T. WADA

MINERALS OF JAPAN

ERRATA

PAGE

1 line 10 from top, for "varous" read "various."

" " 11 " bottom, after "wollastonite" insert "columbite."

" " 10 " " , for "tenorite" read "tetrahedrite."

2 " 12 " " , " "Provinces" " "Province."

" " 8 " " , " "magnetite" " "pyrrhotite."

3 " 12 " " , " "Rikuzen" " "Iwaki."

" " 7 " " , and in the succeeding pages, for "S. Sasamoto," read "J. Sasamoto."

5 " 12 " " , for "have" read "and."

7 " 16 " top, for "$\frac{1}{2}R$," read "$-\frac{1}{2}R$."

9 " 11 " bottom, for "Keda" read "Tage."

12 " 19 " top, for "antimony" " "stibnite."

" " 10 " bottom, for "Kai" " "Shikaori."

16, insert the foot note: + indicates Dana's determination, − Krenner's, and * new face.

21 line 10 from top, after both "VII" insert "2."

25 " 15 " " , for "$\frac{\infty O \infty}{2}$" read "$\frac{\infty O 2}{2}$".

26 " " " " , " " "

29 " 16 " " , " "Rikuchū" " "Rikuzen."

41 " 8 " " , " "25 mm." " "250 mm."

50 " 17 " bottom, for "$\infty P(n)$" " "$\infty P(m)$."

54 " 8 " " , " "Yoroibata" read "Abumibata."

61 " 2 " " , " "$R7(o)$" read "$R7(\varsigma)$."

62 " 2 " top, for "$4R(m)$" read "$4R(M)$."

72 " 16 " " , " "axes" " "axis."

75 " 12 " " , " "$\infty P\infty(e)$" " "$P\infty(e)$."

77 " 11 " " , " "$\infty P \cdot \infty P\bar{\infty}$ and in others with faces of $P \cdot \infty P\breve{\infty}$" read "$\infty P$ and $\infty P\bar{\infty}$, and sometimes P and $P\breve{\infty}$ in addition."

78 " 7 " " , " "$2P\grave{\infty}(u)$" read "$2P\bar{\infty}(u)$."

79 " 11 " " , " "Kōshi" " "Katchi."

" " 13 " bottom, for "0·12" " "0·92."

" " 10 " " , " "$\infty P\bar{\infty}$" " "$\infty P\grave{\infty}$."

80 " 5 " " , " "18·25" " "13·25."

83 " 2 " " , " "$0P(i)$" " "$0P(c)$."

84 " 10 " top, after "$2P2(s)$" insert "$4P\frac{4}{3}(n)$, $\infty P\frac{3}{2}(h)$."

85 " 3 and 11 from top, for "P2" read "2P."

86 " 14 from top, for "$P\infty(e)$" read "$P\breve{\infty}(e)$."

88 " " and 13 from bottom, erase "At Fudōzaka, it forms both prismatic and tabular crystals. The surface has been decomposed into mica."

90 " 8 from top, for "1880" read "1884."

98 " 3 " " , " "Fig. 40" read "Fig. 41."

101 " 2 " " , " "ever" read "even."

103 " 3 " " , " "J. Sugiura" read "J. Sugimura."

103 " 11 " bottom, for "Nobori" " "Noborio."

106 " 6 " " , " "$P\frac{28}{25}$" " "$P\frac{\overline{28}}{25}$."

107 " 12 " " , " "crystals" " "crystal."

109 " 6 " " , " "Tōshōtō" " "Higashi-Shōdo."

111 " 10 " " , " "lost" " "loss."

114 " 6 " top, for "1880" read "1884."

" and 115, " " " "$b = \infty P\grave{\infty}$, $q = 5'P\grave{5}$, $Y = 3{,}P\grave{3}$, $X = 2'P\grave{\infty}$, $y = 2P'\grave{\infty}$" read "$b = \infty P\infty$, $q = 5'P\breve{5}$, $Y = 3{,}P\breve{3}$, $X = 2'P\breve{\infty}$, $y = 2P'\breve{\infty}$."

" line 17, 18 and 19 from top, for "v" read "r."

116 " 8 from bottom, for "15·35" read "15·53."

" " " " " , " "99·92" " "100·10."

117 " 12 " " , " "103·53" " "101·54."

120 " 11 " " , " "$P\bar{2}(e)$" " "$P\breve{2}(e)$."

136 " 9 " " , " "1870" " "1874."

137 " 18 " top, before "$(2P'\acute{\infty})$" insert "e."

" " 6 " bottom, for "$2P{,}\bar{\infty}$" read "$2{,}P{,}\bar{\infty}$."

138 " 15 " top, for "Fig. 56" " "Fig. 59."

140 " 6 " bottom, for "Nishikawa" read "Tamura."

Pl. XXII for "Fudōzaka, Hitachi Pr." read "Ishikawa, Iwaki Pr."

MINERALS OF JAPAN

MINERALS OF JAPAN

BY

TSUNASHIRŌ WADA

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TRANSLATED

BY

TAKUDZI OGAWA

Geologist of the Imperial Geological Survey

TŌKYŌ

1904

PREFACE

Thirty years have elapsed since the writer began to collect and study Japanese minerals, but he has until recently been prevented by public duties from attempting to thoroughly work out his investigations. It has been during this interval that the science of mineralogy, like most other sciences, has developed in Japan.

Mineralogy was first taught here in 1873 by a German mining engineer, Karl Schenk, in the Kaiseigakkō, which has now become the Imperial University of Tōkyō. Then came, as professors to the university and to the Kōbudaigakkō (College of Technology), Henry S. Munroe from America, John Milne from England, Dr. Edm. Naumann, Dr. David Brauns, and Dr. Carl Gottsche from Germany, and under them our knowledge of Japanese minerals by degrees widened and advanced.

To the assiduous researches of these gentlemen as well as to those of our compatriots the Japanese islands have yielded a large number of minerals, some of which are beautifully crystallised and of high mineralogical interest. Among the best known minerals from Japan are stibnite, in crystals most gigantic and splendid of all metallic minerals, topaz, rivaling that of the Ural in beauty, and rock crystal which presents an uncommon form of twinning.

There are also found in our country some minerals of rare occurrence, such as datolite, danburite, columbite, fergusonite and naëgite, a new compound of rare metals, worthy of careful investigation. Some minerals of common occurrence such as chalcopyrite sometimes also are of unusual interest because of forms not known in other lands. Axinite, garnets, felspars, zeolites and various metallic sulphides are also interesting minerals found in abundance. In fact Japan seems to be an instance of remarkable richness in mineral species occurring within a comparatively limited territory. Our mineralogical researches are however at present not greatly advanced, and new Japanese minerals are yearly being added to the list of known species.

Since 1875 the writer has incessantly endeavored to collect Japanese minerals and he can now boast a fairly large collection in which are represented all such minerals as are known to occur in well crystallised forms. His investigations have however been far from satisfactory, interruptions having frequently occurred on account of his other duties. On the occasion of the Universal Exposition at Paris in 1900, Prof. K. Jimbō of the Imperial University of Tōkyō was kind enough to make a catalogue of the writer's minerals there exhibited with other specimens from the Imperial Geological Survey, and wrote an interesting paper on Japanese minerals, partly based on studies of the writer's collection.

Some mineral specimens in the writer's possession being now again allowed to form a part in the exhibit of the Survey's collections, the writer has been invited by Director T. Kochibe to avail himself of the opportunity to prepare a paper devoted to the mineralogy of Japan.

In the following pages, which have been written under these circumstances, there is no attempt to give anything like a comprehensive description of all known Japanese minerals, but merely to summarise in a convenient form the present mineralogical knowledge of the country, as contributed in the works of the late Prof. Y. Kikuchi, Prof. K. Jimbō, Prof. T. Hiki, Prof. K. Yamada, Messrs. S. Kō, T. Takimoto and N. Fukuchi. The paper was originally written in Japanese, which Mr. T. Ogawa, Geologist of the Imperial Geological Survey, has taken the trouble to translate into English. All the chemical analyses given in the paper without special reference have been made in the Chemical Laboratory of the Imperial Geological Survey.

The plates showing the figures of more important Japanese minerals were photographed from specimens belonging to the writer's collection. Descriptions are also founded on the specimens in his collection, except when quoted from some other observers, whose names were given in the text. Fig. 34–40 are intended to give some crystals of topaz in the writer's collection in their natural size. Two figures showing the crystallographical forms of the Japanese stibnite are taken from Prof. E. S. Dana's paper referred in the foot-note (2), p. 15.

The writer is bound here to express his profound obligations to Mr. T. Ogawa, who has so kindly translated the text, and to Messrs. T. Kochibe, Director, and T. Suzuki, Geologist *en chef*, whose ready assistances in many ways are highly appreciated.

TSUNASHIRŌ WADA.

TŌKYŌ, *July 31, 1904*.

CONTENTS

PLATES

MINERALS OF JAPAN

INTRODUCTION

A glance at a geological map of the Japanese Empire will suffice to give an idea of the highly complicated geologic structure of these islands. We find here strata of almost every geological age and rocks of all descriptions crowded into a relatively small space. To this complexity, it seems, is due the mineral wealth of the country, traditional since the time of Marco Polo. Some minerals are peculiar to certain geologic formations, and especially important to the mineral production of the country are granite and varous kinds of volcanic rocks, which occupy extensive areas. By far the greater number of the metallic mines are situated in the regions of the volcanic rocks. Next to them stand crystalline schists and older sedimentary formations, in which cupriferous ore beds of considerable importance are sometimes found interstratified.

As it is the writer's purpose to give a short sketch of such minerals as are of purely mineralogical interest he will give here some minerals which are peculiar to the principal types of terrains. We find in granite : *quartz*, *felspars*, *micas*, *topaz*, *beryl*, *chrysoberyl*, *tourmaline*, *garnet*, *andalusite*, *monazite*, *scheelite*, *ferberite*, *cassiterite*, *wollastonite*, and *gadolinite* ; in crystalline schists : *native copper*, *pyrites*, *pyrrhotite*, *chalcopyrite*, *tenorite*, *rock crystal*, *magnetite*, *calcite*, *rutile*, *garnet*, *piedmontite* and *actinolite* ; in rocks of older formations metamorphosed by intrusion of granite : *calcite*, *fluorspar*, *native bismuth*, *bismuthinite*, *molybdenite*, *magnetite*, *hæmatite*, *chalcopyrite*, *arsenopyrite*, *lievrite*, *rock crystal*, *garnet*, *wollastonite*, *scheelite*, *axinite*, *datolite*, *danburite*, *cordierite*, *andalusite*, *diopside*, *chlorite*, *epidote* and *hedenbergite* ; and in volcanic rocks and their tuffs : *sulphur*, *native arsenic*, *native bismuth*, *native copper*, *native silver*, *native mercury*, *native gold*, *realgar*, *orpiment*, *stibnite*, *bismuthinite*, *molybdenite*, *alabandine*, *zincblende*, *marcasite*, *arsenopy-*

rite, galena, argentite, cinnabar, bornite, chalcopyrite, matildite, jamesonite, pyrargyrite, tenorite, tetrahedrite, stephanite, quartz, agate, chalcedony, opal, manganite, hæmatite, limonite, cerargryrite, fluorspar, calcite, dolomite, magnesite, smithsonite, rhodochrosite, siderite, aragonite, witherite, calamine, malachite, azurite, linarite, gypsum, barytes, anglesite, scheelite, wolframite, apatite, pyromorphite, libethenite, vivianite, garnet, chrysocolla, pyroxene, amphibole, felspars, zeolites, etc.

Beside the minerals found in these rocks, there occur several others, either contained or formed secondarily, in different metalliferous veins.

The minerals which the writer here proposes to describe are 131 in number. He has excluded the minerals of organic origin, *anthracite, black coal, brown coal, retinite, petroleum,* and *asphaltum ;* those which do not appear in good crystals, *covelline, chalcanthite, melanterite, alum, prehnite, laumontite, alunite, serpentine, steatite, agalmatolite* and *kaolin ;* and those which form exclusively rock ingredients, *piedmontite, glaucophane, orthite, zoisite, sillimanite, nepheline* and *iddingsite.* Accordingly all the known species of minerals in Japan number 155.

Of the minerals to be described, *greenockite, wulfenite, tenorite, monazite, naëgite* and some others are known to occur only in single localities and in very small quantities.

Cobalt and nickel are metals much sought after in Japan. Cobalt has been detected in the Provinces of Mino and Ikuno, but only in small quantities. The metal has been obtained in a relatively large quantity in the copper mine of Besshi by the late I. Iwasa, who succeeded in extracting oxide of cobalt during the treatment of tailings in wet process. T. Kochibe detected the metal in magnetite from certain localities. Its content was however not more than 0.1 or 0.2 per cent. Nickel-bearing minerals were also carefully tested by the same observer. The only locality of a nickeliferous mineral is however limited to Uragawa, Province of Tōtōmi, where a green serpentinous mineral resembling garnierite from New Caledonia has been recently found by T. Kochibe. The analysis proved the low content of the metal.

The principal mines noted for minerals are the following :

Kosaka, Kamaishi, Furokura, and Osaruzawa, Rikuchū Pr.[1];
Ani, Daira, Arakawa, Tsubaki, and Innai, Ugo Pr.;
Aikawa, Sado Pr.;
Ashio, Shimotsuke Pr.;
Kamioka, Hida Pr.;
Kuratani, Kaga Pr.;
Ikuno, Tajima Pr.;
Besshi and Ichinokawa, Iyo Pr.

The chief mineral localities other than mines are as follows :

Ishikawa, Iwaki Pr., Yamanō, Hitachi Pr., environs of Kimpū-zan, Kai Pr., environs of Takayama, Mino Pr., Tanokami-yama, Ōmi Pr., in *granite regions* ;

Kiura and Obira, Bungo Pr., Yamaura, Hyūga Pr., in *contact rocks* ;

Obara, Rikuzen Pr., Maze, Echigo Pr., and neighbourhood of Amagi-san, Izu Pr., in *volcanic rocks*.

Among the papers on Japanese minerals which the writer has consulted in the compilation of the following pages, the most important are those by the late Y. Kikuchi, K. Jimbō, T. Hiki, K. Yamada, S. Sasamoto, S. Kō, T. Takimoto, N. Fukuchi, and Y. Ōtsuki. Reference has been made only to such papers as are written in a European language and are accessible to foreign specialists. By far the greater number of the papers has been published in the Journal of the Geological Society of Tōkyō, and in the Journal of Geography of the Tōkyō Geographical Society.

1) The abbreviation Pr. stands for Province (*Kuni*).

DESCRIPTION

1. GRAPHITE

Graphite is most frequently found in gneiss and crystalline limestone in the Archæan formation. In gneiss it forms either nests or is scattered in scales replacing mica, and in limestone it is irregularly mingled with calcite. Sometimes it occurs filling up fissures in granite and volcanic rocks. It is also formed as a product of metamorphism of coal or carbonaceous rocks in younger formations when affected by an igneous rock in contact.

In **Takanuma** and **Shimizu,** Etchū Pr., graphite forms nests in gneiss and is of a fine quality, though not abundant. In **Ashikuraji,** in the same province it takes the form of scales speckled in limestone. In **Katadani,** Kaga Pr. it occurs in comparatively large quantities in clayey veins in liparite. In **Torigoye,** Nagato Pr., graphite occurs as a result of alteration from coal in a Rhætic sandstone.

According to C. Iwasaki, graphite from **Kataura,** Satsuma Pr., occurs in spheroidal or ellipsoidal masses in diorite. These form cores in limonite, which are again covered with a layer of kaolin. The latter is a secondary product from organic substances produced by the igneous intrusion.

Chemical composition of the finest sample from Kataura mentioned in Milne's Catalogue is as follows :

	Carbon	Ash
1.	88.50	16.50
2.	88.09	11.91
3.	89.22	10.78

Analysis 1 by Geerts. 2 and 3 by Gowland.

Graphite of **Kawai,** Hida Pr., contains from 60 to 70 per cent of carbon. One specimen from Katadani, Kaga Pr., contains 90 per cent of carbon, but usually the amount is less than that from Kawai. The ash is mainly clayey matter, as is evident from the following analysis made by J. Takayama :

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	Total.
62.60	30.35	1.64	0.02	1.04	3.62	trace	99.27

2. SULPHUR

Sulphur occurs in various localities in Japan. It actually emanates from many solfataras in craters of active volcanoes, and sometimes in those considered extinct.

There is a single instance of the occurrence of sulphur in other than volcanic localities, namely in the **Kosaka** Mine, Rikuchū Pr. The form of the crystals from Kosaka also differs from that of those from other localities. They are smaller, more compact and not so friable as the crystals formed by volcanic emanations. The crystals are usually less than 2 mm. in the longest diameter and have a large number of faces. The mineral seems to have crystallised after the formation of the ore, locally known as "*Kuromono*" or black ore, for it fills up the interstices of the latter.

Well crystallised sulphur of volcanic origin is found at Yatsukōda-yama and Osore-zan, Mutsu Pr., Doroyu, Rikuzen Pr., Tsurugi-zan, Rikuchū Pr., Shirane-san (Kusatsu), Kōzuke Pr., Tateyama, Etchū Pr., Yonago, Shinano Pr., etc. Crystals from all these localities are of the same habit. Pyramidal faces are well developed; then come $\infty \breve{P} \infty$ and oP, and rarely $\frac{1}{3}$P. The crystals have usually sharply defined edges, have a funnel-shaped depression on P. The only exception is the sulphur of Yonago, which is crystallised compact and has no such depression. In size the crystals from Tsurugi-zan are inferior to those from other localities.

According to C. Iwasaki, there are two kinds of sulphur in **Shirane-san** (Kusatsu). One kind which is found mingled with earthy sulphur at some distance from the solfatara, is not well crystallised. The other kind, which is crystallised near the solfatara, forms beautiful crystals of large dimensions. It is the latter type that sometimes attains 15 mm., and is of bright sulphur yellow colour and of adamantine lustre. The form of the crystals is simple, consisting of the unit pyramid P, sometimes cut by the brachydome $\breve{P}\infty$. In some rare cases, a combination of P, P$\breve{\infty}$, $\frac{1}{3}$P and oP is observed in a single crystal, P being always prominently developed. A parallel growth on the vertical axis *c* is frequent, and sometimes it forms a composite crystal more than 30mm. long. An abnormal prismatic form is sometimes assumed, when the alternate four faces of P are prominently developed. On crystals from Shirane-san is very often observed a remarkable natural etched figure, whose depressed centre lies excentrically below the overlying layers, presenting an appearance not unlike that of a grain of starch when seen under the microscope. The centre is sometimes so excentrically situated that it is wholly covered with overlying layers and can not be seen from the exterior.

At **Yatsukōda-yama,** the mineral forms simple pyramidal crystals with triangular depressions in the middle of the faces. It is paler in colour, and translucent.

Crystals from **Doroyu** resemble most those of Shirane-san. The pyramid P is somtimes found truncated by P$\breve{\infty}$.

Crystals from **Osore-zan** often attain more than 40mm. in the longest diameter. Faces are simply P. The crystals contain earthy impurities, are greenish and partly opaque. On the middle of the faces of P are observed the same hollows as those found in the crystals from Shirane-san.

Sulphur from **Yonago** is brownish yellow and opaque. It occurs in groups of pyramidal crystals, the length of whose vertical axis attains 28mm.

Sulphur of **Iwōjima,** Satsuma Pr. is massive. Pyramidal crystals are seen only in crevices.

Sulphur from **Tsurugi-zan** forms minute polyhedral crystals which have however a coating of green earthy substance on the surface.

In Tateyama, Yonago and Iwōjima (Satsuma), tellurium and selenium are found in sulphur in the form of brownish yellow masses. The following is the result of the analysis of such a specimen of sulphur from Iwōjima by T. Shimizu:

Te	Se.	As	Mo	S
0.17	0.16	0.01	trace	99.76

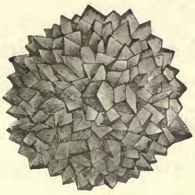
(Divers and Shimizu, Chem. Soc. London, 1883. Vol. XVIII. p. 284.)

3. ARSENIC

Native arsenic occurs in Akatani, Echizen Pr., Ikuno, Tajima Pr., and Sotomo, Wakasa Pr. It is rarely met with in the latter two localities where most probably it is now no longer produced. The mineral from these localities is not crystallised. It is of dark gray colour and has an earthy fracture.

Arsenic from **Akatani** forms globular masses of concentric radial aggregations of rhombohedra, whose polar edges alone are visible projected on the surface. It occurs in clay derived from decomposition of liparite, in whose interstices the mineral was originally formed in association with a fibrous stibnite and a little realgar. This form of crystallisation of native arsenic is not known in other countries.[1] The crystals are in R and the cleavage is parallel to $\frac{1}{2}$R. The content of arsenic in the mineral is 86.6 per cent.[2]

Fig. 1.



4. BISMUTH

The chief localities of native bismuth are Kanagase in the mining district of Ikuno, Tajima Pr., Sotomo, Wakasa Pr., and Sannotake, Buzen Pr.

In **Kanagase**, the mineral forms crystallised masses of irregular shape in vein quartz. The diameters of the masses sometimes are 20–30 cm. The bismuthinite formed on the outer portion of the mass, is probably a product of alteration from the native bismuth.

At **Sotomo**, there was once found during its exploitation the same kind of bismuth which attained a diameter of about 10 mm.

1) It is more than ten years since the late Prof. Stelzner of the Bergakademie of Freiberg in Saxony, who had studied the mineral from Japan, wrote to the writer for information as to the precise locality and the mode of occurrence. The locality was then unknown to the writer, and inquiries at length revealed the occurrence of the crystallised arsenic in Akatani. The original sample in Prof. Stelzner's possession was procured from Dr. Krantz, a German mineral dealer, to whom S. Sasamoto had supplied it, together with various other Japanese minerals.

2) Beck in Tschermak's Mittheilungen, 1897.

The bismuth from **Sannotake** is in minute grains, only 2–3 mm. large, and is found disseminated in vein stuff. Bismuthinite appears in association with the mineral, but the sulphide of bismuth can easily be distinguished by the finely granular appearance of its fractured surface from the native bismuth whose fractured surface is smooth and lamellar.

Bismuth forms enclosures in fluorspar of **Ōkuradani** near Obira, Bungo Pr. S. Sasamoto observed rounded grains of the mineral enclosed in the hedenbergite of the same locality.

5. PLATINUM

Platinum occurs in association with alluvial gold and iridosmine in the **Yūbari-gawa,** the **Pēchan** and other rivers in the Hokkaidō, and with gold and iron sand in **Nishi-Mikawa,** Sado Pr. The mother rock of platinum is not known in either place. In a sample of minerals of higher specific gravity than 5, which were collected in gold washing in the Hokkaidō, there are found platinum, iridosmine, cinnabar and magnetic iron sand mixed with gold. Whether all the five minerals have been derived from one mother rock is not known. It is however beyond all doubt that cinnabar accompanies gold, while platinum and magnetite are always associated with iridosmine. Accordingly it seems not improbable that all the minerals may come from one and the same origin.

Discrimination of platinum and iridosmine is not difficult. Platinum is rather soft and apt to be eroded on the edges, and is usually tarnished dark gray. Iridosmine is, on the contrary, hard and hence has sharp edges, and a brilliant white metallic lustre. Specific gravity of iridosmine of the Pēchan in Esashi is 22.275, and that of platinum of Usotannai in the same mining district is 21.509.[1]

Platinum usually occurs in flattened grains, the largest of which weigh 0.637 gr. The quantity of platinum is only 2 or 3 per cent of that of iridosmine. Platinum found in Sado is in very minute grains. An alloy of platinum and iridosmine seems to exist

1) The determination was made in the Chemical Laboratory of the Imperial Geological Survey.

among the samples obtained from the Hokkaidō. It seems not improbable that a richer deposit of platinum may be found, if more careful researches be made in the placer gold regions of the Hokkaidō.

6. IRIDOSMINE

As above mentioned, iridosmine occurs with placer gold and platinum in the rivers of the Hokkaidō. It is usually found in flattened grains. These are larger than those of platinum, a specimen from the **Usotannai** in Esashi weighing 1.8832 gr. A sifting of grains collected at the Yūbarigawa gave the following results :

2–3 mm.	0.235 per cent.
1–2 mm.	15.205 ,, ,,
0.5–1 mm.	54.400 ,, ,,
0.25–0.5 mm.	24.980 ,, ,,
0.10–0.25 mm.	5.176 ,, ,,

As is obvious from the figures, the grains ranging between 0.5 mm. and 1 mm. make up more than one half the whole bulk.

Iridosmine occurs most abundantly at **Tomarinai** in Wakkanai, Kitami Pr. Here the mineral forms 65 parts and gold only 35 parts of the whole washing.

Small quantities of the metal are reported from several localities in the Main Island (Honshū). At **Tsuya,** Rikuzen Pr., iridosmine occurs with placer gold in a river emptying into the sea.

At **Daigo** and **Keda,** Hitachi Pr., it is found in auriferous veins. It occurs also in placer washing with gold in the **Dōzangawa,** Iyo Pr., and **Yamashirodani,** Awa Pr. (Shikoku).

No attempt has as yet been made to determine the proportion of iridium and osmium contained in the mineral.

7. COPPER

Native copper is known to occur in many localities in Japan, for it is a mineral frequently associated with other cupriferous ores in copper mines.

Native copper found at **Arakawa,** Ugo Pr., often forms beautiful arborescent crystalline aggregates (Pl. I, Fig. a), but the individual crystals are rarely sufficiently distinct to allow an accurate determination, the only faces recognisable being usually O. In some crystals found here, S. Kō detected twinned octahedra.

Native copper from **Osaruzawa** is of the same kind as the preceding. In **Makimine,** Hyūga Pr., native copper is obtained in thin ramified lamellæ compressed in the plane of foliation of a Palæozoic rock.

At **Kosaka,** Rikuchū Pr., and **Ashio,** Shimotsuke Pr., are also found crystals of native copper, which are however not well defined.

Native copper is a product of reduction from some other copper ores, and may be oxidized into cuprite or malachite. A beautiful transparent variety of cuprite is found in association with native copper at Arakawa and Kosaka. Native copper seems to form a pseudomorph of chalcopyrite at Arakawa.

8. SILVER

Native silver is one of the minerals of most frequent occurrence as it is met with in most silver mines, but fine specimens are of rare occurrence. Crystallised native silver has never been found in Japan.

Native silver has been obtained most abundantly from **Omodani,** Echizen Pr., where thin lamellæ are found traversing fissures of bornite, so as to give a certain constant quantity of silver to the copper ore. Another remarkable occurrence of native silver is in the well-known argentiferous rock, "*fukuishi*" of **Ōmori,** Iwami Pr. A lamellar, arborescent or granular native silver has been found here once in an andesitic rock in such a quantity as to make the deposit fit for profitable extraction.

Though not so abundant as in the last two cases, we find beautiful specimens of native silver at **Kanagase,** Tajima Pr. Silver occurs here in arborescent or wiry forms, sometimes holding crystals of calcite (Pl. I, Fig. b).

At **Iwade,** Echigo Pr., a wiry native silver accompanies argentite. It is also found in a minute lamellar form at **Kago,** Satsuma Pr., and **Nagano,** Ōsumi Pr.

9. MERCURY

Native mercury occurs either independently or in association with cinnabar. At **Minato**, Hyūga, it is found in minute drops in a loamy soil coloured brownish with limonite. The liquid mercury can easily be separated from the earthy mass. To the same type belongs the mercury discovered by Dr. T. Harada in the bay of **Tateyama**, Awa Pr. (Honshū), and further that of **Hirado**, Hizen Pr., where the mineral is found contained in porous Tertiary sandstone. In the same province, mercury of the same mode of occurrence was found about 1830 at **Ainoura**, and was worked for a time by Lord Matsura.

Mercury is found at **Chichinokawa**, Iyo Pr., in a dark gray slate in association with cinnabar. Mercury is not so easily separated from the rock in this case as in that above mentioned.

Mercury from **Suizawa**, Ise Pr., is another example of its association with cinnabar.

10. GOLD

Native gold occurs in most gold mines, but not always in masses large enough to be discernible with the naked eye. Gold obtained by placer washing usually does not form crystals. It is from reefs that we find more often well defined crystals, as for instance, at Yamagano, Osumi Pr., Fuke, Satsuma Pr., and Asahi, Tajima Pr. Minute but beautiful crystals were found at Asahi. Fuke is also noted for fine crystals.

Gold from **Yamagano** is commonly fibrous or arborescent, and well defined crystals are very rarely met with. If found, they have far larger dimensions than those of either of the two preceding localities. We distinguish here two kinds of forms of crystallised gold. It sometimes assumes forms seemingly divergent from crystals of the regular system (Fig. 2). This is most probably due to a complicated twinning on the face of 2O2. The specimen shown in the figure was obtained in 1885, and is the only one of its kind, for crystals of this type

Fig. 2.

have never since been found. Lately we have found there native gold in minute crystals similar to that of Asahi and Fuke, the only difference being a paler colour, obviously due to a higher content of silver. At **Asahi**, crystals are attached to quartz vein, and are especially beautiful and well developed, when formed in cavities. The faces observed are O, 2O and ∞O. Fibrous gold is sometimes observed at Asahi. Similarly crystallised gold is found at **Fuke.**

In the gold mine of **Sado**, one of the oldest known mines in Japan, crystals of native gold are not found. On the only specimen we obtained from the mine, is found a zone of pure gold occupying the innermost part and is surrounded with bands of argentite intimately mixed with vein quartz.

The **Tasei** mine in the mining district of Ikuno, Tajima Pr., is also noted for its rich auriferous deposit, and yet native gold has been rarely met with. It is only recently that a band of native gold about 3 mm. thick, was found forming the centre of banded chalcopyrite, pyrites, argentite and vein-stone. At **Nakase,** Tajima Pr., native gold occurs with antimony. A band of pure gold is formed between bands of quartzose matrix containing stibnite.

At **Iname,** Mikawa Pr., minute crystals of gold are associated with pyrites, zincblende and feather ore.

Native gold accompanies a gray telluride of gold in the interesting deposit of gold in **Setamai,** Rikuchū Pr. A dark yellow alloy is observed beside the gray telluride, which has been proved eventually to be petzite by an analysis made at the Mining Institute of the Technological College, Imperial University of Tōkyō.

At **Kai,** Rikuzen Pr., it occurs in crevices of a white quartzose vein-stone. At **Hashidate,** Echigo Pr., it forms grains in a white quartzose matrix.

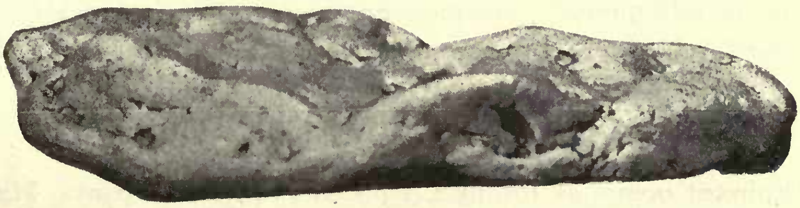
Formosa stands at the front of the gold-producing regions of Japan. The chief localities are **Zuihō** and **Kinkwaseki** near Taihoku in the northeastern part of the island. Auriferous quartzose veins traversing a volcanic rock, are sometimes found to bear a large quantity of native gold. The glittering yellow metal is usually for great part covered with rust-coloured limonite which is surely formed by the decomposition of pyrites.

Fig. 3.

Alluvial gold occurs in numerous places in Honshū, the Hokkaidō and Formosa. It is however in the Hokkaidō that rich placer deposits are found and extensively washed. In the placer mining district of **Esashi** on the northeast of the Hokkaidō, K. Nishio found crytals of native gold, one of which is so large as to measure 6–10 mm. along the edges of its octahedron. The faces of the crystals are depressed in the middle. In another crystal he observed a combination of tetrakis-hexahedron, hexakis-octahedron and rhombic dodecahedron. These are the largest crystals of gold ever found in Japan.

Nuggets of large dimensions have also been met with in Esashi. The largest of these was found in 1900 at the Usotannai in Esashi. It weighed 205 *momme* (769.9 gr.) and measured 106 × 63 × 25 mm.

Fig. 4.



(Fig. 4). This is the largest nugget found in the placers of Japan. The next largest specimen, which weighed 197.6 *momme* (741 gr.), was found in the **Toimakigawa** of the same township. A noteworthy fact in the gold district is the occurrence of cinnabar in association with gold. There was once found at the Usotannai a pebble of cinnabar measuring 10 cm. in longest diameter. This reminds us of an analogy of association observed at Ushio and Ōkuchi, Satsuma Pr., and Hasami, Hizen Pr., where cinnabar seems to have been formed as a product of emanation in the latest phase of the formation of a vein.

In Honshū, a nugget measuring 18 mm. was once found at **Shōgawa,** Hida Pr. Grains of gold in pretty large quantities are sometimes obtained in crevices of a metamorphosed rock in **Yobuno,** Buzen Pr.

At **Miyanojō,** Satsuma Pr., there was found an eroded pebble of quartz cementing flakes of gold, the latter presenting an appearance not unlike that of small shells of certain mollusca embedded in a sedimentary rock.

11. REALGAR

Realgar occurs at Jōzankei in the Hokkaidō, Osore-zan, Mutsu Pr., Monji, Rikuzen Pr., and Kuriyama, Shimotsuke Pr.

Well defined crystals occur at **Monji,** where the mineral is found in tuff accompanied by acicular stibnite and sometimes by calcite. Beautiful cochineal-red crystals are here usually formed in drusy cavities. Larger crystals measure sometimes 10 mm. in length and 3–4 mm. across. The faces most common are pyramid and brachydome, a few other faces being sometimes observed.

At **Jōzankei** and **Osore-zan,** realgar occurs with orpiment in earthy or massive form. It occurs at **Kuriyama** in prismatic crystals in cavities of vein quartz. The faces are however not sufficiently well developed for an accurate determination.

12. ORPIMENT

Orpiment occurs at Jōzankei, Ishikari Pr., and Osore-zan, Mutsu Pr. At **Jōzankei** it forms yellow thin lamellar masses, associated with quartz and sometimes with realgar. It appears rarely in a lamellar crystal. The composition of the specimen is as follows :

	As	S
I	61.10	37.57
II	59.33	38.74

Orpiment from **Osore-zan** is intermixed with sulphur and realgar. It forms stalactitic or botryoidal masses.

13. STIBNITE

There are many stibnite localities in regions of crystalline schists, Mesozoic formation and volcanic rocks. It is however the antimony mine of **Ichinokawa**, Iyo Pr., which has secured the world-wide reputation of producing the most gigantic and beautiful crystals of the mineral. Stibnite occurs in veins traversing graphite schist overlain by Cretaceous conglomerate. The occurrence was known in olden times, for an old Japanese mineralogist in his mineralogical work[1] described crystals of stibnite most probably from this locality. The mine was most prosperous from 1882 to 1886, and produced fine crystals which were exported to Europe and America. It is the Japanese mineral that has attracted the greatest attention of the foreign mineralogists on account of the magnificence of its crystals, and consequently it has been studied most carefully abroad. Among other researches, especially important are those made by E. S. Dana and Krenner.[2] As a result of their investigations 43 new faces were discovered in addition to the previously recognised 45 faces, Dana having found 40, and Krenner 3 more (Fig. 5 and 6).

Fig. 5.

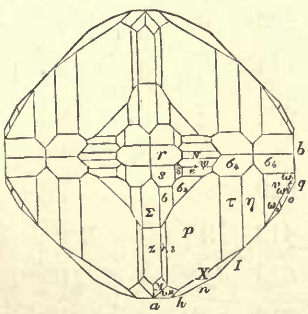
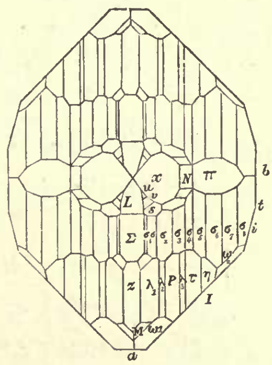


Fig. 6.



The two mineralogists came to almost the same result in calculating the axial ratio. According to Dana who reckoned from angular measurements of the polar edges of the pyramid η, 80°21′ and 124°59′,

$$a : b : c = 1 : 1{\cdot}00749 : 1{\cdot}02550 = 0{\cdot}99256 : 1 : 1{\cdot}01787.$$

Krenner obtained from the unit pyramid,

$$a : b : c = 0{\cdot}99304 : 1 : 1{\cdot}0188.$$

1) Sekitei: "Unkon-shi" (A description of stones).
2) Referred in N. J. f. Mineralogie, etc. 1885.
E. S. Dana: On the Stibnite from Japan. Am. Journ. Science. 1883. XXVI.
Jos. Alex. Krenner: Ueber den Antimonit aus Japan. Földtani Közlöny. 1883. XIII.

The following are the faces determined by the two mineralogists:

		Naumann.	Miller.			Naumann.	Miller.			Naumann.	Miller.
a	+	$\infty P\bar{\infty}$	100	J		$\frac{5}{3}P\breve{\infty}$	053	E^*	+	$5P\breve{\frac{3}{2}}$	10.15.3
b	±	$\infty P\breve{\infty}$	010	Π^*	+	$2P\breve{\infty}$	021	ω_2^*	+	$\frac{8}{3}P\breve{\frac{8}{5}}$	583
h	±	$\infty P\bar{3}$	310	j		$3P\breve{\infty}$	031	F^*	+	$\frac{25}{6}P\breve{\frac{5}{3}}$	15.25.6
n	+	$\infty P\bar{2}$	210	Y^*	+	$4P\breve{\infty}$	041	η	±	$\frac{5}{3}P\breve{\frac{5}{3}}$	353
ι^*	+	$\infty P\bar{\frac{3}{2}}$	320	g		$\frac{9}{2}P\breve{\infty}$	092	e	±	$\frac{2}{3}P\breve{2}$	123
k		$\infty P\bar{\frac{4}{3}}$	430					$\sigma_4^*(T)$	±	$\frac{4}{3}P\breve{2}$	243
m	±	∞P	110	H_1^*	−	$\frac{3}{17}P$	3.3.17	v	+	$2P\breve{2}$	121
$\varkappa^*$	+	$\infty P\breve{\frac{6}{5}}$	560	G_1^*	−	$\frac{3}{13}P$	3.3.13	$\omega_3^*(B)$	±	$\frac{10}{3}P\breve{2}$	5.10.3
r	±	$\infty P\breve{\frac{4}{3}}$	340	μ	+	$\frac{1}{4}P$	114	A	+	$6P\breve{2}$	361
d	±	$\infty P\breve{\frac{3}{2}}$	230	F_1^*	−	$\frac{5}{19}P$	5.5.19	ω_4^*	+	$\frac{11}{3}P\breve{\frac{11}{5}}$	5.11.3
l	+	$\infty P\breve{\frac{5}{3}}$	350	ν^*	+	$\frac{2}{7}P$	227	H^*	+	$P\breve{\frac{5}{2}}$	255
o	±	$\infty P\breve{2}$	120	s	±	$\frac{1}{3}P$	113	Z^*	+	$\frac{10}{3}P\breve{\frac{10}{9}}$	9.10.3
χ^*(⅃)	±	$\infty P\breve{\frac{5}{2}}$	250	π		$\frac{1}{2}P$	112	β	+	$\frac{7}{8}P\breve{\frac{7}{6}}$	676
q	±	$\infty P\breve{3}$	130	$\sigma_2^*(\theta)$	±	$\frac{2}{3}P$	223	δ^*	+	$\frac{5}{12}P\breve{\frac{5}{4}}$	4.5.12
i	±	$\infty P\breve{4}$	140	p	±	P	111	Γ^*	+	$\frac{2}{3}P\breve{\frac{4}{3}}$	346
t	+	$\infty P\breve{5}$	150	ξ	+	$3P$	331	τ	±	$\frac{4}{3}P\breve{\frac{4}{3}}$	343
ϑ^*	+	$\infty P\breve{6}$	160					D^*	+	$\frac{20}{3}P\breve{\frac{4}{3}}$	15.20.3
θ^*	+	$\infty P\breve{7}$	170	Ψ^*	+	$\frac{8}{9}P\bar{4}$	829	σ_3^*	+	$P\breve{\frac{3}{2}}$	233
				M	+	$\frac{4}{3}P\bar{4}$	413	W^*	+	$\frac{10}{3}P\breve{\frac{3}{2}}$	20.30.9
R		$\frac{1}{6}P\bar{\infty}$	106	σ_1^*	+	$\frac{2}{3}P\bar{3}$	629	$\sigma_5^*(S)$	±	$\frac{5}{3}P\breve{\frac{5}{2}}$	253
L	±	$\frac{1}{3}P\bar{\infty}$	103	λ_1^*	+	$P\bar{3}$	313	$\sigma_5^*(U)$	±	$2P\breve{3}$	263
y		$\frac{1}{2}P\bar{\infty}$	102	ω_1^*	+	$\frac{5}{3}P\bar{\frac{5}{2}}$	523	w		$3P\breve{3}$	131
Σ^*	+	$\frac{2}{3}P\bar{\infty}$	203	$T^*(K)$	±	$5P\bar{\frac{5}{2}}$	521	V^*	+	$\frac{10}{3}P\breve{3}$	10.30.9
z	±	$P\bar{\infty}$	101	f		$\frac{1}{2}P\bar{2}$	214	σ_7^*	+	$\frac{7}{3}P\breve{\frac{7}{2}}$	273
Φ^*	+	$9P\bar{\infty}$	901	σ	±	$\frac{2}{3}P\bar{2}$	213	ψ	±	$\frac{2}{3}P\breve{4}$	146
				λ_2^*	+	$P\bar{\frac{3}{2}}$	323	G^*	+	$P\breve{4}$	144
γ	+	$\frac{1}{3}P\breve{\infty}$	013	α		$P\bar{\frac{4}{3}}$	434	φ		$\frac{4}{3}P\breve{4}$	143
x	+	$\frac{1}{2}P\breve{\infty}$	012	X^*	+	$4P\bar{\frac{4}{3}}$	431	σ_8^*	+	$\frac{8}{3}P\breve{4}$	283
N	±	$\frac{2}{3}P\breve{\infty}$	023	λ_3^*	+	$P\bar{\frac{6}{5}}$	656	ρ		$\frac{5}{3}P\breve{5}$	153
u	+	$P\breve{\infty}$	011	ε		$P\bar{\frac{8}{7}}$	878	σ_9^*	+	$4P\breve{6}$	2.12.3
Q		$\frac{4}{3}P\breve{\infty}$	043								

For the new forms are shown the following angular measurements :

Zone	Edge	Measured	Calculated	
$a : m$	$b : \iota$	123° 10′	123° 29½′	DANA
,,	$: \varkappa$	139° 56′	139° 59′	,,
,,	$: \chi(\Delta)$	157° 51′	158° 3′	,,
		158° 9′	id.	KRENNER
,,	$: \vartheta$	170° 18′	170° 28′	DANA
,,	$: \theta$	171° 39′	171° 48½′	,,
$a : z$	$a : \Sigma$	124° 20′	124° 21½′	,,
,,	$: \Phi$	173° 40′	173° 49′	,,
$b : u$	$b : \pi$	153° 40′	153° 50¼′	,,
,,	$: Y$	166°	166° 12′	,,
$m : p$	$m : H_1$	104° 26′	104° 19′	KRENNER
,,	$: G_1$	108° 18′	108° 27′	,,
,,	$: \mu$	109° 43′	109° 52′	DANA
,,	$: F_1$	111° 10′	110° 50′	KRENNER
,,	ν	also in the zone $x : \Sigma$		DANA
,,	$\sigma_2(\theta)$	,, ,, ,,	$\Sigma : b$	,,
,,	$p : \sigma_2(\theta)$	168° 36′	168° 37′	KRENNER
$\sigma_1 : b$	$\Sigma : \sigma_1$	169° 30′	169° 25½′	DANA
,,	$: \sigma_3$	140°	139° 57½′	,,
,,	$: \sigma_4(T)$	131° 59′	131° 45′	,,
,,	$b : \sigma_4(T)$	138° 10′	138° 16′	KRENNER
,,	$\Sigma : \sigma_5(S)$	125° 43′	125° 32′	DANA
,,	$b : \sigma_5(S)$	144° 25′	144° 29′	KRENNER
,,	$\Sigma : \sigma_6(U)$	120° 53′	120° 44′	DANA
,,	$b : \sigma_6(U)$	149° 16′	149° 16′	KRENNER
,,	$\Sigma : \sigma_7$	117° 5′	117° 1½′	DANA
,,	$: \sigma_8$	114° 50′	114° 3′	,,
$\sigma_9 : Y : \sigma_9$	$Y : \sigma_9$	171°	170° 44′	,,
$z : b$	$b : \lambda_1$	103°	103° 19½′	,,
,,	$: \lambda_2$	115° 30′	115° 21′	,,
,,	$: \lambda_3$	120° 30′	120° 38′	,,
—	$\left.\begin{matrix}\omega_3 : \omega_3\\(B : B)\end{matrix}\right\}$ (Edge X.)	60° 33′	60° 33′	,,

Zone	Edge	Measured	Calculated	
—	$\omega_3 : \omega_3$ $(B : B)$ } (Edge Y.)	128° 26′	128° 25½′	DANA
—	,, ,,	128° 24′	128° 27′	KRENNER
$\omega_3(B) : b$	$b : \omega_3(B)$	149° 40′	149° 45′	,,
,,	ω_1	also in the zone $m : z$		DANA
,,	$l : \omega_2$	144° 29′	144° 59½′	,,
,,	ω_4	also in the zone $q : \eta$		,,
$\omega_3(B) : a$	$\omega_3(B) : V$	172°	172° 4′	,,
,,	$: W$	173°	173°	,,
$m:\omega_3(B):\sigma_7$	$m : D$	170°	169° 28′	,,
,,	$: E$	165° 30′	165° 24½′	,,
,,	$: F$	161°	161° 58′	,,
$m : z$	$: X$	166°	166° 18′	,,
$N:\psi:\sigma_2(\theta)$	$N : T$	156° 40′	157° 1½′	,,
$a : \sigma_1$	$\sigma_1 : \Psi$	167° 30′	167° 37′	,,
—	$T : T$ $(K : K)$ } (Edge X.)	137° 45′	137° 26′	,,
—	,, (Edge Y.)	48° 2′	47° 44′	KRENNER
—	$T(K) : h$	169°	169° 12′	DANA
—	$T(K) : b$	111° 24′	111° 18′	KRENNER
$a : u$	$u : G$	170°	169° 49′	DANA
,,	$: H$	164° 30′	163° 58′	,,

The result of Brun's[1)] measurements of a single crystal is

$\infty P \breve{\infty}$ (010)
$\infty P \frac{4}{3}$ (340)
P (111)
$\frac{3}{4} P \breve{\frac{4}{3}}$ (343)
$\frac{4}{5}$P (445)
$\frac{9}{10}$P (9.9.10)
$\frac{5}{4} P \breve{\frac{4}{3}}$ (15.20.16)

The faces belong to the following four zones : [011. 340] [111, 343, 010] [111, 446, 9·9·10] and [15·20·16, 343, 340],

1) A. Brun: Note sur un cristal de Stibine de l'île de Shikoku. Arch. de Sciences phys. et nat. de Genève., III. pèr Bd. 9 p. 514.

and the angles are

$$111 : 343 = 172^\circ\ 2'$$
$$111 : 010 = 125^\circ\ 29'$$
$$111 : 1\bar{1}1 = 109^\circ\ 6'$$
$$343 : 3\bar{4}3 = 93^\circ\ 10'$$
$$010 : 343 = 133^\circ\ 27'$$
$$111 : 455 = 173^\circ\ 58'$$
$$111 : 9{\cdot}9{\cdot}10 = 177^\circ\ 10'$$
$$340 : 343 = 149^\circ\ 20'$$
$$340 : 15{\cdot}20{\cdot}16 = 147^\circ\ 40'$$

From 133° 2′ and 149° 20′, follows the axial ratio :

$$a : b : c = 0{\cdot}99839 : 1 : 1{\cdot}0117.$$

Most of the faces discovered by these researches were found in smaller crystals accompanying the gigantic crystals, for the latter in spite of their magnificence generally have simpler forms. It is to be regretted that such small crystals rich in rarer faces are no more found in our country. During the last twenty years the writer has striven to make as perfect a collection of crystals as possible. In angular measurements he however has failed to recognise many faces described by Dana, Krenner, and Brun. One cause for the failure may be an imperfect reflection on account of the tarnishing of the mineral with the lapse of time.

Fig. 7.

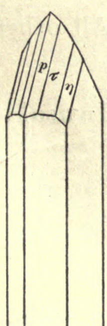


Fig. 8.

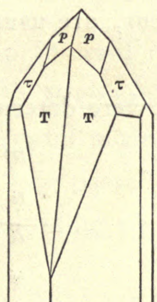
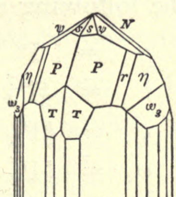


Fig. 9.



In habit we find two distinct types of most common occurrence ; namely,

(1) The chief terminal faces being p, τ, n etc. (Fig. 7 and Pl. VI, Fig. b),

(2) The chief terminal faces T (Fig. 8 and Pl. VI, Fig. *a*), though some crystals have an intermediate habit (Fig. 9). In Pl. VII, *a* and *b*, is shown another habit of rarer occurrence. The faces of such crystals photographed are not determinable on account of their dullness.

The following determinations were made on smaller crystals in my collection by N. Fukuchi, Y. Ōtake, and M. Nishimura :

$b = \infty \mathrm{P}\breve{\infty}$	$T = 5\mathrm{P}\bar{\tfrac{5}{2}}$
$z = \mathrm{P}\bar{\infty}$	$\omega_1 = \tfrac{5}{3}\mathrm{P}\bar{\tfrac{5}{2}}$
$\lambda_2 = \mathrm{P}\bar{\tfrac{3}{2}}$	$\sigma = \tfrac{2}{3}\mathrm{P}\bar{2}$
$\varepsilon = \mathrm{P}\bar{\tfrac{8}{7}}$	$\Psi = \tfrac{2}{3}\mathrm{P}\breve{4}$
$p = \mathrm{P}$	$s = \tfrac{1}{3}\mathrm{P}$
$\tau = \tfrac{4}{3}\mathrm{P}\breve{\tfrac{4}{3}}$	$t = \infty \mathrm{P}\breve{5}$
$\eta = \tfrac{5}{3}\mathrm{P}\breve{\tfrac{5}{3}}$	$Q = \tfrac{4}{3}\mathrm{P}\breve{\infty}$
$m = \infty \mathrm{P}$	$n = \infty \mathrm{P}\bar{2}$
$o = \infty \mathrm{P}\breve{2}$	$M = \tfrac{4}{3}\mathrm{P}\bar{4}$
$q = \infty \mathrm{P}\breve{3}$	

The result is unfortunately not very reliable, as the crystallisation is not perfect.

The faces best developed beside prisms are $\tau = \tfrac{4}{3}\mathrm{P}\breve{\tfrac{4}{3}}$, and $p = \mathrm{P}$, and, next to these, $\eta = \tfrac{5}{3}\mathrm{P}\breve{\tfrac{5}{3}}$. The faces $T = 5\mathrm{P}\bar{\tfrac{5}{2}}$ are not of common occurrence, but when they occur, are usually large. All other rarer faces are small.

The following eleven faces were determined by C. Iwasaki :

$p = \mathrm{P}$	$m = \infty \mathrm{P}$
$\tau = \tfrac{4}{3}\mathrm{P}\breve{\tfrac{4}{3}}$	$n = \infty \mathrm{P}\bar{2}$
$\eta = \tfrac{5}{3}\mathrm{P}\breve{\tfrac{5}{3}}$	$h = \infty \mathrm{P}\bar{3}$
$\omega_1 = \tfrac{5}{3}\mathrm{P}\bar{\tfrac{5}{2}}$	$q = \infty \mathrm{P}\breve{3}$
$\omega_3 = \tfrac{10}{3}\mathrm{P}\breve{2}$	$b = \infty \mathrm{P}\breve{\infty}$
$s = \tfrac{1}{3}\mathrm{P}$	

At Ichinokawa, stibnite occurs with quartz. The mineral is attached to the surface of quartz, or forms strings or radial needles in its interstices (Pl. III, *a* and *b*). Minute crystals of calcite are sometimes formed in a later stage in the formation of the veins, and are attached to the faces of stibnite.

Stibnite grows either parallel to the surface of the vein-stone or is radial or in confused groups on the surface. The crystals which stand at right angles on a salband, usually reach the opposite wall, and hence have no terminal face. It is the crystals grown obliquely that have pyramidal faces well developed. Mechanical deformation is common in stibnite crystals, some are bent or distorted (Pl. VII, Fig. a), and some broken and faulted (Pl. VII, Fig. b). Terminal faces may be sometimes present in the bent crystals, but never in the broken, which seem to have resulted from a shifting of the walls of the veins.

Magnificent crystals were once obtained from the now exhausted Yokohi mine in Ichinokawa, where crystals more than 60 cm. long were found. Crystals from Sengabi, which is now the sole locality for crystallised stibnite of the mine, have usually empty spaces along the vertical axis, and are not so compact and well crystallised as those formerly obtained from Yokohi, where the vein lies nearly horizontal.

Stibnite easily tarnishes and loses its beautiful lustre on exposure to the air. It sometimes has as a product of oxidation *in situ* a thin yellow coating which is most probably stibiconite. The same alteration is observed in other localities, as in the stibnite from Mikawa.

In other localities the mineral never forms good crystals like those from Ichinokawa. At **Hosokura,** Rikuzen Pr., the mineral was found in the form of botryoidal masses of a radial fibrous structure, with a velvet lustre, and long passed for the feather ore. The composition of the mineral, according to T. Hiki, is $Sb_2S_3 = 27{\cdot}746$ and $Fe\ S = 1{\cdot}650$.

Bundles or confused threads of stibnite occur at **Iname,** Mikawa Pr. Some crystals found in cavities are not distinct, and as mentioned above, are covered with a yellow incrustation. Acicular crystals are found in a quartz vein traversing Cretaceous sandstone at **Takahama** in Amakusa, Higo Pr.

14. BISMUTHINITE

This mineral is an alteration product from native bismuth, and occurs both at Kanagase in the mining district of Ikuno, Tajima Pr., and at Sannotake, Buzen Pr. At **Kanagase,** it forms the outer layer of native bismuth, and is easily distinguishable from the latter by its finely granular appearance. At **Sannotake,** the mineral occurs in minute grains in the vein-stone of copper ore in association with garnet and calcite.

The presence of a considerable quantity of bismuth in slags has led some to infer the mixture of bismuthinite in the silver ore of **Kamioka,** Hida Pr. Yet its occurrence is not certain, for the metal may be contained in galena as observed at Nishizawa, Shimotsuke Pr.

15. MOLYBDENITE

Molybdenite has long been known to occur at Tamatsukuri, Izumo Pr. It has also been found at Kawachi, Echigo Pr., Komagatake and Tsuruze, Kai Pr., Shirakawa, Hida Pr. and Sannotake, Buzen Pr.

At **Kawachi** it occurs in milk white quartz in the form of hexagonal plates attaining 10 cm. in diameter, sometimes with blunt pyramidal faces in addition to the base. Similar crystallised specimens have been obtained from Komagatake, where the mineral occurs in quartz veins which traverse granite and are stained yellow with limonite.

The molybdenite from **Shirakawa** is sometimes crystallised like that of Kawachi. From **Tamatsukuri** we have a platy or lamellar variety without definite crystalline form, and from **Sannotake,** minute flakes in limestone metamorphosed by eruption of amphibole granite.

16. ALABANDINE

Alabandine occurs at **Saimyōji,** Ugo Pr. The mineral here forms a brownish black crystalline incrustation about 10 cm. thick on the surface of the vein-stone, which is found in andesite.

It is covered with a crystallised layer of rosy coloured rhodochrosite, and then with beautiful rhombohedral crystals of calcite, which are found in the latest phase of generation.

17. BLENDE

As blende occurs associated with other sulphides in almost every metallic mine, it is of very wide distribution. The following are descriptions of some of the more important localities producing well defined crystals.

At **Daira,** Ugo Pr., there is found a combination of $+\frac{O}{2}$ and $-\frac{O}{2}$. The crystals however usually resemble simple $\frac{O}{2}$ on account of the predominance of one kind of the tetrahedra over the other, thus forming narrow faces cutting the corners.

It is associated with chalcopyrite, pyrites and galena at **Kayakusa** in the Ani mine, Ugo Pr. Here chalcopyrite, blende, galena and pyrites form successive bandings on the vein-stone according to the order of formation, and then quartz and calcite as the last members. The mineral is brown or yellow in colour, and when yellow is subtransparent. Crystals apparently resemble O, but seem probably to have been formed by lamellar twinning. Large crystals are sometimes 10 cm. in diameter. Common forms are combinations of ∞O and $\infty O \infty$, or ∞O and 3O3.

At **Osaruzawa,** Rikuchū Pr., is found a brown and opaque blende forming large crystals more than 8 cm. in diameter. The faces are O and ∞O, but rough and dull.

From **Shiraita,** Echigo Pr., we have also large crystals measuring 10 cm. Faces observed are ∞O, O, $\frac{3}{2}O\frac{3}{2}$.

The blende found associated with quartz, chalcopyrite and galena, at **Maze,** Echigo Pr., is yellowish brown in colour, and sometimes transparent. The form is a combination of $\infty O \infty$, O and ∞O. The surface is often covered with a thin layer of chalcopyrite.

Blende is found at **Fudōjima** in the Kuratani mine, Kaga Pr., associated with pyrites and chalcopyrite, forming crystals like those of Kayakusa, but smaller.

At **Ōmori**, Iwami Pr., blende occurs with siderite, and is yellow or dark brown in colour, and sometimes transparent. The faces are often rough with a thin incrustation of argentite.

Blende from **Uchinokuchi**, Bungo Pr., forms opaque brown octahedral crystals about 3 cm. in diameter. It is often twinned on O.

18. GREENOCKITE

This mineral occurs at Sennō, Echizen Pr., forming yellow incrustation on the brown-coloured blende. It resembles the yellow scaly coating of wulfenite.

19. PYRRHOTITE

Pyrrhotite occurs widely distributed in copper deposits of older formation. It is usually massive and of little interest to mineralogists. Well crystallised pyrrhotite is found only at **Yoshioka**, Bitchū Pr. The crystals are hexagonal plates of bronze colour and metallic lustre (Pl. IX, Fig. b).

20. PYRITES

Pyrites is a mineral of the widest distribution. We find crystals well defined and rich in faces at Sagi and Udō, Izumo Pr. Beautiful crystals are also found at the mines of Osaruzawa, Rikuchū Pr., Ani and Arakawa, Ugo Pr., Akadani, Echigo Pr., Kuratani, Kaga Pr., etc.

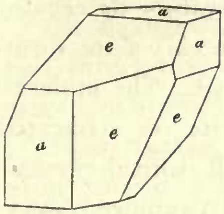
The pyrites from **Osaruzawa** is crystallised in pentagonal dodecahedra measuring 4 cm. in diameter and found in groups.

At **Kayakusa** in the Ani mine we obtain the same form of crystals, 35 mm. in diameter, sometimes O being observed in the same crystal. Penetration twinning is common. From Sammai in the same concession, are found crystals of an abnormal habit such as were also found by T. Hiki at Tōhira, Rikuchū Pr. of which we shall speak below.

The crystals of pyrites from **Arakawa** are not so large as those found in the preceding two localities, but have well developed faces of $\frac{\infty O2}{2}$ and $\infty O \infty$.

According to T. Hiki pyrites from **Tōhira** exhibit two different habits; viz.:

Fig. 10.



1) Unequally developed $\infty O \infty$ (a);

2) Combination of $\frac{\infty O 2}{2}$ (e) and $\infty O \infty$ (a) (Fig. 10).

The first type is due to the unequal development of two parallel faces of $\infty O \infty$, obviously on account of the difference of growth in different directions. The second is formed, as in the case of pyrites from the southern Ural,[1] by the development of the alternate six faces of a pentagonal dodecahedron, with which however in this case the cube is combined to give rise to the peculiar habit. The angle measured on the edges of $\frac{\infty O \infty}{2}$ or e is 113° 34′, while it was found to be 113°34′41″ on the crystal from the Ural. The faces $\infty O \infty$ can easily be distinguished from the other faces by the presence of striation. The composition of pyrites from Tōhira is (T. Omori):

Fe	S	Cu	Insoluble residue
46·53	52·48	0·04	0·73

At **Hosokura,** pyrites forms crystal aggregates resembling stalactite.

At **Akadani,** Echigo Pr., there occur two kinds of crystals of pyrites, one in cube measuring 40 mm., and the other in the above mentioned tetartohedral form simple or in combination with cube.

Pyrites occurs with rhodochrosite, galena and chalcopyrite at **Kuratani,** Kaga Pr., forming small crystals in $\frac{\infty O 2}{2}$, combined with cube.

At **Ogoya,** Kaga Pr., pyrites occurs in the simple $\frac{\infty O 2}{2}$, combination of O, $\frac{\infty O 2}{2}$, $\infty O \infty$, and of O, $\infty O \infty$.

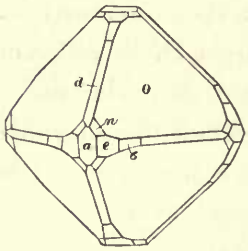
On the pyrites from **Udō,** Izumo Pr., T. Hiki distinguished two principal forms, one in the combination of O and $\infty O \infty$, the other of O, $\infty O \infty$ and $\frac{\infty O 2}{2}$. Besides there are other combinations, such as of O, $\infty O \infty$, and ∞O, of O, $\infty O \infty$, ∞O and $\frac{\infty O 2}{2}$, of O, $\infty O \infty$, ∞O and

1) N. J. f. M. G. u. P. 1889. II. 258.

2O2, and of $\frac{\infty O2}{2}$ and O, or simple O. In any case the first named three faces predominate. Striations are seen on the faces of O and $\infty O \infty$.

At **Sagi,** Izumo Pr., pyrites occurs in isolated crystals or crystal aggregates, either in the mass of chalcopyrite or in clay-slate forming the foot wall of the deposit. The mineral, when it occurs in chalcopyrite, is separated from the latter and forms well defined crystals about 25mm. in diameter. T. Wakimizu observed in the crystals the faces O, $\infty O \infty$, $O \infty$, $\frac{\infty O2}{2}$, $\frac{\infty On}{2}$, 2O2, $\frac{mOn}{2}$, and $\frac{3O\frac{3}{2}}{2}$ or $\frac{4O2}{2}$. According to the determination by careful angular measurements by S. Kawasaki and F. Otsuki, there were present in the crystal the faces of O, ∞O, $\infty O \infty$, $\infty O2$, $\frac{\infty O\frac{7}{6}}{2}$, and 2O2, forming octahedral or hexahedral crystals. The octahedral crystals always appear in a combination while hexahedral sometimes occur simple. Pyrites, in which so many faces of different forms are developed, is of rare occurrence.

Fig. 11.



Small but beautiful crystals of pyrites are found at Futto, Mikawa Pr., and at Subara, Shinano Pr. At **Futto** the crystals are only a few millimetres in diameter, in simple $\infty O \infty$ or O or in the combination of O and $\frac{\infty O2}{2}$, of $\infty O \infty$ and ∞O or of $\frac{\infty O2}{2}$ and O. Pyrites from **Subara** forms crystals from 2 to 5 mm. in simple O or $\infty O \infty$ or the combination of the two forms.

In **Chichijima** and **Hahajima** of the Bonin Islands, pyrites is found in crystals varying from 15 to 40 mm. in diameter. Among the faces observed $\frac{\infty O2}{2}$ are most common.

21. MARCASITE

Marcasite is not found in well defined crystals in Japan. At **Osaruzawa,** Rikuchū Pr., we find aggregates of minute crystals assuming a pyramidal form caused by twinning.

At **Ani,** Ugo Pr., the mineral sometimes forms botryoidal masses, of which the interior consists of spear-head-shaped crystal groups, and is sometimes stalactitic.

At **Aikawa,** Sado Pr., it covers the surface of the vein-stone with its granular incrustation.

At **Makugawa,** Iwashiro Pr., it occurs in spear-head-shaped crystals, which are, according to N. Fukuchi, a combination of base and macropynacoid twinned on the unit prism.

Near **Nagano,** Shinano Pr., there occur brownish rounded grains of marcasite, 5 to 25 mm. in diameter, the interior of which have a greenish yellow colour and a radial structure when broken.

It occurs at Kaseda, Satsuma Pr. and some other localities.

22. ARSENOPYRITE

Arsenopyrite occurs at **Awashiro** near Furikusa, Mikawa Pr., in well defined stout prisms, 4 to 8 mm. in diameter. According to N. Fukuchi they occur in liparite tuff in isolated crystals, simply consisting of ∞P (*m*), $\frac{1}{4}P\breve{\infty}$ (*u*). Its specific gravity is 6·092. From angular measurements, $mm''=68° 31'$ and $uu'=32° 56'$, the writer calculated the axial ratio,

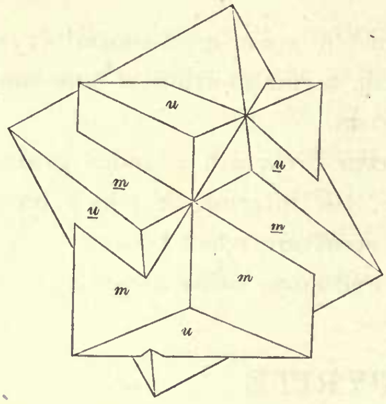
$$a : b : c = 0{\cdot}68109 : 1 : 1{\cdot}18232.$$

Two habits are recognised in the arsenopyrite of Awashiro. One type has a flat rhombic shape being very short in the direction of the vertical axis, while the other forms a more elongated prism. The first is the form by far the more frequently met with.

Striations parallel to the brachy-axis are usually observed on *u*, and are especially frequent in the crystals of the first type. In this we often find the parallel aggregates forming a saddle-shaped depression on *u*. The face *m* is smooth and not striated and has a bright metallic lustre.

There are two modes of twinning in the crystals. One has the unit prism and the other the unit macrodome for the twinning plane. The first type is more common in crystals of rhombic form; and then the face *u* is as a consequence of striation so flat that it may be taken for the base. Moreover it is very common in this type to find penetration twins, of which the individual crystals are of unequal dimensions. Sometimes we find several small crystals penetrating into a comparatively large one. Rarely they form contact twins on ∞P. The second type which is twinned on the macrodome P∞ (*e*) is of much more frequent occurrence, and forms penetration twins in both prismatic and thick rhombic crystals. In this case the twinning individuals have the macro-axes parallel and the vertical axes crossing at an angle of nearly 60° or more exactly 59° 53′, as can be calculated from $mm'''=68° 31'$ and $uu'=32° 56'$. As a natural consequence, we have a trilling crossing apparently at 60°, when a third crystal comes to cross either of the two at the same time, though it makes in reality an angle of 60° 14′ with both individuals (Fig. 14).

Fig. 12.



Crystals of similar habit occur at **Kuratani,** Kaga Pr., in association with pyrites and galena.

From **Aratsuchi,** we have perfect short prismatic crystals, 2 to 3 mm. in diameter, sometimes in penetration twins. Minute but perfect crystals are found also at **Inukai,** Ise Pr. Penetration twins are common as at Aratsuchi.

Arsenopyrite occurs with chalcopyrite at **Yoshioka,** Bitchū Pr., and forms well defined prismatic crystals. According to N. Fukuchi, they are most often grouped, perfectly isolated crystals being rarely met with. The following faces were determined by him :

$$\infty P(m) \qquad \tfrac{1}{4}P\breve{\infty}\,(u) \qquad P\bar{\infty}\,(e) \qquad 0P(c)\ ?$$

The face *u* is striated, but the saddle-like depression, observed in the crystals from Awashiro, is never present. The face *c* is also very much striated, and so are also the faces lying in the zone of *u* and *c*. They are so much striated as to make it uncertain, whether the base *c* really exists. The faces *m* are smooth, and those of *e* perfectly smooth.

Generally speaking the habit of the crystals is prismatic, i. e. elongated in the direction of the *c* axis. Yet there exist types, differing from one another in the development of the macrodome *e*. One is decidedly prismatic, the chief faces being *m* and *u*, and *e* being insignificantly developed. In the second *m* and *e* are largely developed, and the resulting form resembles a Japanese envelope which has longer and shorter sides *vice versâ* to those of the European. The faces of *u*, sometimes appear.

At **Hasegawa,** Bungo Pr., there occur with small crystals of quartz, crystals of arsenopyrite ranging from 5 mm. to 10 mm. in longest diameter. The faces ∞P and $\frac{1}{2}P\bar{\infty}$ are recognised in them. Other faces remain yet to be ascertained.

Arsenopyrite from **Takachiho,** Hyūga Pr., forms aggregates of rhombus-shaped crystals, without distinct faces.

23. GALENA

Good crystals are not found in such silver and lead mines, as Hosokura, Rikuchū Pr., Kamioka, Hida Pr., Ponshikaribetsu in the Hokkaidō, where galena is the chief ore. We obtain perfect crystals from Daira and Ani, Ugo Pr., and Kuratani, Kaga Pr.

At **Daira,** there are found large crystals measuring 10 cm. in diameter. They are mostly aggregated and perfectly bounded ones are rare. Their chief faces are O and $\infty O \infty$, both being equally developed in combination. Galena is here associated with chalcopyrite, pyrites and zincblende. Minute rhombohedra of calcite are sometimes attached to the surface.

The galena from Ani is superior to that from Daira, in the perfection of its crystallisation. In the crystals from this locality $\infty O \infty$ is largely developed and O appears only on the corners.

On the mineral from **Hosokura,** imperfectly developed faces are sometimes observed, but the crystals are usually thin, and much corroded.

At **Kuratani,** galena does not form large crystals, the largest measuring only 25 mm. They are well defined; in habit they are the same as those from Ani. Their surface is often etched, and sometimes has the appearance of having been melted.

From **Wasamori**, Echizen Pr., we find crystals of the same habit, usually forming aggregates. Their surface is sometimes corroded.

At **Nishizawa**, Shimotsuke Pr., galena occurs in crystalline masses having a peculiar lattice-work structure which is evidently due to the presence of a large quantity of antimony.

At **Uchinokuchi**, Bungo Pr., it occurs as crystals in the combination of $\infty O \infty$ and O. They are aggregated and their solid angles alone are visible. Hexahedral crystals of pyrites are here associated with galena.

24. ARGENTITE

Argentite is the principal silver ore. It is rarely well crystallised, and when crystals are found, they are in small sizes from 1 mm. to 2 mm., the largest very rarely attaining about 6 mm. The crystals moreover never have well defined edges fit for the determination of their faces.

At **Aikawa**, Sado Pr., it occurs in well bounded crystals, in which the faces ∞O and O can be recognised, beside several undeterminable faces. Wiry native silver is sometimes found projecting from among the crystals.

At **Innai**, Ugo Pr., we find crystals in combination of O and ∞O, resembling those of Aikawa, and attached to quartz. The edges of the crystals from both mines are often found rounded by melting.

Minute crystals of argentite occur sporadically in cavities of vein-stone at **Ikuno**, Tajima Pr. The faces O and ∞O are distinct.

Argentite occurs at **Ōmori**, Iwami Pr., in association with chalcopyrite and siderite. It is not well crystallised.

At **Handa**, Iwashiro Pr., crystals are sometimes met with. The specimens thus far obtained have however been so worn as to make the determination of form quite impossible.

Chalcocite

25. COPPER-GLANCE

Copper-glance occurs with other cupriferous ores in some copper mines. It is usually massive and mixed with chalcopyrite. The chief localities are Osaruzawa, Rikuchū Pr., Omodani, Echizen Pr., and Ginzan, Settsu Pr.

26. SYLVANITE and PETZITE

Sylvanite and petzite occur at the **Nojiri** Mine, Rikuzen Pr. They occur in minute grains with native gold and argentite in a milk white quartz. The telluride ores of gold were first reported by Nardin[1] in 1902. They do not exhibit the characteristic graphic structure of sylvanite. The only difference between the minerals is in the colour, sylvanite being silver white, and petzite grayish.

Petzite was analysed at the Mining and Metallurgical Institute of the Technological College, Imperial University of Tōkyō, and the ratio of gold to silver was found to be 1 : 1·59. The large content of silver indicates that the mineral is closely allied to petzite from the Golden Rule Mine of California, which contains 41·86 to 40·87 of silver and 25·60 to 24·96 of gold.

27. CINNABAR

Cinnabar occurs at Komagaëri and Tōnomine, Yamato Pr., Kamodani, Awa Pr., and Chichinokawa, Iyo Pr. It is no longer found in the cinnabar localities formerly known at Suizawa, Ise Pr. and Hirado, Hizen Pr.

At **Komagaëri**, cinnabar occurs in quartz vein, forming in cavities minute sub-transparent crystals of beautiful cochineal-red colour. The faces are probably ∞R and 0R.

At **Tōnomine** it forms a thin incrustation on the surface of the rock. Minute prismatic crystals are sometimes observed. Their faces are however not distinct. At **Kamodani** it occurs in Palæozoic limestone, and at **Chichinokawa** in slate of the Palæozoic formation. The crystals in cavities are so minute that it is impossible to distinguish the faces.

Cinnabar is an interesting mineral found paragenetically with gold, as at **Hasami**, Hizen Pr., and **Ushio** and **Ōkuchi**, Satsuma Pr.,

1) Australian Mining Standard. (May 1902, 22).

where the mineral occurs partly impregnated in vein-stone and partly filling cavities in the veins. The occurrence of cinnabar in pebbles of the **Usotannai** Esashi, and as sand in several auriferous placer deposits in the Hokkaidō, has been already mentioned. Cinnabar sand was long known to occur at **Setamai,** which is the present site of the gold mine of Nojiri. It is reported also from the gold mine of **Kusaki,** Bungo Pr. In these occurrences it seems natural to suppose cases of paragenesis of cinnabar and gold, which may be interesting from a practical point of view.

A curious occurrence of the mineral has been observed by T. Kochibe at **Nagano,** Yamato Pr., where it forms a thin incrustation on the surface of lignite.

28. BORNITE

Bornite occurs only in massive forms in association with chalcopyrite, the chief localities being Omodani, Echizen Pr., Kanagase in Ikuno, Tajima Pr., Kawada, Awa Pr., etc. The presence of native silver in the bornite of Omodani and Kanagase is a noteworthy fact as has been already mentioned.

29. CHALCOPYRITE

Chalcopyrite occurs in great abundance in Japan as the chief copper ore. It presents widely different mineralogical characters according to its occurrence either in the older formations or in younger volcanic rocks. In phyllitic and older eruptive rocks the mineral is intimately mixed with pyrites, together with magnetite and pyrrhotite. Hence it is rarely crystallised, except in drusy cavities, as is the case with Makimine and Hibira, Hyūga Pr., Besshi and other copper mines in Shikoku, Yoshioka, Bitchū Pr., and Kune, Tōtōmi Pr. In volcanic rocks on the contrary the mineral is seldom associated with magnetite, and never with pyrrhotite. Here pyrites is usually found with chalcopyrite, but the two sulphides are not mixed in a mass as in the previous case. So the well crystallised chalcopyrite is almost exclusively found in the copper veins of regions of younger volcanic rocks.

On account of its wide distribution and of the simplicity of its form, the chalcopyrite of Japan has not yet attracted much attention. Interesting results may be attained by a careful investigation of the crystals from such mines as Daira, Ani and Arakawa, Ugo Pr., Kusakura, Echigo Pr., Ashio, Shimotsuke Pr., Ogoya, Kaga Pr., etc.

Fig. 13.

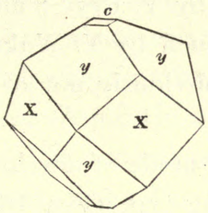


Fig. 14.

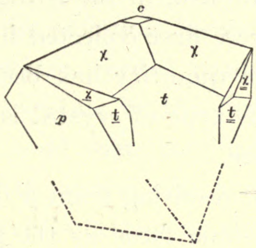


Fig. 15.

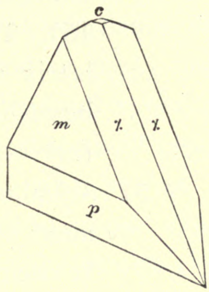


Fig. 16.

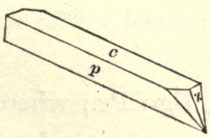
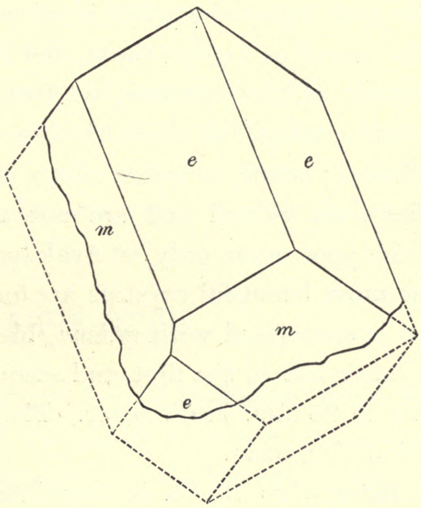


Fig. 17.



$c = 0P$	$e = P\infty$
$\chi = P2$	$m = \infty P$
$t = 2P$	$y = P3$
$p = P$	$X = 3P$

We shall provisionarily distinguish the following five types of crystallographical habits of chalcopyrite :

1) Simple crystal in $\frac{P}{2}$.
2) Combination of P3 and 3P (Fig. 13).
3) Combination of P2, 2P, and P twinned on P (Fig. 14). This form, though not described from any foreign locality, has been found in the crystals of several localities in Japan, since it was first observed in chalcopyrite from Ogoya.
4) Triangular crystals of combination of ∞P, P2, and P, found at Hisan-ichi, in the Arakawa mine, Ugo Pr. (Fig. 15). They were first collected in 1892 by Y. Uryū; and lately a large quantity has been obtained by Y. Wakabayashi. This type of crystal is thus obviously not of a rare occurrence.
5) Acicular form, resulting from a different mode of development of the same faces as the preceding type (Fig. 16). It occurs at Hisan-ichi and was first found by Y. Wakabayashi.

The first type of crystal is of very common occurrence. Since first discovered at Ogoya the second type has been found to be widely distributed, as, for instance, at Osaruzawa, Ani, Arakawa, Kusakura, Ashio, etc. The third has been observed only in chalcopyrite from Daira; some crystals from Ashio resemble this type, but their faces are curved and are not to be ascertained. The fourth and fifth types occur only at Arakawa.

The most beautiful crystals are found at **Ani,** Ugo Pr., where the mineral is associated with galena, blende, pyrites, quartz and calcite. The crystals are of the first and second types, sometimes measuring from 15 to 25 mm. in diameter. The surface of the crystals is often covered with galena.

At **Daira,** Ugo Pr., it is associated with galena, blende, quartz and calcite, and forms crystals of the third type, whose edges sometimes measure from 68 to 80 mm. (Figs. 13 and 17). The most interesting locality for chalcopyrite is **Arakawa,** Ugo Pr., where we find all types of the crystals except the third, in association with minute crystals of quartz and sometimes pyrites. The largest crystals of the fourth type attain a diameter of 60 mm. Those of the fifth type are about 35 mm. long and only 2 mm. wide. Chalcopyrite, like quartz, forms pseudomorphs of barytes ; casts of barytes on chalcopyrite are also frequently observed.

At **Osaruzawa,** the mineral most frequently accompanies quartz, and forms crystals of the first and second types, sometimes measuring 12 mm. in diameter. The mineral from Kusakura is identical with that of Osaruzawa in form. Calcite is found frequently attached to its surface.

The mineral occurs at **Ashio,** Shimotsuke Pr., with quartz or calcite, the latter sometimes covering its surface. It sometimes also accompanies apatite. Besides pyrites is also found in many cases with chalcopyrite. The crystals of the first and second types are most frequently observed, and some may belong to the third type.

The mineral occurs with quartz and sometimes with pyrites, at **Ogoya,** Kaga Pr. The crystals belong to the first and second types. It is here that we find the most perfect crystals of the second type. In some crystals grown in cavities, are found rare faces not yet determined. The surface of the crystals is often of a steel gray colour; but sometimes is coloured green with malachite.

At the well known copper mine of **Besshi,** Iyo Pr., crystals of the mineral are sparingly found in cavities of the bedded ore masses. The crystals are simple and measure only 2 to 4 mm. in diameter. Minute crystals of calcite and siderite are grown with chalcopyrite.

30. MATILDITE

The rare mineral matildite occurs at the **Nishizawa** mine, Shimotsuke Pr., with pyrargyrite and realgar in a quartz vein traversing a volcanic rock. It is a black impregnation in the vein-stone. Crystallised matildite has not yet been found.

A chemical analysis by F. Kodera gives the following results :

S	Se	Bi	Ag	Au	SiO_2	$Al_2O_3 + Fe_2O_3$
8·66	1·34	31·12	11·63	0·44	42·46	3·44 = 99·11

beside traces of Mn, Cu, and Te. The ratio of silver to bismuth is 1 : 2·6, and of silver to gold 100 : 3·7.

31. JAMESONITE

At **Kuratani,** Kaga Pr., jamesonite occurs in cavities of quartzose veins, associated with galena and rhodochrosite. This feathery mineral which is sometimes from 2 to 3 cm. in length is in generation later than the two other minerals, as is obvious from the fact that it covers the surface of the latter. It is reported to occur at Iname and Awashiro, Mikawa Pr., but its chemical composition has not yet been ascertained.

32. PYRARGYRITE

The dark ruby silver is sometimes difficult to distinguish from proustite or light ruby silver, especially when these minerals occur in minute crystals. Though the chemical nature of the mineral here named has not been determined, most of our ruby silver probably belongs to pyrargyrite. The occurrence of the mineral has been reported from Innai, Ugo Pr., Ikuno and Mikobata, Tajima Pr. It is also met with at Ōmori, Iwami Pr., Yamagano, Ōsumi Pr.

It is found at **Innai** associated with pyrites in cavities in quartzose vein-stone, and forms minute but perfect crystals. Some are in stout prisms with faces R and ∞R. Some are in long prisms with faces 0R and ∞R. The base 0R is rough and dull.

The most beautiful specimens of the mineral are found at **Mikobata,** in quartzose vein-stone. It forms minute crystals measuring only 3 to 4 mm., of a blood red colour, and resembling crystals of cinnabar. The faces are 0R and ∞R. The mineral found at Kanagase is rarely crystallised, and never so beautiful as that of Mikobata.

Pyrargyrite from **Ōmori,** Iwami Pr., is also rarely crystallised, but never well defined.

At **Yamagano,** Satsuma Pr., it is associated with native gold and argentite, and rivals the specimens from Mikobata in beauty of colour and transparency, though the crystals are smaller. The form is also identical.

33. TETRAHEDRITE

Tetrahedrite occurs at Aikawa, Sado Pr., Ikuno, Tajima Pr., Besshi, Iyo Pr., Kiura, Bungo Pr., etc.

Crystals of the mineral from **Aikawa** are tetrahedra, about 3 mm. in diameter. Their surface is rough and covered with a coating of chalcopyrite. The mineral here occurs in small quantities.

It occurs more abundantly at **Kanagase,** Tajima Pr., in minute well defined crystals in combinations of $O \cdot \infty O$ and $\frac{O}{2} \cdot \infty O \cdot \infty O \infty \cdot \frac{2O2}{2}$. They measure about 2·5 mm. in diameter.

The mineral from **Besshi,** Iyo Pr., forms minute, but fresh crystals in $+\frac{O}{2}$, sometimes truncated with $-\frac{O}{2}$. Other faces are undeterminable.

The most perfect crystals of tetrahedrite are found at **Kiura,** Bungo Pr., where occur crystal groups about 5 mm. in diameter having well defined faces of $\frac{O}{2}$. The mineral is sparing in quantity here, as well as at Besshi and Aikawa.

34. STANNITE

Stannite occurs at **Kanagase,** Tajima Pr., where it forms usually compact bronze-coloured masses mixed with chalcopyrite and tetrahedrite. It is found rarely in a pure state forming alternate bands 2 or 3 cm. thick, with chalcopyrite and bornite. On account of impurity the percentage of tin is low, being only about 17% of the whole mass.

T. Kochibe found at the **Sakura** mine, Harima Pr. the same mineral containing a large quantity of impurity.

35. STEPHANITE

Stephanite is the best crystallised silver ore found in Japan. The chief localities are Innai, Ugo Pr., Aikawa, Sado Pr., Handa, Iwashiro Pr., and Ikuno, Tajima Pr.

Both at **Innai** and **Aikawa** the mineral occurs in cavities of the vein-stone, forming hexagonal plates, 2 or 3 mm. in diameter. The faces usually observed are 0P, ∞P and ∞P$\breve{\infty}$, and rarely 0P, P and 2P$\breve{\infty}$.[1] Innai is especially rich in this type of crystals, which sometimes measure some 10 mm. in diameter. They are very often found perched among crystals of quartz in cavities of vein-stone.

At **Ikuno**, it is found forming hexagonal plates like those from Aikawa and Innai, but smaller. It occurs here only sparingly.

36. QUARTZ

Quartz is one of the most widely distributed minerals. It occurs in more or less considerable quantities in those mines which are working deposits in quartzose vein-stone. Its second home is granite which has the mineral as one of its essential constituents. The localities well known since olden time for beautiful crystals of quartz are the granitic regions around Kimpū-zan,[2] Kai Pr. It is in this region that colourless and transparent crystals for ornamental work have been obtained for centuries.

The chief mines where well crystallised quartz is found are Daira, Ani, Arakawa, Innai and Tabanematsu, Ugo Pr., Osaruzawa, Rikuchū Pr., Aikawa, Sado Pr., Ichinokawa, Iyo Pr., etc. Localities outside of mines are Obara, Iwaki Pr., the environs of Kimpū-zan, Kai Pr., Arimine, Etchū Pr., Ena-gōri, Kamo-gōri, Mino Pr., Akatsu, Owari Pr., Tanokamiyama, Ōmi Pr., Tanabe, Kii Pr., Fujiya, Hōki Pr., and Narushima in the Gotō Islands, Hizen Pr. Smoky quartz is seldom met with in Kai, while it is of frequent occurrence in Ōmi, Mino and at Akatsu, Owari Pr. Amethyst is found at Obara, Iwaki Pr., Kōshinzan, Shimotsuke Pr., Tsunagi, Echigo Pr., Fujiya, Hōki Pr., and rarely at Aikawa, Sado Pr., and at Tanokamiyama, Ōmi Pr.

The following four different types of habit are observed in crystals of quartz according to different modes of occurrence; viz.

1) *Rock crystals from mines in volcanic rocks* in the Province of Ugo have either one of the positive and negative rhombohedral

1) Rösing: Silber bergwerk Innai. Z. f. Berg.-u. Hüttenkunde. XXXII.
2) *zan* = mountain.

faces prominently developed, so as to give triangular cross sections; as those from Daira, Ani, Innai, Tabanematsu, etc.

2) In *rock crystals found in granite and older formations* neither of the rhombohedral faces is as unequally developed as in the previous type, as we see in quartz from Kai, Owari and Ōmi.

3) In *crystals from volcanic rocks* tetartohedral faces are seldom observed and the inclined twinning never.

4) The *crystals of amethyst* from different localities exhibit only a slight difference in the development of the positive and negative faces, and rarely have tetartohedral faces. The inclined twinning is never observed. They are poor in inclusions.

At **Daira,** Ugo Pr., there occur rock crystals of prismatic habit which vary from 5 to 6 mm. in diameter on the horizontal axes and measure up to 40 mm. in length. One kind of R and ∞R is prominently developed, forming a triangular prism terminating in a sharp trigonal pyramid. The other R and ∞R appear as extremely narrow faces on the edges. The crystals often contain liquid lacunæ, which sometimes seem to be arranged parallel to the faces R. The accompanying minerals are galena and blende. Minute crystals of calcite are attached.

Quartz occurs at **Ani,** in the same form as that from Daira, and is associated with chalcopyrite, galena and blende. With quartz calcite is sometimes found, forming 3R, different from the form observed at Daira. Pseudomorphs of quartz after barytes sometimes occur here, but being neither so sharp nor so abundant as those from Arakawa, they are not easy to find.

At **Arakawa,** the quartz was crystallised at a later stage of mineralisation. Beside the pseudomorphs it forms minute colourless and transparent crystals with faces of R divided into brilliant and dull sections as a result of Brazilian twinning. Such crystals are sometimes coloured purplish, wholly or on the polar end only. The second type is smoky acicular crystal groups associated with pyrites, and of a different generation.

The well-known pseudomorphs of quartz after barytes found here are of some mineralogical interest, the original crystals of barytes existing in varying forms and sizes.

1) In the most common of the pseudomorphs, barytes has been crystallised in rhombic prism, whose surfaces were covered with a coating of quartz, one or two millimetres in thickness. This afterward wholly dissolved and disappeared, leaving a hollow space behind. Quartz does not form a homogenous crystalline mass with a smooth surface but rough and porous aggregates of minute crystals mixed with crystals of chalcopyrite. The largest of the pseudomorphs measures 55 mm. in length and 30 mm. in the longer diameter of the cross section. Though many such crystals are found irregularly grouped, yet they are isolated from one another and often perfectly bounded exhibiting all the crystal faces. They are sometimes covered with groups of minute needles of quartz.

2) The second type of pseudomorphs is of a much inferior size and occurs in groups consisting of pseudomorphs of nearly equal dimensions. They are casts of simple rhombic prisms in quartzose mass.

3) The third type is found in groups in cavities of a volcanic rock. The original crystals of barytes were in combinations of 0P, $\infty \bar{P} \infty$, and $\infty \breve{P} \infty$, 5 mm. in diameter, and covered with quartz. These casts are left in the gray rock matrix after the dissolution of the crystals.

Quartz from **Innai,** Ugo Pr., forms crystals ranging from 30 to 50 mm. in length and from 10 to 20 mm. in diameter. They are usually colourless, but in rare cases take a light purple colour. The faces observed are unequally developed pyramids and prisms of both positive and negative rhombohedra. Liquid inclusions with air bubbles are sometimes observed.

At **Tabanematsu,** Ugo Pr., quartz occurs in crystals sometimes 10 cm. long and 15 mm. in diameter. They are sometimes terminated at both ends. The difference in development of the positive and negative rhombohedra is not so remarkable as in the crystals from the preceding locality.

Quartz from **Osaruzawa,** Rikuchū Pr., has hexagonal prismatic and pyramidal faces, and is only partially transparent at the top. It is associated with chalcopyrite.

Quartz from **Kamaishi,** Rikuchū Pr., is found associated with epidote, which is often enclosed in layers parallel to the faces of the pyramid. The crystals are in flattened hexagonal prisms measuring about 35 mm. in length and 15 mm. in diameter. The sharp termination in R is sometimes observed in them.

Obara, Iwaki Pr., is a locality well known for its *amethyst*, which is found in groups on a quartzose rock. The dimensions of the crystals are variable, sometimes attaining 25 mm. in length and 70 mm. in diameter. They are transparent and of a beautiful purple colour of different shades. They form six-sided prisms with one kind of the rhombohedral pyramids prominently developed, and rarely with the tetartohedral face *s* cutting the prism. Some contain negative crystals or liquid inclusions parallel to the prism.

Quartz from **Kōshinzan**, Shimotsuke Pr., forms hexagonal crystals gradually tapering at the end, making it difficult to distinguish the faces of the pyramid from those of the prism. The largest of them measure frequently 150 mm. in length and 40 mm. in diameter. They are light purple, but not beautiful in colour. Their occurrence has long been known, but they are not abundant.

The *amethyst* from **Tsunagi**, Echigo Pr., is the finest of the variety. It occurs in stout crystals measuring 2 cm. in diameter, sometimes having no ∞R. The surface may sometimes be a little dull, but the interior is of a beautiful deep purple colour.

Localities in the province of Kai, being the most noted for quartz, have been visited by many mineralogists, whose researches will here be briefly mentioned.

According to S. Sasamoto, the occurrence of quartz in the environs of **Kimpūzan** are:

1) Mukaiyama, in the upper valley of the Arakawa.
2) Kurasawa, about 12 km. NE of Mukaiyama.
3) Otomezaka, on the opposite side of Kurasawa.
4) Samusawa, 2 km. N of Mukaiyama.
5) Hachiman, 16 km. NE of Obi.
6) Gojōgoshaku, 12 km. NE of Obi.

1) Quartz from **Mukaiyama** frequently contains as inclusions epidote, and chloritic or asbestos-like substances. The forms are the positive and negative rhombohedra and prisms. The prismatic faces

are striated parallel to the horizontal axes. The etched figures are seldom observed on crystals from this locality.

2) The quartz from **Kurasawa** is rich in rare scalenohedral faces of different values, beside the common rhombohedral faces. The specimens of the inclined twins on P2 are also obtained here. The surface of crystals from the locality is covered with limonite or an earthy manganiferous substance, and, when washed, presents numerous minute etched figures. The interior is comparatively clear except for some microscopic liquid inclusions and yellowish white lamellae of chalcopyrite and a little epidote and some chloritic substances.

3) and 4) At **Otomezaka** and **Samusawa,** similar specimens are obtained. The inclined twins however occur here more rarely than at Kurasawa. Limonite is found coating the surface. The crystals from these three localities are especially noted for richness in faces and etched figures.

5) and 6) At **Hachiman** and **Gojōgoshaku** crystals with rare faces are seldom met with. They have irregular striations running not exactly parallel with one another, are elongated on the vertical axis, and generally taper, but sometimes swell slightly and gradually towards the end. One set of faces of the rhombohedron are prominently developed to the expense of the other, in a nearly triangular prisms terminating on a trigonal pyramid. Rarely the crystals are finely striated, on the prismatic faces and then they have numerous etched figures. The inclusion is limited to a little chloritic substance which forms three, four or even five successive layers parallel to the faces of the pyramid.

Colourless and transparent rock crystal occurs chiefly at Otomezaka, Kurasawa, Hachiman and sometimes Mukaiyama. The faces are usually $\pm$ R and ∞ P. The positive and negative faces, though not quite equal, are yet both well developed. Sometimes the tetartohedral faces *s*, *x* and *t* are observed on the edges between prism and pyramid. At Takemori, is observed a face of a large parameter ratio (11R?) on the crystal. Here is found a crystal with chloritic inclusions forming the so-called "**ghost quartz**" (Pl. XII, Fig. a).

There are three types of twinning in the crystals from these localities. The Dauphiné type of twinning is recognised in the form with ± R and ∞ P, by the presence of a brilliant portion (+R) and dull portion (−R) on a single R face, and further by the fact that the face *x* is below each face of R, when the face is present. In the Brazil type two faces of *x* are simultaneously present, forming trapezoids in a face R. When the face *x* is lacking, the twinning should be detected by examination of the interference figure in polarised light.

Beside these two types there is the third or the twinning on inclined axes, in which two crystals cross on the face P2, their *c* axes forming an angle of 84° 34′ with each other. Each of the individuals often forms twinning according to the Dauphiné or Brazil law. The third type of twinning is found chiefly at Kurasawa and Otomezaka, and sometimes at Hachiman; those from the last locality are easily distinguished by the characteristic ghost-quartz inclusions.

Quartz twinned according to the third law occurs in the provinces of Kai, Shinano, and Hyūga and in the Gotō Islands. The first known specimen of the twinned quartz was taken to Germany by Mohnike who seems to have bought it at Hakodate. It was described by vom Rath in Poggendorf's Annalen. Since 1895 the specimens have been abundantly obtained from Kai. The individuals are usually flattened and ratio of the width of the prismatic faces is commonly 1:3 or 1:4. Flattening is not restricted to the twinned individuals, but sometimes is also observed in single crystals. As the flattening is common in all twinned crystals both from Gotō and Hyūga, this mode of growth seems to be a particularly favourable condition for the development of the twinning. No optical anomaly has ever been observed in the flattened crystals. They are obviously due neither to a hindrance nor to a tension, for the flattened crystals may be found among ordinary prismatic crystals, and no optical anomaly has been observed in them.

The faces of the crystals from Kai are sometimes corroded. The etched figures are triangular in the middle of the faces, and furrows parallel to the edges run near the margins. When the corrosion is extreme, crystals are all rounded on the edges so as to form a cylinder terminating in a cone.

Sometimes two crystals are found accidentally crossing each other, evidently without any crystallographical significance. Some crystals are distorted like the bent crystals of stibnite from Ichinokawa. Some have a second smaller crystal grown obliquely upon a face of R. Some prismatic crystals are capped at the end like a sceptre with a second much larger crystal, grown stout and parallel to the former.

Inclusions of quartz are chiefly found at Mukaiyama and Takemori, and sometimes at Masutomi. The green fibrous inclusions are epidote, and the brown fibrous ones are tourmaline. White star-like or irregular inclusions are probably mica. Further lamellar mica, crystals of pyrites, and acicular stibnite are found among inclusions in quartz from these localities. The inclusion of beautifully yellow sulphur is limited to the quartz from Takemori. Fluid inclusions are very common, and are usually distributed irregularly throughout the crystal, sometimes in definite layers parallel to the faces of the rhombohedron. They are obviously formed by the attachment of bubbles to the faces during the successive stages in the growth of the crystals.

Minerals found in association with quartz in the localities mentioned are felspars, micas, tourmaline, garnet, apatite, scheelite, reinite and ferberite—the alteration product of scheelite—epidote, pyrites, chalcopyrite, magnetite, and arsenopyrite. Apatite was found quite abundantly in 1880, but since then it has become rare. Garnet in grains is found in felspar. Reinite is a mineral first discovered by the well known German explorer, Prof. Rein, in the province some thirty years ago, but it was not until about ten years ago that a large quantity of the tungsten-bearing mineral was obtained from Kurasawa and Otomezaka. Mica, pyrites and limonite form a dirty covering of crystals. Faces of the crystals of pyrites and mica are often revealed as scars after the removal of the coating by washing.

Quartz occurs at **Kawahake,** Shinano Pr., on the northern flank of Kimpūzan. In quality the crystals are inferior to those from Kai, most frequently being milk white, and having no *s*, *x* or other rare faces. They are usually single and perfectly bounded, and sometimes occur in irregular groups. The twins of the inclined axes are here sometimes met with.

Quartz occurs at **Kurodake**, Etchū Pr., associated with garnet and magnetite in a contact rock. The largest crystals attain a length of 10 cm. and a diameter of 10 to 25 mm. in cross section and usually are in a single form consisting of the ordinary prism and pyramid. Sometimes ± 4R, 2P2, 6P$\frac{6}{5}$, and rarely 3R are observed. Some are twinned according to the Dauphiné law. The crystals are usually transparent; round grains of hyalite are often enclosed in or attached to them.

At **Aikawa**, Sado Pr., transparent crystals are found in druses in the cavities of vein-stone. The habit is triangular by the development of one set of rhombohedra and rhombohedral prisms. A characteristic of the crystals is the inclusion of numerous negative crystals with liquid in regular forms. Amethyst is sometimes found in quartzose vein-stone. Crystals of milky white quartz with both terminations are also reported from Aikawa.

At **Sakasagawa**, Izu Pr., quartz occurs in transparent colourless crystals measuring about 30 mm. One rhombohedron and prism are prominently developed. Negative crystals are very frequently present in them.

An extensive granitic region occupying Toki-Gōri and Ena-Gori in **Mino** has many localities noted for quartz, felspar, topaz and rare minerals. Here we find beautiful *rock crystal* and *smoky quartz* in various shades.

At **Tashiro**, Ena-Gōri, we find rock crystal with brilliant faces of the tetartohedron, beside those of normal prisms and rhombohedra. Smoky quartz from **Naëgi** in the same district has also the faces x and are twinned according to the Dauphiné law. The mineral is black in colour and of a high lustre. Inclusions are unknown in the quartz of these localities.

Smoky quartz is found at **Akatsu**, Owari Pr. Some small crystals resemble those from Naëgi and Tashiro. A zonal structure of different colours is often observed in them. The outermost layer is sometimes colourless.

At **Tanokamiyama**, Ōmi Pr., rock crystal and smoky quartz occur in granite, associated with topaz, mica and felspar. The smoky quartz presents an interesting zonal structure of colourless, smoky and sometimes amethystine layers. The boundaries of the successive zones are sometimes so distinct that the different coloured layers can be separated from one another.

K. Jimbō observed in the crystals of smoky quartz from this locality ∞R, R, $2R$, $3R$, $4R$, $-R$, $-2R$, $-3R$, $-4R$, $2P2$, $+r4P\frac{4}{3}$, $+r6P\frac{6}{5}$ $+14P\frac{4}{3}$, and $+16P\frac{6}{5}$. Tetartohedral faces are seldom observed. Etched figures are not distinct.

At **Tanabe,** Kii Pr., quartz occurs in crystals terminated at both ends, one end often being capped with a second stouter rock crystal in the form of the so-called "*sceptre quartz.*"

Fujiya, Hōki Pr., is the most important *amethyst* locality in Japan. We find here also smoky quartz and rock crystal, which are however of inferior quality, specimens obtained being much worn and having common faces. A distinct zonal structure is observed in the crystals of the locality. They have usually a core consisting of layers of smoky quartz and rock crystal which is covered with an amethyst layer. Amethyst sometimes caps one end of the prismatic crystal of smoky quartz. When the former is grown upon a rock crystal, it does not form a perfectly bounded face, but appears as irregular patches upon the latter.

At **Ichinokawa** a beautiful rock crystal occurs in association with stibnite. The crystals are not perfectly developed, and leave faces partially unfilled and the edges discontinuous. Stibnite which is a mineral of a later generation than quartz, is seen entangling the crystals.

Quartz occurs with axinite at **Hajikami,** Bungo Pr. The quartz is green on account of a compact mass of inclusion, but changes to a brownish or yellow colour on long exposure. It is translucent or opaque. The crystals taper gradually so that there is no distinction of prism and pyramid.

At **Obira,** Bungo Pr., and **Yamaura,** Hyūga Pr., quartz is found with axinite and datolite. It forms minute colourless and transparent crystals, which are sometimes twinned on P2. Such twinned crystals are usually flattened, are much thinner than the crystals from Narushima, Gotō Islands, and are rarely developed in the ordinary prismatic form.

Quartz from **Amakusa,** Higo Pr., forms minute colourless and transparent crystals of brilliant lustre up to 5 mm. They are perfect and bipyramidal, and the faces of the prism are only slightly developed. They are derived from the weathering of liparite, in which they formed phenocrysts.

Narushima, in the Gotō Group, off the coast of Nagasaki, is one of the well known localities of twins of the inclined axes of quartz. Single crystals are rare. The twinned crystals are, as usual, flattened, of small size, about 10 mm. in length, colourless and transparent.

Beside the well crystallised quartz, there are compact aggregates of quartz, or siliceous matter such as ferruginous quartz, opal, and agate found at many places in Japan.

Rose quartz is found at **Gotō,** Iwaki Pr. It is a compact translucent mass of a beautiful pink colour.

Ferruginous quartz from **Hanawa,** Rikuchū Pr., occurs in compact opaque masses stained red with iron. Minute faces are seen on the surface. Some of the masses form bands or spheroidal grains composed of alternate light and dark coloured bands, which take a beautiful polish.

Chalcedony occurs at **Tamagawa,** Hitachi Pr., in botryoidal masses. It is translucent and of grayish colour. At **Natani,** Kaga Pr., it occurs in volcanic tuff, forming concretions with a stalactitic surface. At **Tsunokawa,** Etchū Pr., it forms botryoidal masses with jasper, and ferruginous quartz.

"*Soroban-ishi*" or the abacus stone is a variety of chalcedony, so named because it occurs in shapes resembling the counters of the Japanese abacus. The stones are flat biconical bodies consisting of chalcedony, with radial striations, and with either prominences or depressions on the apices. On account of its peculiar shape, this variety of chalcedony was once taken for a coral in America, and called *Palæotrochis*, until its inorganic nature was proved beyond all doubt by J. S. Diller[1]. At **Oguni,** Ugo Pr.,

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1) Origin of Palaeotrochis. Am. J. Sc. 1899. p. 157.

soroban-ishi occurs in a spherulitic liparite, whose spherulitic cavities are filled with the chalcedonic substance. It is also found at **Hasedō,** Ugo Pr., **Funame, Takanosuyama,** and **Akadani,** Ugo Pr., and **Kumidani,** Tango Pr.

Chalcedony occurs on the sea shore of **Aritonohama,** Mutsu Pr., as pebbles measuring about 30 mm. in diameter and 15 mm in thickness. The movement of the bubble in the liquid, which occupies the hollow interior is visible through a thin and translucent layer.

Jasper occurs at **Yumachi,** Izumo Pr. It forms a dark green opaque and compact mass, which has been used for ornaments as it takes a high polish.

37. TRIDYMITE

Tridymite occurs in cavities of volcanic rocks. Crystals are usually in minute hexagonal scales often in aggregates and sometimes in characteristic trillings. The localities are **Gōroyama** near Nagano, Shinano Pr., quarries near **Numazu,** Suruga Pr., **Ishigami,** Higo Pr., and **Fuke,** Satsuma Pr.

38. RUTILE

Rutile is obtained in washing for stream tin at **Takayama,** Mino Pr. It forms crystals, some of which are 30 mm. long and 18 mm. wide and 8 mm. thick. They are of a brownish red colour and dull lustre, and have only a few well defined faces. At **Besshi,** Iyo Pr., rutile is reported to occur forming masses measuring about 20 mm. in diameter.

39. ZIRCON

Zircon was detected by Y. Okamoto in the sand of the **Kilung-gawa,** Formosa, associated with gold, magnetite sand, and quartz. The mineral is in spite of its minute size easily discernible with the naked eye. It is usually in fine oblong grains of a dark colour. There is a red variety, which is larger being nearly 2 mm., and well crystallised. The faces present in such crystals are most probably

∞P, P, 3P3, and ∞P∞. A combination of ∞P∞ and 3P3 forms acutely terminated crystals, which in rare instances are bevelled at the end with small faces of the unit pyramid P. They contain inclusions which very often are arranged parallel to the c axis. The occurrence is scanty.

At **Ariho,** Tajima Pr., the mineral is said to have been sometimes found in magnetite sand. The mineral, being a frequent accessory ingredient of granite, may be detected by careful search in sand from granitic regions.

40. NAËGITE

The mineral was collected together with fergusonite by the late Y. Kikuchi from the placer tin washings near **Takayama,** Mino Pr. The latter mineral which is there found in much greater abundance than the former was identified in 1894 by chemical analysis made by T. Tamura. By the assiduity of the same chemist the other has now at length been proved to be a new mineral of some scientific interest.

It is of a dark pistacio-green, greenish gray, brown or reddish brown colour, and forms small spheroidal aggregates, on whose surface the terminal faces are imperfectly recognisable. Rarely we find minute single crystals varying from 3 to 5 mm. in length. They have prismatic, tabular or pseudo-dodecahedral habits. Approximate results obtained on rough angular measurements by T. Ogawa are

$$P : P \text{ (on the polar edges)} = 56°\tfrac{1}{2}$$

$$\infty P\infty : \infty P\infty = 90°$$

$$\text{and} \quad \infty P\infty : \infty P = 45°$$

The mineral is therefore very probably tetragonal and isomorphous with zircon. Beside the two prominent faces P and ∞P∞, a single face of ∞P has been observed on a crystal flattened on ∞P∞. The P faces are commonly convex. The trace of the geniculate twinning on P∞ has been observed in only one crystal.

Under the microscope, the mineral is transparent, grass-green, highly refractive, and when double refraction is discernible, extinguishes light parallel to either nicol. But the crystals are often almost isotropic. Their coloration is not uniformly distributed, the terminal portion being often shaded a reddish brown.

The hardness is about 7·5 and the specific gravity 4·09. The chemical analysis made by T. Tamura gives the following result :

SiO_2	UO_2	ThO_2	Ta_2O_5	Nb_2O_5	CeO_2	Fe_2O_3	CaO	MgO	H_2O
34·89	28·27	16·50	7·00	4·10	1·59	1·60	1·71	0·57	3·12 = 99·35

The mineral is thus chiefly composed of silicate of uranium and thorium, and is one as yet unknown to the mineralogists. As may be conjectured from its chemical composition, the mineral has a pronounced radio-active property. The writer here proposes to call this new member of the zircon-thorite group, "*naëgite*" after Naëgi the site of its occurrence near Takayama.

41. CASSITERITE

Cassiterite sometimes occurs in fluviatile deposits as in the provinces of Mino and Bungo, and sometimes in rocks, as in the provinces of Satsuma, Hitachi, Suō and Hyūga. It occurs usually in small quantities, the mineral being worked only in Satsuma and Hyūga. S. Kō has observed the faces, P(*s*), ∞P(*n*), P∞(*e*), ∞P∞ (*a*), 3P$\frac{3}{2}$(*z*) and ∞P$\frac{3}{2}$(*r*) common in all the crystals from these different localities.

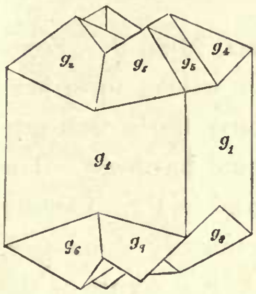
At **Suzugōya,** Hitachi Pr., the mineral occurs in a Palæozoic sandstone, which is traversed by quartzose veins with drusy cavities. The mineral forms single crystals about 5 mm. in diameter on the surface of an incrustation. It is associated with minute scales of dark brown mica, and is reported by S. Kō to be associated with magnetite, pyrites, and galena as well as mica.

The mineral occurs at **Takayama** and other placer tin districts in Mino Pr., associated with topaz, sapphire, beryl, tourmaline, quartz wolframite, fergusonite and naëgite. It appears in the form of spheroidal masses formed by cyclic twinning. Crystals are usually worn on the surface, and rarely have perfectly sharp edges. The large crystals are brownish black with quite opaque surfaces while the smaller ones are of a brownish red colour and partly translucent. The size of the crystals varies in the largest specimens from

20 to 25 mm. in diameter. The best developed faces are, according to S. Kō, *m* and *z*, and then *s*, beside which there are other more complicated faces not yet determined.

Repeated twinning on P∞, has been observed by K. Jimbō. The annexed figure shows a perfect crystal measuring 8 mm. in diameter (Fig. 18), g_1, g_2, g_3, etc. being the faces of the prism ∞P of the first, second, third, etc. individuals respectively. A zonal structure is frequently observed in thin sections.

Fig. 18.



At the tin mine of **Kiwada,** Suō Pr., cassiterite once occurred in veins traversing metamorphosed Palæozoic clayslate. The vein-stone consists of quartz with more or less pyroxene and garnet, and mineral is accompanied by magnetite, chalcopyrite, blende, and calcite, sometimes also by scheelite and fluorite. The specimens which were formerly obtained at the mine are masses with minute crystals.

Cassiterite from **Taniyama,** Satsuma Pr., occurs in quartz veins in Mesozoic clayslate, and is accompanied by pyrites, pyrrhotite, blende, and galena of secondary formation. In some specimens the mineral forms crystallised incrustations 8 mm. thick on the surface of the vein-stone. Perfect crystals are seldom met with.

At **Iwato,** Hyūga Pr., cassiterite occurs in masses mixed with limonite. Its surface is of a brown colour, and crystals have not yet been found.

At **Kiura,** Bungo Pr., it occurs in the form of minute sand without any definite crystallographical form.

42. PYROLUSITE

There occur in Japan various oxides of manganese ore whose chemical composition and mineralogical nature have not been accurately determined. It is very probable that in many cases several kinds of manganiferous ores are mingled together. The manganese ore from Niseunbetsu, Shiribeshi Pr., Ōwani, Mutsu Pr., and Numadate, Ugo Pr., is very probably pyrolusite.

The mineral from **Niseunbetsu** is of black colour and radio-fibrous, while that from **Ōwani** forms compact masses, in whose cavities radial aggregates of acicular crystals are seen. That from **Numadate** is compact or radial aggregate, sometimes with tolerably well defined crystals.

43. SAPPHIRE

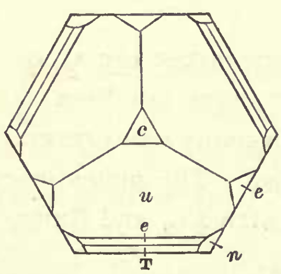
Sapphire occurs with the cassiterite at **Takayama,** Mino Pr. Some crystals are prismatic, and of gray colour, while others form hexagonal plates of a beautiful blue colour. They have fairly well preserved edges, on account of the mineral's extreme hardness. The faces observed by S. Kō are R, $\frac{4}{3}$P2, $\frac{8}{3}$P2, 0R, and ∞P2. Usually the faces ∞P2 and 0R are by far the most prominently developed, and the prismatic or tabular habit of the crystals is a result of the prominence of one of these faces. In blue tabular crystals, the colour is usually unequally distributed. They have sometimes a zonal structure of light and dark blue bands parallel to the faces of the prism, and sometimes striations perpendicular to the ∞P faces. Such crystals are usually 2 to 3 mm. in diameter.

44. HÆMATITE

Hæmatite often occurs in the contact zone of Palæozoic strata with granite. The micaceous iron ore is usually associated with magnetite, pyrites, and chalcopyrite.

At Sankaku in the **Sennin** iron mine, Rikuchū Pr., it occurs in the form of well-defined hexagonal plates of iron black colour and of a bright metallic lustre. The faces are 0P(c), ?$\frac{1}{16}$R, ?$\frac{1}{6}$R, $\frac{1}{4}$R(u), $\frac{3}{5}$R(T), $\frac{2}{5}$P(e), $\frac{4}{3}$P2(n), ∞P(m), ∞P2(a), and also a very acute rhombohedral pyramid of an unknown parameter ratio. The more prominent of these faces are 0P, $\frac{1}{16}$R, $\frac{1}{6}$R, $\frac{1}{4}$R, and ∞P, and rarely $\frac{1}{4}$R. The R faces are usually striated parallel to the edge of the prism. The stria-

Fig. 19.



tions are sometimes observed on the base. The constant occurrence of ∞P is a character of the crystal from this locality. The faces $\frac{2}{5}P$, $\frac{4}{3}P2$, and $\frac{3}{5}R$ are of rare occurrence, and are usually small, $\frac{4}{3}P2$ being most imperfectly developed.

Well crystallised hæmatite like that from Sennin has been found at **Okutsu,** Mimasaka Pr., where a few specimens of single tabular crystals have been obtained ranging from 20 to 25 mm. in diameter and about 4 mm. in thickness. The most prominent faces are 0R, with R and $\infty P2$ slightly developed.

Hæmatite from **Masaki,** Hyūga Pr., seems to be the deposit of a chalybeate spring. It forms here with limonite compact masses, covering the surface of a liparitic rock.

At **Akadani** and **Kamo,** Echigo Pr., it occurs as a contact deposit of a granite intrusion in Palæozoic rocks and sometimes also in volcanic tuffs. It forms scaly or fine granular masses without crystallographical form.

At **Isagozawa,** Rikuchū Pr., the mineral forms nests with quartzose matrix in Palæozoic radiolarian slate.

45. CUPRITE

Cuprite occurs in compact masses associated with native copper at Arakawa, Ugo Pr., Kosaka, Rikuchū Pr., and Kakinoki, Settsu Pr.

At **Arakawa** it sometimes forms in drusy cavities well defined beautifully red and transparent crystals in rhombic dodecahedra. At **Kosaka,** it occurs in crimson-red crystals in simple O, and at **Kakinoki,** there are found large masses, sometimes with well defined transparent crystals in O in the cavities.

Chalcotrichite or plush copper ore is a variety of cuprite found at **Arakawa.** It forms in cavities of other copper ores capillary crystals with a beautiful silky lustre.

46. TENORITE

Tenorite occurs at **Kosaka,** Rikuchū Pr., where the mineral forms unequally six-sided plates, 1 to 3 mm. in diameter and of a steel gray metallic lustre. The faces have not yet been determined. Earthy tenorite is reported to occur at **Arakawa**.

47. HYALITE and OPAL

Among the varieties of amorphous silica, the most interesting is *hyalite* which occurs at **Tateyama,** Etchū Pr., as a deposit of a thermal spring. It forms colourless transparent globules 2 or 3 mm. in diameter. The surface of the grains is usually dull white. They occur in masses, which are often loosely cemented together, but sometimes are quite compact and not easily separable. The mineral may even form a hyaline mass with globular structure. It is colourless and transparent when pure, but is sometimes coloured slightly yellow with impurities. Each globule, when broken, contains as the nucleus a minute grain of sand.

At **Daikonjima,** Izumo Pr., hyalite occurs in vesicular cavities of basalt forming a transparent glue-like coating on the rock. According to S. Sasamoto, it occurs at Unzendake, Hizen Pr., Tatsutayama, Higo Pr., and Onogawa near Obira, Bungo Pr.

Typical specimens of the common *opal* are found at **Bodai,** Kaga Pr., where it occurs in liparite and its tuffs. It is of a milky white or pale bluish colour, and forms stalactitic protuberances on the surface. Opal with weak iridescence is sometimes here found.

Opal from **Nihonmatsu,** Iwashiro Pr., is opaque and usually of a brown colour, and sometimes banded. Opal from **Minowa** in the same province is almost opaque, and irregularly coloured in brown and red. Of the same colour as this is the opal from **Tsuno,** Buzen Pr., while the opal from **Yoroibata** in the same province resembles that from Nihonmatsu.

48. MANGANITE

Manganite is found only at **Ōwani,** Mutsu Pr., the site of the most important manganese mine in Japan. It occurs here in cavities of other manganiferous ore masses in slender prismatic crystals of a black colour and high semi-metallic lustre. Some crystals are as much as 10 mm. in length.

49. LIMONITE

As limonite is a mineral of wide distribution, but little scientific interest, we shall here describe only a few of the more important occurrences of the mineral.

At **Akadani,** Echigo Pr., stalactitic limonite is formed as a product of the hydration of micaceous iron ore. Some stalactites are 16 cm. long. The mineral from **Yanahara,** Mimasaka Pr., is a decomposition product of pyrites and forms a mammillary or stalactitic mass. The limonite bed recently found near **Kisakata,** Ugo Pr., has impressions of the leaves and branches of dicotyledonous plants.

Pseudomorphs of limonite after pyrites are of frequent occurrence, as at Takeshi, Shinano Pr., Tabe, Nagato Pr., Kiura, Bungo Pr., etc.

At **Takeshi,** it forms simple cubes or combinations of $\infty O \infty$ and $\frac{\infty O 2}{2}$, and is of a brownish black colour. The limonite from **Tabe** is in crystals of the same form, measuring 2 to 7 mm., and of a dark brown colour and metallic lustre. Similar pseudomorphs found at **Kiura** are larger, measuring 3 to 10 mm., but are dull in lustre. Such pseudomorphs are known to occur in many other localities.

50. CERARGYRITE

Cerargyrite is a product of the alteration of sulphides of silver. At **Tsubaki,** Ugo Pr., it occurs as a gray-coloured incrustation on black quartzite. The crystals are about 2 mm. in diameter. The faces are chiefly $\infty O \infty$ with O truncating the quoins. The mineral is also found at **Nukumi,** Satsuma Pr.

51. FLUORITE

Fluorite occurs at Hosokura, Rikuzen Pr., Komatsukawa, Iwashiro Pr., Hōtatsuzan, Noto Pr., Omodani, Echizen Pr., Ikuno, Tajima Pr., Kinshōzan, Mimasaka Pr., Obira, Bungo Pr., and sometimes at Ashio, Shimotsuke Pr.

At **Hosokura** it occurs with galena and blende, forming single crystals in O. They measure about 6 mm. in diameter and are colourless.

At **Komatsukawa** it forms crystal aggregates of a light green colour. The faces O are only partly developed.

Fluorite from **Hōtatsuzan** forms light green crystal aggregates. Their interior is transparent, though the surface is rough and of a dull lustre. The faces are chiefly O, truncated with ∞O∞. Single crystals in combinations of ∞O2 and ∞O∞ are found in druses.

The fluorite from **Ishigure** forms crystalline masses consisting of bluish green, purple and colourless sections. Apices of O truncated with ∞O∞ are seen projecting on the surface.

At **Omodani,** fluorite occurs as vein-stone in abundance. In one instance it is found in crystals of a light green colour, and with faces of O and ∞O∞.

At **Ikuno** it forms colourless or light green crystals in regular ∞O∞, sometimes truncated by ∞O. They are usually single, and when grouped individuals exhibit a great portion of the faces exposed on the surface of the vein-stone. The crystals are of minute size, usually 2 to 3 mm. and rarely up to 15 mm. in diameter. They are usually translucent, but sometimes are transparent.

At **Kinshōzan,** fluorite is crystallised in O and has a zonal structure, the core being of a green colour and the outer layer light purple.

The fluorite from **Obira** is associated with hedenbergite, sometimes covering the surface of the latter. The fracture is conchoidal and of a vitreous lustre. Crystals are usually in O, and in rare cases minute ones occur in 2O. Native bismuth is found enclosed in fluorite parallel to the faces of O. A green mineral of prismatic habit is also sometimes enclosed in it.

Fluorite sometimes occurs with chalcopyrite in the **Ashio** copper mine. It forms here minute octahedral crystals, about 2 mm. in diameter, and is translucent and colourless or of a light green colour.

Light purple fluorite occurs at **Ōkita,** Sado Pr. Fluorite is further found at Tanokamiyama, Ōmi Pr., Takayama, Mino Pr., etc. but in scanty quantities.

52. CALCITE

Calcite is widely distributed in Japan. We will here describe only those localities where well crystallised specimens are to be found, such as Ani and Daira, Ugo Pr., Furokura, Rikuchū Pr., Maze, Echigo Pr., Aikawa, Sado Pr., Ashio, Shimotsuke Pr., Kamioka, Hida Pr., Akasaka, Mino Pr., Kozu-ura, Izumo Pr., etc.

At **Kayakusa** in the Ani copper mine, calcite occurs in three different forms, namely, —2R, R3 and in combinations of —2R and numerous other faces. The crystals of the first type are 10 to 20 mm. in diameter, and are either single or in groups. On their surface they have a layer about ½ mm. thick, which is rough, opaque and of a different appearance from the transparent interior. This difference is probably a result of growth under a different condition in the last stage of crystallisation, though it may possibly be due to the corrosive action of some liquid. The crystals are associated with quartz, chalcopyrite, galena and blende. Sometimes there are found identical crystals, transparent and of a brownish yellow colour. The second are aggregates of regular crystals in R3, which measure about 15 mm. in the shorter diameter and 35 mm. in the longer. Their surface has a beautifully silky lustre. The third are the smallest of the three, only up to 4 mm., and transparent and glistening. They are attached to the surface of chalcopyrite.

The calcite from **Daira,** Ugo Pr., is crystallised in well defined —½R, measuring about 6 mm. in diameter. It is colourless and translucent, and covers quartz and other minerals, with which it is in association.

Furokura is a locality noted for beautiful specimens of calcite. Here are found two different types of crystals. One kind of the crystals is in R3, of a rosy colour and has smooth faces. The crystals form well individualised groups. Some are twinned upon 0R, (Fig. 20). The other kind is also crystallised in R3, but is of far larger dimensions, often measuring 60 mm. in length. Twins upon —2R are very common in this type of crystals (Fig. 22). They are light reddish, semi-transparent, and their surface is not smooth, but reflects light fairly well (Pl. XVI and XVII).

At **Hosokura,** Rikuzen Pr., calcite occurs as a coating on rhodochrosite, which is sometimes dissolved away and partially replaced by calcite pseudomorph. The centre of such pseudomorphs is in general left hollow.

Fig. 21.

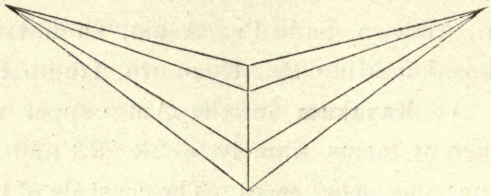


Fig. 20.

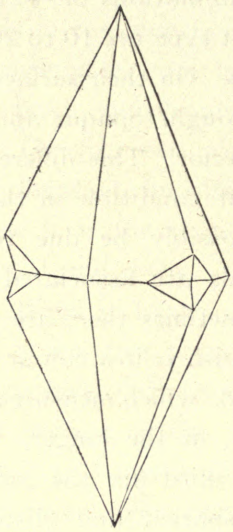
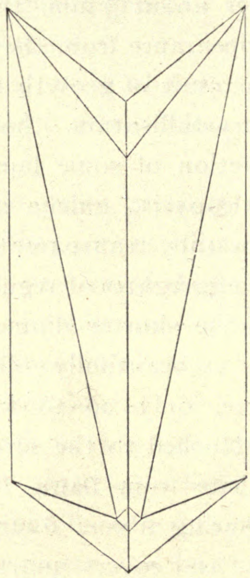


Fig. 22.



Beautiful specimens of calcite twinned upon $-\frac{1}{2}R$ occur at Hide, on the bay of **Miyako**, Rikuchū Pr. According to T. Takimoto, the mineral occurs here in Cretaceous sandstone. The faces are dull and somewhat rounded, so that the angular measurements were made by T. Takimoto with the contact goniometer and by schimmering. The angle X being the angle of the acute edges and Y of the obtuse edges, the result is

$X = 111° 40'$ (111° 38′ 45″)[1]

$Y = 120° 53'$ (130° 9′ 52″)

The form is thus evidently R7. Besides there are facettes truncating the edges.

1) The figures in brackets are those given by Kokhscharow, in Mat. z. Mineralog. Russ. Bd. VII. p. 86.

All the crystals are twinned. The suture of the twins is parallel to one of the edges made by the cleaved faces. The salient angle of the cleaved faces, not in the same zone as the twinning plane, is determined to be 141° 45′ by angular measurements with a reflection goniometer, and further the twinning plane bisects the salient angle formed by the twinned individuals. So the crystals are obviously twinned upon $-\frac{1}{2}$R (Fig. 21).

At **Maze,** Echigo Pr., calcite occurs with chalcopyrite and blende in vein-stone. It appears as well defined crystals in R3, measuring 50 mm. in the longest diameter. Their colour is white. Beside this form there are found in the locality two other kinds of calcite associated with zeolites. One kind is nearly transparent, and has a yellowish colour and vitreous lustre. The crystals are in -2R, 20 mm. in diameter, and are associated with natrolite. The other forms minute but well defined rhombohedra of $\frac{3}{2}$R, resembling cubes, also associated with natrolite in acicular forms, to which calcite is posterior in formation, and upon which it is often attached.

Calcite from **Aikawa,** Sado Pr., is associated with quartz. The forms are R, $-\frac{1}{2}$R, R3, ∞P, etc., R3 appearing singly or combined with $-\frac{1}{2}$R. The crystals vary in sizes from a few millimetres to 30 mm., and are translucent or opaque and of a white colour. Their faces are often dull. Pink-coloured manganiferous calcite is found at **Kunihirai** in the same province. It forms in druses crystal aggregates of a light red crystalline mass (Pl. XVIII, b).

Calcite from **Ōtaki,** Musashi Pr., is colourless and nearly transparent like Iceland spar. Complex faces observed on the crystals here found have not yet been accurately determined.

At **Sawada,** Izu Pr., calcite occurs in cavities in a greenish tuff of Tertiary formation. F. Ōtsuki recognised two types of habit in crystals from this locality. The larger crystals measure up to 35 mm. along the *c* axis, are colourless and transparent or translucent, and have a white coating of zeolites. The form is simply $-\frac{3}{2}$R, or a combination of $-\frac{3}{2}$R and +R. The faces $-\frac{3}{2}$R are usually curved. The smaller but more beautiful crystals are colourless and transparent, and elongated, 10 mm. in length and 3 mm. in diameter. Faces observed are R, -2R, 4R, R9, and $-\frac{13}{2}$R. The faces R9 are most perfectly developed, and are sometimes cut with $-\frac{13}{2}R$. The R9 faces have the striation parallel to the edge of R and R9. Etched hillocks are observed on the faces of $-\frac{3}{2}R$ and R. Those on $-\frac{3}{2}R$ present the form of a flat triangular pyramid. The basal triangles are isosceles and have their bases opposite to the pole. Etched hillocks on R are also flat pyramids with isosceles triangles as bases. The apex of the triangular base is directed towards the pole.

At **Ashio**, Shimotsuke Pr., it sometimes forms crystals in $-\frac{1}{2}R$, grouped or lying one upon another, and sometimes in hexagonal plates in ∞P and 0R. An interesting mode of growth from $-\frac{1}{2}R$ to ∞P and 0R is sometimes shown in the crystals of the tabular habit by the presence of an inclusion of an earthy substance in the distinct form of $-\frac{1}{2}R$. There is a third kind of crystals in extremely sharp pyramids. They are bluish in colour and translucent.

Crystals with complicated faces are found at **Kamioka**, Hida Pr. Calcite occurs here as vein-stone, in whose cavities it forms well defined, transparent or translucent, and colourless crystals. Some are large and present a combination of R, $-\frac{1}{2}R$, ∞P, etc. The others are more complex, and have $\frac{2}{5}R2$, R3, etc. in addition to those observed in the former. It is this kind of crystals that are twinned on 0R. Individuals of both kinds are very frequently found only half developed. They are often bent.

According to D. Satō, the mineral forms at **Akasaka**, Mino Pr., gigantic crystals in limestone. The faces are R and ∞R. They are often twinned on ∞R. In crevices of the limestone are formed stalactites which are mostly 12 to 20 cm. in length and 2 to 3 cm. in diameter. The free ends of the stalactites terminate in crystals of R or $-\frac{3}{2}R$. Calcite is here known to occur chiefly at three places, viz., Hanaokayama, Ōkubo, and Futatsuberi, of which the first two afford crystals.

At **Ōkubo**, we find the following three forms of crystals:

1) Combinations of $-\frac{1}{2}R$ and ∞R. The faces of $-\frac{1}{2}R$ are prominently developed at the expense of ∞R so that the crystals have flattened appearance. The size is variable, some crystals being about 10 cm. in the diameter of the lateral axes, while those most often

found are 3 to 4 cm. Zonal structure is often distinct. The R faces are striated.

2) Combinations of R2 and $\frac{2}{5}$R2. A noteworthy feature of these crystals is the mechanical destruction of the apices. The striations are seen on R2 and $\frac{2}{5}$R2 as Prof. Klockmann observed, and also on R, upon which grooves are formed as the result of solvent action on such lines.

3) Combinations of $-\frac{1}{2}$R, ∞R, and R2(?). The faces $-\frac{1}{2}$R are rendered uneven by corrosion, and have a dirty coating of calcareous substance. The faces ∞R and R2 are relatively smooth, but R is sometimes striated. They are about 25 mm. in diameter and 15 mm. along the *c* axes.

Crystals from **Futatsuberi** are in general small, measuring 7 mm. along the *c* axis, and 30 mm. in diameter. Most crystals are yellowish brown, and translucent. Rarely they are white, and nearly transparent. The forms are combinations of —2R, R, 4R, 0R and an undetermined rhombohedron. We have here to remark that T. Wakimizu's observations on the forms are at variance with those of D. Satō above mentioned. He recognised—R, —2R, $\frac{5}{2}$R, —3R, 4R and R5.

Calcite occurs at **Ikuno,** Tajima Pr., in crystals, either in combinations of ∞P and R, or in simple R. Crystals in R are also observed at **Mikobata,** Tajima Pr. They are single or superposed, and sometimes are rich in faces. **Kosenzan,** in the same province also affords beautiful crystals of calcite. Some are rhombohedra resembling cubes, and some are in combinations of ∞P and 0R, the base being best developed. The size is up to 20 mm. in diameter and 25 mm. in height. Calcite is here associated with quartz.

At **Besshi,** Iyo Pr., large crystals of calcite are sometimes found in cavities of the gangue. Their faces are however not perfectly developed, through lack of space. At **Ichinokawa** in the same province it forms beautiful crystals of $-\frac{1}{2}$R on stibnite.

Calcite was first found by M. Fujimori at **Kozu-ura,** Izumo Pr. The crystals are, according to K. Jimbō, chiefly R3(*v*) and R5(*y*) and the faces are striated and curved. R7(*o*) was determined by Y. Ōtsuki. Very often the obtuse edges of *v* are replaced by $\frac{5}{2}$R(*k*), and the obtuse polar edges by 4R(m). There are beside these faces other rhombohedra, one or two mR and two mRn, of unknown facial values, which are difficult to determine.

At **Makimine,** Hyūga Pr., calcite forms translucent crystals in $\frac{1}{2}$R· on the surface of copper ore. S. Sasamoto reports crystals in combinations of R3 and two scalenohedra.

Calcite from **Minami-mura,** near Ishigure, Ise Pr., forms —$\frac{1}{2}$R· ∞P and other combinations, and that from **Handa,** Iwashiro Pr., occurs in combinations of R2 · R in beautiful druses.

Calcite is further reported from Ōta and Naka-kawabe, Mino Pr. At **Ōta,** it occurs in tufaceous sandstone, forming crystals in R, about 15 mm. in diameter. It has an oily yellow colour and an oily lustre.

Calcite from **Naka-kawabe** forms well defined crystals in R3. It is sometimes coated with white chalcedony.

Stalactites terminating in crystals, as mentioned at Akasaka, Mino Pr., are also found at **Kiura,** Bungo Pr.

At **Bessho** and **Urazato,** Shinano Pr., there occur in Tertiary shale pseudomorphs of calcite, locally known as "*Gennō-ishi*" or hammer stone in allusion to its resemblance to a hammer. The general form of the pseudomorphs is pyramidal, but the faces are usually curved and oscillating. Many are single, but some of them cross each other, apparently form penetration twins, and sometimes they occur in groups. The size varies from 2 to more than 14 cm. in length. The form seems to belong to some monoclinic pyramid, gaylussite being referred to as the probable original mineral, which was subsequently replaced with calcium carbonate. The same pseudomorphic calcite has been reported from **Teradomari,** Echigo Pr., and the **Ponporonai** branch of the Ikushumbetsu-gawa and the **Shikaribetsu** branch of the Yūbari-gawa in the Hokkaidō.

Manganiferous calcite occurs at **Innai,** Ugo Pr. Flat rhombohedra of calcite of a straw yellow colour are here associated with quartz of the vein-stone.

In **Murakami-gōri,** Ugo Pr., the same variety of calcite occurs in a quantity sufficient to be worked for ornamental purposes. It is translucent and brownish yellow in colour. The chemical composition is according to H. Yoshida, former chemist of the Imperial Geological Survey, as follows:

CaO	MnO	FeO	MgO	CO_2
50·47	5·22	1·08	trace	43·45 = 100·23

53. DOLOMITE

Beside the compact massive form there occurs crystallised dolomite at **Innai,** Ugo Pr., where it appears in $-\frac{1}{2}R$ in druses of the vein-stone. At **Machiya,** Hitachi Pr., crystalline dolomite of a gray colour forms veinlets in peridotite. It has no crystallographical faces, except the cleavage planes.

The analyses of the mineral made by T. Haga at the Chemical Institute of the Imperial University of Tōkyō, are:

	CO_2	SiO_2 and Insoluble matter	Oxides (Chiefly oxides of iron)	CaO	MgO	Na_2O	K_2O	sum
No. 1	44·73	2·43	2·71	31·37	16·98	0·45	0·95	99·62
No. 2	44·73	2·54	2·45	31·25	16·93	0·43	1·01	99·34
No. 3	44·66	2·51	2·51	31·31	16·91	0·46	0·99	99·35
Average	44·71	2·49	2·56	31·31	16·94	0·45	0·98	99·44

Besides traces of P_2O_5 and Mn_2O_3.

54. MAGNESITE

Magnesite is found at Arakawa, Ugo Pr., and Machiya, Hitachi Pr., in a white earthy form.

The analysis of the mineral from **Arakawa** made by K. Tōjō is

CO_2	MgO	CaO	FeO_3, Al_2O_3 & P_2O_5	SiO_2	H_2O
47·34	38·40	8·97	4·65	0·13	0·21 = 99·70

At **Kuratani,** Kaga Pr., it forms aggregates of round grains, about 2 mm. in diameter and of a gray colour, on the surface of the ores.

Magnesite occurs also in talcose rock as sporadic single crystals at **Besshi,** Iyo Pr., **Uryūno,** Tosa Pr., **Kamesaku,** Hitachi Pr., etc.

55. SMITHSONITE

Smithsonite does not appear in distinct crystals. At **Mozumi,** Hida Pr., it forms a gray incrustation on the ore and at **Kamioka,** Hida Pr., white fibres, coloured slightly yellow. Here it sometimes coats calcite, and forms a kind of pseudomorph after calcite on the disappearance of the latter. It forms botryoidal masses of a yellow or gray colour at **Hosokura**, Rikuzen Pr.

56. RHODOCHROSITE

Rhodochrosite is met with as a vein-stuff in districts of younger volcanic rocks.

At **Ponshikaribetsu**, Shiribeshi Pr. are found beautiful rhombohedral crystals of rhodochrosite, sometimes measuring more than 30 mm. They are often grouped. Some specimens bear the proof of cementation of broken crystals in the course of subsequent growth.

As before mentioned, rhodochrosite from **Saimyōji**, Ugo Pr., is associated with alabandine. The crystals are beautiful like those from Ponshikaribetsu, and have a bright rose colour.

At **Innai**, Ugo Pr., rhodochrosite, as the last member of mineralisation, appears in minute crystals of a rose colour.

At **Kuratani**, Kaga Pr., are found beautiful specimens of the mineral. It forms here flat rhombohedra whose faces are so curved as to form radial and somewhat petalloidal groups. It is associated with jamesonite.

57. SIDERITE

Siderite is not known in Japan to occur as a rock mass, and is limited to certain mineral veins of younger volcanic rocks. It is usually found in cavities of vein-stones in minute crystal aggregates, and hence rarely has well defined faces.

It occurs at **Akadani**, Echigo Pr., with hæmatite, on whose surface it forms minute but regular rhombohedra of a light brownish yellow colour.

At **Ashio**, Shimotsuke Pr., siderite forms aggregates of minute brownish crystals with curved faces. The mineral is found in small quantities.

At **Ōmori**, Iwami Pr., it forms aggregates of rhombohedra, whose edges alone are visible. It is of a yellowish brown colour and regular form.

At **Uchinokuchi**, Bungo Pr., we find siderite in rhombohedra with curved faces, aggregated with pyrites.

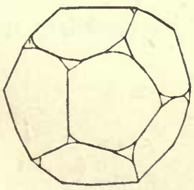
Siderite also occurs replacing wood in diluvial gravel beds in the environs of Tōkyō, as at **Shibuya**, where are found concretionary masses of siderite preserving the original form of the wood.

58. ARAGONITE

Aragonite does not occur in Japan in crystals.

At **Taira**, Shinano Pr., there occurs a variety of the mineral in globular form known as "*Arare-ishi*" or hail-stone. According to K. Jimbō, who visited the locality, the balls are found in hot springs. They have a concentric and radial-fibrous structure with a nucleus of some rock-fragments, similar to the hyalite from Tateyama. The size varies from very minute grains to large globules, about 4 cm. in diameter. The balls occur as minute grains, but larger ones assume a curious dodecahedral form in which the edges are quite rounded and the pentagonal faces slightly depressed in centre (Fig. 23). This peculiar form seems to be due, according to N. Fukuchi, to the growth of globules nearly equal in size, piled up in their most stable position.

Fig. 23.



There is a difference in the chemical composition of the mineral in the centre and in the outer layer, as is shown by the following analysis of H. Yoshida:—

		CO_2	CaO	MgO	MnO	Fe_2O_3 Al_2O_3		SiO_2	Sum
I	Centre	43·24	51·95	2·99	—	1·78		—	=99·96
	Outer	39·02	55·96	4·46	—	0·48		—	=99·92
II	Centre	43·20	48·96	0·36	7·11	0·29	Trace	0·02	=99·94
	Outer	lost	53·37	0·25	2·61	0·10	Trace	Trace	....

From these results it is evident that the carbonic acid is partly lost after long exposure to the air, the difference amounting to about 4% ; also the quantity of manganese, present in the second specimen, is more than 4% greater in the centre than in the outer layer.

Beside this globular form, aragonite is found as a sinter-like incrustation of a pale pink colour.

At **Kashio**, Shinano Pr., the mineral occurs as a mammillary incrustation, consisting of layers in light and dark brown colours. The polished face exhibits the beautiful banded structure of the layers.

Aragonite from **Mutsure**, Nagato Pr., occurs in cavities of basalt in semi-spheroidal masses about 5 mm. in diameter. They have a radio-fibrous structure. Globular aragonite like that from Taira, but of a more minute size, is found at **Ichinokawa**, Iyo Pr., in sparing quantities.

Aragonite is found at **Ikao**, Kōzuke Pr., **Kwankaiji**, Buzen Pr., and **Aso**, Higo Pr., where it forms in aqueducts of thermal springs an incrustation with a fibrous structure.

At **Kanayama**, Hitachi Pr., a beautiful specimen of *flos-ferri* or *Eisenblüthe* was found by N. Matoba. It forms arborescent groups of delicate interlacing stems of a snow white colour, thus resembling a coral.

A scaly massive form of aragonite known as *Schaumkalk* occurs at Arata near **Myōken-zan**, Harima Pr. It is milk white and has a pearly lustre like that of an oyster shell.

59. WITHERITE

Witherite occurs at **Tsubaki**, Ugo Pr., in white radial aggregates. It is sometimes crystallised in apparently hexagonal prisms formed by penetration trilling of rhombic prisms and terminating in basal pinacoids and sometimes in apparently hexagonal pyramids, which are also in reality penetration trillings of rhombic pyramids, often bevelled by a blunt pyramid on the poles.

60. CERUSSITE

Cerussite occurs at Arakawa, Ugo Pr., and Mozumi, Hida Pr., and also at Kosaka, Rikuchū Pr., and Obira, Bungo Pr. The mineral occurs in identical forms in trillings and fibrous masses. The faces observed are $m = \infty P$, $p = P$, $k = P\breve{\infty}$, $b = \infty P\breve{\infty}$, and $a = \infty P\bar{\infty}$.

At **Arakawa** there are found two habits of twinned crystals. One kind is white, translucent, and without lustre, P having chiefly developed, and forming by trilling seemingly hexagonal pyramids. The other has the faces *m*, *p*, *k*, *b* and *a*, and forms six-rayed stellate trillings with open spaces between the re-entrant angles. Some of the crystals are single and tabular, the best developed faces being $P\breve{\infty}$. They are transparent and lustrous, and smaller than the first type, measuring about 20 mm. in diameter. There is besides a fibrous form of cerussite with a high silky lustre.

Cerussite is found at **Kosaka** in six-rayed trillings which have the same faces (viz. *p*, *b*, *m*, and *k*) as those from Arakawa.

At **Mozumi,** Hida Pr., it forms fibrous aggregates of a white colour and silky lustre. The fibres are in compact or loose groups, the latter being beautiful but apt to crumble. Stellate trillings are here rarely met with, the crystals presenting the faces *p*, *m*, *k*, and *b* like the faces seen in those from Arakawa.

At **Obira,** Bungo Pr., there occur flattened prismatic crystals of a white colour, up to 20 mm. in length. The faces are not distinct.

61. MALACHITE

Malachite is usually found in botryoidal incrustations, rarely in fibrous aggregates. The fibrous variety is known to occur at **Arakawa,** Ugo Pr. It is deep green and of silky lustre, and forms beautiful tufts grouped on the surface of other copper ores. We find here also botryoidal malachite of compact structure. The compact botryoidal variety occurs further at Ani, Ugo Pr., and Shōgawa, Hida Pr.

62. AZURITE

Like malachite, azurite occurs associated with other copper ores as their oxidation product. It occurs usually in earthy form or minute crystal aggregates, and rarely tabular crystals. It has a beautiful azure-blue colour. As azurite and linarite have the same colour and one may easily pass for the other, it seems that what was really the latter mineral was taken for a time for azurite.

Azurite from **Kamegatani,** Etchū Pr., forms azure-blue translucent tabular crystals. The faces are difficult to determine.

At **Hiyoshi,** Bitchū Pr., it occurs as thin incrustations of a blue colour.

63. PSILOMELANE

This manganese ore occurs in different geological formations, sometimes in workable quantities. As it is however of but slight mineralogical interest, we shall mention only two localities, **Numadate,** Ugo Pr., where it forms compact radio-fibrous aggregates of a black colour, and **Ikeda,** Mino Pr., where it occurs in black compact botryoidal masses.

64. ASBOLITE

An earthy cobalt containing manganese, iron and alumina is found as a cementing material of the river gravel in the neighbourhood of **Seto,** Owari Pr. The original mineral, from which the cobalt was derived, is however unknown. Cobalt has also been extracted by I. Iwasa from the residue from the precipitation of copper in the copper mine of Besshi, Iyo Pr.

65. BARYTES

At Osaruzawa, Tsubaki, Aikawa, etc., there are found well crystallised specimens of barytes. The faces observed are $\infty P\bar{\infty}$ (a), $\infty P\breve{\infty}$ (b), $0P$ (c), ∞P (m), $\infty P\breve{\tfrac{3}{2}}$ (N), $\infty P\breve{2}$ (n), $P\bar{\infty}$ (u), $\frac{1}{2}P\bar{\infty}$ (d), $\frac{1}{4}P\bar{\infty}$ (l), $P\breve{\infty}$ (o), $\frac{1}{2}P\breve{\infty}$ (φ), P(z), $\frac{1}{2}P$(r), and $P\breve{2}$(y).

At **Ponshikaribetsu** in the Hokkaidō, it forms rhombic crystals of tabular habit. Their surface is often covered with a thin crust of earthy matter. The faces are $0P$ and ∞P.

Tsubaki, Ugo Pr., is one of the chief localities of barytes. The locality has been visited by S. Sasamoto, S. Kō, and T. Takimoto. According to the last observer, the crystals of barytes here found differ in habit from tabular crystals of other localities. The form is simple and the faces determined are *c*, *b*, *a*, *o*, *d*, and *m*. The principal distinction is the development of *c*, *a* and *b*, and the prominence of *a* above *m*. The simplest form is a combination of *c*, *a*, *m* and *o*, *d* and rarely *b* being added to these faces. It has a prismatic habit, resulting from the development of *a* and *m* (Fig. 24).

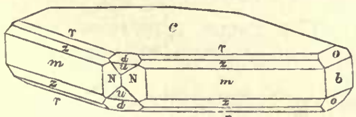
The angles measured are

o : *o* = 109° 28′ (105° 24′ 40″)[1]   *m* : *m* = 78° 16′ 36″ (78° 18′ 46″)
d : *c* = 141° (141° 9′ 55″)

The *c* faces are large and well reflect the light. The *a* faces do not reflect and are vertically striated. The *c* faces reflect well, but are uneven. The *m* and *b* faces reflect light fairly well. They are in general colourless and transparent, but the larger crystals are white and translucent.

According to the same observer, there occur at Osaruzawa two kinds of crystals. One is found in the tunnel on the way to Akazawa. The mineral here forms a vein, in whose cavities crystals are found covered with brown ferruginous earth. The other and smaller of the two occurs on quartz or marcasite, in the Tatsuana-lode of the Akazawa mine.

Fig. 24.



The faces determined on the first kind are (Fig. 24) $0P(c)$, $\infty P\breve{\infty}(b)$, $\infty P\bar{\infty}(a)$, $\infty P(m)$, $\infty P\breve{\tfrac{3}{2}}(N)$, $P\bar{\infty}(u)$, $\tfrac{1}{2}P\breve{\infty}(d)$, $P\breve{\infty}(o)$, $P(z)$, and $\tfrac{1}{2}P(r)$. The angular measurements give the following results:

o : *o* = 105° 20′ 7″ (105° 24′ 40″)[2]   *d* : *u* = 160° 35′ 12″ (160° 40′ 45″)
z : *m* = 154° 19′ 30″ (154° 18′ 30″)   *N* : *m* = 169° 30′ (169° 21′)
d : *c* = 141° 1′ 26″ (141° 9′ 55″)   *r* : *m* = 41° 40′ (41° 44′ 52″)
m : *m* = 78° 13′ 30″ (78° 18′ 46 ′)

1) The figures in the brackets are Kokhsharow's results.

2) The figures in the brackets are those given by Kokhsharow.

The faces usually observed are *o*, *z*, *m*, and *c*, and next to them *d*, *a*, *p*, *m*, *u*, *d*, *o*, and *z* reflect light well. Zonal structure is observed on the *c* face.

The most common are simple combinations of *o*, *m* and *c*, of *o*, *m*, *c* and *z*, and sometimes of *o*, *m*, *c*, *z*, and *b*. Rarely there is a complicated combination of all faces except the *a* face (Fig. 24).

In the writer's collection, the largest crystal from this locality is 45 mm. in the longer diameter, 35 mm. in the shorter and 7·5 mm. in thinckness. Fewer faces are observed in the smaller crystals found at Akazawa. The usual from is a combination of *m*, *c*, and *o*, rarely with *d* in addition. In size they run up to 9 mm. in the shorter diameter of the rhombic section, 7 mm. on the edge of *m* and *c*, and 1·5 mm. along the vertical axis. The *c* faces are in general covered with a blackish substance. The other faces reflect the light fairly well, like those of the former habit.

Barytes from **Kosaka**, Rikuchū Pr., forms rhombic crystals of tabular habit, in which the faces observed are $0P$, $P\breve{\infty}$, $\frac{1}{2}P\bar{\infty}$, $\infty P\bar{\infty}$, $\frac{1}{2}P\breve{\infty}$, and $\infty P\breve{\infty}$.

Barytes occurs at **Arakawa**, Ugo Pr., in groups of crystals in the same form about 7 mm. in the longer diameter. They are colourless and transparent.

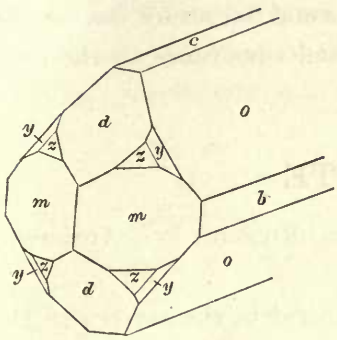
Barytes from **Innai** also appears in simple rhombic tabular crystals with the faces *c* and *m*, and is white and translucent. The same form of crystals is reported from **Ani**, Ugo Pr.

Barytes from **Komaki**, Rikuchū Pr., forms on pyrites colourless and transparent crystals of the same habit. The faces observed are *c*, *m* and *d*.

The barytes from **Kusakura**, Echigo Pr., is associated with chalcopyrites, of the same habit, and forms milk white crystals measuring 60 mm. in the longer diameter. The faces are *c*, *m*, *d* and *o*.

Aikawa, Sado Pr., is one of the important localities of well crystallised barytes. According to K. Yamada the mineral is found here at two different places in the mining district. One is Nakayamatōge, where it occurs as a cementing material in crevices of sandy-clayey nodules in Tertiary strata, and as isolated crystals in the detrital earth on the hill slope. The crystals thus found in the earth

Fig 25.



are remarkably rich in the rarer faces, such as $\infty P \bar{\infty}$ (*a*), $\infty P \breve{\infty}$ (*o*), $0P$ (*c*), ∞P (*m*), $\infty P \bar{2}$ (*n*), $P\bar{\infty}$ (*u*), $\frac{1}{2}P\bar{\infty}$ (*a*), $\frac{1}{4}P\bar{\infty}$ (*l*), $P\bar{\infty}$ (*o*), $P\breve{2}$ (*y*), P (*z*), and one pyramid and one brachydome, not determined (Fig. 25). Of all these faces, *m*, *d* and *o* are prominently developed, often at the expense of the other faces. All the crystals are elongated in the direction of the brachy-axes, one end alone being well preserved. This fact makes it probable that the crystals were originally formed in druses, from which they were subsequently detached by destruction. They are colourless and transparent when pure, but usually are a pale yellow and have the faces more or less dulled by the attrition of the sand in which the crystals have been embedded.

Barytes has been obtained from the Aikawa mine itself. According to the same observer, a specimen from Takatō-jiki, preserved in the Mining School, is more than 70 mm. long and about 15 mm. wide. It is translucent and of a yellowish colour. The faces are *c*, *d*, *u* and *φ* ($\frac{1}{2}P\breve{\infty}$). A beautiful crystal from the same gallery has been shown in Pl. XVIII, a. According to K. Jimbō, the faces most prominently developed are *c* and then *m*, *b*, *o* and *u*, and *d* in mere lines. The base is finely striated parallel to the lateral edge of *z*. A tendency towards the formation of vicinal faces is observed on the face.

In the writer's collection there is beside these a pale greenish and translucent crystal of tabular habit, measuring 130 mm. in the longer diameter and 86 mm. in the shorter, associated with pink-coloured manganiferous calcite (Pl. XVIII, b). The faces are *c*, *m* and *o*. The crystals consist of numerous subindividuals.

Barytes from **Kuratani,** Kaga Pr., appears in rhombic tabular crystals, sometimes truncated on the acute angles. The forms are combinations of *c*, *m*, *u*, *o*, *d*, etc., and the size runs up to 6 mm. in the longer diameter and 10 mm. in thickness. Some are colourless and transparent, and others blackish and translucent, while some are quite opaque and very dark coloured on account of the inclusion of the feather ore. Some have a distinct zonal structure due to the alternate light and dark coloured shells, and sometimes to the presence of thin reddish layers.

66. ANGLESITE

Anglesite is known to occur at Kosaka, Rikuchū Pr., Arakawa, Ugo Pr., Mizunashi-jiki, Echizen Pr.

At **Kosaka** it occurs as a secondary mineral in the cavities of the vein-stone. Single well-defined crystals, less than 6 mm. thick, form groups on an incrustation of the crystalline aggregates of the same mineral lining the cavities. The forms are the simple combinations of $P\bar{\infty}$ and ∞P.

The mineral has been recently found at **Arakawa.** It here forms prismatic crystals, about 35 mm. long. They have rough faces and many cracks in the interior, and are translucent and of a dark gray colour. The crystals are elongated along the vertical axes, and terminate in macrodome and base, the faces being $\infty P(m)$, $P\bar{\infty}(d)$ and $0P(c)$ respectively. According to N. Fukuchi, the angles are $m:m=76° 25'$ and $d:d=78° 55'$.

At **Mizunashi-jiki** it appears in colourless transparent crystals, attaining 8 mm. in diameter. The faces are simple like those of the mineral from Kosaka.

67. WULFENITE

Wulfenite was first found by S. Sasamoto at the **Sennō** mine, Echizen Pr. It forms orange-yellow scaly crystals of an adamantine lustre. They are minute in size, tabular in combination of prism and base; rarely with a very flat pyramid in addition.

68. SCHEELITE

Scheelite occurs in Japan in association with quartz in druses of granite in the Province of Kai. It occurs further with copper and lead ores at Kamioka, Hida Pr., Sakura, Tamba Pr., Ikuno, Tajima Pr., Ofuku and Yakuōji, Nagato Pr., and Sannotake, Buzen Pr.

From **Sannotake**, a few crystals of the mineral were found in 1885 by the late I. Iwasa. It was however through rediscovery by S. Kō that a large number of perfect crystals were brought from that locality. The mineral was discovered by S. Sasamoto from quarries of

Fig. 26.

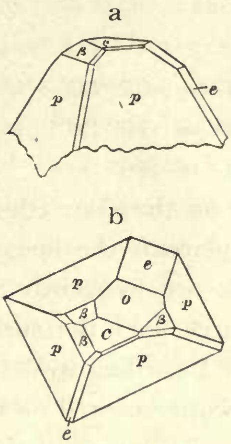
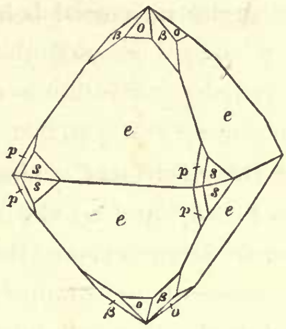


Fig. 27.



rock crystal in the Province of Kai. The forms of scheelite found in Japan are $\infty P\infty\,(a)$, $0P(c)$, $P(p)$, $\frac{1}{3}P\,(\beta)$, $3P3(s)$, $P\infty\,(e)$, and $\frac{1}{2}P\infty$ (o), as shown in the cuts (Fig. 26 and 27).

There are two localities of scheelite in Kai. One is the site of the first find by S. Sasamoto at **Sakasagawa** in Kami-Kane-Mura. The mineral occurs here in yellowish crystals with rough faces, but recently translucent brownish yellow crystals with smooth faces have been found here. They are in combinations of *p* and *c*.

The second are the well known places, **Otomezaka** and **Kurasawa,** situated in the upper valley of the Arakawa. Scheelite is here associated with pyrites, chalcopyrite, galena, blende and arsenopyrite in quartz veins traversing the granite of the region. As an alteration product we find the black ferberite, a tungstate of iron, in place of the tungstate of lime. Reinite as named by Luedecke is nothing but pseudomorphs of scheelite replaced with the black massive compact tungstate of iron. The true ferberite occurs side by side with Luedecke's reinite in radio-fibrous aggregates of prismatic crystals of a black colour and of submetallic lustre.

Unaltered scheelite is chiefly found at Otomezaka and Kanayama.

The fresh scheelite is translucent and of a yellow or light oily-brownish colour, and sometimes well crystallised. T. Takimoto identified by angular measurements with the contact goniometer the following five faces :

$p = P$	$\beta = \frac{1}{3}P$	$c = 0P$
$o = \frac{1}{2}P\infty$	$e = P\infty$	

The angles measured being

$p : p' = 80°$	$c : o = 37° 30'$
$c : p = 65°$	$o : e = 19° 30'$
$c : \beta = 36°$	$e : p = 40°$

P is the chief faces, replaced by narrow *e* on the polar edges. Of the two faces *β* and *o*, the former is usually much the larger, but the reverse is sometimes the case. Crystals are frequently yellow and translucent or opaque, with rough faces, and the surface is partly altered into a yellowish green powder. According to Y. Ōtsuki, interesting naturally etched figures of microscopic as well as macroscopic sizes are often detected on the *p* faces. They present the form of a scalene triangle. The results of analyses of this scheelite are as follows :[1]

	SiO_2	CaO	WO_3	FeO
I	9·018	17·049	72·519	0·472=99·048
II	4·182	16·062	74·780	3·183=98·007

SiO_2 is the chief impurity present, and the content of iron is very low in all the specimens.

Scheelite is found at **Kamioka** in the residue of the washed ore. The crystals, when detected among crushed grains, rarely preserve some of the *p* faces. They are white and opaque, sometimes having a thin coating of a black colour.

Scheelite has been recently found by M. Abe at **Kanagase** in the Ikuno mine. It appears in minute crystals of a brownish yellow colour in the cavities of the vein. They are transparent and have fresh faces well reflecting the light. Numerous faces beside *p* are seen, but are not determinable on account of their minute size.

At **Ofuku**, Nagato Pr., there occur scheelite and cupro-scheelite in metalliferous deposit formed in the contact zone of Mesozoic rocks

1) These analyses were made at the Mining Institute of the Engineering College, Tōkyō.

and granite. The minerals in association are chalcopyrite, pyrrhotite, calcite, quartz, orthoclase, actinolite, garnet, and lievrite, while malachite, chrysocolla, azurite, bornite, and cupro-scheelite are of the secondary formation. Scheelite is white and translucent, and has a vitreous or adamantine lustre. Cupro-scheelite is an alteration product derived from scheelite by the replacement of lime with copper. Accordingly there are crystals of different shades of green, graduating from dark green to light greenish, according to the larger or smaller amount of the replacing copper. Cupro-scheelite has a lower specific gravity than ordinary scheelite. Both the crystals are sometimes 6 cm. long. The faces observed are P(*p*), $\frac{1}{3}$P(*β*), ∞P∞(*e*), $\frac{1}{2}$P∞(*o*) and 3P3(*s*), *e* being most prominent though small, but both constantly present. The face *s* is relatively large, and horizontally striated (Fig. 27).

Scheelite has been reported to occur at **Yakuōji**, in Ayagi-Mura, associated with chalcopyrite in diorite.

According to S. Kō, scheelite from **Sannotake**, Buzen Pr., occurs in a copper deposit formed by the contact of amphibole-granite and marmorised limestone. The minerals associated in the deposit are chalcopyrite, pyrites, molybdenite, garnet, actinolite, epidote, wollastonite, orthoclase, quartz, calcite, bismuthinite, and scheelite. The two first named sulphides are of the latest formation, and scheelite is the next new mineral. It is often of a dark brown or black colour, due to partial alteration into reinite. It has then a dull vitreous lustre, and is semi-translucent. The fresh specimens are white, translucent, and have an adamantine lustre. Cleavage parallel to the base is perfect. The faces determined are P (*p*), $\frac{1}{3}$P(*β*), P∞(*e*), $\frac{1}{2}$P∞ (*o*), 3P3(*s*), and 0P(*c*). Of the faces, *p* is prominently developed. P∞ is on the contrary very imperfect and small, though it, like *e*, is present in all crystals (Fig. 27). In very rare cases the relative dimensions of the two faces are reversed. All the other faces are insignificant and but rarely appear. Crystals are sometimes as large as 9 cm. in length, and vary commonly from 3 cm. to 6 cm.

The composition of scheelite from Sannotake is as follows :

	CaO	FeO	WO_3	Fe_2O_3	Al_2O_3	Mn_2O_3	Insol.	
I	29·33	0·66	69·76	—	—	—	—	=99·75

II	18·50	—	78·05	2·01	0·18	0·50	0·56 = 99·80
III	19·433	0·141	79·996	—	—	—	— = 99·569

I. Iwasa who made the first analysis and gained the result (I), of the above table and calculated the formula $5CaO \cdot 3WO_3$. At the writer's request the doubtful mineral was later analysed by J. Takayama, whose results were as in II, demonstrating the mineral to be ordinary scheelite. The analysis (III) since made in the Imperial Geological Survey gives almost the same results as those by J. Takayama.

69. FERBERITE and REINITE

As above mentioned, iron tungstate is a product of the replacement of lime with iron in scheelite. It occurs in two forms at **Otomezaka** and **Kurasawa.** One is of a brownish black colour and has a submetallic lustre. It forms radial columnar aggregates of prismatic crystals. The other forms black compact masses giving an earthy fracture. It is this latter form of iron tungstate which assumes more often the form of scheelite and has been named by K. v. Fritsch "*reinite*" after Rein, the discoverer of the mineral. The specimen obtained by Rein is a pyramidal crystal with the lateral edges 45 mm. long. The chemical composition by E. Schmidt is

FeO	WO_3	
24·33	75·47	= 99·80

The calculated result from $FeWO_4$ being FeO 23·68 and WO_3 76·32. According to Luedecke, the mineral appears in tetragonal pyramids, P being truncated on the polar edges with the pyramid of the second order P∞. From the angles of the polar edge 103° 32′, he calculated the axial ratio 1 : 1·279. The specific gravity is 6·640.

This mineral was not afterwards found until a few years ago, when at Kurasawa a quantity was obtained together with scheelite. There were found beside this form of pure iron tungstate specimens of crystals of scheelite in intermediate stages of replacement, having iron and calcium in variable ratios. There are reasons for believing, as K. Jimbō has shown, that the reinite of K. v. Fritsch is a pseu-

1) Otto Luedecke: Ueber Reinit etc. N. Jahrbuch f. Mineralogie. etc. 1879. s. 286.

domorph of iron tungstate after scheelite and not a new mineral of tetragonal system.

It is however not only the compact massive reinite that assumes the form of scheelite. We have also pseudomorphs of divergent columnar aggregates of ferberite after scheelite (Pl. XIX, b). In some specimens there appear minute tabular-prismatic crystals terminating in a sharp chisel-like edge, as already observed by K. Jimbō. The form, though too minute for accurate measurements, strongly suggests certain crystals of wolframite, tabular parallel to $\infty P \bar{\infty}$, and terminating in $-\frac{1}{2}P\bar{\infty}$ and other domes. The specimen analysed by F. Kodera gave WO_3 75·214 and FeO 24·372, beside MnO 0·185 and trace of MgO. The specific gravity is 7·079 ; the hardness is 4.

Thus we have here a naturally crystallised tungstate of iron presenting many characters in common with the ferberite of Breithaupt. We recommend therefore that the name "*reinite*" be limited to that pseudomorphic, compact massive variety of tungstate of iron, and that to the whole be applied the name ferberite which is found to answer the extreme member of the hübnerite-wolframite group.

S. Kō has reported an occurrence of reinitic pseudomorphs after scheelite from **Sannotake,** Buzen Pr.

70. WOLFRAMITE

Some years ago, a dozen crystals of wolframite were found at **Takayama,** Mino Pr., in stanniferous river sand. They are in some cases perfectly bounded with the faces of $\infty P \cdot \infty P\bar{\infty}$ and in others with faces of $P \cdot P\bar{\infty}$. The mineral is brownish black in colour, and has a metallic lustre. Topaz is sometimes found attached to wolframite.

At **Ashio,** Shimotsuke Pr., wolframite occurs in association with quartz and chalcopyrite, in thin lamellar crystals about 7 mm. wide, and of a high metallic lustre. It is here found only sparingly.

At **Kanagase** in the Ikuno mine, it appears in cavities in the same form of lamellar crystals, though in smaller sizes.

At **Hayasaki** in Yakushima, it forms tabular crystals associated with quartz. The crystals are not well defined.

71. LINARITE

Linarite occurs at Arakawa, Ugo Pr., Kosaka, Rikuchū Pr., Kawai, Iwashiro Pr., and Kamioka, Hida Pr.

Linarite from **Arakawa**, forms azure-blue transparent crystals of flattened habit. The size runs up to 20 mm. in length. According to N. Fukuchi, the faces observed are $0P(c)$, $\infty P\bar{\infty}(a)$, $2P\bar{\infty}(u)$, and $\infty P(m)$, besides a macrodome $mP\bar{\infty}$ and two pyramids. The faces *c*, *a* and *m* are well developed, smooth and brilliant; *u* is smaller, while $mP\bar{\infty}$ is large but dull. The results of angular measurements by T. Takimoto and N. Fukuchi are

$c : a = 102° 38' \tfrac{1}{2}$ (102° 37′) $m : a = 120° 43'$ (120° 51′)
$u : a = 127° 37'$ (127° 29′) $mP\bar{\infty} : a = 107° 28'$

It is not certain whether the face $mP\bar{\infty}$ be $P\bar{\infty}(s)$ or $\tfrac{3}{2}P\bar{\infty}(x)$. The two pyramidal faces are curved and unfit for measurement.

The analysis made by T. Tamura gave the following results:

CuO	PbO	SO_3	H_2O	Fe_2O_3
19·08	55·52	19·94	5·35	0·18 = 100·07

Linarite is found at **Kosaka** in crystals larger than those from Arakawa. The mineral is however rarer and has not yet been investigated.

At **Kawai**, Iwashiro Pr., linarite appears in identically the same form, associated with quartz, malachite and barytes.

According to T. Ogawa, linarite occurs at **Kamioka**, Hida Pr., sometimes in the same larger crystals as above mentioned, but more frequently in radio-fibrous aggregates of azure-blue crystals, associated with chrysocolla. The fibres are less than 10 mm. in length and 0·5 mm. in thickness. The faces recognised under the microscope in comparison with those of linarite from Argentine[1)] are $\infty P(m)$, $P\bar{\infty}(s)$, $P\breve{\infty}(r)$, $\tfrac{3}{2}P\bar{\infty}(x)$, $0P(c)$, $\infty P\bar{\infty}(a)$, $2P\breve{\infty}(u)$ and $2P\bar{2}(g)$. The presence of Cu, Pb and S have been determined by blow-pipe. The specific gravity is 4·96–5, hence much higher than that of azurite.

72. GYPSUM

In Japan, gypsum has been formed by hydro-thermal action or by decomposition of sulphide ores, and never occurs in large quantities

1) vom Rath in Groth's Krystall. Mittheilung. Bd. 4., p. 426.

as is often the case in other countries. We can distinguish three modes in the occurrence of gypsum, viz., (1) in beds formed by sedimentation or hydro-thermal action, as found at Yuta, Rikuchū, Pr., Miyazaki, Rikuzen Pr., Mogura, Kai Pr., etc., (2) in single crystals scattered in clay or tuff as a product of decomposition of pyrites, as at Kuwabara, Shinano Pr., Satobara, Kōzuke Pr., Shizukawa, Kai Pr., Ogasawara-jima, Torishima, Musashi Pr., etc., and (3) in sulphide ore beds and veins, as at Kosaka, Rikuchū Pr., Aikawa, Sado Pr., Ashio, Shimotsuke Pr., Kamioka, Hida Pr., Besshi, Iyo Pr., etc.

At Kōshi, near **Yuta**, Rikuchū Pr., gypsum forms in Tertiary tuff a bed about 6 cm. thick, of which the upper part is fibrous, and the lower transparent.

At **Miyazaki**, Rikuzen Pr., it occurs interstratified in tuff in transparent plates but without crystallographical form. Alabaster has been reported from Narigo in the same province.

Gypsum forms at **Mogura**, Kai Pr., a bed 3 m. thick in the tuff of the Misaka Series. It has a layer of white finely granular alabaster in the middle of the bed.

Gypsum is found at **Toi**, Izu Pr., usually in fibrous form and sometimes in compact masses. The results of analysis by H. Yoshida are as follows :

SO_3	CaO	MgO	Fe_2O_3	Al_2O_3	K_2O	Mn_2O_3	SiO_2	H_2O
53·77	37·60	0·25	0·85	0·40	0·06	0·27	1·44	5·33 = 100·07
55·50	39·01	trace	0·55	0·07	0·03	0·11	0·12	3·95 = 100·14

Single crystals of gypsum are the same in all specimens from different localities. They are white, translucent, and have rough surfaces. The forms are $\infty P\bar{\infty} \cdot -P \cdot \infty P$. Arrowhead twins on $\infty P\bar{\infty}$ are very common. Crystals of this form occur at **Sanoyama** in Kuwabara-Mura, Shinano Pr., and **Gōhara**, Kōzuke Pr. At the latter place gypsum is found in the crevices of shale. The crystals though not well defined are large, the size varying from 40 to 50 mm. in length.

More perfect crystals are found at **Yagosawa** in Shizukawa-Mura, Kai Pr. They are partially transparent, and often twinned on $\infty P\bar{\infty}$ or $-P\bar{\infty}$. The same crystals of gypsum, especially the twinned ones, are reported to occur at **Ogasawara-jima**. Gypsum in colourless and transparent crystals, about 35 mm. long, has been found in crevices of rock ejected during the explosion of **Tori-shima** (Ponafidin I.) in 1901. The three faces above named are perfectly developed in the crystals.

The gypsum found in sulphide ore-deposits appears in vertically elongated, acicular crystals of minute dimensions. At **Kosaka** it forms parallel fibrous aggregates, and is colourless and transparent, or white and translucent. It never appears crystallised. At **Kotaki** in the Ashio mine, it appears in slender columnar crystals, colourless and transparent, attached to chalcopyrite and pyrites. At **Aikawa,** Sado Pr., it is found in crystals, perfect ones being rare.

Gypsum in the same habit as the preceding is further reported from **Kamioka** and **Besshi.** Colourless and transparent crystals of perfect form, about 30 mm. long, are sometimes found in association with the cupriferous pyrites ore of Besshi.

73. CHROMITE

Chromite occurs as an ingredient of serpentine, in which it forms lenticular beds generally of inconsiderable dimensions. It forms single crystals only when it occurs sporadically in serpentine. Kämmererite is a mineral associated with chromite.

At **Panke-Iyaputeushi** on the upper Mukawa, Iburi Pr., massive chromite has been found in serpentine. It has a thin coating of grass-green chrome ochre.

Chromite in masses of varying size has been found in serpentine further up the stream at its confluence with the Penkemotou, a branch of the river. The specimens analysed by T. Yoshii gave the following results :[1]

	Cr_2O_3	FeO	Al_2O_3	CaO	MgO	Insoluble
I	59·12	18·25	8·18	—	7·83	6.60 = 99·98
II	49·40	17·93	9·07	2·00	12·32	9·64 = 100·38

At **Washidani,** Bungo Pr., chromite occurs in serpentine in lenticular masses, whose fissures are filled with pink-coloured kämmererite.

1) I From Panke-Iyaputeushi, II from Penkemotou.

Besides octahedral crystals of chromite are scattered throughout the serpentine.

Chromite is further reported from **Yakiyama** and **Sasaguri**, Chikuzen Pr., **Tsumori**, Higo Pr., etc.

74. MAGNETITE

Magnetite occurs in abundance in metamorphosed rocks in the contact zone of igneous rocks, and is also widely distributed as an accessory mineral in crystalline schists, granite, and volcanic rocks. Good crystals are however limited to a small number of localities. Faces of most frequent occurrence are O and ∞O. The faces ∞O∞, 2O and 3O3 appear in combination with the two faces first named. It is sometimes twinned on O. The best crystallised magnetite is found at Kamaishi, Rikuchū Pr. We also find good crystals at Sannotake, Buzen Pr., and Ōgushi, Hizen Pr.

At **Kamaishi**, it occurs in association with garnet in the contact zone of granite. The faces most often observed are ∞O, then ∞O and O. In addition to these faces, the face 2O appears in crystals from Shin-Taneyama and Sahinai. The face O is most perfectly, developed in the crystals from Sahinai. The crystals here appear in groups, in which individuals are about 2 cm. in diameter. They are black, and brilliant or dull.

At **Minano**, Musashi Pr., single crystals of magnetite are found in chlorite-schist. The form is simply O.

Magnetite from **Kurodake**, Etchū Pr., is associated with garnet in the contact rock, as is the case with Kamaishi. It is crystallised in ∞O, but the crystals are minute and not very well defined.

At **Akadani**, Echigo Pr., magnetite occurs in crystalline masses in alternation with green chloritic earth.

At **Besshi**, Iyo Pr., magnetite forms thin layers in cupriferous pyrites ore-beds. Single crystals are rarely met with in quartzose druses.

Magnetite from **Sannotake** has usually a fused surface, and rarely well defined faces. The faces are ∞O, 3O3 and O. The face ∞O is always prominent. The crystals measure more than 20 mm. in the largest specimens.

Magnetite has been found in talc-schist near **Ōgushi,** Hizen Pr. It appears in well bounded single crystals in O, less than 10 mm. in diameter.

S. Kō has given a very complete list of the localities of this mineral, as well as its respective forms and modes of occurrence.[1]

75. CHRYSOBERYL

One crystal of chrysoberyl has been found in stanniferous sand of **Takayama,** Mino Pr. It is pale greenish yellow in colour and minute in size, being only 2·5 mm. in diameter. It is however well crystallised, and forms cyclic trilling of alexandrite. The faces detected are ∞P and 0P. Crystals of the same form were bought in 1884 by the writer at Ceylon.

76. FERGUSONITE

This rare mineral, like the preceding is found with cassiterite in river sand in the neighbourhood of Takayama. It varies in colour from ash-gray to dark gray, has an irregular columnar form tapering to one extremity, and a rough surface. The specific gravity is 4·3. The mineral was collected by Y. Kikuchi and its nature was first determined by the following chemical analysis made by T. Tamura of the Imperial Geological Survey:

SiO_2	$Nb_2O_5+Ta_2O_5$	UO_3	$Y_2O_3+Er_2O_3$	CeO_2	Fe_2O_3	H_2O
2·10	48·39	2·95	35·60	5·69	1·04	4·12=99·89

T. Takimoto was the first to detect crystallised fergusonite, which is about 3 mm. in diameter of the cross section and presents the form of a combination of a tetragonal prism and P(*s*). The *s* faces which reflect light fairly well, give for the angle $s:s$ a numerical value approximating 79° 6′. As the vertical faces are curved and dull, it is not sure whether they are ∞P. The hemihedral habit peculiar to the mineral is distinctly seen in the specimen. D. Satō

1) Journal of the Geological Society of Tōkyō. Vol. VI.

who recognised P(*s*) and 0P(*i*), suggested that the curved faces might represent $\frac{3P\frac{3}{2}}{2}$ (*z*).

77. MONAZITE

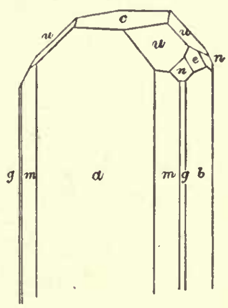
Monazite is found at **Tanokamiyama,** Ōmi Pr., as an inclusion in topaz from which it has been extracted by splitting. The mineral is dark red and semi-transparent grains running up to 6 mm. in the longest diameter, the faces being curved and indistinct.

78. COLUMBITE

Columbite occurs at Yamanō near Makabe, Hitachi Pr., and Ishikawayama, Iwaki Pr. It forms well defined crystals, in which the following faces are recognised (Fig. 28).

$\infty P\bar{\infty}$ (*a*)	$\infty P\bar{2}$ (*y*)	$2P\breve{\infty}$ (*e*)
$\infty P\breve{\infty}$ (*b*)	$\infty P\breve{\frac{5}{3}}$ (*z*)	$2P\breve{6}$ (*n*)
0P (*c*)	$\infty P\breve{3}$ (*g*)	$P\breve{3}$ (*u*)
∞P (*m*)		

Fig. 28.



Columbite from **Yamanō** is figured in Pl. XXI, a ; it has a black colour, and submetallic lustre. The faces found in the crystal in the collection of the Imperial University in Tōkyō are *a, b, e, u, g, m* and *y*, and those in the photographed crystal *a, b, c, e, u, g, m* and *n* (Fig. 28). The cleavage is parallel to a.

Crystal from **Ishikawayama,** collected by Y. Mori, presents according to N. Fukuchi, the faces *a, b, c, m, g, z, e, n* and *u*. The angles measured being

$m : m' = 100° 50'$		$b : e = 29° 35'$
$g : g' = 44° 10'$		$n : n' = 20° 0'$
$z : z' = 127° 0'$		$a : u = 75° 10'$

The mineral is here embraced by beryl, quartz or felspar.

The chemical composition of columbite from Yamanō, shown by T. Tamura is as follows :

Nb_2O_5	Ta_2O_5	FeO	MnO	CaO	MgO	SnO_2	WO_3
57·95	22·19	10·81	7·06	1·13	0·26	0·49	trace=99·89

79. APATITE

Apatite occurs in crystals at Ashio, Shimotsuke Pr., Kurokura, Sagami Pr., and Nōsen, Kai Pr.

It is found with chalcopyrite and quartz in the Rinsei-lode in the **Ashio** mine, where it forms colourless and transparent crystals of a flat tabular habit (Pl. XXI, b). The surface is covered with ash-gray earth, especially at the base. T. Takimoto who investigated the crystals determined the faces, $0P(c)$, $\frac{1}{2}P(r)$, $P(x)$, $2P(y)$, $\infty P(m)$, $\frac{3P\frac{3}{2}}{2}$ (μ), $2P2$ (s) and $\infty P2$ (a), measured angles being

$s : c = 124° 28'$ $(124° 26')$[1]	$r : x = 163°$ $(162° 44')$
$s : m = 135° 35'$ $(135° 35')$	$x : y = 160° 42'$ $(160° 48')$
$r : c = 157° 15'$ $(157° 10')$	$y : m = 149° 15'$ $(149° 18')$
$m : h = 16° 10'$ $(16° 26')$	$m : n = 22° 30'$ $(22° 41')$

Fig. 29.

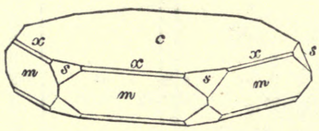
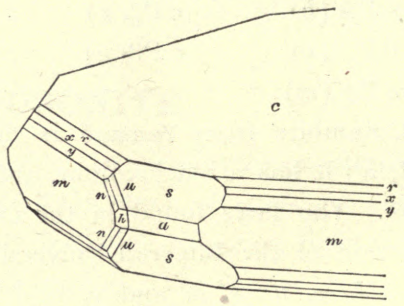


Fig. 30.



The faces *m* and *a* give the best reflection, but are vertically striated, moreover *u* is small. *c* is large and often uneven, but sometimes well reflects light. The faces *r*, *x* and *y* are small but brilliant, *s* and *μ* being rarely so.

The simplest form of apatite from Ashio is a combination of *c*, *m*, and *s*, sometimes with *a* and *x* in addition. The *μ* faces are rather rare; *r* and *y* are rarer still. Sometimes all the faces except *μ* are observed in an individual in a complicated combination (Fig. 30). *c* is the largest of all, *y* next, while *s* smaller. Other faces are still smaller and variable. The size usually varies from 4·5 to 15 mm. on the edge of *m* and *c*, being from 1 to 3 mm. in thickness. H. Ha-

1) The figures in brackets are those of the crystals from the Laacher See and the Ural in Kokhscharow's Mat. Russ. Mineralien. II. p. 73.

chiya detected etched hillocks and depressions, hexagonal in form on 0P, and a scalene triangular etched depression on P2.

At Kotaki in the same mine, apatite attached to chalcopyrite with pyrites and calcite, forms crystals of a different habit, with the faces, ∞P, P and 0P almost equally developed, and in thicker tabulæ. The size varies from 2 to 9 mm. in horizontal diameter.

Apatite from **Kurokura** appears in elongated columnar crystals, 40 mm. long. These are of a white colour, translucent and have rough surfaces. They have a green fibrous mineral as inclusions. The faces are ∞P, P and P2.

Apatite from Mukai-yama in **Nōsen-mura,** Kai Pr., is found in a quartz quarry. It forms here yellow transparent crystals of a stout prismatic habit. The faces recognised are 0P, ∞P, ∞P2, $\frac{3}{2}$P and $\frac{3}{4}$P, beside a pyramid of the second order of an uncertain facial value. A large crystal measures 90 mm. in diameter. The analysis made by H. Yoshida gave CaO 55·16, P_2O_5 42·01 and a trace of Cl. If we take the difference 3·83 for F, which has not been determined, the result agrees fairly accurately with the formula Ca_4 (Cl, F) $(PO_4)_3$ of a fluor-apatite in which the calculated P_2O_5 and F are 42·26 and 3·78 respectively.

According to S. Miura, there was found at the **Arakawa** mine, Ugo Pr., a white or brownish white mineral of earthy or massive form, in association with barytes. An analysis of the substance gave P_2O_5 36·42, and CaO 45·55 beside Fe, Al and other impurities. This mineral is thus proved to be a massive apatite or phosphorite. It occurred formerly on the hanging wall of the copper deposits.

An earthy form of phosphorite has been found at **Kōchi,** Shima Pr., in a manganese deposit. The percentage of P_2O_5 is sometimes as high as 28 ; or 6 on the average. Phosphorite is also reported to occur at Hiuchidani, Noto Pr., where a white clay contains phosphorite in the form of yellow spots, the percentage being above 20%.

80. PYROMORPHITE

Pyromorphite which is known at some copper mines in Japan, forms in general olive green hexagonal prisms, terminating in bases.

The faces are often curved. At **Arakawa,** Ugo Pr., it forms irregularly grouped crystals of hexagonal prisms, 3 mm. in length and 2 mm. in diameter. At **Kosaka,** there occur crystals of the same form, but of smaller size. The crystals from **Namaridani,** Hida Pr., are larger, measuring 13 mm. in length and 10 mm. in diameter. The middle portion of the hexagonal prism is swollen and barrel-shaped. Those from **Kamioka** and **Mozumi** have slender columnar shape. The mineral is further known to occur at **Nagamine,** Etchū Pr.

81. LIBETHENITE

The mineral closely related to libethenite has been found by H. Wakabayashi at **Hisan-ichi** in the Arakawa mine, Ugo Pr. It forms blue-green crystals about 6 mm. in length. The faces recognised by T. Takimoto and N. Fukuchi are 0P(c), P(s), ∞P(m), P∞(e), the measured angles being

$m : m = 86° 40'$ ($87° 40'$)[1] $e : e = 110°$ ($109° 52'$)

The crystals are elongated along the a axis, and have 0P, which is not mentioned by J. D. Dana in his System of Mineralogy. A qualitative analysis made by H. Wakabayashi leads us to presume that the mineral is a phosphate of copper. But its optical characters are quite different from those of libethenite. The mineral has the optical plane parallel to $\infty P\bar{\infty}$, and its acute bisectrix makes an angle of nearly 32° with the c axis, while the plane is parallel to 0P in libethenite, the acute bisectrix being parallel to the b axis. Moreover, one of the optical axes is nearly perpendicular to 0P in our specimen. The mineral thus appears to be monoclinic, and not referable to libethenite which belongs to the rhombic system.

82. VIVIANITE

Beautiful crystals of vivianite were once found at Ashio, Shimotsuke Pr. They were at first light blue, but became darker after ex-

1) The figures in the brackets are those given in Dana's System of Mineralogy.

posure to the air. The crystals are prismatic in habit and irregularly grouped. They are 25 mm. long and 10 mm. wide. The faces determined by T. Hiki are $\infty P\bar{\infty}$ (*a*), $\infty P\breve{\infty}$ (*b*), ∞P(*m*), P(*v*), $P\bar{\infty}$ (*w*), and ?—P(*x*), and ?—$P\bar{\infty}$ (*n*), the angles measured being

$a : m = 36° 0' 6''$	$v : v = 58° 50' 30''$
$a : b = 90°$	$v : w = 29° 29'$

The analysis gave

P_2O_5	FeO	MgO	Insol.	H_2O
31·48	39·50	trace	trace	29·02 = 100·00

in which H_2O has been calculated by mere subtraction.

A massive or earthy form of vivianite occurs at Shibigawa, Ugo Pr., Shimauchi, Hyūga Pr., Kimbōsan, Higo Pr., and Haruta, Ise Pr. A blue fibrous mass of vivianite was found by S. Kō at Kiura in association with scorodite.

83. ERYTHRITE

This mineral is known only at Kanagase in the Ikuno mine, Tajima Pr., where it occurs in the form of a powder on the ores.

84. SCORODITE

Scorodite, according to S. Kō, occurs at Kiura, Bungo Pr., as a secondary mineral associated with arsenopyrite, quartz, limonite and vivianite. The mineral is usually dark green, sometimes with yellowish, bluish or brownish tints, or is colourless, and have a vitreous lustre. It forms minute crystals rarely above 3 mm. but very well defined. The habit is pyramidal, with the following faces :

0P (*c*)	$\infty P\breve{2}$ (*d*)	$P\breve{\infty}$ (*g*)
P (*p*)	$\infty P\breve{\infty}$ (*b*)	$P\bar{\infty}$ (*β*)
$2P\breve{2}$(*s*)	$\infty P\bar{\infty}$ (*a*)	$2P\bar{\infty}$ (*n*)

beside the doubtful ones, $\frac{1}{2}P$(*i*), $\infty P\bar{2}$(*k*), $\frac{1}{2}P\breve{\infty}$ (*e*), $2P\breve{\infty}$ (*h*), $\frac{1}{2}P\bar{\infty}$ (*ω*), and $\frac{3}{2}P\breve{\infty}$ (*M*).

The *p* faces are prominently developed, *g*, *d*, *β*, and *n* being next to them, while the other faces rarely appear. The faces are sometimes striated parallel to the edge of *g* and *p*.

85. HEMIMORPHITE

Hemimorphite occurs at **Mozumi**, Hida Pr., as a product of alteration from blende. It forms incrustations of fibrous aggregates of minute size, and perfect form are found at Kamioka, Hida Pr.

Hemimorphite from the **Kiura**, mine, Bungo Pr., is found in cavities of brick-red earth. The crystals are white or colourless and transparent, and not perfectly developed, being too closely aggregated. Individual crystals 2 or 3 mm. in diameter are found in the mine at Kuranari in cavities of the rock.

86. ANDALUSITE

Andalusite appears in large, well bounded crystals at Ishikawa, Iwaki Pr., and Fudōzaka, Hitachi Pr.

In the environs of **Ishikawa** it occurs with white quartz in pegmatite in elongated prismatic crystals, sometimes 5 cm. in length. They are usually more or less decomposed, and mica is formed on the surface. The faces are therefore uneven and dull. The red coloration of the interior is also often lost. It occurs at Mujinamori near Ishikawa in the vein, associated with tourmaline and garnet. Crystals are found detached from pegmatite at Minami-Sugama and also at Mujinamori.

At **Fudōzaka**, it forms both prismatic and tabular crystals. The surface has been decomposed into mica. The larger crystals measure about 8 cm. in length and 5 cm. in width (Pl. XXII).

The analysis of the mineral by T. Tamura is

SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Na_2O	K_2O	H_2O
37·03	1·15	52·00	0·58	0·08	2·51	3·95	3·06 = 100·36

The result indicates the state of a mineral in decomposition in which about 9 per cent of alumina has been lost and replaced by various oxides and water.

Andalusite is further found at several places in the contact zone of granite as at **Hamada**, Rikuzen Pr., where it occurs in prismatic crystals of an orange colour and prismatic habit in contact slate. They are in the fresh state and transparent. The same form of andalusite occurs also at **Niiyamahama**, Rikuzen Pr.

Chiastolite occurs at **Usuginu,** Rikuchū Pr., in black slate in contact with amphibole granite. The crystals are from 6 to 9 mm. in length. The cross sections show a square outline with the characteristic black cross formed by the original carbonaceous substance.

At **Matsuda** and **Nagusa,** Shimotsuke Pr., andalusite occurs with chiastolitic inclusions in metamorphosed clayslate near amphibole granite. The cross section is square and traversed by diagonal fissures. The inner portion is red, while the outer is colourless. The former is pleochroic, being red in the direction of the vertical axis and greenish in the direction of the lateral axes.

Andalusite from **Miyata,** Shinano Pr., appears in prismatic crystals of a reddish colour in a contact rock. The cruciform carbonaceous inclusion is observed in cross sections.

Andalusite from **Chihara,** Mikawa Pr., is found in mica-schist. It is partially fresh and of a reddish colour with pronounced pleochroism.

Andalusite from **Shimoshima,** Yamashiro Pr., forms minute crystals of an elongated columnar habit. The fresh portion is reddish and nearly transparent, while the part decomposed is white and opaque.

87. TOPAZ

Topaz is the most conspicuous of the gems found in Japan. Its home is in pegmatite veins in granite, as in Takayama and Hosokute, Mino Pr., Ishigure, Ise Pr., Tanokamiyama, Ōmi Pr. Ishigure produced a few specimens in 1882, but since then has supplied no more. The large crystals once obtained at Hosokute were not good. These two places if well searched may yet prove to be productive of the mineral. The richest sources of topaz however are the neighbourhood of Takayama and Tanokamiyama.

Topaz has been known to occur with quartz at Tanokamiyama for a long time, but the people rejected the harder mineral preferring quartz which they found easier to work. The nature of the mineral was first recognised about 1877, when it was exhibited in the National Exhibition held at Tōkyō. The find of topaz in the province of Mino was about ten years later than this, being first obtained in the working of stream tin there. We will now give a brief notice of the common traits of Japanese topaz in general before entering into the description of the specimens obtained from the various localities.

Form: The first investigation of topaz from Mino and Ōmi was made in 1880 by the writer[1] while at the University of Berlin. The specimens then at his disposal were those belonging to the collections of the University of Tōkyō and of the writer himself. They consisted for the greater part of crystals of the larger dimensions, for which direct angular measurements were impracticable. For this reason Lipowitz alloy was employed for casting the edges. Beside these there were six or seven smaller crystals from Mino which answered the purpose better. The investigation has since been followed by those by A. Hahn,[2] W. D. Matthew,[3] Penfield and Minor,[4] and Y. Kikuchi and T. Hiki.[5]

The faces determined by the writer were

	Writer	Kokhscharow	Locality
o : *m* =	153° 53′ 45″	153° 54′ 8″	Ōmi
i : *u* =	168° 27′ 45″	168° 38′ 50″	,,
i : *m* =	124° 14′ 30″	124° 14′ 5″	,,
u : *m* =	135° 47′ 00″	135° 35′ 15″	,,
u : *o* =	161° 47′ 20″	161° 41′ 7″	,,
m : *m* =	124° 18′ 2″	124° 17′ 00″	Mino
,, ,, =	124° 21′ 42″		Omi
l : *m* =	161° 43′ 00″	161° 16′ 15″	,,
h : *u* =	157° 55′ 12″	157° 42′ 10″	,,
h : *i* =	164° 56′ 15″	164° 45′ 30″	,,

From these results and those of the subsequent investigators are known the seventeen faces beside a few more recognised by other

1) T. Wada: Sitzungsb. Gesells. Naturf. Freunde. Berlin, 1884.

2) Groth, Zeits. Kryst. 1893.

3) N. Jahrb. f. Mineral., etc. I. (Referate) 1894.

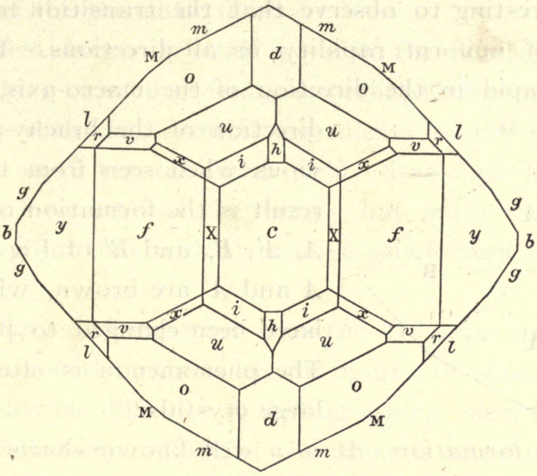
4) Groth, Zeits. Kryst. 1894.

5) Journ. Science College, University Tōkyō. Vol. IX. 1895-98.

European and American writers but not definitely determined (Fig. 31). They are:

$b = \infty P\breve{\infty}$	$\pi = \infty P\breve{\tfrac{5}{2}}$	$X = \tfrac{4}{3}P\breve{\infty}$	$x = \tfrac{4}{3}P\breve{2}$
$c = 0P$	$O = \infty P\breve{\tfrac{6}{5}}$	$f = 2P\breve{\infty}$	$v = 2P\breve{2}$
$m = \infty P$	$\lambda = \infty P\breve{\tfrac{7}{4}}$	$y = 4P\infty$	$r = 4P\breve{2}$
$M = \infty P\breve{\tfrac{3}{2}}$	$T = \infty P\tfrac{5}{3}$	$i = \tfrac{2}{3}P$	
$l = \infty P\breve{2}$	$h = \tfrac{2}{3}P\bar{\infty}$	$u = P$	
$g = \infty P\breve{3}$	$d = 2P\bar{\infty}$	$o = 2P$	

Fig. 31.



The habit is the same in the larger crystals from both localities. They are chiefly of the domal or Russian type. The only difference is the rarity of the face *x* in those from Mino, while it is often observed in those from Ōmi. The smaller crystals from Mino are, on the contrary, of the pyramidal or Brazil type.

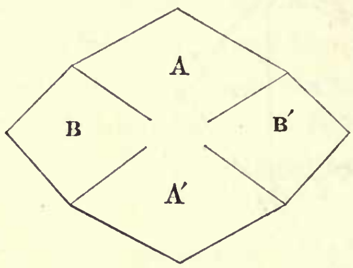
Colour: Six different colours are observed in topaz from Japan; viz. (1) colourless, (2) wine-yellow or brownish yellow, (3) pale blue, (4) pale brown and pale blue in sectors, (5) pale green, and (6) brown. Of these colours, brown, brownish yellow and blue are subject to alteration, and according to the writer's experience of twenty five years, brown and brownish yellow shade into blue, and blue into the colourless condition on long exposure to day light. Brown is limited to a few specimens freshly quarried. It has never been observed in specimens kept for a long time in the day light.

Green is also rare and is represented in one large specimen bought in 1881 by the Imperial University of Tōkyō, and four in the writer's collection. None of these shows any signs of decoloration.

From these observations we are led to believe the original colours of topaz from the two places to be (1) colourless, (2) brown and (3) green, some colourless specimens having of course resulted from decoloration. The usual transition of colour is from brown to brownish yellow in gradually paler shades, until from pale blue it becomes colourless.

It is interesting to observe that the transition from brown to blue is not of uniform rapidity in all directions. The process is much more rapid in the direction of the macro-axis, than in the direction of the brachy-axis, as is obvious when seen from the base. The result is the formation of four sectors, *A*, *A′*, *B*, and *B′* of Fig. 32, in which *A* and *A′* are brown, while *B* and *B′* have been changed to blue (Fig. 32). The phenomenon is often observed in large crystals.

Fig. 32.



Phases of formation: It is a well known characteristic of the topaz from both localities that the larger crystals are simpler in form and coloured, and have many fissures in the interior, while the smaller crystals are colourless, rich in faces, and free from fissures. In occurrence the two kinds are never found in association with each other. They are evidently formed in different phases of mineralisation. Topaz, being later in formation than quartz which is the last formed mineral of granite as is the case at Tanokamiyama, is found attached to quartz, and not to felspar. Such crystals are often covered by felspar of a secondary formation, and then all the felspars, including those of the primary formation, may be erroneously regarded as later in formation than the topaz. The larger crystals, being attached to quartz at one end, naturally have only one end well terminated. The paucity of faces and the presence of fissures and cavities in such crystals may be due to too rapid growth in crystallisation.

Smaller crystals from Mino seem to differ much from those of

Ōmi in the mode of their formation. For the crystals from the former locality are colourless and transparent, and rich in the rarer faces, while those from the latter region are dull, translucent and full of fissures, and as poor in the number of faces as the larger crystals. The smaller crystals from Mino may probably have been formed not only like the larger ones in druses in a later stage of mineralisation, but also in the superficial portions of the granite outside of the druses. The smaller crystals from Ōmi are evidently secondary, because they are attached to secondary white orthoclase on the edges of the prismatic faces.

The coloured larger crystals poor in the number of faces are generally speaking older in generation, perhaps being of simultaneous crystallisation with the essential ingredients of the granite, while the colourless small crystals with richly developed faces, are subsequent to the formation of the former, but much earlier than the small crystals from Ōmi, which are obviously formed in a secondary generation.

Etched figures and *imperfect growth*: However interesting may be observations on the natural etched figures of topaz, there seems to exist considerable difficulty in distinguishing them from imperfections of crystallisation. Natural corrosion is more intense on the brachydome than on the macrodome. In imperfectly developed crystals, it is usually more markedly developed in the direction of the vertical axis on the extremities of the brachydome than on those of the macrodome. As a result grooves with irregular protuberances appear in the place of the brachydome (Pl.XXVII). In such cases we are certainly face to face with the difficult preblem of deciding in favour of one of the two processes, etching or imperfect growth. An interesting field is thus opened for future mineralogenetical investigation.

Composition: The results of analysis made at the Imperial Geological Survey are as follows:

	Locality	SiO_2	Al_2O_3	F	
1.	Mino (colourless and transparent)	31·30	56·72	18·36	106·38
2.	Ōmi (yellowish)	31·95	56·59	18·01	106·55
3.	,,	33·15	56·32	17·30	106·77

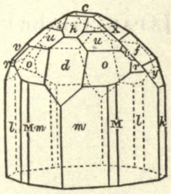
Mino: Topaz occurs in the environs of Takayama and Naëgi around Wakayama, a granitic hill in Ena-Gōri, Mino Pr. The mineral has been found in association with cassiterite, in fluviatile deposits of rivulets from the hill as well as in cultivated soil. Large crystals obtained from river gravel usually have rough faces and rounded edges. Smaller ones from the soil on the hill sides are on the contrary not much injured, and present sharply defined faces fit for exact angular measurements. The large crystals are brown, wine-yellow or light green in colour, and are never less than 15 mm. in diameter. Their length is variable as the crystals are apt to be broken on account of the cleavage plane being parallel to the base. The small crystals are colourless and transparent, and vary in size from 2 to 3 mm. in diameter. The two kinds have never been found mingled together.

The first type of topaz is found in drusy cavities of granite, associated with quartz and felspar. Beryl, blue or black tourmaline and mica are also found in association. Topaz is the latest formed mineral and is found growing most frequently on quartz, and rarely on mica; while beryl and tourmaline are enclosed by it. It is of a smoky brown colour, when fresh, but decolours gradually to a wine yellow, then pale blue and at length becomes wholly colourless. Rarely it is of a homogeneous light green. The largest crystal from Tobiiwagasu in Wakayama measures 7·5 cm. in the shorter lateral diameter and 10 cm. in the longer and 15 cm. in length (Pl. XXV, a and b).

The large crystals are of simple forms of the Russian type. The chief faces are *m* and *f*, with subordinate pyramids *i*, *o*, *u*, domes *y*, *h*, *d*, prisms *M*, *l*, and pinacoids *c*, *b*, rarely *v* in addition. Forms resembling those from Brazil or from Schneckenstein are never observed.

The small crystals as mentioned are colourless, and less than 4 mm. in the longer lateral diameter. They are never found associated with the larger ones, though they are chiefly found in river gravels. Some have perfect terminal faces, which are apparently hemimorphic, though in reality this is due to irregularity of growth. The crystals

Fig. 33.



though minute are well defined and have numerous faces foreign to the large ones. Accordingly the crystallographical investigations of the late Y. Kikuchi, T. Hiki and some foreign *savants* have all been made on these small crystals. T. Hiki's results gave the following faces.

Brachy-domes :	$f = 2P\breve{\infty}$ (021)	$y = 4P\breve{\infty}$ (041)
	$X = \frac{4}{3}P\breve{\infty}$ (043)	
Macro-domes :	$d = 2P\bar{\infty}$ (201)	$h = \frac{2}{3}P\bar{\infty}$ (203)
Pyramids :	$u = P$ (111)	$o = 2P$ (221)
	$i = \frac{2}{3}P$ (223)	$v = 2P\breve{2}$ (121)
	$r = 4P\breve{2}$ (241)	$x = \frac{4}{3}P\breve{2}$ (243)
Prisms :	$m = \infty P$ (110)	$l = \infty P\breve{2}$ (120)
	$M = \infty P\breve{\frac{3}{2}}$ (230)	$g = \infty P\breve{3}$ (130)
	$\pi = \infty P\breve{\frac{5}{2}}$ (250)	$O = \infty P\breve{\frac{6}{5}}$ (560)
	$\lambda = \infty P\breve{\frac{7}{4}}$ (470)	$T = \infty P\breve{\frac{5}{3}}$ (350)
Base :	$c = 0P$ (001)	
Brachy-pinacoid :	$b = \infty P\breve{\infty}$ (010)	

The angles measured are as follows :

	Mino (Hiki)	Ural (Kokscharow) Calculated	Ural (Kokscharow) Measured	Japan (Hahn)
m : *m*	55°42′ 0″	55°43′ 0″	55°43′ 0″	55°45′–55°44′
m : *M*	10 31 24	10 32 58	10 32 30	10 32 0
m : *l*	18 44 0	18 43 52	18 43 45	18 43 0
l : *g*	11 10 20	11 10 20		
l : *M*	8 6 0	8 10 54	8 2 0	
g : *b*	32 15 30	32 14 18		
l : *l*	86 48 0	86 49 16	86 48 0	86 21 0
m : *o*	26 5 30	26 5 52	26 7 0	
l : *o*	31 49 0	31 44 8		
o : *o*	49 34 30	49 37 28	49 37 9	49 39 0
f : *o*	52 33 0	52 33 28		
d : *o*	24 46 30	24 48 44	24 48 30	24 50 0
u : *o*	18 17 30	18 18 53	18 19 0	18 17 0

	MINO (Hiki)	URAL (Kokscharow)		JAPAN (Hahn)
		Calculated	Measured	
y : *o*	54° 45′ 0″	54° 50′ 14″		
u : *u*	38 59 0	38 59 54	38° 59′ 0″	
d : *u*	26 53 30	26 55 42	26 55 40	
i : *u*	11 23 22	11 21 10		
f : *u*	42 32 0	42 32 48	42 32 17	
m : *u*	44 15 30	44 24 45	44 24 50	
l : *u*	47 21 30	47 25 47		
i : *i*	30 27 30	30 29 0	30 28 0	
c : *i*	34 12 0	34 14 5	34 13 0	
m : *d*	39 20 0	39 20 43	39 20 30	
c : *d*	61 1 30	61 0 40	61 1 0	
c : *f*	46 18 30	46 21 0		
y : *f*	18 40 30	18 41 22		
c : *h*	31 2 0	31 1 56		
c : *X*	32 29 30	32 27 19		
r : *o*	17 54 0	17 56 45		
v : *o*	19 23 30	19 24 50		
v : *f*	33 8 0	33 8 40		
m : π	24 55 0			
m : *O*	4 32 0			
m : λ	14 52 0			
m : *T*	13 28 0			
f : *f*	87 7 0			

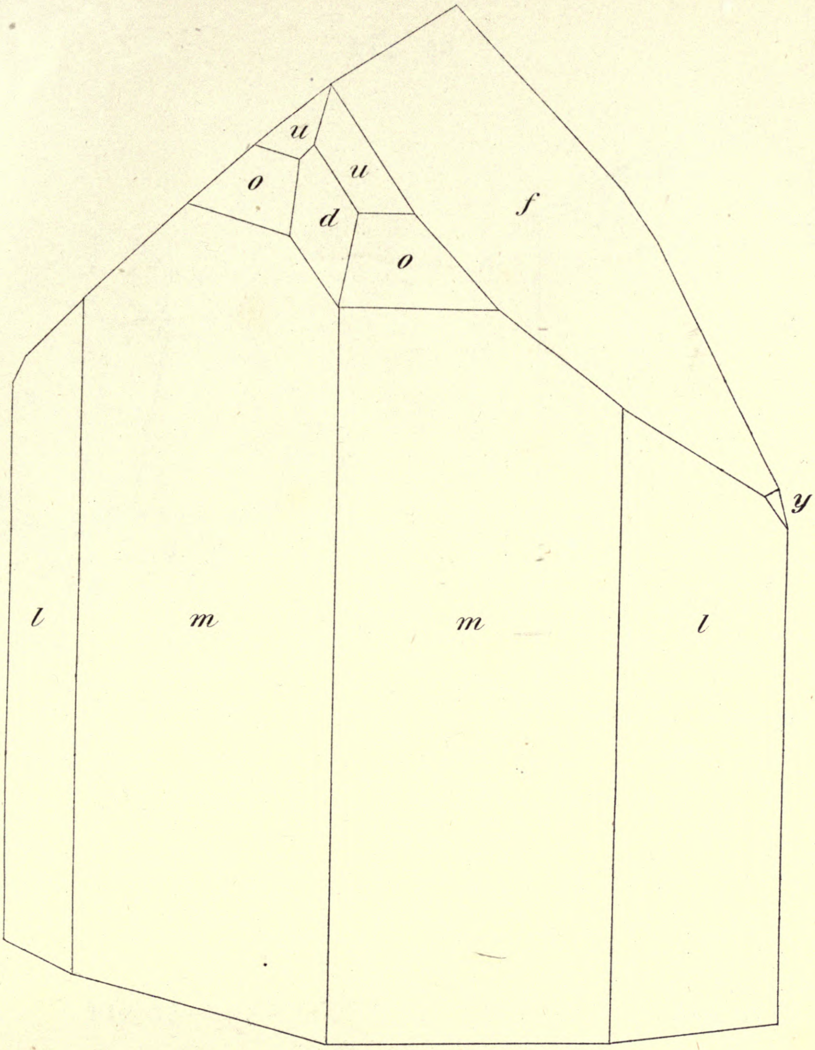
The axial ratio is

$$a : b : c = 0{\cdot}528356 : 1 : 0{\cdot}475587.$$

Among the six pyramids *u*, *o*, *i*, *v*, *r* and *x*, the first two are most frequent, and next to them *i*. The faces *r*, *v* and *x* are chiefly confined to the small crystals, though *v* is sometimes found in the large ones. Of the two macrodomes *d* is the more common, *h* being only occasionally observed.

Among brachydomes, *f* is generally present and well developed. The face *y* is less frequent. The face *X* which is very common in

Fig. 34



a

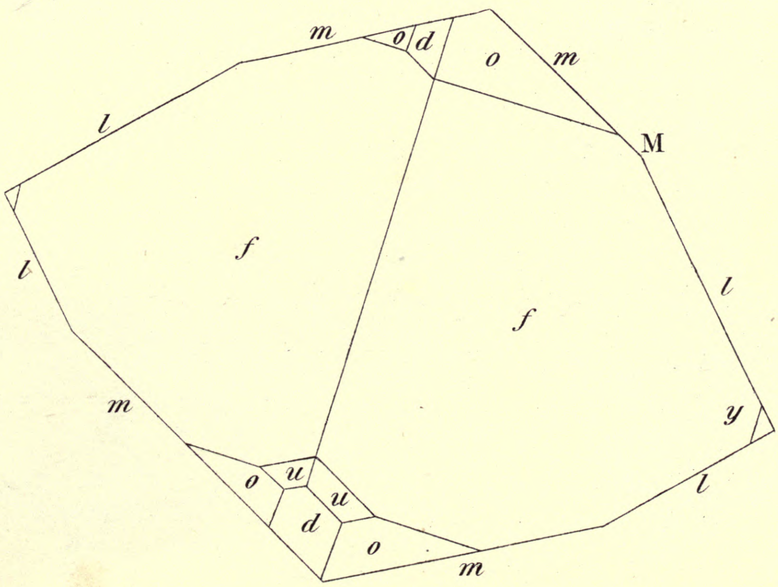
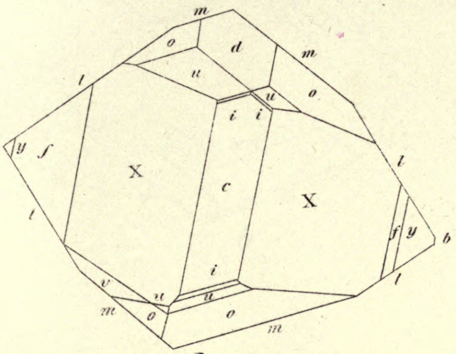
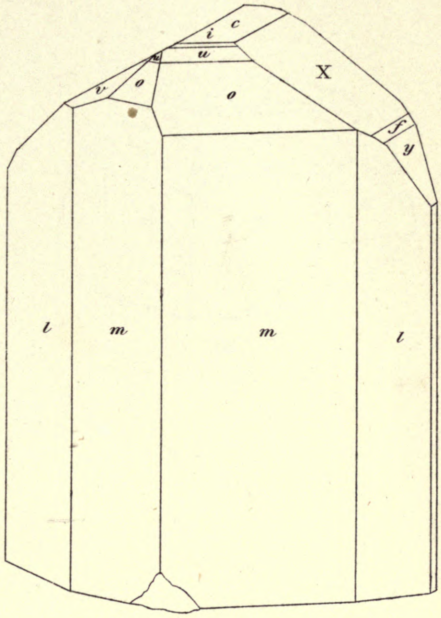


Fig. 35

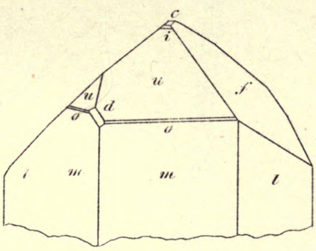


b

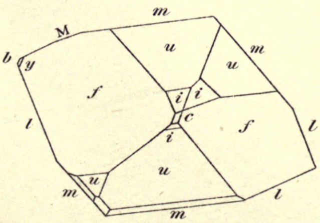


a

Fig. 37

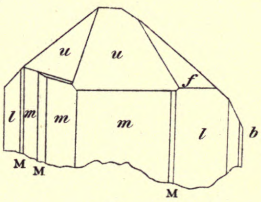


a

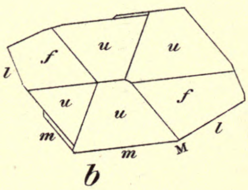


b

Fig. 36

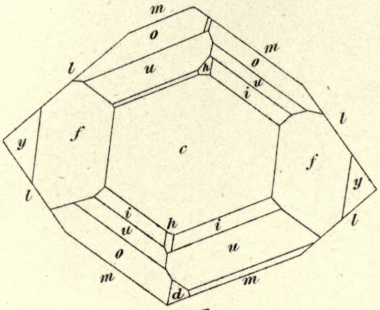


a

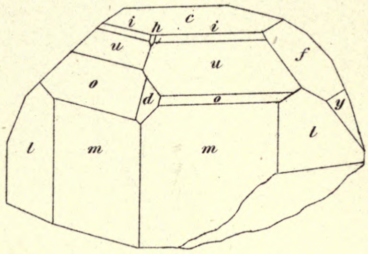


b

Fig. 38

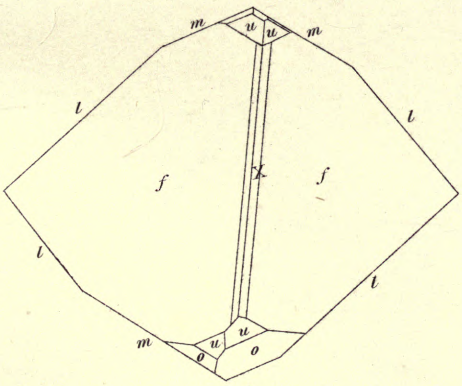


b

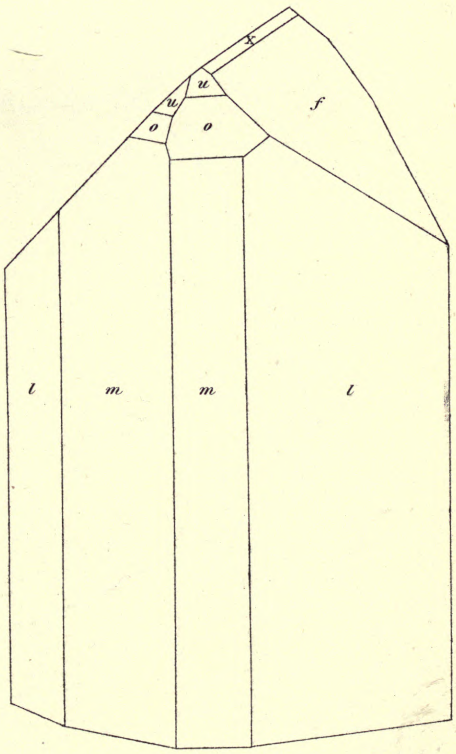


a

Fig. 39

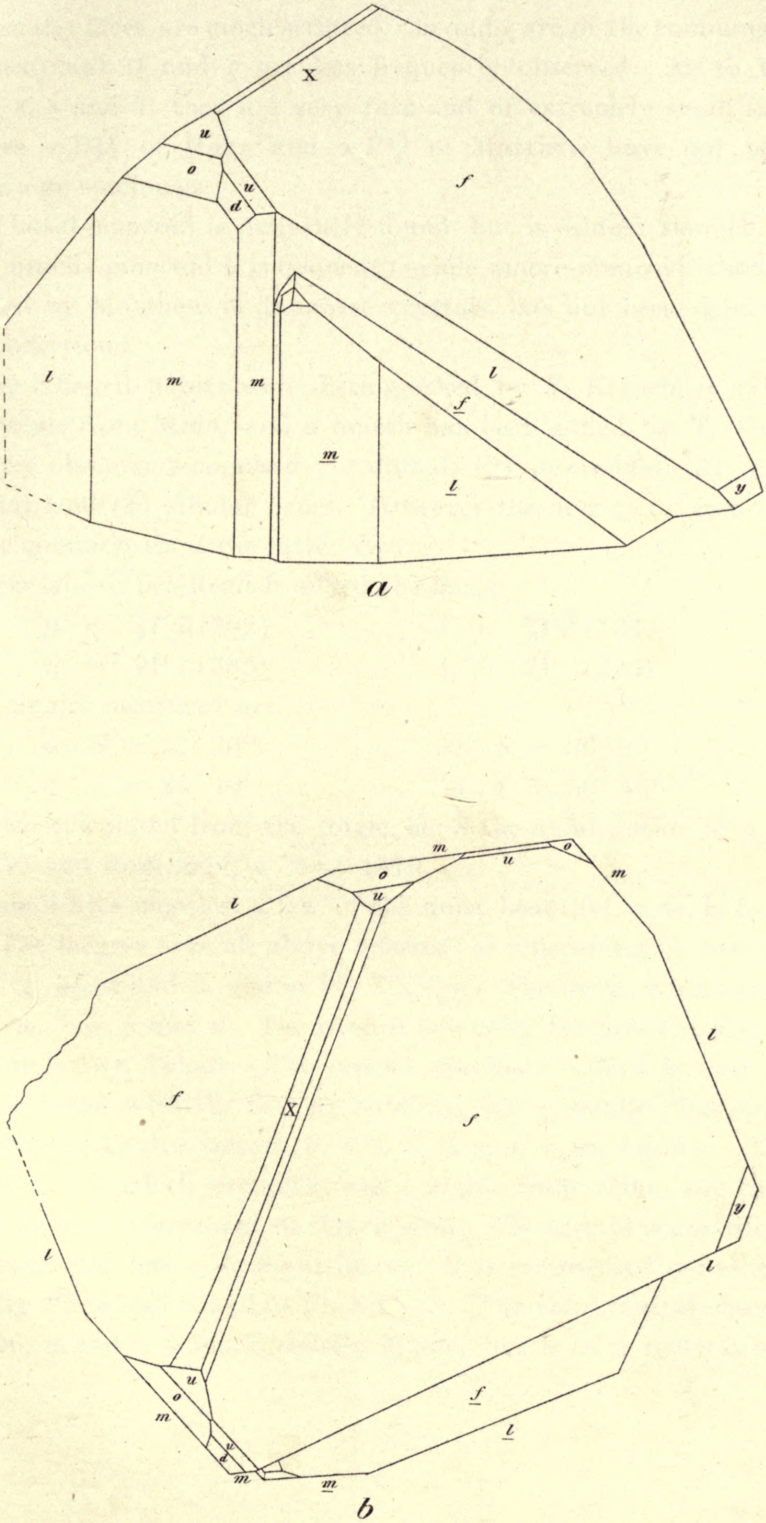


b



a

Fig. 40



the crystals from Ōmi has been seldom met with in those from Mino.

Prismatic faces are much striated. *m* and *l* are of the commonest occurrence, and *M* and *g* are less frequently observed. As to the faces *O*, π, λ and *T*, they are very rare and of extremely small size. The faces $\infty \breve{P}\frac{21}{20}$ of Hahn and $\infty \breve{P}\frac{11}{4}$ of Matthew have not been found in our specimens.

The basal-pinacoid is frequently found, but is seldom smooth.

The brachy-pinacoid *b* is frequent ; while macro-pinacoid, though recognised by Matthew in Japanese crystals, has not been detected in our collections.

Three different habits were distinguished by Y. Kikuchi in crystals of topaz from Mino, and a fourth has been added by T. Hiki. The latter observer recognised (1) domal, (2) pyramidal, (3) base-pyramidal, and (4) tabular types. However the first two types are far more common than the latter two.

To the above list Redlich added the faces

$$p = \tfrac{1}{2}\breve{P}\infty\,(102) \qquad t = \tfrac{3}{5}\breve{P}3\,(135)$$
$$S = \tfrac{3}{5}P\ \ (335) \qquad \mathfrak{f} = \tfrac{2}{5}P\ \ (225)$$

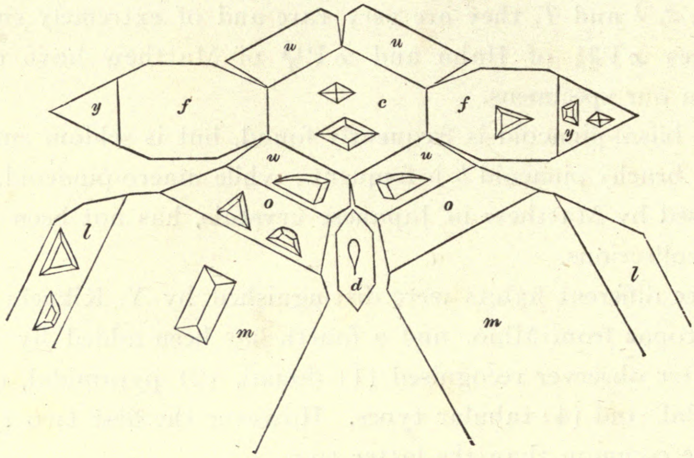
The angles measured are

$$o : S = 13^\circ\,30' \qquad m : S = 39^\circ\,36'$$
$$o : \mathfrak{f} = 24^\circ\,10' \qquad m : \mathfrak{f} = 50^\circ\,46'$$

Redlich calculated from the angle $m : S$ the axial ratios of $a : b = 0{\cdot}58150$ and from $m : \mathfrak{f}$, $a : b = 0{\cdot}4070$.

We shall here mention a few of the most beautiful crystals from Mino. The largest crystal, above referred, is represented in natural size in Fig. 34, *a* and *b*, and in Pl. XXV, a. The faces present in it are *f*, *y*, *m*, *l*, *o*, *u* and *d*. The crystal is wholly transparent and of a uniform brown colour. The second specimen, which is said to have been found with the first at Tobiiwagasu, is smaller, but more perfect, having twelve faces *c*, *b*, *x*, *f*, *y*, *d*, *i*, *o*, *u*, *m*, *l* and *v*. The faces *c*, *x* and *v* which are very rare in topaz from Mino, are thus remarkably well represented in this crystal. The crystal is uniformly transparent and has a brilliant lustre. It is represented in natural size in Fig. 35, *a* and *b*, and in Pl. XXV, b. The third crystal shown in Fig. 36, *a* and *b* is much inferior in size, but is of a remarkably pure blue colour. It is a combination of *u, f, m, M, l* and *b*, belonging to the Brazilian type.

Fig. 40.



Respecting the etched figures of the topaz from Mino, T. Hiki[1] as well as Hahn recognised some figures observed by Laspeyres[2] and Pelikan.[3] Their views have however since been opposed by K. Jimbō. Recently T. Takimoto made a careful study of the phenomenon in question and found

(1) On the base *c* depressions of rhombic outline, with sides parallel to the lateral edges of P. The depressions have a flat bottom parallel to the base. Etched figures of the same form have been described by Laspeyres.[4]

(2) On the brachy-pinacoid *f*, isosceles triangular depressions, with the basal side parallel to the edge of *f* and *c*, and the other two sides parallel to the edges made by *f* and *m*.

(3) On the brachy-dome *y*, two kinds of etched depressions, one being quadrilateral, with two of its sides parallel to the axis *a* and the two others parallel to the edges formed by *l* and *y*. The other

1) Loc. cit. p. 75–76.

2) Groth, Zeitschr. f. Kryst. u. Min. 1877. p. 35.

3) Tschermak, Min. u. Petro. Mitth. 1890.

4) Loc. cit.

is a slightly rounded quadrilateral, in which the acute angle is 38° and is directed from the pole while the opposite angle is 70° and is directed towards the pole.

(4) On the pyramid *u*, four-sided but asymmetric depressions. One side is parallel to the lateral edge of the pyramid, and another nearly perpendicular to it; while the other two sides form an almost continuous curve. The acute angle of this quadrilateral is directed to the end of the axis *b*.

(5) On the pyramid *o*, scalene triangular depressions, one side being parallel to the lateral edge of the pyramid.

(6) On the macro-dome *d*, elongated depressions in which the blunt end is directed towards the pole and the pointed end towards the axis *a*.

(7) On the prism *m*, rectangular depressions, in which the slope of one of the longer sides is steeper than that of the opposite one.

(8) On the prism *l*, isosceles triangular depressions whose bases are opposite to the edge made with the next face of *l*, the angle opposite to this base being 77°. The angle is sometimes cut by a fourth side, the resulting figure being a trapezium.

T. Hiki determined the pleochroism of topaz from Mino with Haidinger's dichroscope, with the result:

a=sky blue, b=pink, c=yellow;

and the absorption, $a > b \gg c$.

The pleochrosm determined by N. Fukuchi on crystals of different colour is as follows:

	Variety	*c*	*a*	*b*
1)	Brown	light straw yellow	yellow brown	brownish red (with purplish blue and darker than *a*)
2)	Decolouring from brown into blue	light straw yellow	light blue	light reddish brown
3)	Decoloured blue	pale straw yellow or nearly colourless	light blue	light brownish blue

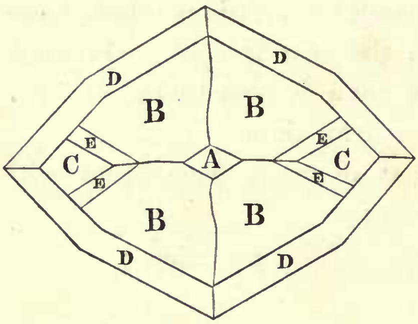
It is obvious from this result that in crystals originally coloured brown the axial colour a=yellowish brown is most susceptible to decoloration under the day light, and rapidly alters into blue and becomes colourless, and the axial colour *b* is less susceptible but also liable to alter into blue and become colourless, while the axial colour *c* remains without much change.

For other optical properties the results given by Hahn and T. Hiki are as follows:

		α	β	γ	2Ha	2V (calc.)	2E (calc.)	2E (measured)
For yellow light[1]	Hiki	1·6134	1·6178	1·6233	——	62° 52′	——	115° 3′
	Hahn	——	1·6182	1·6252	69° 43′	62° 40′	114° 36′	114° 31′
For red light	Hiki	1·6113	1·6142	1·6162	——	62° 24′	——	113° 33′
	Hahn	——	1·6206	1·6277	68° 57′	62° 2′	113° 161′	113° 43′

On the optical anomaly of topaz from Mino, interesting observations have been made by T. Takimoto as well as H. Hachiya, S. Kawasaki and F. Ōtsuki. According to the last three writers, thin sections cut parallel to the base generally present in the crossed nicols sectors of different optical orientations. In some sections an apparently homogeneous crystal is found to consist of as many as five different sets of sectors as shown in Fig. 42. The sectors *A* and *C* have the same optical orientation, and extinguish light parallel to the axes *a* and *b*. The two sets are unequal in dimensions when simultaneously present. Either one is often lacking. The sectors *E* on the inner sides of *C* may be seen around *A*. The sectors *B* form a zone parallel to *m*, and their boundary lines with one another are sometimes distinct, but often wholly continuous or overlapped in lattice-work. The direction of extinction deviates 1° or 2° from the axis *a* on either side, the opposite sectors then having the same orientation. The sectors *D* constitute a narrower but more distinct zone which consists of differently orientated sectors in different quadrants or forms an uninterrupted belt surrounding all the other sectors. The anomalous sectorial partition can be seen in some

Fig. 42.



1) For yellow light both observers used sodium carbonate, while for red light Hiki used strontium chloride and Hahn a thallium salt. Hiki does not point out whether the angles 2V and 2E are results measured or calculated.

basal sections under the microscope, ever without the aid of the crossed nicols.

Inclusions are beryl, black tourmaline, grains of cassiterite, radial-firous chlorite, liquid and gas. They are rare in large crystals, though frequent in small ones.

Small crystals in river gravel are attached to limonite, and rarely to wolframite.

Topaz from **Hosokute** in Toki-Gōri, Mino Pr., has the same mode of occurrence. A specimen in the writer's collection which was found in 1880, is as much as 14·2 cm. in the shorter lateral diameter. The faces observed in the crystal are simply *f*, *x*, *m* and *l*. The faces of the dome are rough and dull. It is partly light green and partly straw-colour.

Topaz from **Ishigure,** Ise Pr., so far as known, is of an inferior quality, and is small in size. A specimen in the writer's collection is yellow, dull on the faces of the dome, and semi-transparent. The longer and shorter diameters are 40 mm. and 35 mm. respectively. The form is very simple, having the faces *m* and *l* only, *u* being scarcely visible. The faces are rough.

Ōmi: Topaz occurs with quartz, felspar and mica in sand at Tanokamiyama, which is a granitic hill without vegetation. It is now difficult to obtain the mineral. Some specimens are large, transparent, of light green or wine yellow colour and comparatively rich in faces. They are generally grown on quartz. The specific gravity is 3·55 on the average. Some are colourless, and perfectly transparent, and smaller than the first; the largest are about 10 cm. in the longer lateral diameter. They are also found grown on quartz. The third type consists of those grown on felspar. They are white or yellowish, rather dull in lustre and semi-transparent. They have simple forms and are small, being not more than 40 mm. in the longer diameter and 25 mm. in shorter diameter. The first two kinds of crystals grown on quartz are sometimes wholly surrounded with felspar of a later formation, but when the latter is removed, the topaz is always found to be grown on quartz. In such cases, the faces of the prisms have their lustre untouched, but those of the domes and pyramids are dulled. The third kind of topaz, which is of the latest formation and grown on flesh-red or milk-white felspar, has simple forms belonging to the domal type. Such crystals do not stand upright like those on quartz, but are attached to felspar on the edge of the prisms, so that in them both the terminations are developed.

In the crystals from Ōmi we find comparatively well developed faces, especially of the second type. In form they are similar to the large crystals from Mino, and can not be compared with the small ones from that locality, so rich in rare faces. Crystals of the Russian type are most frequent, while those of the Schneckenstein type are rare, and those of the Brazilian type very seldom met with (Pl. XXVI, a, b, c, Pl. XXVII, a and Fig. 37 and 38).

The faces recognised are

$b = \infty P\breve{\infty}$	$d = 2P\bar{\infty}$
$c = 0P$	$f = 2P\breve{\infty}$
$m = \infty P$	$y = 4P\breve{\infty}$
$X = \frac{4}{3}P\breve{\infty}$	$i = \frac{2}{3}P$
$M = \infty P\breve{\tfrac{3}{2}}$	$u = P$
$l = \infty P\breve{2}$	$o = 2P$
$g = \infty P\breve{3}$	$v = 2P\breve{2}$
$h = \frac{2}{3}P\bar{\infty}$	$r = 4P\breve{2}$

Beside these faces S. Kō detected $\infty P\breve{4}$ and $P\breve{3}$ and T. Hiki a minute face between *f* and *v*; however they still await accurate determination.

The best developed faces are *f, m, l,* then *o, d,* while the smallest are *c, u, i, M, g, y, X, h,* etc. The faces of the prisms *m* and *g* are vertically striated, the *c* faces rough and dull, the *x* faces also dull, and all the faces of the domes and pyramids are less lustrous than the prismatic faces.

The pleochroism and etching are the same as observed in the Mino topaz. Zonal structure is sometimes observed in topaz from Ōmi. There is found in some specimens a layer about 5 mm. thick, parallel to the prismatic faces often forming upon terminal faces grooves between the outer and inner layers. Structure is sometimes shown by inclusions, which are arranged parallel to the outlines of the crystal as in the so-called "*ghost quartz.*"

The most perfect and beautiful specimen here produced is one found between 1870 and 1880 in J. Sugiura's collection. It afterwards came into the possession of Count K. Inoue, who most generously gave it to the writer. The crystal (Pl. XXIV, a and Fig. 39) measures 84 mm. in length, 64 mm. in the longer diameter and 51 mm. in the shorter. It is grown with quartz, felspar and mica, standing on prismatic faces of quartz. It is transparent and wine yellow in colour, and encloses in its lower part a colourless or white mineral, which is about 3 mm. in size, and resembles felspar. The habit of the crystal is of the Russian type. The faces observed are *m*, *l*, *o*, *u*, *f*, and *y*. The *m* and *f* faces are brilliant, *l* striated, *o* and *u* dull. The *y* faces is very small. The specimen shown in Fig. 40 is short vertically, but of a large size and perfectly crystallised. It is light wine yellow in colour.

One of the inclusions of topaz from Ōmi is monazite, which is of a red colour, and appears in grains or irregular crystals, 2 mm. in diameter. Another inclusion is colourless or white crystals about 5 mm. in length and 4 mm. in diameter. They resemble felspar in form. White cotton-like masses, sometimes present in some specimens, are probably the same mineral. Black tourmaline, grains of pale green beryl, and liquid and gaseous lacunæ are sometimes contained in the mineral here found.

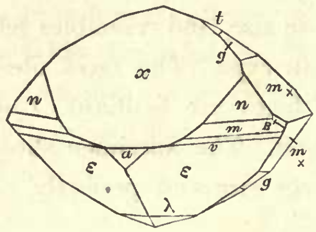
88. DATOLITE

Datolite occurs at Nobori in Iwato-Mura, Hyūga Pr., not far from Obira, Bungo Pr. T. Takimoto recognised 13 faces and S. Kō 18 on the crystals here found. According to the latter observer, datolite occurs here associated with axinite, quartz, green pyroxene, garnet, mica, epidote, calcite, galena etc., quartz and axinite being the commonest accompanying minerals. It is formed later than these two minerals, which are sometimes found penetrating, and sometimes wholly enclosed in it. It is of an oil yellow, or pale blue colour or is colourless. The lustre is vitreous, but by corrosion some of the faces have much less lustre than others. It has a conchoidal fracture and lacks any distinct cleavage.

The faces observed by S. Kō are (Fig. 43)[1]:

$\mu = \frac{1}{4}P^*$	$a = \infty P\bar{\infty}^*$	$t = \frac{1}{3}P\breve{\infty}^*$
$\lambda = \frac{1}{3}P^*$	$c = 0P^*$	$g = \frac{1}{2}P\breve{\infty}^*$
$\varepsilon = \frac{1}{2}P^*$	$m = \infty P^*$	$m_\times = P\breve{\infty}^*$
$\mathfrak{d} = \frac{2}{3}P$	$o = \infty P\grave{2}$	$n = -P^*$
$\nu = P$	$u = -\frac{1}{4}P\bar{\infty}$	$\omega = \frac{1}{6}P^*$
$B = 2P\grave{2}$	$x = -\frac{1}{2}P\bar{\infty}^*$	$\varkappa = \frac{1}{5}P^*$

Fig. 43.



The best developed faces are ε and x, which are large and present in all crystals. The n face is smaller but appears almost constant. These three faces are therefore to be regarded as characteristic of the crystals. The faces $m_\times$, g, and m are next to those mentioned, the most frequent. The faces μ, λ, a and ν are more rare. The others are still rare and of minute size. The m face is horizontally striated, as is also often the case with n, ν, ε, λ, μ, $\mathfrak{d}$, $\varkappa$, and ω which are on the same zone as m.

The crystals have very often been subjected to corrosion, the x face being especially roughened and made uneven. The faces belonging to the zone of the faces $m_\times$, g, t, and c and the faces a and u in the zone of a, x, u and c do not sensibly suffer from the action.

Large crystals may be as much as 9 cm. in length and 6 cm. in diameter.

The analysis of the mineral by T. Tamura is

SiO_2	B_2O_3	CaO	H_2O	Al_2O_3	Fe_2O_3	MgO	K_2O	Na_2O	
38·22	18·24	35·33	7·86	0·07	0·34	0·38	trace	0·01	=100·45

A characteristic feature is the small quantity of boric acid as compared with the results obtained with specimens of the mineral from foreign localities.

1) The faces with * are those before recognised by T. Takimoto.

89. GADOLINITE

The mineral has been found by Hanaoka at **Ishigure**, Ise Pr., and determined by S. Kō. A fragment of crystal in the writer's collection is 20 mm. in diameter. It is greenish black incolour and opaque. Though a few faces are visible, they do not reflect light well enough to permit accurate angular measurements.

90. TOURMALINE

Tourmaline occurs in granite, crystalline schists and contact-rocks. It is usually black and opaque. The exceptions are a green variety from Sakihama, Rikuzen Pr., one of sky blue colour from Takayama, Mino Pr. Druses of blue tourmaline have also been reported by T. Kochibe from Tadachi, Shinano Pr.

The crystal from **Sakihama,** Rikuzen Pr., is 36 mm. in length and 17 mm. in diameter, and has the same crystal habit as ordinary black ones. It is dark green and transparent. The faces of the prism are vertically striated. On one end, we see R5 (?). A zonal structure exhibiting a red outer layer and green interior is visible on the end. The same zonal structure has also been found by the writer in tourmalines sold as gems in China.

The tourmaline from **Ishikawa**, Iwashiro Pr., is pitch-black and opaque. In quartz and rarely in the felspar of pegmatitic veins it occurs in crystals sometimes more than 7 cm. in diameter and 1 m. in length. The faces seen in such crystals are simply $-\frac{1}{2}$R. Small crystals are richer in faces, having the faces R, $-\frac{1}{2}$R, ∞ P, and ∞ P2.

The tourmaline from **Yamanō**, Hitachi Pr., is pitch-black and opaque. It is contained in quartz. The crystals have only the faces of the trigonal prism and common rhombohedron.

The tourmaline associated with quartz in the mountains around **Kimpūzan,** Kai Pr., is the same as that from Hitachi. Acicular crystals in radiating bundles are locally called "*Karakasa-ishi*" or umbrella-stone.

The crystals from **Goshodaira,** Shinano Pr., are rough on surface, and have very short prismatic faces terminating on $-\frac{1}{2}$R resembling the crystal from Chudleigh in England. Sometimes two or three such individuals unite in one composite crystal.

At **Takayama**, Mino Pr., there is found a blue transparent variety of tourmaline. The crystals are slender, being 9 mm. in diameter and 50 mm. in length. In some specimens, one end is transparent and of a lighter colour, while the other is decidedly darker and only semi-transparent. They appear in six-sided columns, the edges being often rounded. The faces of the prism are much striated vertically, and not smooth. Beryl found here resembles the tourmaline in colour and form. The beryl crystals are however not so striated as those of the tourmaline, and moreover they are coloured uniformly. Black acicular crystals in radiating bundles were formerly found here. Well terminated black crystals are sometimes detected in river sand.

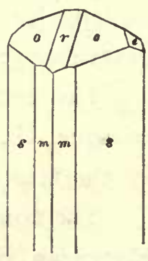
At **Obira**, Bungo Pr., there are found columnar crystals and globular groups of tourmaline in quartz.

The tourmaline from **Takakumayama**, Ōsumi Pr., is associated with quartz and mica like that of Hitachi. Some crystals have the terminal faces R and $-\frac{1}{2}R$ well defined, though of small size.

91. LIEVRITE

Lievrite occurs at Kusakura, Echigo Pr., Kamioka, Hida Pr., Zōmeki, Nagato Pr., Yanagigaura, Buzen Pr., Kiura, Bungo Pr., etc. in black and opaque crystals of columnar habit (Fig. 44). The faces recognised by S. Kō and N. Fukuchi are

Fig. 44.



$c = 0P$	$s = \infty P\breve{2}$	$r = P\bar{\infty}$
$m = \infty P$	$n = \frac{1}{2}P\breve{\infty}$	$o = P$
$\nu = \infty P\breve{\frac{4}{3}}$	$e = 2P\breve{\infty}$	

S. Kō mentioned in addition $\infty P\bar{2}$ and $P\frac{28}{25}$, which are however not accurately ascertained. The faces *m*, *s*, *o*, and *r* are usually well developed in specimens from all localities. The faces *e* and *c* are generally imperfectly developed and very small, *c* being observed in crystals from Zōmeki and Yanagigaura, and *e* in those from Kamioka and Zōmeki. Prismatic faces are vertically striated. The faces *c*, *p* and *o* have sometimes also striations parallel to the brachy-axis.

At **Kusakura** lievrite forms masses, in whose cavities crystals are found. They are associated with green coloured quartz and sometimes are covered with calcite.

Lievrite has been found at **Kamioka** by S. Kō, who collected beautifully crystallised specimens. According to the observer the commonest forms are combinations of *s*, *r*, *m*, and *e*. N. Fukuchi found also combinations of *o*, *ν*, *m*, *s*, *e*, *n*, *r*, etc. The prismatic faces are vertically striated. They measured from 6 to 9 mm. in diameter and from 15 to 20 mm. in length.

T. Kochibe has reported the occurrence at **Zōmeki** of the mineral in masses with minute crystals in drusy cavities.

At **Yanagigaura** near Kokura, S. Kō found lievrite in a green rock, the mineral sometimes forming columnar crystals in cavities. Lievrite from **Kiura,** Bungo Pr., is also beautifully crystallised.

92. EPIDOTE

Epidote occurs at Kamaishi, Rikuchū Pr. and Takeshi, Shinano Pr. The mineral from **Kamaishi** usually forms fibrous masses of yellowish green colour. Well crystallised specimens have been found here by S. Kō. The diameters of a crystals given by him to the writer are 12 mm. and 22 mm. respectively. The well defined faces of 0P, $P\bar{\infty}$, $P\breve{\infty}$, and $\infty P\bar{\infty}$ are recognised in it. Acicular crystals are also found in druses covered with calcite (?).

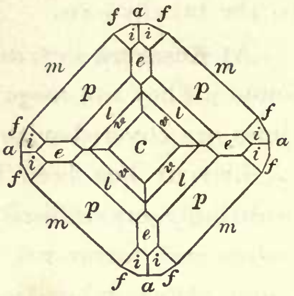
Epidote occurs at **Takeshi** in volcanic tuff in rounded masses, which, when broken, exhibit the drusy cavities with beautiful green needles of the mineral. Sometimes the faces $P\bar{\infty}$, $\infty P\bar{\infty}$, P and 0P can be recognised in these crystals.

93. VESUVIANITE

Vesuvianite occurs at **Kiura,** Bungo Pr., in well defined crystals of a green-black colour, up to 15 mm. in diameter and 45 mm. in length. According to Y. Kikuchi, it is a contact mineral formed in the metamorphosed part of limestone in contact with granite. The faces observed are

$c = 0P$	$e = P\infty$	$i = \frac{3}{2}P3$
$a = \infty P\infty$	$X = \frac{1}{3}P\infty$	$f = \infty P2$
$m = \infty P$	$\iota = \frac{1}{2}P$	
$p = P$	$\delta = \frac{1}{3}P$	

Fig. 45.



Of these faces, *c*, *p*, *i*, *m*, and *a* are in general best developed, *ι* and *δ* less common and usually small (Fig. 45). The face *X* has also been found. Y. Kikuchi observed a zonal structure under the microscope.

T. Hiki found at **Gobessho** near Kyōto metamorphosed limestone containing the mineral. It forms crystals, in which the faces of the prisms of the first and second orders are alone visible.

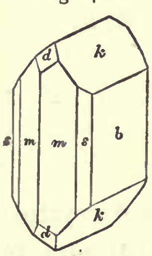
94. OLIVINE

This mineral which forms rock masses, is for the most part changed into serpentine. We find the original mineralogical character preserved only in dunite from **Saimaru,** Hitachi Pr. The crystals are sometimes found separated in younger volcanic rocks.

Olivine occurs in sand on the shore of Suëyoshi in **Hachijō-jima.** It forms minute transparent crystals of a greenish yellow colour.

Olivine and pyroxene appear as large phenocrysts in basalt forming a conical hill named **Ōguso-yama** in Ino-mura, Iwami Pr. Isolated crystals of large size can be obtained here. The mineral seems to belong to the ferruginous variety, fayalite.

Fig. 46.



At **Nishinotake,** Hizen Pr., olivine occurs with pyroxene in basalt, from which crystals of the two minerals are detached. According to Y. Ishii, crystals of olivine here found are well defined, and in spite of alteration as seen under the microscope, they generally have fairly well reflecting faces. The faces observed are two domes $2P\breve{\infty}$ (*k*) and $P\breve{\infty}$ (*d*), two prisms ∞P(*m*), and $\infty P2$(*s*) and the brachy-pinacoid $\infty P\breve{\infty}$ (*b*) (Fig. 46).

The angles measured are

$k : k' = 99° 35'$	$99° 6'$ (Dana)	
$m : m' = 47° 17'$	$49° 57'$	,,
$s : s' = 95° 4'$	$94° 4'$	,,

The axial ratios calculated from these angles is

$a : b : c = 0{\cdot}45763 : 1 : 0{\cdot}5923$ (olivine from Nishigatake)

$0{\cdot}46815 : 1 : 0{\cdot}58996$ (hyalosiderite)

$0{\cdot}46575 : 1 : 0{\cdot}58651$ (olivine from Dingestedt)

The analysis made by K. Kondō is

SiO_2	MgO	FeO	CaO	
38·74	43·53	16·60	trace	=98·87

The ratio of MgO to Fe is 2·41 : 1, while in hyalosiderite from Kaiserthal it is 2 : 1.

The specific gravity is 3·4 and the hardness 5, obviously diminished by decomposition.

S. Sasamoto mentions the following ten faces on crystals from the same locality:

$a = \infty P\bar{\infty}$	$s = \infty P\breve{2}$	$d = P\bar{\infty}$
$b = \infty P\breve{\infty}$	$h = P\breve{\infty}$	$e = P$
$c = 0P$	$k = 2P\breve{\infty}$	$f = 2P\breve{2}$
$m = \infty P$		

Occasionally olivine occurs at **Yatsugatake** in isolated crystals from olivine-bearing andesite.

Analysis of dunite from Saimaru made by S. Hida gives

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	Na_2O	K_2O	H_2O
41·14	2·62	3·52	4·64	46·62	0·75	0·06	0·85=100·20

95. DANBURITE

Danburite occurs at **Tōshōtō** in Obira, Bungo Pr. It was mistaken for topaz until the writer made the determinations on its specific gravity and crystallographic forms. It appears in well defined colourless crystals. Among the results of investigations made by several mineralogists, those of K. Jimbō and S. Kō are noteworthy.

According to the latter observer, the mineral occurs associated with galena, blende, brown garnet, quartz, and calcite in a vein traversing granular limestone. Good crystals are found in groups in the druses of the vein. They are covered with white crusts, by the removal of which colourless, transparent or semi-transparent crystals are obtained.

The faces observed are

$a = \infty P\bar{\infty}$	$x = 3P\bar{\infty}$	$Y = \frac{1}{3}P\breve{\infty}$
$b = \infty P\breve{\infty}$	$d = P\bar{\infty}$	$u = \frac{1}{2}P\breve{2}(?)$
$c = 0P$	$X = 4P\bar{\infty}$	$\lambda = 2P\breve{4}$
$m = \infty P$	$t = 2P\breve{\infty}$	$r = 2P\breve{2}$
$l = \infty P\breve{2}$	$w = 4P\breve{\infty}$	$v = P\breve{2}$
$\xi = \infty P\breve{3}(?)$	$p = 8P\bar{\infty}$	$s = 3P\bar{\tfrac{3}{2}}$
$n = \infty P\breve{4}$	$h = 11P\breve{\infty}$	$e = 2P$
$z = \frac{1}{3}P\bar{\infty}$	$q = 16P\bar{\infty}$	$o = P(?)$

Fig. 47.

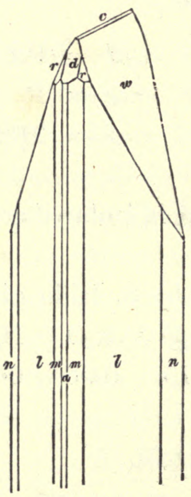
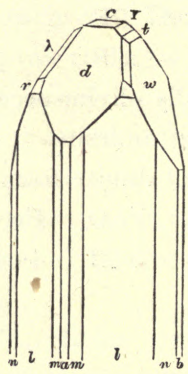


Fig. 48.



There is one more prismatic face of undetermined value truncating the edges between *n* and *b*.

The faces *w* and *l* are the largest and most common, *d* is smaller but also common. The crystals either sword-shaped or chisel-shaped, according as the development of the *d* face. The *w* faces are horizontally striated and have etched figures and vertical grooves, while the prismatic faces are vertically striated. K. Jimbō also made interesting observations on etching and corrosion of the mineral. Some crystals measure 45 mm. in length and 18 mm. in diameter.

The inclusions are according to S. Sasamoto dodecahedra of brown garnet, 0·5 mm. in diameter, and a white globular substance.

Analysis made by T. Tamura is as follows:

SiO_2	B_2O_3	CaO	Al_2O_3	Fe_2O_3	MgO	K_2O	Na_2O	H_2O
48·87	25·73	14·47	0·89	0·12	7·67	0·77	0·96	0·58 = 100·06

The specific gravity is 3·09.

The result shows that small content of lime in this specimen is compensated by magnesia.

96. GARNET

Garnet occurs in contact rocks, crystalline schists, serpentine and volcanic rocks. The localities are Kamaishi, Rikuchū Pr., Ishikawa, Sugama, and Tokurayama, Iwaki Pr., Yamanō, Hitachi Pr., Wadatōge, Iijima, Kawahage, and Tokiwa, Shinano Pr., Tomiyama, Mikawa Pr., Arimine, and Kanetsuriyama, Etchū Pr., Anamushi, Yamato Pr., Shimohogi, Nagato Pr., Yanagiura, Buzen Pr., and Kiura and Obira, Bungo Pr.

Of these localities garnet found at Kamaishi, Arimine, Shimohoki, Yanagiura, Kiura and Obira is in contact rocks; and that at Wadatōge and Anamushi in the younger volcanic rocks and in all other cases in granite regions.

Analysis have been made in view of ascertaining the chemical composition of the garnets of these different occurrences. The results are

		SiO_2	Fe_2O_3	Al_2O_3	MnO	CaO	MgO	K_2O	Na_2O	lost of ignition
1)	Shimohogi	35·70	26·09	3·45	0·22	31·20	1·43	0·18	0·22	1·65
2)	Kurodake	35·96	7·41	17·12	8·71	28·76	0·75	0·59	0·86	0 00
3)	Tokura	41·05	6·13	17·77	0·53	30·81	1·43	0·25	0·68	1·11
4)	Ishikawa	37·23	19·24	25·02	14·38	1·62	0·95	0·56	1·66	0·00
5)	Wadatōge	41·96	17·81	16·81	19·38	1·30	0·38	0·22	0·51	0·22

From these results it is obvious that garnet in contact rocks belongs to the calcareous variety. Respecting the mineral from other rocks, however, we do not possess data sufficient to enable us to deduce any chemical relation with mother rocks.

Garnet occurs at **Kamaishi,** in association with magnetite. We find here brown and green varieties. The brown garnet is crystallised in 2O2, ∞O or in a combination of the two forms. Individuals are often flattened or deformed by irregular growth. The green garnet is smaller in size and crystallised in a combination of 2O2 and ∞O. It sometimes has a zonal structure resulting from a green layer covering a brown one.

At several places in the neighbourhood of **Ishikawa** garnet occurs in granite. The mineral found in the felspathic matrix is large, some individual crystals measuring 20 mm. in diameter, and brown and opaque. That found in quartzose matrix is red and transparent, but the crystals are minute, being rarely 4 mm. and usually about 1 mm. in diameter. The faces observed are 2O2 and ∞O.

At **Tokura,** garnet occurs in reddish brown or brownish yellow crystals in combinations ∞O and 2O2, sometimes with $3O\frac{3}{2}$ in addition. It is associated with wollastonite. At **Takanuki** in the same province we find garnet which is almost black in single crystals in 2O2. These vary in size from 20 mm. to 30 mm. in diameter.

At **Yamanō,** Hitachi Pr., garnet occurs in pegmatite in well defined single crystals in 2O2. It is brownish red and sometimes partially transparent. The crystals appear sometimes in combination of 2O2 and ∞O.

At **Wada-tōge,** Shinano Pr., garnet occurs in andesitic obsidian in almost black and opaque single crystals in combination of 2O2 and ∞O. They are seldom perfectly bounded.

At **Iijima,** garnet occurs in gneiss in black opaque crystals about 10 mm. in diameter. It forms perfect crystals of 2O2. Garnet from **Kawahage** is dark green and opaque. The crystals are ∞O truncated with 2O2, and are in groups. The garnet from **Tokiwa** is olive green in colour and forms groups of crystals in ∞O.

At **Arimine,** Etchū Pr., it occurs with magnetite and quartz in contact rock. Some of the garnet is brown and forms crystals in a combination of ∞O and 2O2 aggregated in crystalline masses. Some, as found at Kurodake, is dark brown or yellowish brown and also forms crystalline masses of ∞O. A greenish brown garnet found here forms distinct crystals in groups. Their size is about 10 mm.

We find here also an yellowish green variety in minute crystals occuring with a fibrous mineral like pyroxene.

Garnet occurs at **Kanetsuriyama**, Etchū Pr., in contact zone of limestone and gneissic granite. It is greenish in colour and forms crystals in ∞O, up to 18 mm. in diameter.

Garnet from **Tomiyama**, Mikawa Pr., occurs in gneiss, and is dark red, and crystallised in 2O2.

Garnet from **Hatasa**, Mino Pr., forms dark green well defined crystals of ∞O.

Garnet occurs at **Anamushi**, Yamato Pr., as sand derived by the decomposition of andesite. It is brown red in colour and is usually translucent; it occasionally forms icositetrahedral crystals.

Garnet occurs at **Shimo-hogi** in crystalline masses of greenish brown crystals in ∞O. The crystals present an optical anomaly in thin sections, seen under the microscope, and exhibits a zonal structure consisting of layers of different optic orientations.

Garnet occurs at **Yanagigaura**, Buzen Pr., with magnetite in the contact zone of limestone with granite. It appears as crystals of 2O2, and is of a dark brown colour.

Garnet from **Kiura**, Bungo Pr., forms crystalline masses in whose drusy cavities appear crystals in ∞O truncated with 2O2. It is pitch black in colour and opaque. Smaller crystals attached to vesuvianite are reddish brown.

Garnet occurs also at **Yamaura** near Obira, associated with danburite. It is brownish yellow in colour and forms perfect dodecahedral crystals varying from 2 to 3 mm. in diameter. The mineral is formed as a product of contact metamorphism at both places.

Beside the above mentioned occurrences, garnet is found widely distributed in crystalline schists of Shikoku, and further in contact rocks at Dorogawa, Yamato Pr., Gobbesho near Kyōto, etc.

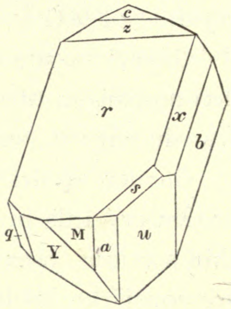
97. CHRYSOCOLLA

Chrysocolla is a secondary mineral found with other copper ores in copper mines, as at **Arakawa**, where it forms beautiful green coating on veinstone, and also pseudomorphs of an undeterminable mineral in rectangular prisms. It occurs at **Hosonokuchi,** Echizen Pr., **Kamioka,** Hida Pr., etc.

98. AXINITE

Axinite was found in 1877 at Ōkurajiki near Obira, Bungo Pr. In 1880 the writer investigated the mineral at the University of Berlin, and since then Y. Kikuchi has studied it. The faces thus recognised are[1] (Fig. 49)

Fig. 49.



$^*a = \infty P\bar{\infty}$	$z = \frac{1}{2}'P$
$^*b = \infty P\breve{\infty}$	$^*s = 2P'\bar{\infty}$
$c = 0P$	$q = 5'P\grave{5}$
$^*M = \infty 'P$	$Y = 3{,}P\grave{3}$
$^*m = \infty P'$	$X = 2'P\breve{\infty}$
$^*r = 'P$	$y = 2P'\bar{\infty}$
$^*x = P'$	

the angles measured being

$M : v$	$= 135° 2'$	134° 45' (Des Cloizeaux)
$v : x$	$= 139° 25'$	139° 13' ,,
$v : s$	$= 143° 31'$	143° 55' ,,
$b : u$	$= 147° 32'$	147° 13' ,,

The crystals unlike those of the foreign occurrences have not the acute edges, which the name axinite implies, though they are rich in rare faces, such as *X* and *Y*. The pleochroism is pronounced. The interference figure is seen on *x*.

According to Kajiura, the chemical composition is

SiO_2	Al_2O_3	Fe_2O_3	CaO	MnO	B_2O_3	Na_2O	H_2O	K_2O	MgO
41·87	19·25	11·79	17·75	5·62	1·59	1·79	0·87	trace	trace=100·53

A noteworthy feature of this axinite is the small content of B_2O_3 which is about 4 % less than in foreign specimens.

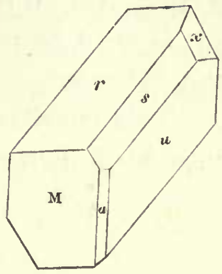
Axinite has since been found by S. Sasamoto and S. Kō at Hajikami and Noborio, Hyūga Pr., and many other places in the neighbourhood of Obira.

At **Hajikami** the mineral occurs abundantly and in a fresh

1) * indicates the faces measured by the writer,

state. It is dark brown or dark brownish purple and translucent, and has a brilliant vitreous lustre. Quartz and a green botryoidal mineral are associated with it.

Fig. 50.



The forms of the crystals are apparently different from those of Ōkurajiki, on account of a different mode of development of the same faces (Fig. 50). They are

$a = \infty P\bar{\infty}$	$u = \infty P'$	$s = 2P'\bar{\infty}$
$b = \infty P\breve{\infty}$	$r = {}'P$	$q = 5'P\breve{5}$
$c = 0P$	$x = P'$	$Y = 3,P\breve{3}$
$M = \infty{}'P$	$z = \frac{1}{2}{}'P$	$y = 2P'\bar{\infty}$.

The only face wanting is *X*. The *r* faces are best developed, next *M*, *b*, and *Y*, the others being very imperfect and minute. On account of the development of *r*, the crystals assume a tabular habit, differing from that of the crystals from Ōkurajiki. The well developed faces *M* which make with *r* acute edges, characteristic of axinite, are another difference. The large crystals are often as much as 45 mm. in length. The faces *a*, *c*, *z*, *r*, *s*, *M*, and *u* are striated, but lustrous, *Y*, *q*, and *b* rough and dull. Moreover *b* has a different colour, being greenish or yellowish brown, while other faces are dark brown. So are also *Y* and *q*.

We often find here crystals in which the *r* face is curved and gives rise to a wedge-shape. They are in reality groups formed by juxtaposition of many crystals.

The axinite from **Shōdo** is epidote green or brownish purple and transparent, and has a high vitreous lustre. The crystals are small, the longest being only 9 mm. in length. Their habit is typical and resembles to that of axinite from Bourg d'Oisans. *M*, *r*, and *u* are well developed, and striated. The *X* faces are smaller in size, but are also constantly present. The faces *y*, *s*, *b*, and *a* are rarely observed.

The axinite from **Noborio** is yellowish or purplish brown, translucent, and only slightly lustrous (Pl. XXVIII, b).

The analysis of the axinite from Obira as given by W. E. Ford[1] is

1) Chem. Zusammensetz. d. Axinits. Zeits. d. Kryst. XXXVIII. 1904.

SiO_2	B_2O_3	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	H_2O	
41·80	5·61	17·15	1·11	2·84	10·71	19·51	0·21	1·22 = 100·16	G = 3·028

It is to be regretted that the exact locality of the specimen is not indicated.

Thin lamellar crystals of axinite occur at **Kamaishi.** It is of a purplish brown colour.

THE MICA GROUP

Though mica occurs in wide distribution as an essential ingredient of granite, gneiss, and schists, well defined crystals are of rare occurrence, being limited to druses. Tanokamiyama, Ōmi Pr., is the chief locality of crystallised micas.

As careful studies on the chemical, crystallographical and optical nature of the micas of Japan are wanting, we have to be content with the distinction, however incomplete, of four principal varieties, viz. biotite, zinnwaldite, muscovite, and lepidolite.

99. BIOTITE

The biotite from **Miyamori,** Rikuchū Pr., occurs in granite. It forms hexagonal plates 60 mm. in diameter.

Biotite from **Miyamoto,** Kai Pr., also occurs in granite in greenish black plates, which are weathered.

At **Hajikano** in the same province, there occurs vermiculite, locally known as "*Hiru-ishi*" or leech-stone, in hexagonal plates less than 5 mm. in diameter. The chemical composition of their mineral is

SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	H_2O
38·45	15·35	22·73	1·71	2·22	7·85	2·16	2·25	7·20 = 99·92

This mica is rich in iron and alumina and comparatively poor in magnesia. The large content of water is evidently a result of decomposition.

Biotite from **Takayama,** Mino Pr., occurs in granite in greenish brown lamellæ, rarely with hexagonal outlines.

Biotite from **Tanokamiyama,** Ōmi Pr., forms thin plates which are of a dark brownish green. According to K. Jimbō the optic axial plane is parallel to one of the six sides. Wrinkles parallel to the glide plane are seen on the cleaved surface. The optic axial angle is very small. It is sometimes zonally surrounded with silvery white mica of the same outline and orientation. Two analyses have been made by F. Kodera and T. Tamura respectively. The results are

	SiO_2	Al_2O_3	Fe_2O_3	FeO	Mn_3O_4	MgO	CaO	K_2O	Na_2O	Li_2O	F	H_2O
I.	35·87	22·69	20·90	—	5·65	0·33	—	6·70	2·53	0·35	3·19	1·00=99·21
II.	36·57	16·94	4·68	24·87	—	0·65	0·69	10·91	2·06	—	—	2·60=99·97

Though both results are unsatisfactory, yet the mica is obviously that variety of biotite which is extremely poor in magnesia and rich in iron and potash.

100. ZINNWALDITE

A variety of mica found at **Tanokamiyama** forms six-sided plates with a zonal structure. They are of a light brown colour at the core, which is surrounded with light purplish and white zones. According to K. Jimbō, the optic axial plane is parallel to one of the six rays of the percussion figure, and the optic axial angle is large. Wrinkles are observed on the cleaved faces of 0P. They are parallel to the glide plane.

An analysis made by F. Kodera gives the following results :

SiO_2	Al_2O_3	Fe_2O_3	Mn_3O_4	MgO	K_2O	Na_2O	TiO_2	F	H_2O
46·13	17·03	4·64	6·27	1·29	10·09	4·12	2·77	6·89	2·31=103·53

The absence of lithia in this mica is a fact which deserves more careful investigation.

101. MUSCOVITE

The muscovite from **Takayama,** Mino Pr., is colourless and forms aggregates of hexagonal plates, varying from 30 to 60 mm. in diameter.

The mineral from **Takanokamiyama** is of the same form, but is smaller, being only 5 mm. in diameter. It is found covering the surface of felspar and smoky quartz, with which it occurs in association.

The cleaved surface has wrinkles perpendicular to the sides. The optical axis is parallel to the direction of one of these wrinkles.

Plates are often found to be symmetric twins of the mica law. They often bear cracks parallel to one of the six rays of the percussion figure. We find here two varieties of muscovite. One is in small silvery plates of hexagonal outline, only 6 mm. in diameter. The other is larger and has a zonal structure, being light brown in the fresh central part and white in the weathered marginal portion.

Analyses of the mineral are as follows :

SiO_2	Al_2O_3	Fe_2O_3	Mn_3O_4	CaO	MgO	K_2O	Na_2O	F	H_2O		
41·26	26·24	12·79	2·28	—	1·29	9·54	2·86	2·00	0·98=	99·24	(F. Kodera)
43·44	29·56	6·68	--	0·53	2·13	10·11	2·51	—	5·14=	100·10	(T. Tamura)

102. LEPIDOLITE

Lepidolite occurs at **Suizawa**, Ise Pr., in coarse-grained granite. It is of a rose colour and the plates are sometimes as much as 18 cm. in diameter. The mineral has been reported by T. Kochibe from **Komono** in the same province. It occurs there in thin rosy scales scattered through a quartzose rock.

103. CHLORITE

Although chlorite is abundant in the green schists of the metamorphic terrain, yet well crystallised chlorite is found only at **Kamaishi**, Rikuchū Pr., where it occurs in six-sided plates in cavities of magnetite. Large crystals reach 8 mm. in diameter, but the usual size is 2 to 3 mm.

104. PINITE

Pinite occurs at **Torihama**, Wakasa Pr., as a secondary mineral replacing cordierite, in pseudo-hexagonal prisms, 15 mm. in diameter. It takes the form of colourless, scaly aggregates. A similar pseudomorph is the "*Sakura-ishi*," or cerasite, which occurs in a metamorphosed slate in contact with granite near **Kameoka**, Tamba Pr.

The pinite found at **Ōkaneda**, Hitachi Pr., is a decomposition product of tourmaline.

105. TALC

Talc occurs usually as rock masses. The crystallised form has been observed only at **Ōgushi**, Hizen Pr. In the white talc schist of this locality are found pale greenish translucent plates. Another occurrence of crystallised talc is reported from **Kamaishi**, where the mineral sometimes forms light greenish scales covering magnetite.

An analysis of the mineral gives the following results :

SiO_2	FeO	Al_2O_3	Mn_3O_4	NiO	MgO	K_2O	Na_2O	Ignition loss
61 69	1·96	0·63	trace	0·03	30·52	0·09	0·24	5·45 = 100·61

106. CORDIERITE

Cordierite occurs in metamorphosed slate of contact zones and in volcanic rocks. The first kind has been found by Y. Kikuchi[1] in pebbles of the Watarase-gawa, Shimotsuke Pr., and the latter by Hussak[2] in the ejecta from the volcano of Asama, Shinano Pr. Cordierite as a contact mineral has also been known to occur at Ashio, Shimotsuke Pr., Dōshi, Kai Pr., Torihama, Wakasa Pr., Kameoka, Tamba Pr., etc. Its occurrence in volcanic rocks has been reported by N. Yamasaki at Gōro-yama, near Nagano, Shinano Pr., Iwate-san, Rikuchū Pr., etc. The mineral, especially in contact rocks, is rarely in the fresh state, since it is liable to decompose into pinite or some micaceous substance. It forms pseudo-hexagonal prisms by penetration trilling.

Along the **Watarase-gawa**, Shimotsuke Pr., it occurs in hexagonal columns, about 10 mm. in diameter in metamorphosed slate. The greater part of it is decomposed into white opaque masses.

Cordierite of the same nature is also found at **Ashio** in the same province.

Cordierite from the volcano of **Asama**, Shinano Pr., is found as violet spots in the vitreous ejecta. The characteristic trilling and pleochroism are visible only under the microscope.

1) Journ. Science Coll. Imp. Univ. Tōkyō. Vol. III. 1890.

2) Sitzungsber. Wien. Akad. LXXXVII. 1883.

Cordierite found by N. Yamasaki at **Gōro-yama** near Nagano, in the same province is of a different mode of occurrence from either of the above cases. It here forms minute but well defined and prismatic crystals of a dark purple colour in drusy cavities of hornblende-andesite. Under the microscope the cross sections exhibit the six sectors formed by trilling. The pleochroism is very distinct.

Cordierite from **Dōshi,** Kai Pr., is found in a metamorphosed rock of a dark green colour. It forms six-sided prisms 12 mm. in diameter and 15 to 25 mm. in length, often detached from the rock matrix. The crystals are usually decomposed and the central part is seldom found in the fresh state.

As before mentioned, specimens from **Torihama,** Wakasa Pr., are completely altered into pinite. Those from **Kameoka,** Tamba Pr., are also altered into a micaceous substance.

Cordierite, as a contact mineral, has also been known to occur in **Iriya,** Rikuzen Pr., **Hokkaidō, Nyoigatake** near Kyōto, Yamashiro Pr., **Yakushima,** and in many other places.

107. BRONZITE

Bronzite has been found by Y. Kikuchi[1] in **Ogasawarajima** (Bonin Islands), in a glassy andesite. It forms stout well defined crystals of a green colour flattened along $\infty \mathrm{P}\bar{\infty}$. The size ranges from 5 to 10 mm. in the direction of the vertical axis. The faces observed by Y. Kikuchi are $\infty \mathrm{P}\bar{\infty}\,(a)$, $\infty \mathrm{P}\breve{\infty}\,(b)$, $\infty \mathrm{P}(m)$, $\mathrm{P}\bar{2}(e)$, and $2\mathrm{P}\bar{2}(i)$.

The predominating faces are *a*, *b* and *c*; the faces *m* and *i* are small. The measured angles are

$e : e$	$= 153° 11'$	$i : m$	$= 138° 35'$
and	$= 121° 12'$	$a : m$	$= 136° 5'$

The pleochroism is very marked. The axial colours are α = reddish brown, β = greenish yellow, γ = yellowish green, and the absorption $\alpha > \beta > \gamma$.

An analysis made by T. Shimizu gives the following result :

1) Pyroxenic components in certain volcanic rocks from Bonin Islands. Journ. Coll. Science. Imp. Univ. Tōkyō, Vol. III. 1890.

SiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	CaO	MgO	H_2O	
55·04	0·88	0·29	9·40	0·18	1·55	32·65	0·45	=100·64

The composition is approximately equivalent to $FeSiO_3 + 6\,MgSiO_3$, and the mineral may be called bronzite.

108. DIOPSIDE

Diopside has been found by S. Kō at **Kamaishi** in druses of massive magnetite. It occurs in groups of elongate prismatic crystals of a greenish blue colour, reaching 30 mm. in length and 10 mm. in diameter.

109. HEDENBERGITE

Hedenbergite was first found by Y. Kikuchi, at Ōkurajiki in **Obira.** K. Jimbō has investigated crystals recently found there. The mineral occurs with fluorspar, chalcopyrite, pyrites, arsenopyrite, and garnet in a crystalline limestone. It is dark green and has distinct cleavages parallel to ∞P, $\infty P\bar{\infty}$ and $\infty P\breve{\infty}$. One of the lemniscates of the interference figure is seen in sections approximately parallel to the vertical axis. The crystals are developed in the direction of the axes *b* and *c*, and have a thick tabular habit.

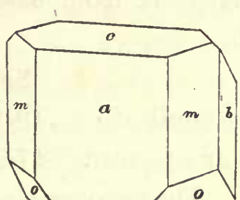
The faces recognised are

$a = \infty P\bar{\infty}$ $m = \infty P$

$b = \infty P\breve{\infty}$ $p = +P\bar{\infty}$

$c = 0P$ $o = +2P$

Fig. 51.



There is also one more face truncating the obtuse angle of *o* and *c*, but is too minute to be determined.

The angles measured are

$c : a$ =	74° (?)	74° 10′ 9″ (Hintze)
$p : c$ =	147° 30′	148° 40′ ,,
$m : m$ =	88°	87° 10′ ,,
$o : p$ =	134° 10′	133° 29′ ,,
$b : o$ =	132° 36′	133° 5′ 30″ ,,
$c : o$ =	112° 45′	

Large crystals are 35 mm. in lateral diameter and 10 mm. in thickness.

The analyses of the hedenbergite from Obira made in the Imperial Geological Survey are

	SiO_2	Al_2O_3	CaO	FeO	MnO	MgO	Na_2O	K_2O	H_2O
I	49·56	1·14	22·13	23·76	1·48	1·64	0·45		— =100·16
II	47·13	—	23·23	24·46	0·73	2·40	0·98	0·13	1·08=100 14
III (Calculated from $CaSiO_3$ $FeSiO_3$)	48·39	—	22·18	29·43	—	—	—		— =100·00

The result shows that a part of the iron has been replaced with magnesium and manganese.

At **Matanosawa**, Musashi Pr., situated near the junction of the boundary lines of the provinces of Musashi, Kai and Shinano, hedenbergite is found in association with calcite in an auriferous quartz vein. It appears in minute well defined crystals, from 2 to 3 mm. in length. The forms observed are $\infty P\breve{\infty}$, $\infty P\bar{\infty}$, and a slightly developed ∞P, with $-P(u)$ at the end. The angles measured are $m : m = 92° 56'$ and $u : u = 48° 26'$. Under the microscope, $\mathfrak{c}$ lies in the angle $-\beta$ and $c : \mathfrak{c} = 49° 33'$.

Hedenbergite in rare instances occurs with quartz at **Kamioka,** Hida Pr. in dark green columnar crystals about 20 mm. in length. The faces are $\infty P\bar{\infty}$, $\infty P\breve{\infty}$, and ∞P; the terminal faces are not determinable.

S. Kō gives the following results of his analysis of green fibrous pyroxene from **Sasagatani,** Iwami Pr. and from **Yanagigaura,** Buzen Pr.

	SiO_2	Al_2O_3	FeO	CaO	MgO	MnO
Sasagatani	48·40	3·66	20·81	22·20	1·20	4·65=100·92
Yanagigaura	47·50	5·03	23·29	20·17	0·49	2·60= 99·08

The pyroxene from Sasagatani seems to be allied to manganiferous hedenbergite; and that from Yanagigaura, an intermediate between hedenbergite and sahlite.

110. AUGITE

Augite is formed as an ingredient of andesite, from which isolated crystals of it are detached by decomposition. The chief localities are Yoshino-gawa, Uzen Pr., Onnadani, Echigo Pr., Tateshinayama, Shinano Pr., Myōgi-san, Kōzuke Pr., Nishigatake, Hizen Pr., etc. An exceptional occurrence of augite in a dyke of dioritic porphyrite is found at Kami-sano, Kai Pr.

The faces observed in the augite of Japan are

$a = \infty P\bar{\infty}$	$u = -P$	$n = +\frac{2}{3}P\bar{\infty}$
$b = \infty P\grave{\infty}$	$o = +2P$	$p = P\bar{\infty}$
$c = 0P$	$v = -2P$	$e = P\grave{\infty}$
$m = \infty P$	$l = -\frac{1}{3}P\bar{\infty}$	$z = 2P\grave{\infty}$
$s = +P$		

Fig. 52.

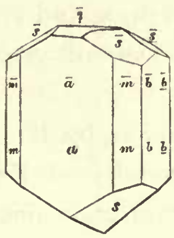
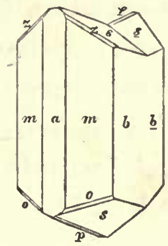


Fig. 53.



The common habit is eight-sided columns formed by combinations of *a*, *b*, *m*, *c*, *s*, and other pyramids and domes. The twinning on the plane of the orthopinacoid is very frequent; either the two individuals are united by this face or a crystal is traversed by twin lamellæ parallel to it (Fig. 52 and 53).

Augite from **Yoshinogawa**, Uzen Pr., is dark green in colour, and appears in perfect crystals varying from 4 to 15 mm. in diameter. The faces recognised are *a*, *b*, *m*, *s*, *v*, and *o*. Rough faces, perhaps *p* and *c*, are also seen in them. Twins on *a* are frequent.

Augite from **Onnadani** on the south-east of Yoneyama, Echigo Pr. occurs in rather large quantities in brook gravel. The crystals have well preserved prismatic edges, but the terminal faces are usually rounded, the domes being markedly roughened. The faces observed by C. Iwasaki are *a*, *b*, *c*, *m*, *s*, *o*, *l*, and *n*. Angles measured by C. Iwasaki are $o:m=35°32'$, $l:a=65°$, $n:a=85°$ and $\beta=74°$. Further results of angular measurements by T. Takimoto are $a:m=46°\ 10'$, $b:m=43°\ 42'$, $s:a=76°\ 43'$, and $s:b=60°\ 35'$. Broadly speaking, there are two combinations as observed by C. Iwasaki; viz. one *a*, *b*, *m*, *c* and *s*, the other *a*, *b*, *m*, *l* and *n*, beside crystals twinned on *a*. The crystals of the first type are large, and developed in the direction of the axis *b*, some measuring 12 mm. in this direction. Those of the second type are rarer and smaller than the preceding, measuring about 6 mm. in the directions of *b* and *c*, and 3 mm. in the direction of *a*. Rarely the face *o* is observed in these crystals. Twins are of common occurrence. The characteristic "*hour-glass*" structure is often observed in thin sections.

The terminal sectors are light in colour and the angle of extinction $c:\mathfrak{c}=42°—46°$, while the sectors on the front and back as well as at the centre are darker, and the angle $c:\mathfrak{c}=46°$. The pleochroism is not pronounced on *b*, but is quite distinct on *a* and *c*.

$\mathfrak{a}$ and $\mathfrak{c}$=yellowish green $\mathfrak{b}$=oil green

The specific gravity averages 3·42.

A chemical analysis of the mineral was made by H. Yoshida, in the Chemical Institute of the Imperial University of Kyōto, on a sample which had been carefully separated from glass inclusions and magnetite with Thoulet's solution and the magnet. The result was

SiO_2	Fe_2O_3	Al_2O_3	FeO	CaO	MgO	K_2O	Na_2O
53·56	2·75	0·26	8·69	30·16	1·70	0·21	2·64=99·97

Accordingly this augite belongs to a variety very rich in lime and poor in magnesia.

Augite from **Tateshinayama,** Shinano Pr., is of the same habit but of smaller size.

Augite from **Ishii,** Kōzuke Pr., forms perfect, slender prismatic crystals about 10 mm. in length, is of a black colour and has a high lustre. The chief faces are ∞P, $\infty P\bar{\infty}$, $\infty P\breve{\infty}$, and $+P$.

Augite from **Myōgi-san,** is stout prismatic, and occurs in andesite.

Augite from **Atsuna** near Yatsugatake, Kai Pr., occurs associated with olivine in a gravel layer. It has been detached from blocks of andesite imbedded in it. The faces determined by H. Ishiwara are *a, b, m, s* and *p*. The angles measured by the observer are $m:m=92° 44'$, $s:a=76° 10'$, $s:b=60° 0'$, and $s:s=60° 0'$.

The axial ratio $a:b:c=1·9360:1:0·54711$, and $\beta=74°$.

Beside simple crystals in combinations of *a, b, s,* and *m*, there are various kinds of twins. Some are juxtaposed on *a*; some are doubly twinned with a third sub-individual which forms with one of the two a contact twin on *c;* some are doubly twinned in the same manner as the preceding, but the portion of the third sub-individual and the second are reversed with respect to the first; while still others are twinned in a more complicated manner. The hour-glass structure is observed in sections parallel to the clinopinacoid.

The axial colours are

$\mathfrak{a}$=light brownish yellow, $\mathfrak{b}$=light yellow,

$\mathfrak{c}$=light green,

and the absorption is $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$.

Augite from **Kami-Sano** occurs in well defined crystals of a dark-green colour. The crystals vary usually from 6 to 20 mm. in diameter. One rare specimen in the writer's collection is 30 mm. in the diameter along the axis *b*, 47 mm. in the other lateral diameter, and 65 mm. in length. It occurs in a dark green dyke rock with large phenocrysts of augite. The commonest form of the crystals is a combination of ∞P, $\infty P\grave{\infty}$, $\infty P\bar{\infty}$ and P, less commonly with 0P in addition, rarely in a combination of ∞P, $\infty P\bar{\infty}$, $\infty P\grave{\infty}$, P, $-P$, 2P, $-2P$, and $2P\grave{\infty}$. Twins are on the face $\infty P\bar{\infty}$. A noteworthy fact is the occurrence of both elongate and stout prismatic crystals.

The analysis by S. Shimizu gives

SiO_2	Fe_2O_3	Al_2O_3	Mn_3O_4	CaO	MgO	Na_2O K_2O	
50·58	4·36	4·24	0·12	22·69	17·23	0·44	=99·66

This augite is richer in alumina and magnesia, and poorer in lime, than the augite from Onnadani. The content of iron of this augite is considerably less than that of the augite from Nishigatake, which we shall next describe.

According to S. Sasamoto, the augite of **Nishigatake** occurs at Takigawachi near Imari, Hizen Pr. The occurrence is due to the decomposition of the basalt which forms Nishigatake and the adjacent mountains. Hence it is found with olivine in brook sand. The mineral is dark, light, or yellowish green, and sometimes reddish or pitch black in colour. The green crystals have perfect forms, while the black ones are broken or massive. The faces observed by Y. Ishii who investigated the mineral were *a, b, c, m, s, o, p,* and *e.* The terminal faces are duller than the prismatic, and the face *c* is excessively corroded and uneven. The faces *o* and *c* are minute but brilliant. The common habit of the crystals is either long prisms, wanting *c* and *p*, or stout columns developed in the direction of the *b* axis, often wanting *c*, but often furnished with *p*. Less common are crystals with well defined *c* and *p* faces. Rarest is the short tabular form produced by a prominent development of the faces *c*. Twins on $\infty P \bar{\infty}$ are very common.

The mineral is very rich in inclusions of glass and its devitrified products. This is especially the case with green coloured crystals, which under the microscope exhibit crowds of inclusions, cavities and cracks of different shapes. On the contrary the black crystals are quite compact and devoid of any such foreign substances. Sometimes the black compact augite has a greenish honeycombed coating.

The chemical analyses of the augite from Nishigatake made by M. Chikashige are

	SiO_2	CaO	FeO	Al_2O_3	MgO	H_2O
I.	50·18	19·79	12·50	2·80	13·54	1·02 = 99·83
II.	53·64	18·03	14·77	5·76	6·89	— = 99·09

The first analysis was made on the black augite, and the second on the green. As the inclusions were not separated from the second, it is impossible to draw any conclusion from the result. A comparative richness of magnesia and lime in the first type of crystals seems to be a fairly certain fact. No noteworthy difference in the angle of extinction between the two differently coloured varieties, has been observed by Y. Ishii, $c : \mathfrak{c}$ being about 40° in both. The hour-glass structure is very commonly seen in thin sections of this augite.

111. WOLLASTONITE

Wollastonite occurs as a contact mineral in limestone, in which it forms white fibrous aggregates. The localities are **Tokiwa,** Shinano Pr., **Yoshizuka,** Mino Pr., **Saimyōji** and **Ishiyamadera,** Omi Pr. The composition of the mineral is

	SiO_2	CaO	Al_2O_3 Fe_2O_3	MgO	Ignition loss		
I.	49·18	44·82	0·73	1·87	3·05	=	99·65
II.	51·51	47·65	—	0·09	0·43	=	99·68

112. DIALLAGE

Diallage occurs at **Ubu**, Mikawa Pr., in serpentine derived from gabbro. Large crystals measure as much as 7 cm. in the longest diameter. The cleaved plates have a gray colour and a pearly lustre.

113. RHODONITE

Rhodonite occurs usually as compact or fibrous masses of a beautiful rosy colour, and rarely in crystals. The mineral found at **Innai**, Ugo Pr., forms radiating fibres. That from **Ōtsuchi**, Rikuzen Pr., is compact, but traces of crystalline outlines are rarely observed.

Oyamada, Mikawa Pr., is the only locality where minute but well defined crystals have been found. Rhodonite here occurs with transparent yellowish green garnet in crystalline masses. Minute transparent red crystals of rhodonite are found in the druses. The faces recognised are OP, $\infty P\breve{\infty}$, $\infty'P$, $\infty P'$, $2P'$, $2P_{,,}$, $2,P$, P', and $P_{,}$.

Rhodonite from **Hirudani**, Omi Pr., **Kiura**, Bungo Pr., etc., forms compact pink coloured masses. Some are partly changed to gray or black by decomposition.

114. TREMOLITE

Tremolite occurs at **Ishigure**, **Furuno** and **Tadoyama**, Ise Pr., in white fibrous or acicular bundles. On account of the external resemblance, the mineral has been mistaken for wollastonite. The following analyses made by H. Yoshida show the mineral to be tremolite, in which a part of the magnesia has been replaced with other metals

		SiO_2	CaO	MgO	Al_2O_3	FeO	K_2O	Na_2O	Ignition loss
I	Ishigure	58·36	14·70	23·10	1·38	0·46	0·40	1·38	0·46 = 100·23
II	Tadoyama	57·31	12·75	25·44	1·37	0·36	0·45	0·53	0·40 = 99·15

I. G = 2·932 II. G = 2·956

At **Kawahake**, Shinano Pr., tremolite occurs in quartz in columnar or fibrous crystals, partly decomposed into talc.

115. ACTINOLITE

Actinolite is a mineral very common in crystalline schists, but appears in well defined crystals only at **Sekigawa**, Iyo Pr. It is found in a talcose schist in green prismatic or fibrous crystals, more than 10 cm. in length, but without terminations. The faces observed are only ∞P and $\infty P\breve{\infty}$. The mineral is green or gray, transparent or translucent and has a vitreous lustre. It is nearly colourless in thin sections, and therefore the pleochroism is not strong, $\mathfrak{c}$ being green, and $\mathfrak{b}$ and $\mathfrak{a}$ yellow, and the direction of extinction $c : \mathfrak{c}$ about 15°. Grains of magnetite and calcite are enclosed in the crystals.

116. HORNBLENDE

Hornblende, though one of the very frequent ingredients in andesite, is of rarer occurrence than augite. The mineral from the provinces of Kōzuke, and Kaga, and from Taiwan (Formosa) is found in disintegrated andesite. That from Shikanoshima is the only instance of its occurrence in rocks other than andesite.

At **Shimo-Ōya**, Kōzuke Pr., hornblende occurs in andesite in crystals reaching 15 mm. in length. It is black in colour and has a reddish brown earthy coating which can be easily removed. The faces observed are ∞P, $\infty P\breve{\infty}$, P, and $0P$. Some crystals are twinned on $\infty P\bar{\infty}$.

Crystals of hornblende from **Hakusan**, Kaga Pr., are about 10 mm. in length. Like those from Kōzuke, they are covered with a brown earthy substance, the faces being ∞P, $\infty P\breve{\infty}$, P and $0P$. Some of them are twinned on $\infty P\bar{\infty}$.

In northern Taiwan hornblende occurs in Kwōkei at the foot of **Sha-bō-zan** in the volcanic group of Tai-ton-zan near Taihoku. The crystals found near the solfatara in the valley are well defined in form and dark brick red or grayish green in colour. The red coloured crystals especially have many pores like cork and are exceedingly brittle. Those found in the bed of the stream are usually eroded on the edges, but are more compact, and have a black colour with a vitreous lustre. The characteristic cleavage is distinct in the pitch-black crystals which are free from inclusions. Grayish-green crystals sometimes bear pyroxene grains partly imbedded in them.

The crystals are prismatic, elongate along the vertical axis, and reach 20 mm. in length. Some however are nearly equally developed along the axes *c* and *b*. Their cross sections are commonly eight-sided, or rarely six-sided by the disappearance of $\infty P \bar{\infty}$. The ∞P faces are best developed. The faces are vertically striated in the pitch-black crystals. There are in the zone two other faces which are imperfectly developed. Of the eight kinds of terminal faces observed, the only determinable ones are $P \breve{\infty}$ and $+P \bar{\infty}$. The angle between the axis *c* and $\mathfrak{c}$ is 16°.

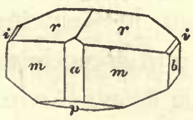
The chemical analysis of the fresh pitch-black variety is as follows:

SiO_2	FeO	Al_2O_3	MnO	CaO	MgO	Na_2O+K_2O	
41·67	16·18	14·14	0·69	11·10	14·16	1·98	=99·92

The paucity of silica and lime and the richness of iron and alumina may be due to the admixture of some foreign substance.

According to S. Kō who found the mineral, the hornblende from **Shikanoshima,** Chikuzen Pr., occurs in diorite, in which phenocrysts of hornblende can easily be separated from the felspar. The crystals are dark green and translucent, and in habit stout prismatic. The faces recognised are *a, b, c, m, i* and *r*, of which *m* and *r* are best developed, *b* being smaller but always present (Fig. 54). The faces *c, a* and *i* are rarer and smaller. The faces of the prismatic zone are fairly smooth and have a vitreous lustre, while *r* and *c* are rough and dull.

Fig. 54.



At **Hiyoshi,** Buzen Pr., dark green hornblende occurs in crystals which are sometimes 30 mm. in length. They have no well defined faces.

Hornblende has also been reported from Echigo, Tosa, Hizen, Higo, and other provinces.

117. BERYL

Beryl occurs in pegmatitic veins in granite at Ishikawa, Iwaki Pr., Yamanō, Hitachi Pr., Takayama, Mino Pr. and Tanokamiyama, Omi Pr.

In Iwaki Pr., beryl occurs at **Mujinamori, Tomaki,** and other places near Ishikawa, in association with orthoclase, quartz and black tourmaline. It is usually imbedded in orthoclase. There are two kinds of beryl. The one that is by far the most abundant here, occurs in light green and almost opaque crystals of the hexagonal prism. Some of them have $\infty P2$ and $0P$ beside the prism ∞P. The largest of this kind of crystals are 60 mm. in diameter and more than 100 mm. long ; but most of the crystals are of about half these dimensions. The crystals of the second kind are smaller, measuring about 25 mm. in length and 15 mm. in diameter, but are transparent and a little darker in colour. Their form is the same as that of those just described.

Beryl from **Yamanō,** Hitachi Pr., is associated with quartz and orthoclase, both of which, being of a later formation, enclose the mineral. It is light green or yellowish gray or an opaque yellowish gray. It forms simple hexagonal columns, less than 40 mm. in length.

Beryl from the environs of **Takayama,** Mino Pr., is obtained usually from the river sand, and rarely from druses *in situ*, in which case it is found enclosed in quartz. The crystals here found are, unlike those from Iwaki and Hitachi, perfectly transparent and light greenish or nearly colourless. The crystals reach 2 mm. in diameter and 45 mm. in length, and present the faces of ∞P and sometimes $0P$. Some of them are much striated on the prismatic faces. Acute pyramids of the first and second order are seen in such striated crystals, but the faces are too rough for accurate determination. Slender crystals, up to 4 mm. in length, have also been found here.

At **Tanokamiyama,** beryl has not been found in association with other minerals, except as inclusions in topaz. We find here both the opaque and the transparent varieties. The opaque beryl is light green, and forms hexagonal columns up to 45 mm. in diameter. The other variety is on the contrary only about 16 mm. in diameter in the largest specimens, but is so elongated as to measure more than 150 mm. It is light green, perfectly transparent, and most crystals are so extremely striated as to make their hexagonal prismatic character hardly recognisable. They are however perfectly terminated on 0P, sometimes with P and 2P2 in addition. These faces are smooth and reflect the light well. The cleavage parallel to 0P is perfect in both varieties.

THE FELSPAR GROUP

Felspar in single perfectly bounded crystals occurs comparatively rarely. As such doubtless first of all stand orthoclase and microcline, which occur in druses in granite. Tanokami-yama in Ōmi Pr. is the locality most noted for these kinds of felspars, as well as for many others of the rarer minerals already described. Among other less noted localities, Takayama, Mino Pr., Ishikawa, Iwaki Pr., the environs of Kimpū-zan, Kai Pr., and Akatsu, Owari Pr. are also important. Crystals of sanidine have not yet been found freed from volcanic rocks. Of plagioclase, which occurs in volcanic rocks in abundance, the anorthite from Miyake-jima, Izu Pr., Tōnosawa in Hakone, Sagami Pr., and Zaōsan, Iwaki Pr. and the andesine from Mae-yama, Shinano Pr., are the chief occurrences.

Except in a few instances, the investigation of the felspars of Japan has not been so satisfactory as could be desired and has been mostly limited to the morphological characters. There remains much to be done on the optical and chemical properties. Accordingly we shall here limit our remarks to those occurrences, of which the more reliable accounts have been obtained.

118. ORTHOCLASE

The orthoclase of Japan was first studied by the writer in 1877. The materials then at his disposal were for the most part crystals from Tanokami-yama, and a few specimens from Kai Pr. Some of the results were given in the writer's "Short Descriptions of Japanese Minerals."[1)]

The crystals of Japanese orthoclase are by far the most frequently twinned, being but rarely simple. The law of twinning is usually that of Baveno and next Carlsbad. The Manebach type of twinning

1) Published in Japanese in 1880.

is of rarer occurrence. The colour is white, yellowish white or flesh-coloured. The bluish variety known as amazon-stone is found only at Mitake, Kai Pr., and Tadachi, Shinano Pr.

The faces observed in Japanese orthoclase are $a=\infty P\bar{\infty}$, $b=\infty P\breve{\infty}$, $c=0P$, $m=\infty P$, $z=\infty P\grave{3}$, $x=P\bar{\infty}$, $y=2P\bar{\infty}$, $n=2P\breve{\infty}$, and $o=+P$. Orthoclase from Tanokami-yama and Naëgi has all these faces. S. Kō recognised $\frac{7}{6}P\bar{\infty}$ in addition to these.

Fig. 55.

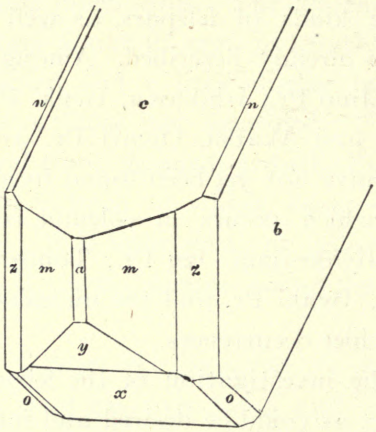
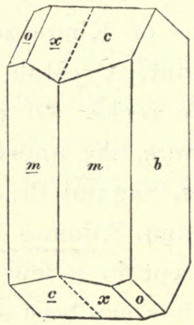


Fig. 56.



The orthoclase from **Ishikawa,** Iwaki Pr., is flesh-coloured. The crystals vary in size from 50 to 70 mm. in the direction of the *b* axis and about 75 mm. in the direction of the *a* axis. They are partially decomposed. The faces observed are *c*, *x*, *n*, *y*, *o*, *b*, *z*, and *m*. Most of them are twinned on the Carlsbad law.

Orthoclase from **Morai-yama,** Shinano Pr., is brownish or reddish in colour and coated with a yellowish earth. The crystals are less than 20 mm. in diameter. They are twinned on the Baveno law. Polysynthetic twinning of three or four individuals on this law is a characteristic of the orthoclase from this locality. The faces observed are a few common ones.

The orthoclase from **Tadachi,** Shinano Pr., is the light blue variety called amazon-stone. The surface of the crystals is rough and uneven, and often covered with scales of talc or mica. The form is simple and consists of the four commonest faces. It appears rarely in twins.

Amazon-stone found at **Mitake,** Kai Pr., is associated with quartz. The size of the crystals varies from 15 to 20 mm. in diameter, the length being about 35 mm. They are blue in colour, and are in a fresh state. They are single, twinning being never observed (Pl. XXIX, b). We find here besides a common orthoclase of yellowish white colour reaching 80 mm. in diameter, twinned on the Baveno law. In the environs of **Kimpū-zan,** further north up the valley of Mitake, there occurs a yellowish white orthoclase in groups consisting of numerous crystals. Rarely we find here somewhat large crystals of a pure white colour or a translucent rose colour. The faces recognised are only *m*, *a*, *c*, and *x* of the commonest occurrence, and sometimes *y* in addition. At **Masutomi** orthoclase, stained dark brown with iron, forms twins on the Baveno law. Grains of garnet, 7 to 13 mm. in diameter, are found half imbedded in them.

The orthoclase from Mukō-yama near **Naëgi,** Mino Pr., is white in colour and has lost its lustre through the decomposition of the superficial portion. Crystals are usually twinned on the Baveno law, rarely on the Carlsbad law and very rarely on the perfect Manebach law (Pl. XXX, b). The dimensions are variable. They are partially vitreous and transparent. The chief faces present are *m*, *b*, *c*, and *x*. Minute crystals of a white vitreous felspar are often seen attached to them. The crystals are presumably albite.

The orthoclase from **Takayama** in the same district is the same as the preceding. It is however much decomposed, and a kaolin-like earthy substance is formed on the surface. Twins on the Baveno law are very frequent, and those on the Carsbad rarer.

At **Akatsu,** Owari Pr., orthoclase occurs in pure white crystals superficially decomposed. They are often associated with smoky quartz. They have never yet been found in twins. The faces observed are *m*, *b*, and *c* forming nearly hexagonal prisms, and *y*, *x* and *o*.

The orthoclase from **Ishigure,** Ise Pr., is white and twinned on the Baveno law. The *z* faces are sometimes very prominently developed. Twinning on the other two laws have been reported to occur.

At **Tanokamiyama** there appear to be various kinds of orthoclase, but the apparent difference is in reality mostly due to different stages of weathering. The following is the chief variety distinguished by external characters :

(1) White orthoclase, with a good lustre. This seems to be not at all weathered.

(2) Light yellowish or light flesh coloured orthoclase, with some lustre, but more or less weathered.

(3) Flesh-coloured orthoclase without lustre, much weathered.

(4) White orthoclase, semi-transparent on the edges.

(5) Aggregates of minute white crystals, attached to other orthoclase, and destitute of distinct crystalline faces. The faces are very often curved. This last was long mistaken for albite, before the chemical analyses of these felspars were made by F. Kodera, who obtained the following results :[1)]

Variety	SiO_2	CaO	Al_2O_3	Fe_2O_3	MgO	K_2O	Na_2O	
(1)	64·78	0·14	17·86	1·46	0·11	12·87	2·25	= 99·47
(3)	64·62	0·20	21·00	0·34	0·09	12·22	2·41	=100·88
(4)	63·77	—	19·52	1·39	0·08	13·70	1·84	=100·30
(5)	64·98	—	22·18	0·33	0·86	10·59	0·60	= 99·54
Calculated from $KAlSi_3O_8$	64·70	—	18·40	—	—	16·90	—	=100·00

The results show that these varieties are all orthoclase, in which K_2O has been partly replaced by Na_2O and some alkaline earths.

The specimen (1) is quite fresh and (2) nearly fresh. Some of these varieties may belong to the microclines. The specimen (4) is adularia. The specimen (5) is proved by the analysis not to be albite as once supposed but potash-felspar. It is obviously of a younger formation than the other varieties, and is found in association with secondary mica.

Beside kaolin, mica and a talcose substance are frequently formed as decomposition products of orthoclase, and the scales of these secondary minerals are found covering the surface of the weathered mineral.

The faces which most frequently occur are *m*, *b*, *c*, *x*, *y*, and *o*, but *a*, *z*, *n* and other rarer faces are also often observed in them. Twins are commoner than simple individuals. The common twinning is on the Baveno law, while the Carlsbad and Manebach laws are

1) (2) has not been analysed.

less common (Pl. XXX, *a* and *c*). The twins on the Baveno law are far more numerous than those on the other two laws and the simple individuals taken together. Repeated twinning on the first law like that observed at Moraiyama in Shinano is also common. Some of the twins on the Carlsbad law are composed of supplementary individuals and appear like simple crystals (Fig. 56). Some twins on the Baveno law seem to have been again twinned on the Manebach law.

The orthoclase from **Kōchi**, Harima Pr., is of a light flesh colour and always appears in simple crystals. The crystals are well defined and are in combinations of *m*, *b*, *c*, *x*, *y*, etc. They vary in size from 18 to 23 mm. in diameter. Crystals in groups are very common.

In **Ōtsujima**, Suō Pr., orthoclase occurs in druses of quartz in minute crystals of a light greenish colour, which are simple and single.

119. ALBITE

Albite has been found in druses of chlorite schist in the neighbourhood of **Besshi**, Iyo Pr. The mineral occurs here in minute crystals of irregular shapes, 7 to 8 mm. in diameter. The analysis of the mineral is as follows:[1]

SiO_2	Al_2O_3	CaO	Na_2O	Fe_2O_3	MgO	K_2O	H_2O
66·92	20·56	0·80	7·39	0·64	0·92	trace	1·00 = 98·23

As mentioned above white secondary felspar covering orthoclase has been taken for albite, but most felspars of such form are of doubtful nature.

120. ANDESINE

Felspar from **Mayeyama**, Shinano Pr., has been determined as andesine by T. Hiki. The crystals are about 7 mm. in diameter, and are white in colour. They are elongate in the direction of the axis

1) Dr. T. Harada: Japanischen-Inseln. 1890 P. 50.

a, and form cross twins, hence the local name "**Chigai-ishi**" or "cross stone." The analysis by T. Nishikawa is as follows :

SiO_2	Al_2O_3	CaO	Na_2O	K_2O	
58·21	26·46	7·58	6·32	1·28	=99·85

121. LABRADORITE

Felspar, as an ingredient of gabbro at **Mineokayama,** Awa Pr., appears sometimes in large crystals of a gray or bluish colour. Some are slightly iridiscent. T. Kochibe has recognised the mineral to be bytownite by the following analysis.

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	H_2O
43·59	31·62	0·90	17·25	0·27	trace	1·78	4·51=99·92

The specific gravity is 2·62.

122. ANORTHITE

This mineral appears in the younger volcanic rocks. That from **Miyakejima** has been investigated and described by Y. Kikuchi. The crystals of anorthite were ejected during the eruption of the volcano of Miyakejima in 1870. Hence they have a black slaggy coating of lava. They have a stout prismatic habit, and are 15 mm. in length. In spite of the black outer coating the interior is transparent. They are either simple or twinned.

The faces recognised by Y. Kikuchi are (Fig. 57 and 58) :

Fig. 57.

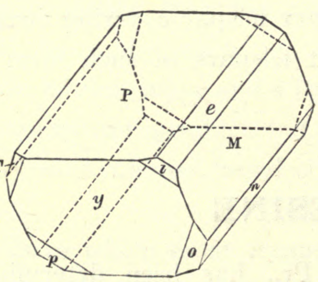
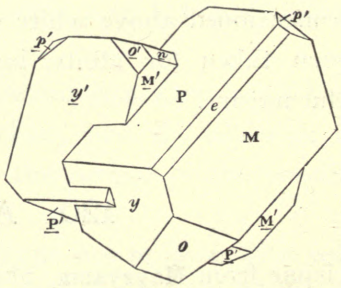


Fig. 58.



c(P) = OP (001)	$q = 2'P'\breve{\infty}$ (201)	o = P, $(11\bar{1})$
b(M) = $\infty P\breve{\infty}$ (010)	$y = 2,P,\bar{\infty}$ $(20\bar{1})$	p = ,P $(1\bar{1}\bar{1})$
M(T) = ∞,'P $(1\bar{1}0)$	x = ,P,$\bar{\infty}$ $(10\bar{1})$	χ = 4'P $\breve{2}$ $(2\bar{4}1)$

$m = \infty P,' \ (110)$	$e = 2P'\breve{\infty} \ (021)$	$v = 4P,\breve{2} \ (24\bar{1})$
$z = \infty,'\breve{P}3 \ (1\bar{3}0)$	$n = 2'P\breve{\infty} \ (0\bar{2}1)$	$w = 4,\breve{P}2 \ (2\bar{4}\bar{1})$
$f = \infty P,'\breve{3} \ (130)$	$\mathrm{m} = P' \ (111)$	$u = 2P, \ (22\bar{1})$

The angles measured are

$c : b = 94°8' = 94°10'$ (anorthite from Vesuvius)

$c : b' = 85°51' = 85°50'$ (,, ,, ,,)

The faces *q*, m, *χ*, *v*, *w*, and *u* are rare, and *x* is very rare. Common faces are *c*, *b*, *y*, *e*, and *n*. The faces *M* and *m* are less common. There are two habits in crystals of this anorthite. One is tabular along the *c* face. The other is also tabular, but along the *b* face. The first type is by far the more frequent form of the two. Twins are very common, especially on the Carlsbad law. The angle which the axes of two individuals make with each other is 128°. The second mode of twinning is the pericline law, and then the mineral has a lamellar structure. The extinction is 38°—40° on *c*, and 40°—41° on *b*. The positive bisectrix is almost perpendicular to $(2P'\breve{\infty})$.

The chemical composition of this felspar, according to Y. Kitamura is as follows :

SiO_2	Al_2O_3	CaO	MgO	Na_2O	H_2O	
44·03	36·80	19·29	0·20	0·23	0·12	=100·67

Y. Kikuchi found the same variety of felspar at **Tōnosawa** in Hakone, Sagami Pr., in a decomposed andesitic dyke. Anorthite like that from Miyake-jima occurs as phenocrysts in the dyke rock, from which they can be easily removed. Two different habits, as observed in the anorthite from Miyake-jima are seen in the crystals. The twins on the Carlsbad law are very frequent in those with $\infty P\breve{\infty}$ prominent. The faces are

$c = 0P$	$m = \infty P,'$	$n = 2'P\breve{\infty}$
$b = \infty P\breve{\infty}$	$z = \infty,'\breve{P}3$	$w = 4,\breve{P}2$
$y = 2P,\breve{\infty}$	$q = 2'P'\breve{\infty}$	
$M = \infty,'P$	$e = 2P'\breve{\infty}$	

Lamellar structure due to the twinning on the pericline law is seen on *b*. The crystals tabular on *c* are often twinned on both the pericline and albite laws at the same time.

Anorthite has been found by D. Satō in the ejecta of the volcano of **Iwate-san,** Rikuchū Pr. The crystals have the same coating as those from Miyake-jima. The same observer found anorthite on the north of the volcano of **Zaō-san,** Iwaki Pr. Here the mineral has been separated from pyroxene-andesite by the weathering of the rock matrix.

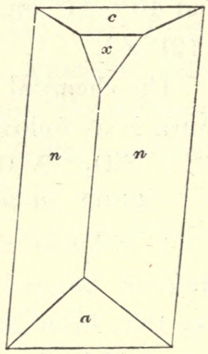
At **Kōshin-zan** near Ashio, Shimotsuke Pr., there occur large porphyritic crystals of anorthite. They have a prismatic habit and reach 15 cm. in length. The faces observed are OP, 'P, P', ,P, P,, ∞'P, ∞P', 2,P,$\bar{\infty}$, 2'P$\breve{\infty}$, and 2P'$\breve{\infty}$.

Anorthite ejecta have been reported to occur at **Sulphur Island** in the Volcano Group, near the Bonin Islands.

Crystals of anorthite like those from Tōnosawa occur at **Obara,** Iwaki Pr.

123. TITANITE

Fig. 56.



Titanite occurs in well defined crystals in dioritic gneiss near **Kamioka,** Hida Pr. The crystals are of a yellowish brown colour and have the faces OP (c),—$\frac{1}{2}$P$\breve{\infty}$ (x),—P(n) and ∞P$\breve{\infty}$ (a). In general they are about 10 mm. in length and 4 mm. in diameter. The same mineral occurs at **Ozō,** Kaga Pr. The chemical composition of the mineral from the latter locality, according to H. Yoshida, is as follows :

SiO_2	TiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	
30·81	40·21	0·51	0·61	26·42	1·21	=99·77

THE ZEOLITE GROUP

Zeolites occur in volcanic rocks and their tuffs as products of decomposition. Of the various species, such as natrolite, analcime, apophyllite, epistilbite, desmine, heulandite, chabasite, gmelinite, etc., by far the more common are natrolite, apophyllite, heulandite, and chabasite. They occur associated with one another. Noteworthy localities are Maze, Echigo Pr., Obara, Iwaki Pr., Ogasawara-jima, Shioda, Shinano Pr., Nikkō, Shimotsuke Pr., Amagi, Izu Pr., etc.

124. NATROLITE

According to N. Fukuchi, there are two places worthy of special notice at **Maze**, Echigo Pr., which is the chief locality for zeolites in Japan. One is a quarry, where blocks of basalt in agglomerate contain druses in their vesicular cavities. Of the zeolites which have been found in the druses, acicular or fibrous natrolite is the most frequent ; next come analcime in 2O2, and apophyllite. Calcite is associated with these zeolites. The second locality is the sea coast near Benten-iwa, where apophyllite occurs in abundance and is associated with heulandite and analcime. No natrolite has been found here. The natrolite found at the quarries is white and forms radiofibrous globules, sometimes measuring 25 mm., but usually half that size. Very slender needles of the same mineral have been seen radiating from the surface of the globules.

The chemical composition of the mineral, as given by O. Matsumoto, is as follows :

SiO_2	Al_2O_3	CaO	MgO	Na_2O	H_2O	
53·03	25·28	0·75	0·25	12·47	8·41	=100·19

Natrolite from **Shioda**, Shinano Pr., is in white radio-fibrous aggregates, which are compactly fibrous in the centre. The fibres become thicker towards their exterior ends, and form thin prisms. The faces, according to K. Jimbō, are P and ∞P.

Natrolite from **Obara**, Iwaki Pr., is white and fibrous, and has a silky lustre.

Crystals from **Osawa** in Nikkō, Shimotsuke Pr., are slender needles formed in cavities of a volcanic rock. They are associated with chabasite. The surface is often stained reddish brown.

125. ANALCIME

Analcime occurs at **Maze** in colourless crystals in 2O2 with small ∞O∞, 15 mm. in diameter. The crystals line vesicular cavities, and are associated with natrolite and apophyllite. They are colourless and transparent, and beautifully crystallised. Interesting observations have been made by T. Takimoto on the optical anomaly of this mineral as described by Klein. The chemical composition is as follows :

SiO_2	Al_2O_3	CaO	MgO	Na_2O	H_2O	
42·14	30·76	8·31	0·16	6·11	12·54	=100·02

126. APOPHYLLITE

There occurs at **Maze** two varieties of apophyllite, one being colourless and transparent or white, and the other translucent or a translucent blue. The P faces are prominent ; OP and ∞P∞ are also frequent. The size reaches 15 mm. in length. K. Jimbō made observations on its optical anomaly, which is in the main identical with the phenomenon described by Klein.

Apophyllite is well known to occur at **Hatsuneura** in Chichijima of the Ogasawara Group. According to T. Hiki, it forms groups of crystals with calcite and stilbite. Some single crystals are 20 mm. in length and 10 to 15 mm. in diameter. Small crystals are colourless and transparent, but the larger ones are white and only partially transparent. The crystal-aggregates are usually radial or globular. On account of easy cleavage parallel to OP, the pyramidal faces are very badly preserved. Some crystals are reddish. Others with interposition of native copper have also been observed. The faces observed are

$c = 0P \qquad z = \frac{1}{3}P \qquad y = \infty P3$

$p = P \qquad a = \infty P \infty$

and the measured angles,

$p : p = 104°16'30'' \qquad a : y = 161°24'$

$p : z = 148°23' \qquad a : p = 127°20'$

The axial ratio $a : c = 1 : 1.23697$.

The chemical composition of this apophyllite as given by T. Nishikawa is

SiO_2	Al_2O_3	FeO	CaO	MgO	K_2O	Na_2O	H_2O
53·16	0·20	0·23	25·14	0·12	2·34	0·54	16·96=98·69

Fluorine has not been determined.

This specimen presents a slight optical anomaly. The crystal is optically negative.

127. EPISTILBITE

Y. Ōtsuki has described Epistilbite from **Amagi,** Izu Pr., in association with chabasite, whose surface it covers. The length of the crystals is sometimes 45 mm. The faces observed are ∞P and $0P$, and they construct the characteristic envelope-shaped crystals. They are colourless and transparent.

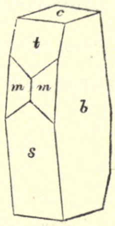
128. HEULANDITE

Heulandite from **Ogasawarajima** is white or bluish in colour and forms aggregates of thick tabular crystals. The form of the crystals, according to K. Jimbō, are (Fig. 60):

$c = 0P \qquad m = \infty P \qquad s = 2P\bar{\infty}$

$b = \infty P\breve{\infty} \qquad t = -2P\bar{\infty}$

Fig. 60.



According to S. Kō, some crystals are twinned according to the harmotome type of twinning. The mineral is always associated with apophyllite.

Heulandite from **Obara,** Iwaki Pr., occurs according to N. Yamasaki in andesite in snow white crystals. Small crystals are transparent in their sections. The cleavage is perfectly parallel to $\infty P\breve{\infty}$. The cleaved face has a pearly lustre. The crystals vary in size from 5 to 10 mm. in the longest diameter, and have the faces $\infty P\breve{\infty}$, $\infty P\bar{\infty}$, $P\bar{\infty}$, $2P\bar{\infty}$ and $2P$ perfectly developed.

The chemical composition as given by T. Shinowara is as follows:

SiO_2	Al_2O_3	CaO	H_2O	
58·4	14·4	12·2	14·9	=99·9

Heulandite from **Ōmori,** Echizen Pr. is found in cavities of andesite in white radial aggregates. Some crystals are minute but well defined.

129. DESMINE

Desmine occurs at **Obara,** Iwaki Pr., in bundles of acicular crystals, lining cavities.

130. CHABASITE

Chabasite from **Mitaka,** Izu Pr., appears in colourless crystals of nearly cubic outline, lining cavities of andesite. It occurs also in the tunnel at **Amagi.** It is found in druses of basalt lined with other zeolites, natrolite and epistilbite.

The crystals from **Osawa** near Nikkō, Shimotsuke Pr. are the same as those from Izu. They are often stained with iron.

Chabasite has been further known to occur at Shishihama, near Numazu, Suruga Pr., at Hishikari, Ōsumi Pr., at Takahokojima and Fukuda also near Nagasaki and at Hirado, Hizen Pr. The mineral from **Takahokojima** occurs as minute colourless crystals in cavities of the rock matrix, and that from **Fukuda** forms veinlets in cracks of andesite. That from **Hirado** is found filling vesicular cavities. The crystals are small and form well defined rhombohedra often in interpenetration twins.

131. GMELINITE

Gmelinite occurs at **Mitaki** near Sendai, Rikuzen Pr., in cavities of andesite, in association with other zeolites and calcite. It forms crystals in colourless pseudohexagonal double pyramids about 3 mm. in diameter. The faces recognised by Y. Ōtsuki are P2, ∞P2, and $\frac{3}{2}$P. The crystals are always twinned in the interpenetration form like tridymite. The P2 faces are lustrous, $\frac{3}{2}$P is also lustrous, but sometimes a little striated. The ∞P2 faces are dull. Sections cut parallel to the base exhibit in crossed nicols three pairs of sectors of different optical orientation.

THE END

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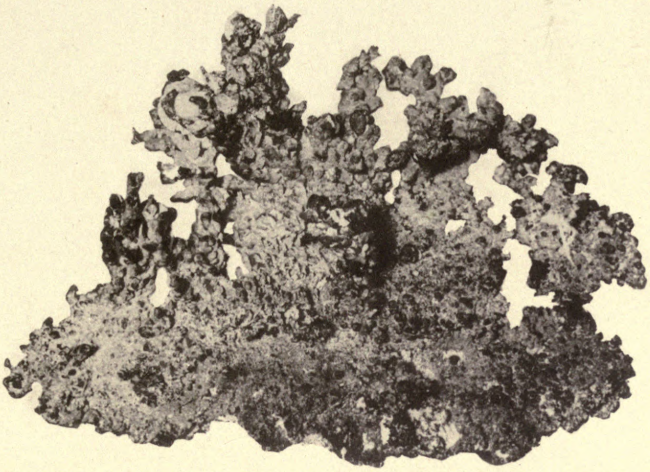

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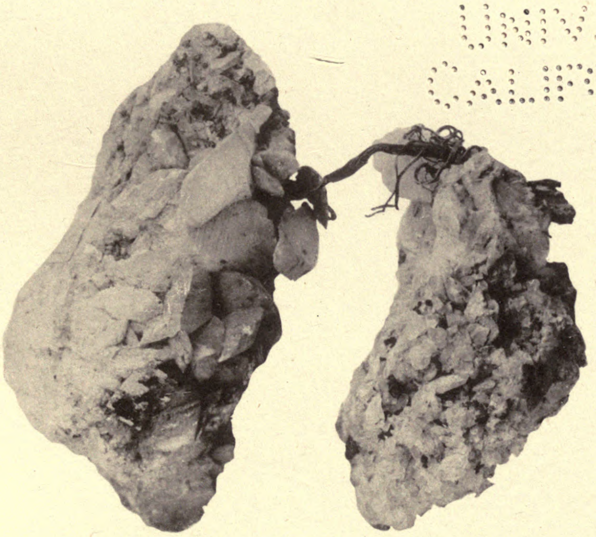

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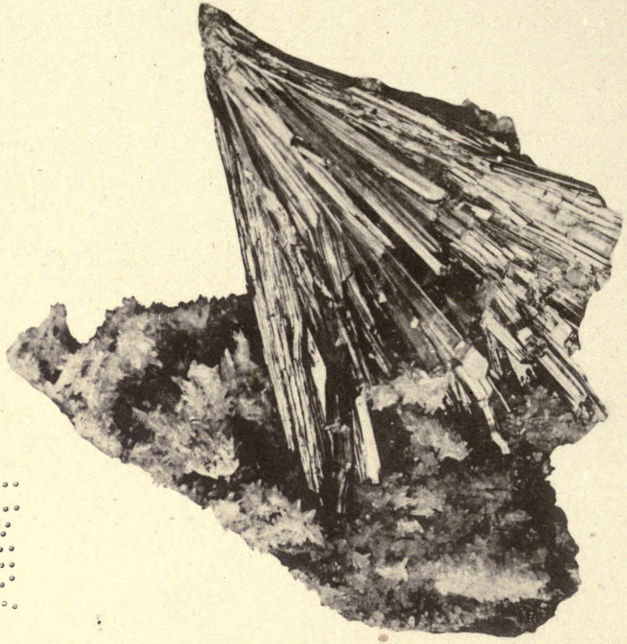

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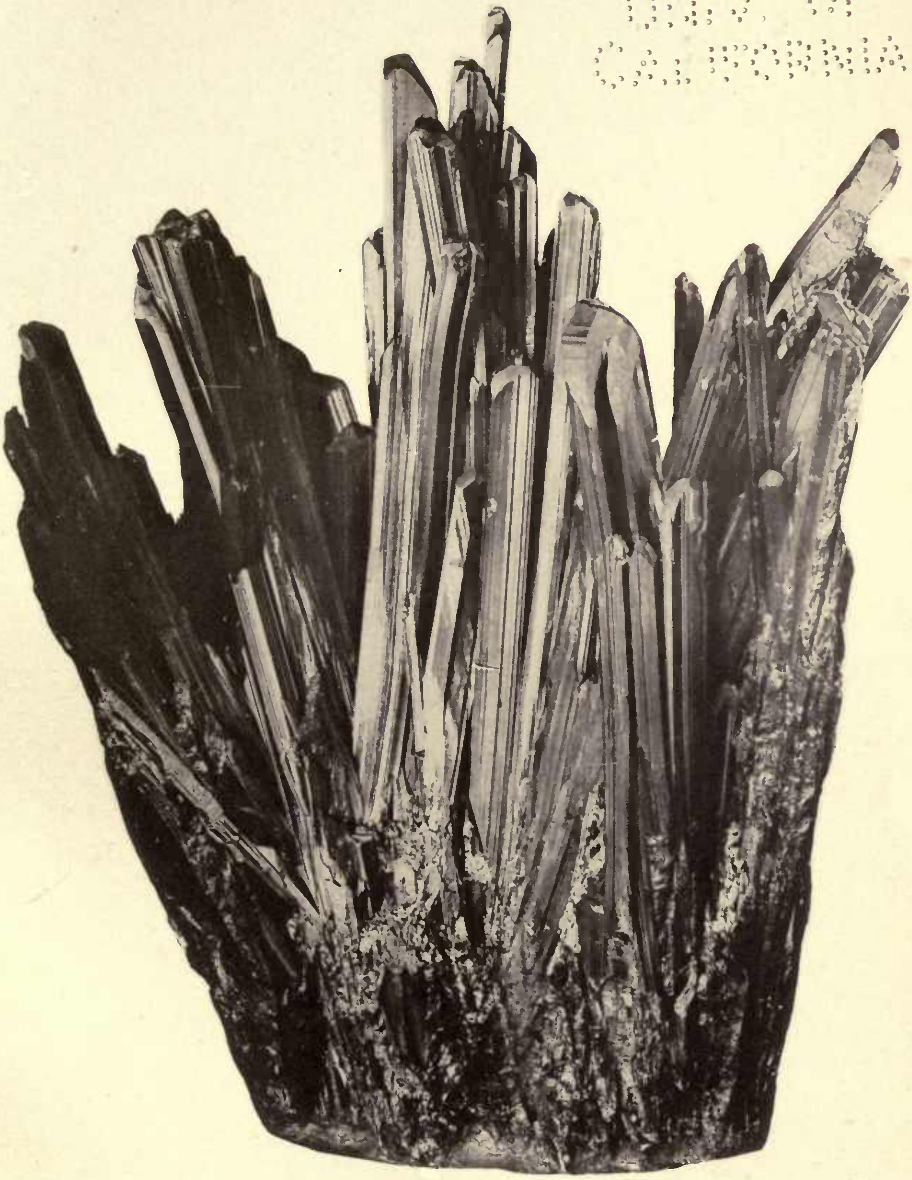

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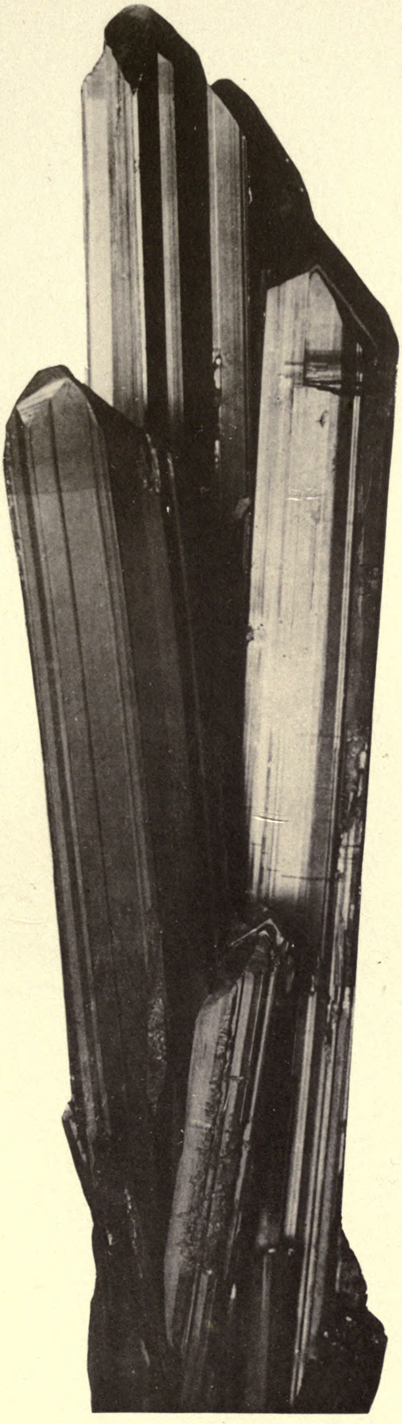

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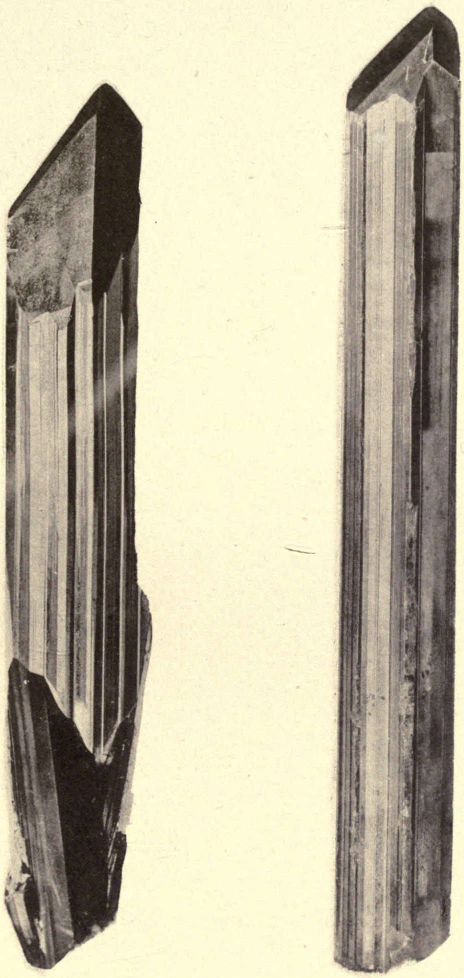

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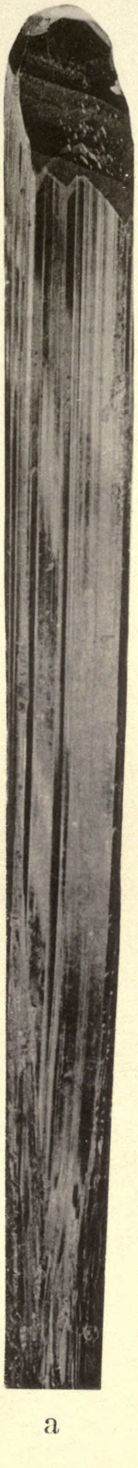

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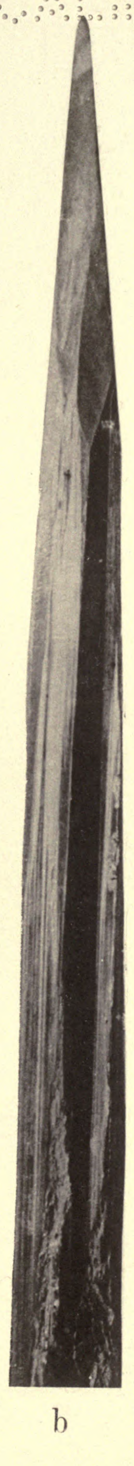

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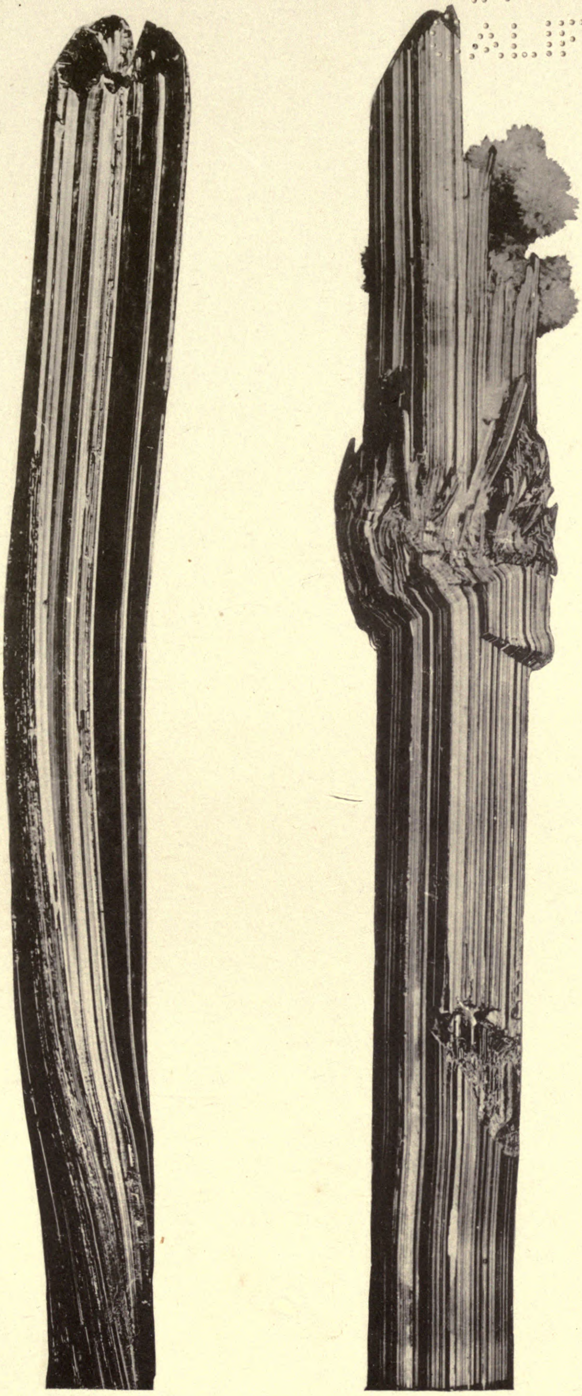

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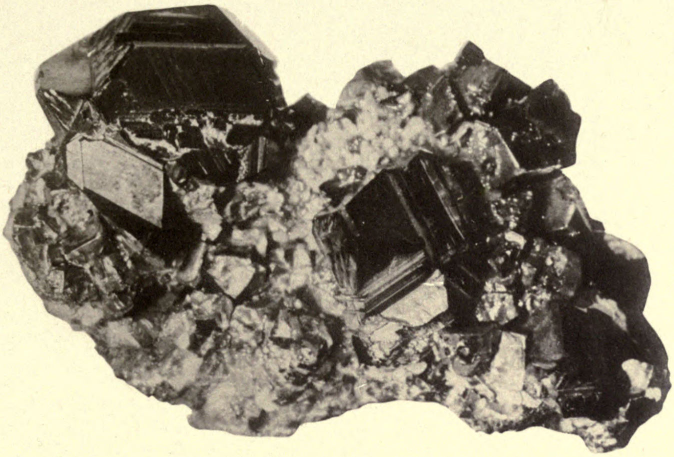

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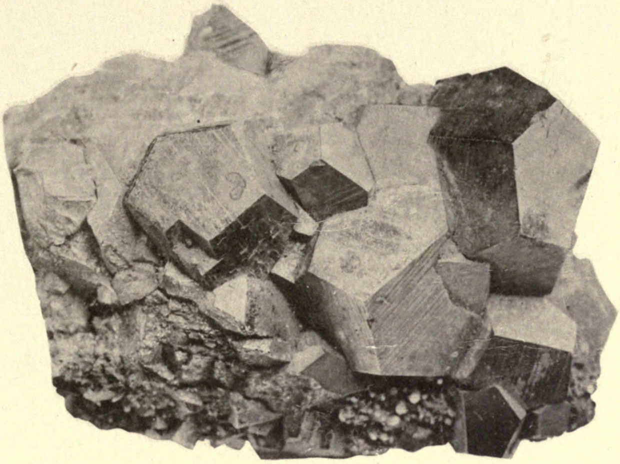

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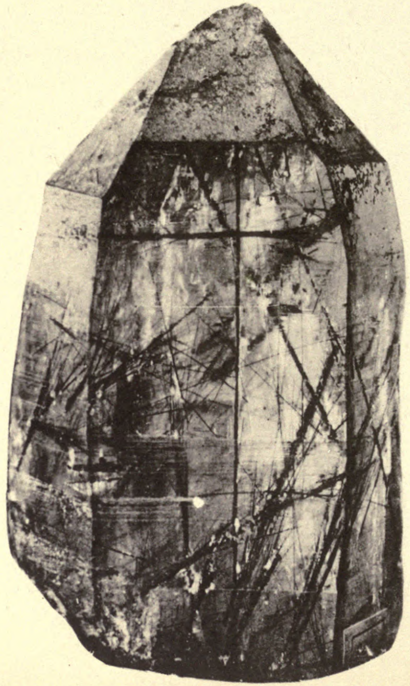

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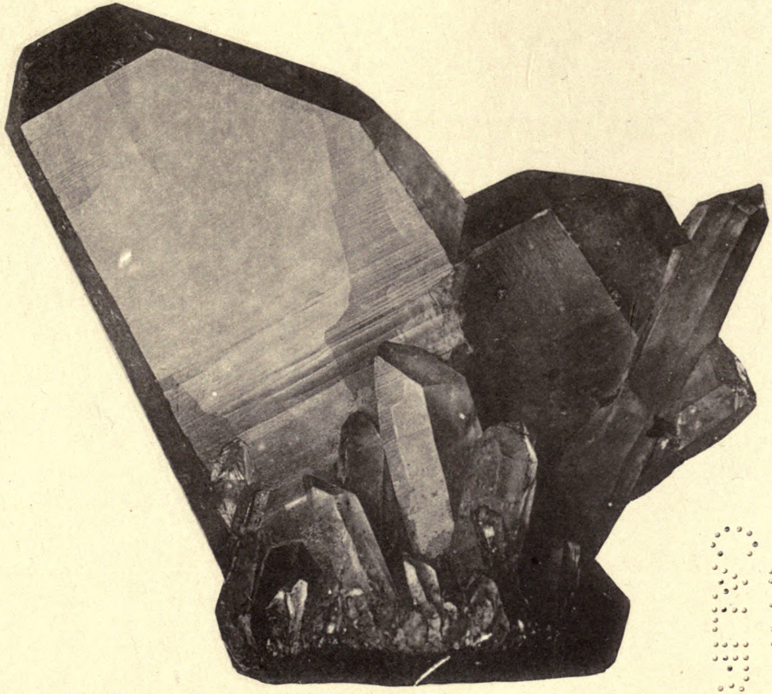

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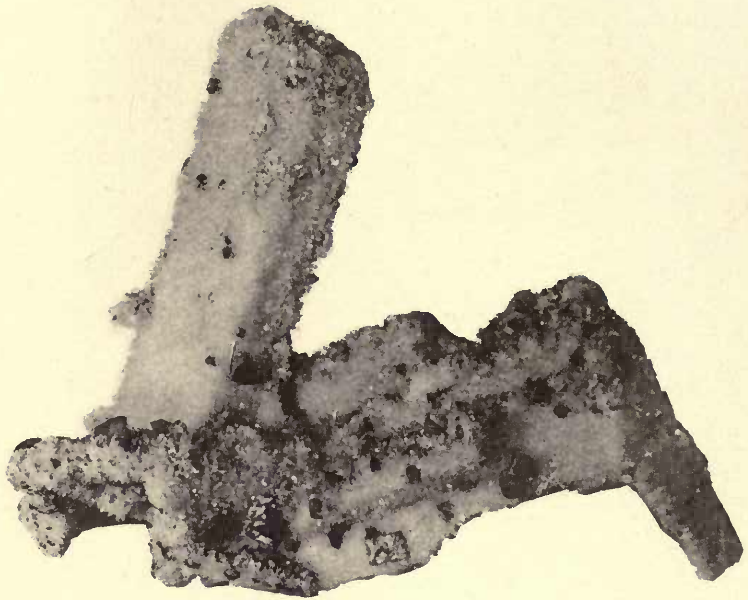

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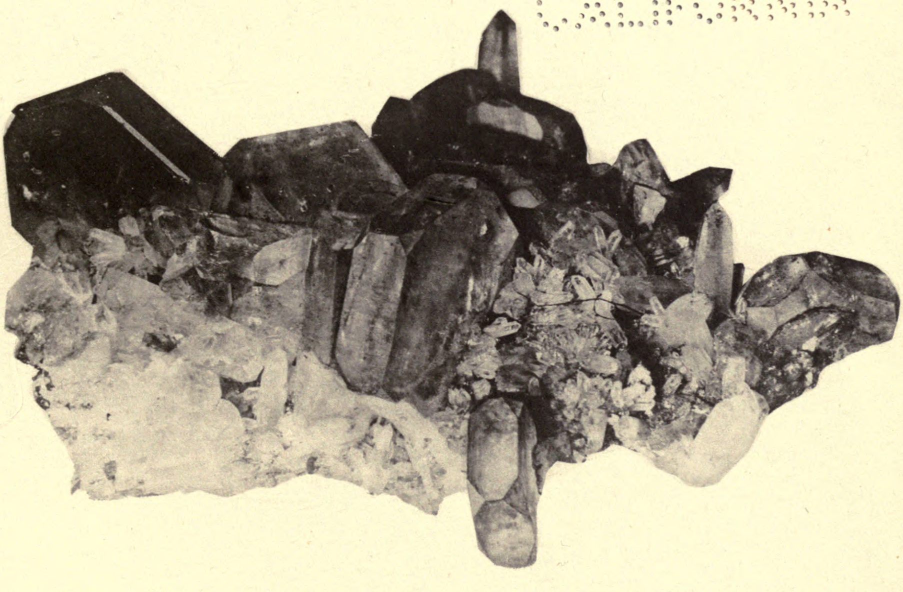

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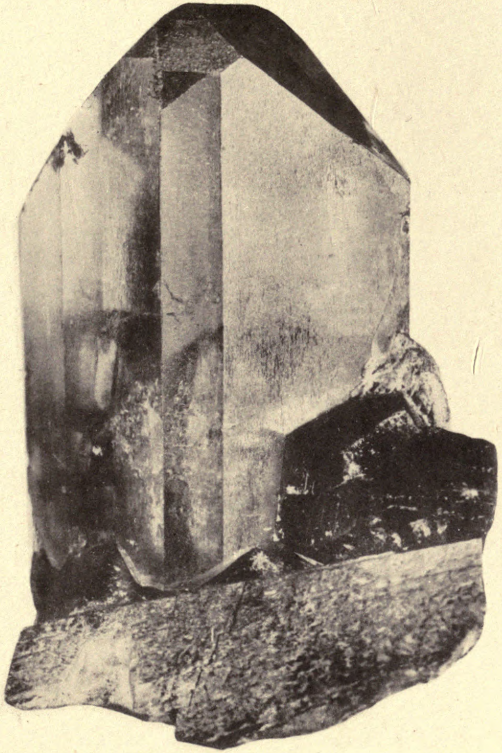

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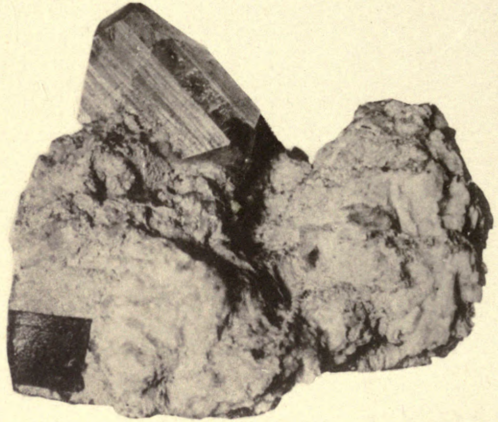

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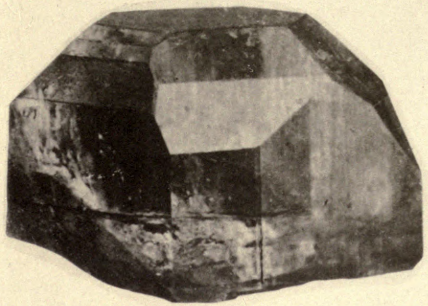

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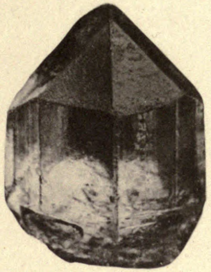

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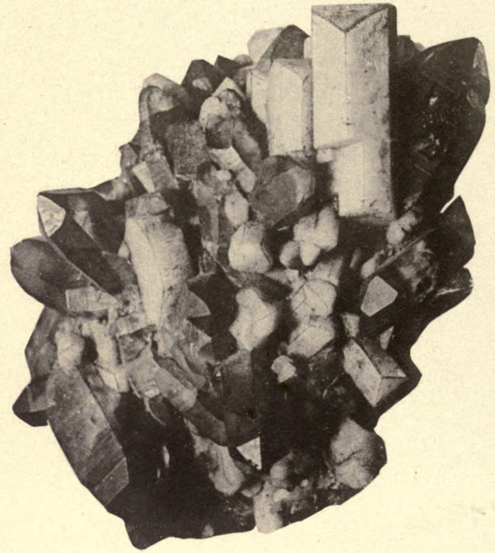

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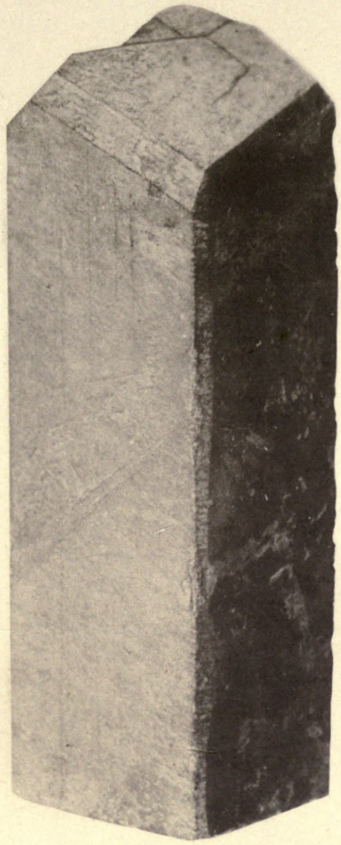

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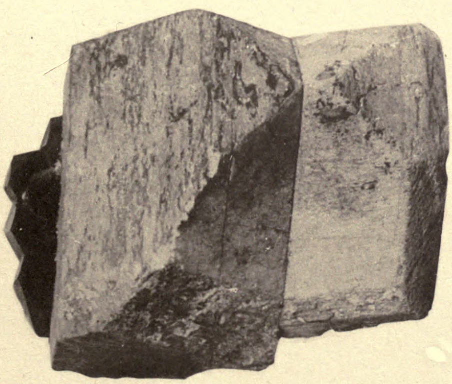

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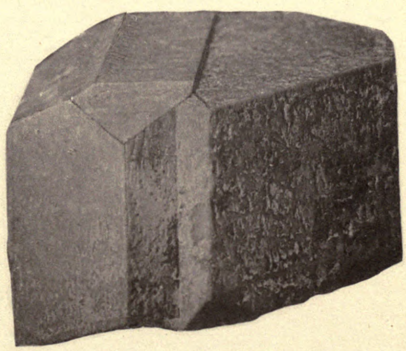

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