-schist from the TOYOGAWA river and from CHIKURAZAWA in Mikawa contain small decomposed andalusite crystals, like those observed by Kotō, &c., near Kankyozan in Hitachi and other places.

According to Kikuchi and Nishiwada, chiastolite crystals in clay-slate, with a sectional diameter measuring about 0.2 cm., are found at Usuginu in Rikuchū.

#### 85. Sillimanite.

Only found as microscopic aggregates in the mica schist near TSUKUBA in Hitachi, and also in the shape of eyes in the biotite schist of Okunoin on HONGŪZAN in Mikawa.

#### 86. Cyanite.

Sasamoto, &c. found cyanite without terminal faces, at the contact of crystalline schist with diorite at ŌGUSHI in Hizen.

#### 87. Topaz.

The two principal localities of topaz in Japan are TAKAYAMA, &c., in Mino, and TANOKAMIYAMA in Ōmi. Hiki (Journal of the Science College of the Imperial University of Tōkyō, 1895) has described the crystal form and other characters of the Mino crystals and the etching figures of those of Mino and Ōmi. Kō has given general characters of the Ōmi specimens. Those from Mino are often rounded by rolling, but those of Ōmi are less deformed. The difference is probably due to the greater length of the river course, along which the Mino crystals were rolled downwards by water.

MINO.—The larger crystals from Takayama, &c., have mostly domatic, but sometimes basal or pyramidal, terminations.

The colour of topaz from Mino are bluish or brownish to quite colourless. Pleochroism is sometimes distinct.

As in the crystals from Tanokamiyama, we often find a peculiar division of individuals into differently coloured sections, being light brownish on the ends of the  $a$  axis and light bluish on those of the  $b$  axis. The topaz crystals from Mino are from 0.2 cm. to 12.5 cm. in the longer diameter of basal sections. Enclosures in this mineral consist of tourmaline, cassiterite, chlorite (?), liquid, gas, &c. Crystal faces usually observed are:  $\circ P$ ,  ${}_2P\infty$ ,  ${}_4P\infty$ ,  ${}_2P\bar{\infty}$ ,  $P$ ,  ${}_2P$ ,  $\infty P$ , and  $\infty P\bar{2}$ . Besides these, are less frequently observed:  $\infty P\bar{3}$ ,  $\infty P\frac{3}{2}$ ,  $\infty P\frac{5}{2}$ ,  $\infty P\frac{7}{4}$ ,  $\infty P\frac{5}{6}$ ,  $\infty P\frac{5}{3}$ ,  $\infty P\infty$ ,  $\frac{4}{3}P\infty$ ,  $\frac{2}{3}P$ ,  $\frac{2}{3}P\bar{\infty}$ ,  ${}_4P\bar{2}$ ,  ${}_2P\bar{2}$ ,  $\frac{4}{3}P\bar{2}$ ,  $\frac{5}{6}P\bar{3}$ ,  $\frac{5}{6}P$ ,  $\frac{4}{3}P$ , &c. The last mentioned three faces were found by Redlich (Tschermak's Mittheilungen 1897).

The following natural etching figures of Mino crystals are mentioned in Hiki's work:—

On  $\circ P$  (c), numerous rectangular pyramids.

On  ${}_2P\infty$  (f), triangular eminences, with their base parallel to the  $a$  axis, with apex directed towards the adjacent face of  $\circ P$ , and with two other sides parallel to the edges of combination of  $\infty P\bar{2}$  and  ${}_2P\infty$ .

On  ${}_2P$  (o), triangular and other eminences.

On  $P$ , (u), irregular horizontal striæ.

On  $\infty P$  (m), quadrilateral eminences.

Besides there are less important figures on various faces.

In the beautiful topaz collection of Wada, which is specially rich in crystal forms, enclosures, etching figures, &c. of the Japanese specimens there are to be seen many other characteristic etching figures. For instance, in one nearly colourless crystal from Mino measuring about 2 cm. along the  $b$  axis, there are

on *oP*, very deep depressions with curvilinear, six or eight-sided pits elongated parallel to the *b* axis. The same crystal is etched on the face *f* with oblong hillocks, pointed downwards. This specimen is, moreover, etched on other faces and edges.

Another crystal from Mino, with a brownish colour at the ends of *a* axis and a bluish along *b*, is etched on the face *f* with oblong depressions which are broader on the upper end and sharp-pointed on the lower. The faces *u* and *o* carry irregular nearly horizontal grooves. The *d* is similarly grooved vertically, and *c* is roughened with small pyramidal elevations.

The above mentioned parallel depressions on *f* are sometimes deep and elongated by their union, thus causing a striated appearance of the face.

One large crystal from Mino is strongly corroded and show numerous projecting pyramidal eminences on the quite irregular upper and lower faces of the individual. This specimen shows the peculiar colouration mentioned in p. 249.

The chagration of the basal face of a brown crystal from Ōmi, which is without lustre on this particular face, represents in miniature the above mentioned pyramids. That these are due to etching action and not to the arrangement of sub-individuals, is shown by some specimens in which the etching figures on *f*, *u*, &c., are in some way connected with the depressions between the pyramidal prominences, which are quite frequently observed on the topaz from Ōmi.

Takimoto has prepared numerous cleavage pieces of the smaller Mino crystals (below 1 cm. in sectional diameter) and found beautiful and complicated optical anomalies, which

slightly differ from those of Brazilian crystals in Brauns' *Optischen Anomalien*, 1890.

$\bar{O}$ MI.—Kō has described topaz of Tanokamiyama in  $\bar{O}$ mi, which attains as large a size as that from Mino. Small individuals less than 1 cm. in diameter of the basal section are very rarely found, in contrast to their abundance in Mino. The crystalline habit is usually short columnar, while long columnar forms, often found in Mino, are exceedingly seldom observed. The colour is mostly brownish. Colourless, bluish and greenish crystals are less frequent; the beautiful light-green colour seen in a specimen of Mino topaz in Wada's collection is found in none from  $\bar{O}$ mi. The following faces have been recognised:—

${}^0P$ ,  $P$ ,  ${}^2P$ ,  $\infty P$ ,  $\infty P_{\bar{2}}$ ,  ${}^2P_{\infty}$ ,  ${}^4P_{\infty}$ ,  ${}^2P_{\infty}$ ; besides,  ${}^{\frac{2}{3}}P$ ,  ${}^2P_{\bar{2}}$ ,  $\infty P_{\frac{2}{3}}$ ,  $\infty P_{\bar{3}}$ ,  $\infty P_{\bar{4}}$ ,  $\infty P_{\infty}$ ,  ${}^{\frac{4}{3}}P_{\infty}$ ,  ${}^{\frac{2}{3}}P_{\infty}$ .

Most of the crystals are domatic in termination, but sometimes we find pyramidal or basal endings.

Enclosures in the Topaz of  $\bar{O}$ mi are tourmaline, beryl (?) and monazite. The last mineral is found in red-brown crystals with curved faces. The etching figures are essentially like those of Mino specimens; only the deep octagonal and hexagonal pits on  $c$  of the latter have not been found.

A peculiar paragenetic connection of the  $\bar{O}$ mi topaz with a flesh-red coloured potash-felspar is known to collectors. Wada recognises the existence of two generations in the  $\bar{O}$ mi topaz. The younger individuals are smaller in size, usually developed at both ends and richer in faces, than the older generation. They lie on felspars instead of making intergrowth with these.

Analysis of  $\bar{O}$ mi topaz by Takayama, chemist to the Imperial Geological Survey:

	I	II
Si O <sub>2</sub>	31.30	31.95
Al <sub>2</sub> O <sub>3</sub>	56.72	56.59
F	18.36	18.01
	<hr/> 106.38	<hr/> 106.55

### 88. Tourmaline.

Black crystals, usually with only R,  $-2R$ ,  $\infty P$ ,  $\infty P_2$  &c., are found (generally not in abundance) in the pegmatite of YAMANOO, SAIMARU, OGANETA, &c., in Hitachi Province. A pseudomorph of mica after tourmaline occurs at YOKOGAWA, &c., in the same province and measures about 2 cm. in diameter of basal sections.

Peculiar flat crystals of black tourmaline, with R prevailing and  $\infty P$  much shortened, occur at GOSHODAIRA in Shinano Province. Their diameter is about 5 cm.

Beautiful radial aggregates of dark needle-shaped tourmaline occur with quartz-vein in pegmatite in an old tin-mine of SENSUI in Obira, Bungo Province. Some of the needles have rhombohedral terminations; many of them are very thin, brown-coloured, and appear as fine enclosures in quartz crystals as well as tufts of hairs on their outside.

Some crystals of tourmaline also occur, according to Kochibe and others, at KUSHIGI in Hizen Province, &c.

### 89. Lievrite.

Crystals of this mineral are known to occur at KAMIOKA in Hida, (according to Kō). Those of GINJIKI in Obira, Bungo Province, are found in abundance, together with grey sharp-edged



brown garnet, &c. Wada possesses a good specimen of the lievrite with crystals about 0.7 cm. broad and showing  $\infty P$ ,  $\infty P\bar{z}$ ,  $P$  and  $P\bar{\infty}$ .

Massive aggregates of lievrite form vein-stuff in the copper mine of ZŌMEKI near Bakwan.

### 90. Epidote.

In the magnetite deposits near KAMAISHI in Rikuchū Province, green to dark-green epidote crystals are found. A good crystal in Wada's collection, about 1 cm. broad, shows  $\infty P$ ,  $P\bar{\infty}$ ,  $P\bar{\infty}$  and  $\infty P\bar{\infty}$ , besides other small faces.

At TAKESHI in Shinano, pretty druses of green epidote needles are found in a decomposed porphyrite-tuff. The geode is irregularly ellipsoidal, and is easily hammered out from the rock containing it. The combination shown by the crystals seem to be  $P\bar{\infty}$ .  $\infty P\bar{\infty}$   $P$ .  $P$ .

### 91. Piedmonite.

This mineral is abundantly found as a microscopic ingredient of the piedmonite schist of SHIKOKU, KWANTŌ, &c. (see Kotō's description, in the Journal of the Science College of the Imperial University of Tōkyō, 1887). Reddish aggregates of piedmontite are found in a rhyolite near the town of UEDA in Shinano, and were described by Yamasaki in the same journal, 1898.

### 92. Orthite.

According to Ishiwara, Ogawa &c., this mineral is found in the granite of AWAJI Province, in that near MIIDERA in Ōmi Province, in the biotite-schist of the neighbourhood of TAHITO in

the Abukuma hills, and in a gneiss of the lower course of the TENRIU river.

### 93. Vesuvianite.

Kikuchi has described crystals of dark brownish-green vesuvianite from INUNAGARE in Kiura in Bungo Province, occurring in a crystalline limestone together with dark-green and brown garnets. The largest crystals are about 3 cm. in width. Zonal structures are quite common, with optically different characters in different zones. Kikuchi has distinguished  $0P$ ,  $\infty P$ ,  $P$ ,  $\frac{1}{3}P$ ,  $\frac{1}{2}P$ ,  $\frac{2}{3}P$  and  $\infty P_2$ , besides which I have found  $\frac{1}{3}P$ , &c.

### 94. Olivine.

Ishii has mentioned the occurrence of brown crystals of olivine in the basaltic rock of NISHINOTAKE in Hizen, where good crystals of dark-green augite are collected. The olivine is about 0.5 cm. in diameter and shows different habits of crystals by the prevalence of different faces. There are found  $P$ ,  $4P$ ,  $\infty P$ ,  $\infty P_2$ ,  $\infty P_3$ ,  $\infty P$ , &c. Analysis by Kondō gave

Si O <sub>2</sub>	38.74
Mg O	43.53
Fe O	16.60
Ca O	trace.
	<hr/> 98.87

### 95. Danburite.

At HIGASHISHŌPŌ in Obira, Bungo Province, are found

among the detritus of a valley, aggregates of danburite and its beautiful crystals. The largest is 1 cm. broad. Yellow garnet is associated with this mineral. Observed crystal faces are  $\infty P \bar{\infty}$ ,  $\infty P \check{\infty}$ ,  ${}_1P \infty P$ ,  $\infty P \bar{2}$ ,  $\infty P \bar{4}$ ,  $P \bar{\infty}$ ,  ${}_4P \check{\infty}$ ,  ${}_2P \bar{4}$  and  ${}_2P \bar{2}$  (?). On the face  ${}_4P \check{\infty}$ , are horizontal striations and nearly rectangular depressions elongated parallel to the  $a$  axis. The edges of combination of  $P \bar{\infty}$  and  ${}_2P \bar{4}$  are usually rounded, while those of  ${}_1P$  with other faces are sometimes similarly modified.

### 96. Garnet.

None of the Japanese garnets has been carefully analyzed, and we have only to classify them, for the present, according to their colour and mode of occurrence.

The garnet rocks on the west of KAMAISHI in Rikuchū, and on KURODAKE in Etchū, which contain magnetite, are very interesting. They are found at the contact of palæozoic rocks with granitic and dioritic masses, and in them at both localities good garnet crystals are often collected. At WADATŌGE in Shinano, cavities in a white glassy rock connected with spherulitic obsidian contain dark-red garnet crystals sitting on their walls. At YAMANŌO in Hitachi, pegmatite contains numerous brownish-red garnet together with silvery and dark-coloured mica scales. At HOGI in Nagato Province, garnet is found in crystalline limestone. Other occurrences of various garnets in the same rock are those at KAWAHAKE and TOKIWA in Shinano Province and other places.

ŌHASHI, &c., on the west of Kamaishi.—Green or dark-green crystals of garnet on magnetite are not seldom observed. Large dark-red crystals in  ${}_2O_2$  with subordinate  ${}_mO_n$ , found in Wada's collection, measure about 3.5 cm. in diameter. These

separate crystals have not yet been optically studied; but each garnet grain in a microscopic slide of the brown garnet rock is finely zonal in structure, very distinctly double-refracting, and shows division into sectors.

KURODAKE in Etchū.—In the garnet rocks of yellow to red-brown colour, are found various garnet crystals either forming druses in the rock or imbedded in quartz veins running through it. Optical anomalies of the dodecahedral type are easily observed in many of them. We can distinguish in this locality the following varieties of garnet:

(1.) Dark-brown crystals attaining 2 cm. in diameter, forming aggregates and druses in the garnet rock.

(2.) Reddish-brown smaller crystals.

(3.) Yellow-coloured minute crystals (rare).

(4.) Dirty brownish-black crystals (rare).

(5.) Brownish-black crystals, always imbedded in quartz.

Nos. 1-3 are found with dodecahedral as well as icositetrahedral habit, while No. 4 is in icositetrahedra with small faces of  $\infty O_2$ . Another  $\infty O_n$  was found in the dodecahedral crystals of No. 2. No. 5 is always dodecahedral. Sometimes we find No. 1 with a brownish-yellow zone outside.

WADATŌGE in Shinano.—The dark-red, brilliant garnet crystals are almost black in external appearance, with prevailing  $\infty O$  and smaller faces of  $2O_2$ , and are less than 2 cm. in diameter.

YAMANŌO in Hitachi.—The brownish-red, much cracked garnet of this locality is in  $2O_2$  with subordinate  $\infty O$ , and is covered with striations parallel to the edges of combination of these two forms. A simple form of  $\infty O$  is seldom observed. Similar garnet crystals are also found in the pegmatite

of KUMINATSU near Tsukuba in Hitachi. The diameter of these garnets is below 1 cm. Small faces of  $mO_n$  are sometimes met with on them.

HOGI in Nagato.—Greenish-yellow to dark-green crystals of garnet, usually in  $\infty O$ .  $2O_2$ , but sometimes in  $\infty O$  only, are found there rarely attaining 6 cm. in diameter. Fine zonal structures, and division into sectors are easily observed. Kō has found a small quantity of wollastonite together with the garnet.

AT TOKIWA in Shinano, brownish-yellow dodecahedral crystals of garnet, essentially resembling those of Hogi, are found with wollastonite, fine-granular green augite aggregates, brown-red garnet masses, &c. These minerals are so abundant that the crystalline limestone containing them does not yield white lime.

Various garnets occur at different places in OBIRA in Bungo. Thus, we have: yellow-coloured small crystals associated with danburite at Higashishōdō; brown garnet, often with yellow zone outside, in the crystalline limestone of the same place; dark-green garnet in the hedenbergite mass of Ōkuradani; brown crystals with lievrite, grey axinite, &c. at Ginjiki; and so forth.

The dark-green garnet in the crystalline limestone of KAWAHAKE in Shinano, where an augite resembling hedenbergite and a pseudomorph of talc after tremolite are found, is nearly similar to the same-coloured garnet of INUNAGARE in Obira found in crystalline limestone.

Dark-brown dirty-looking crystals of garnet in  $2O_2$  found near TAKATŌ in Shinano, occur in biotite-gneiss; while clear brownish-coloured garnet crystals ( $2O_2$ ) of YASUSADA in Mikawa Province are associated with rhodonite in a quartz vein in biotite-gneiss.

A large quantity of brown-red garnet, in the form of separate crystals and sand, taken from KONGŌSAN in Kawachi Province, is used as polishing material in Tōkyō.

### 97. Chrysocolla.

This mineral is found in several Japanese copper mines, but a specially interesting specimen is from HISAN-ICHI near Arakawa in Ugo. On the surface of its amorphous mass, are found numerous small chrysocolla pseudomorphs with curved faces, looking like a rhombic crystal in  $P\infty$ .  $\infty P$ .  $\infty P\infty$ ; angles on the upper edge of the dome and the front edge of the prism measure about  $140^\circ$ . The pseudomorph is about 0.4 cm. wide.

### 98. Axinite.

Two essentially different varieties of axinite are found in OBIRA in Bungo.

Kikuchi has described dark-brown to dark-violet crystals from ŌKURADANI in Obira. They form druses and aggregates of individuals, attaining a length of 2 cm. and characterized by the combination of following faces:—

$\infty P\bar{\infty}$ ,  $\infty P\infty$ ,  ${}_0P$ ,  $\infty'P$ ,  $\infty P'$ ,  $P'$ ,  $'P$ ,  $\frac{1}{2}'P$ ,  ${}_2P'\bar{\infty}$ ,  ${}_3P\bar{3}$ ,  ${}_5P\bar{5}$ , besides,  ${}_2P'\infty$  and  ${}_2P\infty$ , which are but rarely observed.

This variety is not sharp-edged nor thin tabular in habit; but rather prismatic with striations on the broad face of  $P$  and on various prismatic faces. Kajiura's analysis gave the following result:

Si O <sub>2</sub>	41.87
Al <sub>2</sub> O <sub>3</sub>	19.25
Fe <sub>2</sub> O <sub>3</sub>	11.79
Ca O	17.75
Mn <sub>2</sub> O <sub>3</sub>	5.62
B <sub>2</sub> O <sub>3</sub>	1.59
Na <sub>2</sub> O	1.79
H <sub>2</sub> O	0.87
K <sub>2</sub> O	trace
Mg O	trace
	<hr/> 100.53

As minerals occurring in paragenesis with this axinite, we have hedenbergite and its decomposition product, dark-green garnet, magnetic pyrite, arsenopyrite, fluorite, &c.

At GINJIKI in Obira as well as near this place, we find another kind of axinite, which is grey, sharp edged, glassy in appearance, and with striations on prismatic faces. In a dark-green hornblende aggregate associated with this axinite, there was found a vein of argentiferous galena. Brown garnet, lievrite, &c. are found with this variety of axinite.

### 99. Biotite (?).

A well-known locality of the various kinds of mica is TANOKAMIYAMA in Ōmi, which I will take as the starting point of my investigation of Japanese micas. The biotite of this place is found in dark-green six-sided or irregular plates, with foldings parallel to the lines of pressure-figure. The diameter of the plates attains 5 cm. The crystal faces are not measurable, for the lamellae composing each crystal are not

quite parallel to one-another; numerous oblique faces on the lateral sides are therefore of no definite direction. This mica is nearly uniaxial. Analysis by Koderá gave

Si O <sub>2</sub>	35.87
Al <sub>2</sub> O <sub>3</sub>	22.69
Fe <sub>2</sub> O <sub>3</sub>	20.90
Mn O	5.65
K <sub>2</sub> O	6.70
Na <sub>2</sub> O	2.52
Mg O	0.32
Ti O <sub>2</sub>	0.35
H <sub>2</sub> O	1.00
F	3.19
	<hr/>
	99.19

#### 100. Zinnwaldite (?), Muscovite (?), &c.

TANOKAMIYAMA in Ōmi.—In the pegmatite of this place there are found, together with the above mentioned biotite, various light-coloured micas as follows:

a.) Reddish-brown, light brownish-grey to nearly colourless plates, sometimes 15 cm. in diameter. On cleavage surface, there are numerous foldings parallel to the lines of pressure-figure. Fukuchi has distinguished with a contact goniometer,  $\infty P$ ,  $oP$ ,  $\infty P \infty$ ,  $-\frac{2}{3}P\frac{2}{3}$ ,  $-\frac{3}{4}P$ ,  $\infty P \infty$ , &c. He regards the many re-entrant angles on the sides as casts of other minerals found in intergrowth. A parting parallel to P is sometimes observed. Twins are quite numerous. The optical plane is parallel to the symmetry plane; the angle of optical axes is large. With a blowpipe, one can distinctly observe the flame-colour of intense red; but an analysis by Koderá is as follows:



Si O <sub>2</sub>	46.13
Al <sub>2</sub> O <sub>3</sub>	17.03
Fe <sub>2</sub> O <sub>3</sub>	4.64
Mn O	6.27
K <sub>2</sub> O	10.09
Na <sub>2</sub> O	4.12
Mg O	0.43
Ti O <sub>2</sub>	2.77
H <sub>2</sub> O	2.31
F	6.89
	<hr/>
	100.68

This mica is most likely zinnwaldite.

b.) Small silver-white six-sided plates attached to the crystals of potash-felspar. Their diameter is about 1.5 cm. or less. The cleavage-surface is much folded parallel to the lines of pressure-figure. Twinning is sometimes observed. The optical plane is parallel to a line of the pressure figure. The angle of optical axes is large. This variety sometimes overlaps a similarly oriented six-sided biotite plate, so as to form a broad outer zone to it. This mica is probably muscovite.

c.) Minute six-sided plates like (b), but less than 0.8 cm. in diameter and with curved cleavage-lamellæ. They often show, in crossed nicols, a subdivision into six triangular fields and a zonal structure with zones of different orientations.

d.) Brownish-grey six-sided or irregular plates with small angles of optical axes. This variety is sometimes 5 cm. in diameter. It is altered, along cleavage as well as on the surface, into a scaly silver-white mica, with a large angle of optical axes and sometimes forming druses of small tabular crystals.

e.) Purplish-white mica (rare), with a large optical angle and the optical plane parallel to the symmetry plane.

Fukuchi has found, that the muscovite (b) shows a transition into the dark-green biotite, either directly or through intermediate stage of alteration represented by the zinnwaldite (a). The biotite is surrounded sometimes by the zinnwaldite and sometimes by the muscovite, their boundaries against the enclosed biotite being often very distinct.

ODAYAMA near Mt. Tsukuba in Hitachi.—In the granite of this place are found small plates of white mica with a brownish grey tinge. It resembles the zinnwaldite of Tanokamiyama.

Various mica specimens of white, brown, green, and other colours are found at several other localities in Japan. A dirty dark-brown mica of KAI has been known from early times, by its elongating into a long columnar form, when put on charcoal fire. Its analysis by Hida is as follows:

Si O <sub>2</sub>	38.45
Al <sub>2</sub> O <sub>3</sub>	15.53
Fe <sub>2</sub> O <sub>3</sub>	22.73
Fe O	1.71
Ca O	2.22
Mg O	7.85
Na <sub>2</sub> O	2.16
K <sub>2</sub> O	2.25
H <sub>2</sub> O	7.20
	<hr/>
	100.10

#### 101. Ottrelite.

This mineral was found in microscopic individuals in a slide of the hornfels from the HIDAKA mountain-range in Hok-

kaidō (see Jimbō's "Geological sketch," 1892); also in a chlorite schist of SUKEGAWA in Hitachi.

### 102. Serpentine.

Various kinds of peridotites, gabbros and serpentines are found in different parts of Japan (see Harada's *Japanische Inseln*, 1889). The opicalcite of KANASAKI in Musashi and the serpentinized peridotite of MACHIYA in Hitachi are very beautiful when polished. The latter shows black-coloured patches on a white ground. The black colour is due to chromite grains secreted out, while the white part consists of serpentinous and other secondary substances.

Asbestos of economic interest is found in the serpentines of several places, the most important of which are in the provinces of HIZEN and HIGO. Nasa has given the principal localities of Japanese asbestos.

### 103. Talc.

Greenish-white irregular plates of talc are found at ŌGUSHI in Hizen; a pseudomorph after tremolite is found in the crystalline limestone of KAWAHAKE in Shinano.

### 104. Agalmatolite.

At MITSUISHI in Bizen Province, agalmatolite, connected with liparite and believed by Kochibe, &c. to be an alteration product from its tuff, is found in the form of grey, white, yellowish or brownish masses.

### 105. Nepheline.

Ogawa has observed this mineral as a microscopic ingredi-

ent of a dyke rock in the palæozoic region of HOTSUMURA in Tamba Province.

#### 106. Cordierite.

WATARASEGAWA in Shimotsuke Province.—A detailed description of a cordierite trilling of white colour and very weak pleochroism, was given by Kikuchi in the Journal of the Science College of the Imperial University of Tōkyō, 1889. In this locality the cordierite is found only in hexagonal columns, which are trillings with a distinct zonal structure and peculiarly distributed coaly substance. The crystals are about 0.5 cm. in diameter of cross sections and are found in clayslate altered by granite contact. An analysis by Shimizu is mentioned by Kikuchi.

Similar specimens of very minute size are found in the mica clayslate of SEKINOTSU in Ōmi and of many other places, which are mentioned by Jimbō in the Geological Sketch of Hokkaidō and by KIKUCHI in his paper on cordierite. KAMEOKA in Tamba is a locality of green pinite after cordierite trilling, TORIHAMA in Wakasa that of a pale micaceous substance in the same form. Specimens from these two places are about 1 cm. in diameter of basal section.

Hussak has given a description of a blue-coloured, strongly pleochroic, cordierite aggregates found in white porcelain-like fragments. His specimens are from ASAMA volcano in Shinano, while similar fragments were found by Yamasaki on the volcano of GANJUSAN in Rikuchū and by Ogawa on that of NORIKURA in Shinano.

#### 107. Bronzite.

Kikuchi has given an account of a green bronzite from

OGASAWARAJIMA in the Journal of the Science College of the Imperial University of Tōkyō, 1889. The mineral is found in a glass, in the shape of crystal skeletons and crystals, together with a similar-coloured monoclinic pyroxene in  $\infty P \bar{\omega}$ .  $\infty P$ .  ${}_0P$ .  $P$ . The length of the green bronzite is 0.5 to 1 cm.; it forms a parallel growth with the monoclinic pyroxene and has the crystal faces  $\infty P \bar{\omega}$ ,  $\infty P \bar{\omega}$ ,  $\infty P$ ,  $P \bar{z}$  and  ${}_2P \bar{z}$ . An analysis by Shimizu is mentioned in Kikuchi's work.

### 108. Augite.

NISHINOTAKE in Hizen.—Ishii has described porphyritic individuals of a dark-green augite and a brown olivine found in the basalt and its agglomerate exposed at this locality. The augite crystals measure about 0.1 cm. to 2 cm. along the vertical axis and show usually the faces  $\infty P \bar{\omega}$ ,  $\infty P \bar{\omega}$ ,  ${}_0P$ ,  $\infty P$  and  $P$  and sometimes  ${}_2P$  and  ${}_2P \bar{\omega}$  besides.

The crystalline habit is generally thick columnar, but we find also tabular forms with prevailing  ${}_0P$ . Twinning on  $\infty P \bar{\omega}$  is quite frequent, and often repeated in the same individual. Pleochroism is weak, glass and other interpositions are numerous.

AZUNA near Yatsugatake in Kai, TATESHINA, &c. in Shinano, ONNADANI near Yoneyama in Echigo, and MYŌGI in Kōzuke.—The black augites from all these localities are similar in characters, and distinguished from other specimens by showing an apparently simple, rhombic-hemimorphic habit of penetration-twins on  $\infty P \bar{\omega}$ . Specimens from Azuna have been described by Ishiwara, those of Onnadani by Iwasaki, and and those of Tateshina, Myōgi &c. were studied by Takimoto.

The crystals from these different places will be treated together in the following lines:—

The size of the individuals varies in thickness from about 0.1 cm. to more than 0.7 cm., as in the large crystals from Onnadani. Observed crystal faces are  $\infty P \delta$ ,  $\infty P \bar{\omega}$ ,  ${}_0P$ ,  $\infty P$ ,  $P \bar{\omega}$ ,  $P$ ,  ${}_2P$ , &c. The face of  $P \bar{\omega}$  is usually hard to measure with the reflection goniometer. Simple individuals are rare, and ordinary twins on  $\infty P \bar{\omega}$  with a single re-entrant angle are not numerous. Most of the specimens are in the shape of simple looking penetration-twins with different faces on both poles. Sections parallel to  $\infty P \delta$  show a characteristic subdivision into four sectors of twinning individuals. Polysynthetic twins on  $\infty P \bar{\omega}$  are not rare; when the thin wedge-shaped middle lamella of a triling is very small in dimension, the clinopinacoidal section appears like that of a simple crystal. In such a case different arrangements of zonal enclosures in the two members of the twin can be relied upon for tracing the twinning suture. Hour-glass structure is often observed. Interpositions are very numerous.

The mother rocks of these black augites are either andesite or its agglomerate.

Kozōri in Sano in Kai Province.—Hirabayashi, Takimoto and others have collected green augite in a dark-green dyke-rock piercing sandstone. The largest individual attains a length of 4 cm. Observed faces are  $\infty P \delta$ ,  $\infty P \bar{\omega}$ ,  ${}_0P$ ,  $\infty P$ ,  $P$ ,  $-P$ ,  ${}_2P$ ,  $-{}_2P$  and  ${}_2P \delta$ , among which  ${}_2P$ ,  $-{}_2P$  and  ${}_2P \delta$  are small. The most frequent combinations are  $\infty P$ ,  $\infty P \bar{\omega}$ ,  $\infty P \delta$ ,  $P$ . Those with  ${}_0P$  besides are not numerous, also the three last mentioned faces are often not found. Twins on  $\infty P \bar{\omega}$  are frequently observed. A collection of these augite crystals is easily made from

decomposed parts of the mother rock, as is the case with the black augite of Azuna and other localities.

### 109. Wollastonite.

ISHIYAMA and GOBESSHO in Ōmi, INARIYAMA in Yamashiro, ISHIGURE in Ise, TOKIWA in Shinano, a place near KASAMA in Hitachi and other places are localities of fine-fibrous to needle-shaped aggregates of wollastonite in crystalline limestone. Some of the specimens from the provinces of Ōmi and Mino have been analyzed. The wollastonite of Ishiyama is found along the stratification of limestone, those of Gobessho and Tokiwa some times form zones parallel to those of red garnet, of green augite, &c.

### 110. Hedenbergite.

At ŌKURADANI in Obira in Bungo Province, there is an extensive aggregate of hedenbergite in biotite-hornfels. Here the mineral is found in large crystals, sometimes 18 cm. in length, or in radial-columnar as well as granular aggregates. The large individuals are cemented together by fluorite. This hedenbergite rock contains numerous dark-green garnet crystals and is traversed by veins, in which assenopyrite, pyrrhotite, copper pyrite, &c., are found in massive state. The veins just mentioned were formerly worked for copper. In them dark-brown or dark-violet axinite crystals, as well as very good hedenbergite specimens (with  $\infty P$ ,  $\infty P \bar{\omega}$ ,  $\infty P \hat{\omega}$ ,  $\infty P$ ,  $P \bar{\omega}$ ,  $2P$ ,  $2P \hat{\omega}$ , and  $-P$ ) are collected in this. The following is one of the analyses made by the chemists of the Imperial Geological Survey :

Si O <sub>2</sub>	47.13
Fe O	24.46
Mn O	0.73
Ca O	23.23
Mg O	2.40
K <sub>2</sub> O	0.13
Na <sub>2</sub> O	0.98
H <sub>2</sub> O	1.48
	100.54

At KAWAHAKE in Shinano, minute dark-green crystals and coarse crystalline aggregates of hedenbergite (?) are found in crystalline limestones.

At KURODAKE in Etchū, a brownish-grey fibrous aggregate of augite is partly oxidised to a brown-black submetallic substance. Larger individuals of this mineral are in prismatic crystals with cleavages.

### 111. Diallage.

Diallage is found in the gabbros and diallage-rocks of several places in Japan, the most beautiful specimens of large size being found at MINEOKA in Awa (Honshū) and at URITŌGE in Mikawa.

### 112. Rhodonite.

At YASUSADA in Mikawa, Ishikawa has found minute rhodonite crystals on masses of that mineral, found in a quartz vein through gneiss. Observed crystal faces are  $\infty P$ ,  $\infty P\bar{\infty}$ ,  $\infty'P$ ,  $\infty P'$ ,  ${}_2P$ ,  ${}_2P$ ,  $P'$ ,  $P$ .

At OKUSAKO in Kiura in Bungo Province, a rhodonite mass is found in biotite-hornfels.



Black oxides of manganese are associated with these rhodonite specimens.

### 113. Tremolite.

This mineral is found as fine-fibrous aggregates in the crystalline limestone of ISHIGURE in Ise, where wollastonite is found in a large quantity. At this place, the granite, which has altered the palæozoic rocks, contains fluorite veins.

A pseudomorph of white talc after tremolite was found by Hoshina in the crystalline limestone of KAWAHAKE in Shinano. The original form of the tremolite, as columnar aggregates with characteristic prismatic angles, is distinct.

### 114. Hornblende.

Loose black crystals, about 1 cm. long, of porphyritic hornblende, are found covered with grey and brown secondary substances on a road ascending to the mountain of HAKUSAN in Kaga. Crystal faces are  $\infty P$ ,  $\infty P \bar{\infty}$ ,  $oP$  and  $P$ . Twins on  $\infty P \bar{\infty}$  are numerous.

### 115. Glaucophanes.

Blue-coloured glaucophanes-schists and other rocks containing glaucophanes, are found in different parts of Japan. (See Kotō's note on glaucophanes, in the Journal of the Science College of the Imperial University of Tōkyō, 1887).

### 116 Beryl.

TAKAYAMA, &c. in Mino.—There are sometimes found light-bluish to nearly colourless crystals and radial aggregates of beryl. They are often found together with smoky quartz, &c. in the pegmatite of this region. The individuals attain more than

1 cm. in thickness. On some good crystals in Wada's collection, there are found  $\circ P$ ,  $\infty P$ ,  $P$ , &c. Optical anomaly consists of biaxial interference-figures in some part of basal sections. Corrosion-forms in the form of sharp-pointed pyramids with rounded edges are observed on the termination of some crystals.

TANOKAMIYAMA in Ōmi.—At this locality there is occasionally found greenish or bluish, transparent to translucent beryl, whose length is sometimes 13 cm. and whose basal section has sometimes a diameter of 3 cm. Good crystals of the beryl show  $P$ ,  ${}_2P_2$ ,  $\circ P$ , &c. In one specimen with unstriated prisms, there is to be seen on  $\circ P$  a hexagonal pit which might have been produced by natural etching (Wada's collection).

### 117. Orthoclase and Microcline.

TANOKAMIYAMA in Ōmi.—The potash feldspars of this locality, which form druses in pegmatite, are separable into following varieties:

a.) White translucent crystals, usually in Carlsbad and Baveno twins, less frequently in Manebach twins and very seldom in simple crystals. The Carlsbad twins always look like simple crystals, for the  $P^\infty$  of one individual is nearly parallel to  $\circ P$  of the other. They are usually smaller than the Baveno twins which attain a length of 20 cm.

b.) Reddish-white to flesh-red crystals, occurring with topaz.

c.) Glassy crystals mostly in Baveno twins, but rarely in simple individuals, about 3 cm. in diameter. These crystals are usually stained with manganese oxide. Less numerous than *a* and *b*.

d.) Minute platy aggregates of white or bluish-white crystals with curved faces.

Analyses of the varieties *a* and *b* by Kodera are as follows :

	a	b
Si O <sub>2</sub>	64.78	64.62
Al <sub>2</sub> O <sub>3</sub>	17.86	21.00
K <sub>2</sub> O	12.87	12.22
Na <sub>2</sub> O	2.25	2.41
Fe <sub>2</sub> O <sub>3</sub>	1.46	0.33
Ca O	0.14	0.20
Mg O	0.11	0.09
	<hr/> 99.47	<hr/> 100.87

Two analyses of the variety *c* by the same chemist are as follows :

	I	II
Si O <sub>2</sub>	63.77	64.98
Al <sub>2</sub> O <sub>3</sub>	19.52	22.17
K <sub>2</sub> O	13.70	10.59
Na <sub>2</sub> O	1.84	0.60
Fe <sub>2</sub> O <sub>3</sub>	1.39	0.32
Ca O	—	—
Mg O	0.08	0.86
	<hr/> 100.30	<hr/> 99.52

The first sample was taken from a simple individual with an opaque-white internal part, and the second from a Carlsbad twin, also with an opaque-white core. All the specimens, from which samples were taken for the above four analyses, are in Wada's collection.

Crystal faces in the varieties *a*, *b* and *c* of the potash feldspars of Tanokamiyama are  $\infty P \bar{\infty}$ ,  ${}_0P$ ,  $\infty P$ ,  $\infty P_3$ ,  $P$ ,  $P \bar{\infty}$ ,  ${}_2P \bar{\infty}$  and  ${}_2P \bar{\infty}$ ; besides (according to Kō),  $\infty P \bar{\infty}$ , found only in *a* and *b*.

Deviation of the angle PM from a right angle is sometimes very great; this may be due to an imperfection in crystal development.

The Baveno twins are sometimes cyclical and consist of three individuals. A peculiar parallel-growth of two Baveno twins, with a re-entrant angle at their union, is not rare. That of two Manebach twins united on  $\infty P\infty$  with a central depression on one end is also met with, but not often. Albite lamellæ in perthitic intergrowth are found in the potash felspar; the same plagioclase making a parallel growth with principal felspar individuals, also forms crusts and projecting lamellæ on the faces of these.

NAEGI, &c. in Mino.—The varieties *a* and *d* above mentioned, are found, with the same characters and the same mode of occurrence, at Naegi and vicinity. The chief difference of these Mino crystals is their more decomposed and often opaque porcelain-like appearance. The peculiar parallel growth of two twinning crystals met with in Ōmi specimens has not been observed in them.

The form of termination of Baveno twins is of course different with different development of the faces. A specimen in our collection shows a nearly straight truncation.

KAI.—From a locality in Kai province were formerly brought large, glassy simple felspar crystals, about 9 cm. broad and showing  $\infty P\infty$ ,  ${}_0P$ ,  $\infty P$ ,  $\infty P\hat{s}$ ,  $P$ ,  $P\bar{\infty}$  and  ${}_2P\bar{\infty}$ .

AKAZU in Owari Province.—White opaque simple crystals are collected at this locality, together with smoky quartz.

TADACHI in Shinano.—Light-greenish to greenish-grey microcline crystals with  $\infty P\infty$ ,  ${}_0P$ ,  $\infty P$ ,  $\infty P'$ ,  $\infty P'\bar{s}$ ,  $\infty P'\bar{s}$ ,  ${}_1P$ ,  $P$ ,  ${}_1P$ ,  $\bar{\infty}$  and  ${}_2P$ ,  $\bar{\infty}$  are collected in pegmatite, and attain a breadth of 7 cm. They occur along with good smoky quartz crystals.

MORAIYAMA in Shinano.—Iwasaki has described a number of partly decomposed potash felspar crystals from Moraiyama, collected by Ōkubo together with smoky quartz in a pegmatite. They are 2 to 4 cm. in length, and usually covered with brownish decomposition product. Observed crystal faces are  $\infty P \infty$ ,  $\circ P$ ,  $\infty P$ ,  $\infty P_3$ ,  $P$ ,  $P \bar{\infty}$  and  $2P \bar{\infty}$ . Simple crystals are rare; the specimens are usually in Baveno twins. The same twinning is sometimes repeated, thus producing twins of three or four individuals. Sometimes two Baveno twins are united, leaving a re-entrant angle at their union; and even four of them may unite causing a central depression on one end of the composite crystal. Albite lamellæ are enclosed in the crystals, but they are not visible with the naked eye, unlike some of the Ōmi and Mino specimens.

#### 118. Albite.

Wada possesses a good specimen of albite druse found in Tosa Province. The white spots and grains in the chlorite-amphibolite of KWANTŌ are believed to be albite. Besides we have in the pegmatite of Ōmi and Mino, albite as crusts and lamellæ in potash felspars, and as minute crystal-aggregates.

#### 119. Andesine.

SHIODA in Shinano.—Small crystals of this mineral, about 0.6 cm. long along the  $\tilde{a}$  axis, are found as porphyritic crystals in a compact grey plagioclase-rhyolite, which is almost entirely decomposed in yellowish-grey easily crumbling masses. Crystal faces are  $\infty P \infty$ ,  $\circ P$ ,  $P$ ,  $\bar{\infty}$ ,  $\infty' P$ ,  $\infty' P'$ ,  $\infty' P_n$ , and  $\infty P'_n$ . There are found rectangular, cross shaped, or broad tabular roundish forms of individuals. The last two forms are Carlsbad twins consisting

of two crystals, which are in themselves polysynthetic twins, either of the Albite or Pericline type, or of both at the same time. The rectangular crystal, as well as one half of the cross-shaped or broad-tabular twin, is apparently simple, but really shows grooves of the Pericline twinning and striations of the Albite twin. The presence of Manebach twins is doubtful; apparently complex crystals composed of many prismatic forms as in a cross-shaped twin, are nothing but irregular groups.

### 120. Labradorite.

Wada possesses a piece of grey labradorite from MINEOKA in Awa, (Honshū); this specimen labradorizes distinctly in contrast to the plagioclase forming a constituent of the gabbro of this place.

### 121. Anorthite.

Kikuchi (Journal of the Science College of the Imperial University of Tōkyō, 1889) has given a detailed description of separate anorthite crystals of MIYAKEJIMA. They are perfectly developed on all sides and covered with a black coating of lava. Their form is thick tabular, either apparently simple or in Carlsbad twins. The longest diameter of the crystals is about 2 cm. Observed crystal faces are  ${}_0P$ ,  ${}_{\infty}P_{\infty}$ ,  ${}_{\infty}'P$ ,  ${}_{\infty}P'$ ,  ${}_{\infty}'P_{\bar{3}}$ ,  ${}_{\infty}P'_{\bar{3}}$ ,  ${}_1P$ ,  ${}_{\bar{\infty}}$ ,  ${}_2P'_{\bar{\infty}}$ ,  ${}_2P$ ,  ${}_{\bar{\infty}}$ ,  ${}_2P'_{\infty}$ ,  ${}_2P'_{\infty}$ ,  $P'$ ,  ${}_1P$ ,  $P_{,,}$ ,  ${}_4P_{\bar{2}}$ ,  ${}_4P'_{\bar{2}}$ ,  ${}_4P_{\bar{2}}$  and  ${}_2P$ , (?), among which  ${}_0P$ ,  ${}_{\infty}P_{\infty}$ ,  ${}_2P$ ,  ${}_{\bar{\infty}}$ ,  ${}_2P'_{\infty}$ , and  ${}_2P'_{\infty}$  are most frequently found. Kikuchi has mentioned besides analysis by Kitamura, various artificial etching figures, principal optical characters, &c.

The same author found a similar anorthite in a volcanic rock of TŌNOSAWA in the old volcano of Hakone.

Numerous flat felspar crystals with rounded edges and a black coating were collected by Kikuchi at IWŌJIMA in the south-eastern corner of Japan. They are about 1 cm. long and seem to have been found in loose crystals just in the mode of the anorthite crystals of Miyakejima. The nature of this mineral has not yet been studied.

KŌSHINZAN near Ashio in Shimotsuke.—Saitō has found numerous good porphyritic crystals of anorthite in an agglomerate of this place. The largest individual measures about 15 cm. in length. Crystalline habit is thick columnar, with faces  $\infty P$ ,  $'P, P'$ ,  $,P, P,$ ,  $\infty'P$ ,  $\infty P'$ ,  $,P, \infty$ ,  $2,P, \infty$ ,  $2'P \infty$ ,  $2P' \infty$ .

### 122. Titanite.

At and near the mines of KAMIOKA in Hida, are found in diorite numerous, small, yellow-coloured titanite crystals. They are like a letter-envelope in shape, and measure sometimes 0.6 cm. in length. An analysis by Yoshida is as follows:

Si O <sub>2</sub>	30.81
Ti O <sub>2</sub>	40.21
Fe <sub>2</sub> O <sub>3</sub>	0.51
Al <sub>2</sub> O <sub>3</sub>	0.61
Ca O	26.42
Mg O	1.21
	99.77

At KINKWAZAN in Rikuzen, Kotō has found brown titanite crystals in granite.

### 123 Natrolite.

This mineral is found at OSAWA in Nikkō in Shimotsuke, MAZE in Echigo, SHIODA in Shinano, OHARA in Iwaki, &c.

At Nikkō the mineral has been found in fine short needles, together with chabasite, desmine and calcite, all of which occur in a dark-brown decomposed andesite.

At Maze, beautiful colourless needles of natrotite are associated with pretty druses of apophyllite and analcime, together with calcite, heulandite and chabasite, which are all found in a grey volcanic rock with amygdaloidal cavities.

At Shioda, a dark-coloured andesite-agglomerate contains apophyllite, heulandite, chabasite &c., together with radial groups and aggregates of natrolite, which sometimes show pyramidal endings.

The natrolite of Ohara is in the shape of felt-like aggregates found in andesite, together with heulandite druses and less numerous desmine, epistilbite (?), &c.

Optical anomaly of natrolites from the four above-mentioned localities consists of undulatory extinction of the needle-shaped individuals which are often apparently twisted.

#### 124 Apophyllite.

SHIODA in Shinano.—Aggregates of small greenish-white crystals of apophyllite are sometimes found attached to natrolite aggregates of this locality. Less numerous than this apophyllite is a reddish-white variety in larger individuals, sometimes about 0.5 cm. in diameter. Both varieties show  $\infty P \infty, P$ , &c. and division into sectors, like that in the specimens from Golden in Colorado.

MAZE in Echigo.—Colourless to greenish-white partly transparent pyramidal crystals of apophyllite with  $\infty P$ ,  $\infty P \infty$  and  $P$ , sometimes measuring 5 cm. along the  $c$  axis, show the same optical anomaly as the apophyllites of Shioda. Crystal faces are sometimes covered with sub-individuals.



OGASAWARAJIMA.—Druses of white prismatic crystals of apophyllite with  $\circ P$ ,  $\infty P \infty$  and  $P$  (?), (besides  $\infty P_3$  and  $\frac{1}{3}P$ , according to  $K\bar{o}$ ), are found with heulandite in a green earthy mass of an altered eruptive rock (?). Basal sections of the crystals sometimes measure about 1 cm. or more in diameter. Some of the crystals show distinct "Andreasberg-rings," but no division into sectors in crossed Nicols. Others show biaxial interference figures, no division into sectors is there observed, but an intergrowth of irregular patches with a different orientation is found in the principal crystal substance.

Reddish-white apophyllite crystals of a more minute size are comparatively rare at the same locality. They show a combination of  $\circ P$ ,  $P$ ,  $\infty P \infty$ , and are nearly like the white crystals in the different phenomena of optical anomaly they exhibit.

The white crystals of Ogasawarajima have been analyzed.

### 125. Analcime.

MAZE in Echigo, which is the most well-known locality of Japanese analcime and apophyllite, gives crystals of the former mineral always in  $\circ O_2$ , with often striated faces and sometimes modified by  $\infty O \infty$  at their solid angles. The mineral is colourless to greenish-white and is sometimes 2.5 cm. in diameter. Sections parallel to  $\infty O \infty$ , taken from the outer part of the crystal, usually show four sectors, besides rarely a central one. Similar sections from the middle of the crystal show eight subdivisions. Those parallel to  $O$  and taken from near the surface show three or six sectors; and those parallel to  $\circ O_2$  and from the surface are often divided into three parts instead of being quite homogeneous. Double refraction is originally strong, and becomes stronger by heating.

### 126. Desmine and Epistilbite (?).

A few specimens of bundle-shaped zeolite from NIKKŌ and OHARA are probably desmine. At the latter locality we find, besides, small flat crystals about 0.6 cm. long, and showing a complicated division into sectors like the bundle-shaped specimen of the same place.

Small and very rarely observed specimens of flat prismatic crystals, about 0.6 cm. in length, in the compact andesite of OHARA were measured on the prismatic edges and found to be similar in crystalline habit to an epistilbite.

### 127. Heulandite.

OGASAWARAJIMA.—Nearly colourless crystals of heulandite, sometimes 2.5 cm. long (in the direction of the *c* axis), form druses at this locality, together with the already mentioned white apophyllite. The greenish tinge of this mineral is due to an admixture of green particles along the cleavage. Crystal faces observed in the specimens are  $\text{P}$ ,  $\infty \text{P}^\infty$ ,  $\infty \text{P}$ ,  $-\text{P}^\infty$  and  $\text{P}^\infty$ . Cleavage-lamella shows as many fields as there are sides to the section; these fields make transition to the middle field. The size of the middle field is larger in those lamellæ which have been taken from near the surface of the crystal. The extinction angle of each field is not constant even at the same temperature, a slight change of which produces a marked change in the optical orientation.

OHARA.—Yamasaki has described the heulandite of this locality, which measures in larger individuals about 0.8 to 1 cm. in length. Same crystal faces and optical anomaly, as in the specimens from Ogasawarajima, are here observed. The mineral is white and translucent. An analysis by Shinowara gave

Si O <sub>2</sub>	58.4
Al <sub>2</sub> O <sub>3</sub>	14.4
Ca O	12.2
H <sub>2</sub> O	14.9
	99.9

Heulandite occurs, besides, at SASEBO in Hizen (according to Kō), at MAZE in Echigo (according to Takimoto), &c.

### 128. Chabasite.

OSAWA in Nikkō.—Saitō has described the following characters of chabasite from this locality :

Crystals found in druses, more or less tainted with a brown ferruginous substance. Their diameter is about 1 or 2 cm. Numerous twins on R and a comparatively few supplementary twins are observed. Crystal faces are R and  $-\frac{1}{2}R$ , with  $-2R$  in some individuals. Triangular section parallel to  $\circ P$  is divided into six fields which are often quite irregular in boundaries. The corresponding chief sections of two fields lying on one of the corners of the section make an acute angle, opening towards that side of the triangle which is opposite to this corner. Sections parallel to R show a division into two fields, with inserted twin-lamellæ.

MITAKA in Izu.—M. Yamashita has studied minute colourless crystals of chabasite in a fresh greenish-grey coloured rock. Their diameter is only about 0.5 cm. Optical character is nearly like that of the Osawa specimens; but good sections parallel to  $\circ P$  are very difficult to prepare, for the crystals are usually attached to rock by their lateral solid angles.

Other localities of chabasite is in the province HIZEN, &c.



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