Some Occurrences of Piedmontite in Japan.

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With Plate XXI.

As has been already stated in my other paper[1], the occurrence of Manganese epidote or Piedmontite is often associated with the Glaucophane-bearing rock[2] in the so-called crystalline schists-system in Japan. The rock, which contains Piedmontite as an essential component, is well-characterized in outward appearance by being of a

(1) This journal, Vol. I, No. I, p. 85.

(2) I take here the opportunity of adding a few words in way of caution on the statement of Dr. K. Oebbeke in his valuable paper, entitled: 'Ueber den Glaukophan und seine Verbreitung in Gesteinen'; Zeitschrift d. deutsch. geol. Ges. XXXVIII, p. 641 and 653. Vide also Zeitschrift für Krystallographie und Mineralogie, XII, p. 285. I state it here *verbatim*: he says, 'Durch Herrn Dr. Naumann, früheren Director der geologischen Landesaufnahme von Japan, erhielt ich eine Suite von Gesteinen, unter denen einige von der Insel Sikok (Sikoku) meine Aufmerksamkeit sofort erregten wegen ihrer Ähnlichkeit mit Glaukophan-Eklogiten. *Die Untersuchung zeigte jedoch, dass in diesen Gesteinen kein typischer Glaukophan, sondern eine intensiv blaugrün gefärbte Hornblende vorkommt.*' The most excellent glaucophane occurs, however, in the same rock-complex, from which Dr. Naumann had collected the 'Eklogitschiefer' (Garnet-amphibolite?), and other karinthine-bearing schists, although, I believe, they do not come in the same geological horizon. I have given a short description of our glaucophane from Sikoku in my paper: 'A Note on Glaucophane.' I regret very much that the work of Dr. Oebbeke had not come to hand before the publication of mine, since otherwise I should have given a more detailed discussion. I now feel it my duty to call the attention of those who read the paper of Dr. Oebbeke to the fact, that in the island of Sikoku there are both kinds of amphiboles, the one a bluish-black, highly pleochroic Hornblende, the other a true glaucophane; and the rocks in which they respectively occur, show a marked difference in the characters of the associating components, such as garnet etc.. Dr. Oebbeke is perfectly right in his description of a bluish-black hornblende, but what I believe to be a true glaucophane is also a typical one, and has a striking resemblance to those of Zermatt and the island of Groix, specimens of which were kindly given to me by my honoured professor, Geheimenbergrath Dr. Zirkel. I am of opinion, that there are many intermediate forms between a hornblende of crystalline schists, and a Glaucophane, so that *in some cases* it may be difficult to draw a sharp line between them.

dark violet colour; hence the rock is locally named the "*Murasaki*" or violet rock. And this is most typically developed in the island of Sikoku, especially in the neighbourhood of the city of Tokusima.

The very first specimen that came under my notice, was brought from Mount Ōtakisan, one mile to the south-west of the last-named city; but afterwards many localities are added to the list of places where it occurs, so that we are now able to trace out the geological horizon of the Piedmontite-bearing rock everywhere within the crystalline schists-system of that island. This rock is, however, not exclusively confined to this region; it has also a wide distribution in Musasi and Kōzuke provinces, on the main island (Honsiū).

The Piedmontite occurs together with fine Quartz-grains, and in virtue of its parallel disposition gives to the rock itself a schistose structure, a vertical section of the rock presenting a regular banded appearance formed by the fine alternation of Piedmontite and Quartz layers.

The accessory components are Sericite (hydrous Mica of Prof. Bonny)[1], greenish-yellow Garnet, Rutile (which in some cases may be easily mistaken for Piedmontite), non-striped Felspars (probably Orthoclase), blood-red Iron-glance and also opaque crystals of the same mineral; tourmaline has been nowhere found so far in my slides. This is the typical Piedmontite-schist, and the general appearance of a slide of this rock as seen under the microscope with an amplification of 90 diameters is represented in *Fig. I.* In the Glaucophane-rock[2], the Manganese-epidote makes its appearance; but it is subordinate in quantity to Glaucophane, and has its place often supplied by common, yellowish-green Epidote. We shall first of all speak of the Epidote in the Piedmontite-schist.

(1) Min. Mag. Vol. VII, No. 32, July, 1886, p. 3.
(2) Loc. cit. p. 86.

Piedmontite.

Crystals of Piedmontite are usually much elongated, traversed by transversal irregular cracks and fissures, and sometimes broken, when the dismembered parts form chains with faces striated in the direction of the axis of symmetry (ortho-axis); and nearly all the crystals lie with the supposed orthopinacoid ($\infty P\breve{\infty}$), parallel to the plane of schistosity of the rock.

In contrast to common rock-forming Epidote in which the well-defined crystallographic forms are seldom to be observed, the crystal-individuals have here usually well-developed faces of M ($o P$), T ($\infty P\breve{\infty}$), i ($\frac{1}{2} P\breve{\infty}$), r ($P\breve{\infty}$) and n (P). (*Fig. II*).

The vicinal section of the clinopinacoid ($\infty P\breve{\infty}$) is, as a rule, of a rhomboidal outline, caused by the predominance of the traces of T and i (*Fig. III*); and, if the face M is at the same time well-developed, the section will be the six-sided. This latter case is however of less frequent occurrence. In common Epidote the face r ($P\breve{\infty}$) is said to be a predominating element, and, as a rule, it is more perfect than the face T ($\infty P\breve{\infty}$).[1] In our Piedmontite, the face r is very poorly developed, and is commonly not visible even in the clinopinacoidal section (*Fig. III*). Outlines of the clinopinacoidal section are never regular, owing to the fact that there are an infinite number of prominences and indentations. They are sometimes even knee-shaped, just like twins of Rutile.

All these facts are due to the parallel growth and intergrowth ("laterale Juxtaposition und Umwachsung") of two or more individuals of different size; and the striations commonly observed on the faces parallel to the orthoaxis arise mainly from these causes, and comparatively few stripes are assignable to the formation of twins.

(1) Rosenbusch, 'Mikroskopische Physiographie,' I Band, 2te Auflage, p. 496.

Extinction of the light occurs simultaneously in all crystals that have taken part in the formation of the complex-individuals, and this should not occur in the case of twins. Some of these remarkable forms are given in the annexed plate, *Figs. III, IV, V.*

Twins are comparatively rare, and if they are present, they are of a common type whose plane of twinning and composition are T ($\infty P \bar{\infty}$), and the extinction-direction of one individual makes an angle of 6° with that of another (*Fig. VI*). The trace of cleavage upon M of both individuals meets at an angle of about 130°, just as in the case of common Epidote given by E. Becke[1] and H.H. Reusch.[2] The crystal-individuals of twins differ considerably in their size, the one bearing parasitic relations to the other. The colour and the behaviour of pleochroism of twins are exactly similar in most cases so that the presence of twinning formation can only be recognized by a slight difference in the shade of colour of both crystals under crossed Nicols, and also in the direction of the traces of the cleavage upon M in both individuals. Cleavages upon the base ($o P$), and orthopinacoid ($\infty P \bar{\infty}$) are sometimes observed as in the *Fig. III;* but in minute crystals they are, as a rule, less distinctly developed than in the larger individuals; for in the majority of cases the smaller ones are perfectly free from such traces of cleavage.

The angle of oblique extinction: $\mathfrak{c} : \mathfrak{a} = 3°$. The axial colour: $\mathfrak{a}$ = deep reddish-violet; $\mathfrak{c}$ = brownish-red; $\mathfrak{b}$ = light violet. The degree of absorption: $\mathfrak{a} > \mathfrak{c} > \mathfrak{b}$; while in common Epidote it may be expressed by the following scheme[3]: $\mathfrak{c} > \mathfrak{b} > \mathfrak{a}$. Hence the clinopinacoidal sections of our mineral show most intense colours, while those parallel to the orthoaxis display a lighter tinge.

When a slide is made in the plane of schistosity of the rock, we

(1) Tschermak, Min. u. petr. Mitth. 1879, p. 837.
(2) N. Jahrb. f. Min. u. Geol. II, 1883, p. 87.
(3) Rosenbusch, 'Mikroskopische Physiographie.' I Band, IIte Auflage, p. 497.

usually obtain sections approximately parallel to the *b*-axis; but there is a marked difference in the colours of various sections so as to lead observers to think of entirely other minerals, the one being a deep violet, the other a brownish-yellow. As there are great differences in the axial colours already stated, it may be naturally expected that a section parallel to the basal pinacoid *M* is of a brownish-yellow (the facial colour of $\mathfrak{c} + \mathfrak{b}$); and that which is taken nearly parallel to the orthopinacoid *T* of a deep violet (the facial colour of $\mathfrak{a}+\mathfrak{b}$). The clinopinacoidal section shows the deepest shade of colour, the facial colour being of a combination of $\mathfrak{c}$ and $\mathfrak{a}$.

The extinction-direction is, of course, parallel and at right angles to the longer sides of sections in the zone of *M* and *T*, and the intensity of colours also depends upon the section in this zone. The polarization colours are magnificent, varying from an intense violet to an indigo-blue tinge, which become more pronounced, if we insert a Quartz-plate in the tube of the microscope.

The Piedmontite is ideally pure; neither liquid- or gas-inclosures nor any microlithic interpositions are discernible. The mineral was isolated from the other constituents of the schist obtained from Ōtaki-san, Awa province, by means of the Thoulet solution; and the chemical analysis was kindly undertaken by Mr. J. Takayama, of the Geological Survey of Japan, with the following result:—

SiO_2	36,16
Al_2O_3	22,52
Fe_2O_3	9,33
Mn_2O_3	6,43
CaO	22,05
MgO	0,40
K_2O	trace
Na_2O	,44
H_2O	3,20
	100,53

H : Ca :: 1 : 2.2 Ca : ℟ : Si :: 1.25 : 1 : 1.92

Comparison with other Specimens of Piedmontite.

A comparison of the result just stated with analyses of the Swedish and Alpine Epidotes[1], shows our mineral to be in some particulars markedly different from both of them, although there is a general resemblance throughout. The Japanese Piedmontite indeed forms just the link between those of Jacobsberg, in Sweden, and of St. Marcel, in Piedmont. Mr. Takayama informs the writer that he has not yet been able to decide whether in our specimen the Manganese exists as the sesquioxide or monoxide or (thirdly) both together.

As is well known, Igelström suggests that the Swedish mineral contains manganese as the monoxide, while others are of opinion that in the Alpine Epidote there exists only the sesquioxide. Some mineralogists, therefore, hesitate whether they should be put together as the same variety.[2] The writer is unfortunately not able to express himself more decisively on this point, and awaits a more extended research.

Being of a beautiful rosy-red colour and of a highly pleochroic character, and having a needle-shape, the Piedmontite is usually confounded with a Tourmaline, and as such was formerly regarded by us. Dr. E. Naumann[3] says there are two interesting rocks among the crystalline schists of Japan; the one is "ein echter durch charakteristische rothe Färbung kenntlicher *Turmalinschiefer*, der unter dem Mikroskop schöngefärbte starke dichroitische langgestreckte Krystalle zeigt." The original specimens from which E. Naumann had drawn the above-quoted conclusion were kindly placed at my disposal by the Geological Survey of Japan. An inspection of the

(1) Rammelsberg, 'Mineralchemie,' 2te Auflage, p. 595.

(2) Naumann-Zirkel, 'Elemente der Mineralogie,' 12te Auflage, p. 577.

(3) Ueber den Bau und die Entstehung der japanischen Inseln, Berlin, 1885, p. 10.

various slides convinced the writer that the mineral was true Piedmontite, and not a Tourmaline, and the analysis given above has fully confirmed the writer's view.

Geographical Distribution of Piedmontite.

The mineral Piedmontite is not of common occurrence. Treatises on mineralogy recognise up to the present only two typical localities; the one in St. Marcel near Aoste in Piedmont, Italy, where it occurs as a rare mineral together with other manganese ores, and the other in Jacobsberg, in Wermland, Sweden, where it is found localized within a limestone. In both cases, as it seems to me, Piedmontite comes as a rare mineral, and by no means abundant enough to form an independent rock.

The occurrence of it in Japan is something remarkable, and finds scarcely its equal in other parts of the world. The Manganepidote forms with Quartz the Piedmontite-schist, and is an accessory component in the Glaucophane-schist.[1] Geologically speaking, its occurrence is confined to the same horizon as the Glaucophane-rock, i. e. the lower part of Chlorite-Sericite-Gneiss. This unique Piedmontite-bearing rock is unexpectedly of a wide distribution, constituting indeed an essential member in the archaean complex of Japan. The subjoined are some out of many of the typical localities of the Manganese epidote in our country:—

1. Ōtakisan, near the city of Tokusima, Awa province.

2. Bessi mine, in Uma Gōri,[2] Sanuki province.

3. Chihara copper mine, in Siūfu Gōri; Kitanada, in Kami-ukina Gōri; Uchinoko, and Kaya, in Kita Gōri, Iyo province.

(1) Journ. Sci. Imperial University, Tōkyō, Vol. I, Part I. B. Kotō, 'A Note on Glaucophane,' p. 85 et seq.

(2) Gōri or Kōri is synonymous with "Kreis" or a township.

4. Minano, Simo-tano and Yorii, in Chichibu Gōri; Ogawa, in Hiki Gōri, Musasi province.

5. Miyanosawa and Samba-gawa in Kanra Gōri, Kōzuke province.

6. Misaka, in Iwamae Gōri, Iwaki province.

7. Okino-Sima, Kii province, etc..

A peculiar Epidote.

There are still others which may be conveniently described on the present occasion. In speaking of the Glaucophane-schist in the other paper,[1] the writer has already given a brief notice of the presence of the remarkable Piedmontite. There we find, besides others, a peculiar Epidote in the form of long irregular plates (1/2 – 1 cm.), of a slight yellowish-green colour, and variously traversed by transversal cracks and longitudinal striæ. The morphological habitus differs from an ordinary Epidote by its more flattened tabular condition.

It possesses sometimes a faint rosy tint, and its pleochroism is weak, but distinct, being more intense when the short diagonal of the lower Nicol is at right angles to the longer sides of the Epidote. In other instances, the red pigment is localized in the centre (*Fig. VII.*), so as to form a distinct zone; but the reversed case, i. e. a red margin with the yellow centre, has never happened to be observed so far within the reach of the writer's knowledge.

The rosy pigment, which gives a peculiar feature to our Epidote, is due most certainly to the presence of a manganese oxide, and forms an intermediate stage between common Epidote and Piedmontite. One thing should not be passed unnoticed, namely, the abundant enclosures of clumps of opaque Iron glance and blood-red hexagonal scales of the same mineral, the typical Piedmontite being

(1) loc. cit. p. 85.

entirely free from any such, a fact which shows that the latter (Piedmontite) has crystallized out before the yellowish-green Epidote.

Garnet.

In the Glaucophane-schist from Ōtakisan, in the Island of Sikoku, we find a large number of rhombic dodecahedra (the size of peas) of a greenish-yellow Garnet. Under the microscope, a slide of it appears as made up of different minerals as shown in the figure (*Fig. VIII*). This crystal is, indeed, a small mineral-cabinet of all that are found in this rock except Glaucophane. The violet Piedmontite-needles, clumps of dark Iron-glance, hexagonal scales of Iron-glance, the knee-shaped twins of Rutile-needles and, lastly, highly vitreous grains of Quartz, are all thrown together within the crystal, assuming more or less a curved structure. These admixtures are supplemented and completed by a Garnet substance. The colour of the Garnet itself is deep yellow, and its crystal shows an optical anomaly, its behaviour being just like an anisotropic mineral, caused probably by the strain resulting from the interposition of the other minerals. Prof. Bonny[1] has also discovered Garnet in a Glaucophane-bearing rock near Berrioz in the Val d'Aoste, in theAlps. Here the Garnet sometimes contains Glaucophane and dark dust, which he suggests to be possible in certain cases of subsequent infiltration. Our Garnet is entirely free from the interposition of Glaucophane, although the rock itself is a Glaucophane-schist; and the above-mentioned interpositions, i. e. Piedmontite etc., seem to be formed prior to, or cotemporaneous with the formation of Garnet. It is a very remarkable fact that the brownish-red Garnet seems to be absent in the Piedmontite- and the typical Glaucophane-schist; while it is common in the Amphibolite-zone.

(1) 'On a Glaucophane-eclogite from the Val d' Aoste.' Min. Mag. Vol. VII, No. 32, p. 2. 1886.

I am rather inclined to think that the schists containing the yellowish-green Garnet in Sikoku may represent a metamorphic facies of some other schists.

EXPLANATION OF PLATE XXI.

FIG. 1. A slide of Piedmontite-schist taken parallel to the plane of schistosity of the rock, showing purple Piedmontite needles, hexagonal plates of Iron-mica (lighter shade of a blackish colour in the figure), dark Iron-glance, fibrous Sericite-lamellæ, Rutile needles together with round crystals of Garnet. The matrix of the rock left blank in the figure consists of an admixture of Quartz and Felspars. Magnified 90 diameters.

FIG. 2. A usual form of Piedmontite crystals with predominating faces of *M*, *T*, *i*, together with the hemi-pyramid. Such perfect crystallographic forms are not uncommon in the rock.

FIG. 3. A clinopinacoidal section with predominating faces of *T* and *i* usually met with in rock-sections, showing at the same time few cleavage-traces parallel to *M* and *T*.

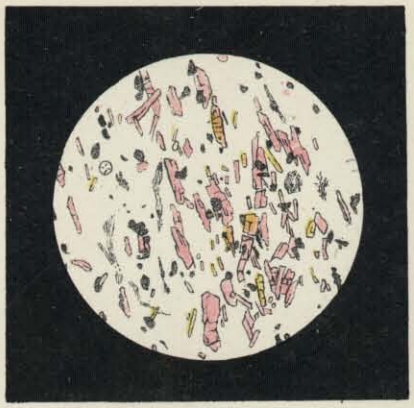
FIG. 4, FIG. 5, and FIG. 3. represent some of the remarkable forms resulting from the intergrowth and supergrowth of crystals of various sizes, whereby the outlines of sections become very irregular.

FIG. 6. Twins of a common type with general forms of crystal-individuals, showing the scheme of optical orientation.

FIG. 7. A light yellowish-green Epidote, having a rosy colour in the centre, caused by an accumulation of the pigment of a manganese-oxide. It represents the transitional stage of Piedmontite and common Epidote.

FIG. 8. A section of the rhombic-dodecahedron of Garnet with admixtures of violet Piedmontite needles, clumps of dark Iron-glance, hexagonal plates of Iron-mica, knee-shaped twins of Rutile needles and highly vitreous grains of Quartz within the crystal of Garnet.

Fig. 1.



X 19.

Fig. 8

Fig. 5.

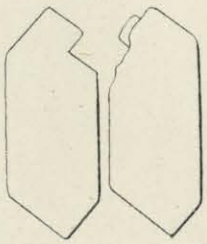


Fig. 3.

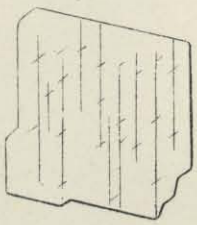


Fig. 2.

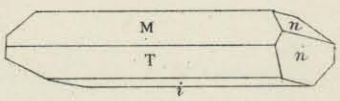


Fig. 7.

Fig. 4.

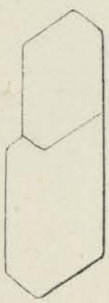
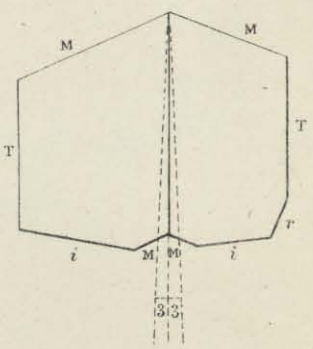


Fig. 6.



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