On Mineralogenesis Appeared in the Main Lodes of the Nakase Mine, Hyôgo Prefecture, Japan.

By

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with 15 Tables, 4 Text-figures and 6 Plates

ABSTRACT: The ore deposited in this mine are naturally considered to have been produced through certain processes during four main periods denoted as *P I*, *P II*, *P III*, and *P IV* representing respectively a different sort of mineralization. The main lodes containing gold, silver, and antimony ores are comprised principally in those produced in *P III* correlated to Plio-Pleistocene, being furthermore subdivided into *S 1* and *S 2* in stage.

Twenty five kinds of ore minerals have so far been described, among which some are found included commonly in all of the lodes formed in each period and the others only in those originated during specific periods.

To be noted is that the main lodes representing *P III* have been excavated along the main gallery, revealing a sort of distorted échelon-like structure in their distribution. Veinlets composing this kind of the lodes have elaborately been scrutinized on their polished specimens and thin sections principally under the microscope so as to establish the mineralogenetic sequence. As was expected, the results obtained seem too complicated to be put in good order. It however is proven to be valid that variation of the mineralizer in property with time is evidently recognized either as decrease of arsenic or as increase of antimony in the lodes produced at *S 1* and *S 2* stages, while variation in mineralic constituents is recognizable in the earlier to later veinlets as is shown in such sequence as arsenopyrite-berthierite-freibergite-stibnite. Each lode revealing discrepancy in arrangement is mineralogically somewhat different from one another, whereas a single lode indicates almost no vertical variation resulted from difference in temperature of mineralization and in mineral assemblage. It thus follows that the lodes under consideration might have been deposited from low-temperature hydrothermal solution displaying no remarkable difference in property on each level. On the other hand it is also to be taken into account that variation of property of the ascending solution might have taken place with time or with characteristics of fissures and that country rocks embracing the lodes might have provided the spaces for deposition of ores without any noticeable effects.

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I. INTRODUCTION

The Nakase mine located in Sekinomiya-chô, Yabu-gun, Hyôgo Prefecture has long been famous for production of gold, silver, and antimony ores.

In the recent report published by the writer (1961) outline of the ore deposits in question as well as of general geology has been described specifically with respect to their kinds, stage of deposition, and ore minerals.

As for mineralogenesis appeared in the ore deposits, it seems general in many cases that the theme is used to have been dealt with on the whole regardless of characteristic of the individual veinlets contained, whereas recaptitulated classification or grouping of mineralization and of mineralization stage have commonly been schemed and put into operation in most of the previous works. It however appears warrantable to expect such mineralizations as were overlapped or repeated even in the similar passage. The fact is that, as was already alluded to, repetition of ore deposition is surely observed in the fissure-filling lodes precipitated some times from low-temperature hydrothermal solution indicating not so much conspicuous variation in property or in range of temperature and thus results in confusion on discriminating each mineralogenesis or its sequence one from another. Although it is problematical to what extent the scheme to reach certain result may successfully be accomplished, gold-, silver-, and antimony-bearing lodes, which have been grouped into *P III* and are now being worked as the main objective in this mine, as well as some data obtained subsequently to the precedent work will hereunder be scrutinized.

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II. REMARKS ON GEOLOGY AND ORE DEPOSITS

Some works have so far been made public in relation either to the geology of the areas located within the northern part of Tango district, Hyôgo Prefecture or to comprehensive disputation of the region concerned. As for these regards the works done by K. WADATSUMI and T. MATSUMOTO (1958), and T. MATSUMOTO and K. WADATSUMI

(1959) are most worthy to be considered. More details concerning the geology appeared in the region confined to the Nakase Mine district have recently been alluded to by the present writer (1961).

Particular reference to the geology as well as to the ore deposits of the very mine have already been published by certain authors such as T. KOCHIBE (1892), T. KATÔ and T. TATSUMI (1942), T. KITA (1950), T. TATSUMI (1951, 1955, 1956), and the writer (1961).

With regard to the lithology distributed in the related district some data obtained subsequently seem necessary to be taken into account. Whereas the main parts have already been more detailedly described and are essentially not distinguishable one from the other, the results are roughly outlined in descending order as follows:

Sangun metamorphics: They are composed mainly of black-colored semischist to phyllitic facies, green-colored semischist to schalstein, and quartz-semischist, which are regarded to have been derived from certain member of the late Paleozoic formation, and embraced in serpentinite on the landsurface as if they were captured as xenolithic mass. The main lodes of the mine are found cutting across the schistosity of this member.

Serpentinite: It is developed with a trend of EW within the district and considered to have been formed at certain stage in Mesozoic in relation to formation of the 'Maizuru zone'.

Granite: It is represented by quartz-diorite, granite-porphyry, quartz-porphyry, and acidic dikes etc. but not by granite proper and believed to be grouped into the granite of San-in type intruded at a later stage in Mesozoic.

Manju volcanics: They are composed chiefly of tuffaceous agglomerate intercalated with augite-bearing hornblende-andesite, their distribution being typically observed merely in the galleries. As for their cylindrical occurrence as well as age of their formation there are rooms to be clarified. According to the writer's opinion (1960, 1961) derived from correlation to the work given by T. MATSUMOTO and K. WADATSUMI (1959), the member concerned is believed to have been formed in a sort of crater at certain stage of the last Cretaceous to Paleogene. On the basis of certain sorts of fossils such as radiolarian tests, spicules of sponge, and O. S. T. etc. obtained from muddy tuff in this member, T. KITA* (1961) points out its sedimentation to have taken place at F_3** stage of Miocene. As for this view, problematical points are, as was already stated by the writer, remained to be solved, while the member may be correlative to the Myôken tuff-breccia (G) grouped into the Kinosaki subgroup shown by K. WADATSUMI and T. MATSUMOTO (1958).

Kinosaki subgroup: The group composed of basal conglomerate, alternation of shale and sandstone, and shale, intercalated partly with volcanics, is found distributed not in the galleries but on the landsurface in the northern area of the mine, being correlated to a member of middle to upper Miocene ($F_3 \sim G$). Stibnite-bearing quartz-

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** Nomination for Tertiary formations, and will later be similarly used.

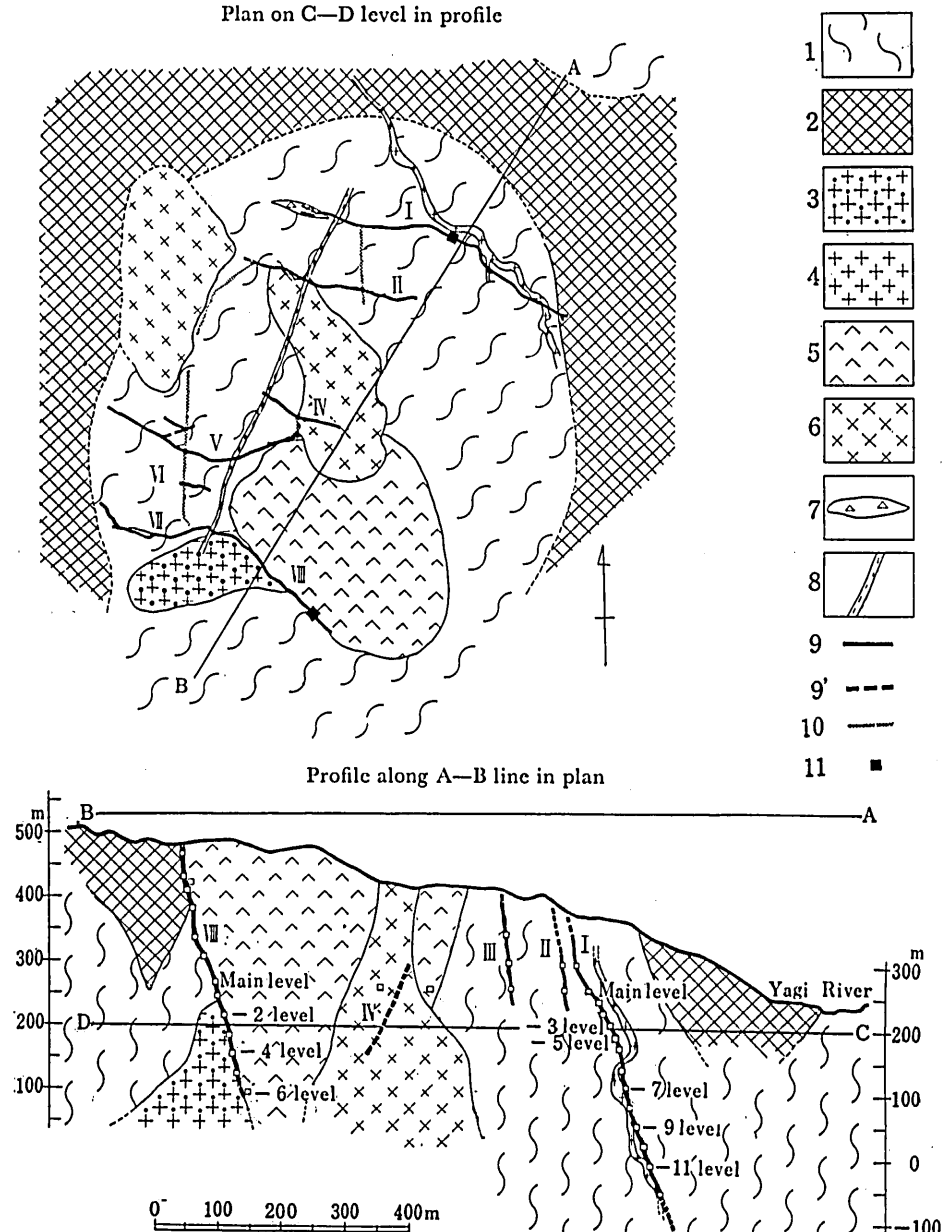

Fig. 1 Geological map of the Nakase Mine shown in horizontal and vertical sections

1 Sangun Metamorphics 2 Serpentinite 3 Quartz-diorite 4 Quartz-porphyry 5 Manju volcanics 6 Micro-quartz-diorite 7 Brecciated rhyolitic rock 8 Basaltic dike 9 Lode 9′ Lode (presumed) 10 Cross-cut 11 Shaft

I Ishimabu II Gingiri III Gingiri No. 2 IV Sasakura V North No. 2 VI North No. 1 VII Manju No. 2 VIII Manju vein appeared at Yagidani located northeast of the mine is included in the fissure of minor fault cutting across this group.

Breccia dikes and their allied rocks: They are developed in comparatively close relation to the lodes. Taking up the view given by H. TAKEDA* (1961) who has alluded to in connection with such mineralogenesis as was so in the case of similar dikes appeared in the 'green-tuff' region, formation of these dikes is considered to have been related to that of the Kawae volcanics (rhyolitic facies) belonging to the Kinosaki subgroup, pointing to that at F_3 stage in Moicence. Lenticular, stock-like mass of brecciated rocks, which are similar to in lithologic feature and considered to have been formed contemporaneously with the dikes concerned, is found developed in the western part of the Ishimabu gallery.

Saruo-no-taki dikes and micro-quartz-diorites: Saruo-no-taki dikes appeared as lenticular masses demonstrating a trend of NS in the northern part of the region are lithologically porphyritic or dioritic in the core. Micro-quartz-diorite observed in the galleries is also reasonably taken as a member of somewhat deeper facies of the former. Saruo-no-taki dikes have been grouped chronologically into H_2 by T. MATSUMOTO and K. WADATSUMI (1959) on one hand and micro-quartz-diorite together with quartz-porphyry revealed in the eastern part of the Ishimabu gallery into a sort of Neogene intrusive by T. KITA* (1961) on the other. The fact may be that, as was reported by T. TATSUMI and pointed out again by him*, the quartz-porphyry in question is to be correlated to the granite of 'San-in type' since its pebbles are certainly included in the basal conglomerate of the Kinosaki subgroup.

Tentaki lava: The lava flowing on the summit of the southern mountain is composed of olivine-augite-basalt belonging to a part of the Daisen volcanics (I) and observed nowhere in the galleries.

Basaltic dike: It is well-continued as dike with a width of 20cm$\sim$1m in the galleries and regarded as the product of the last igneous activity in this region, being correlative to the Gembudô basalt (K).

Besides, porphyritic and rhyolitic dikes appeared in the galleries are believed to have been produced at certain stage earlier than or in Miocene.

Excepting the main fissures filled with the lodes are there no significant faults in the galleries.

Although the geological data mentioned in the preceding may play an important role either in consideration concerning the space for ore deposition, kinematic or chemical properties of country rocks and igneous activity accompanying mineralizer or in determining the stage of ore formation, the fact is that the Kinosaki subgroup only is chronologically determinable, while the respective ages of other members are not deducible but for correlation to one another, as to which the previous works given by the writer are believed useful to certain extent.

The ores containing gold, silver, and antimony have long been excavated as the

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objective for mining in the Nakase mine, and it accordingly seems that gold- and stibnite-bearing lodes representing a sort of fissure-filling quartz-veins have merely been researched in detail as if the ores under consideration were produced uniquely in the lodes concerned.

T. Kita (1950) is the first who has classified the lodes and established the sequence of mineralization appeared in this mine. Afterward (1960, 1961), he has divided the mineralization into M_1 and M_2, as is indicated in Table 1.

Table 1

Stage	Elements	Minerals
M_1	As-Fe-Zn-Cu-Bi-Pb.	Pyrite-arsenopyrite-sphalerite-pyrrhotite-chalcopyrite-native bismuth-bismuthinite-wittichenite-galena-magnetite.
	Breccia dike	
M_2	As-Zn-Cu-Pb-Au-Sb-Hg.	Pyrite-arsenopyrite-sphalerite-berthierite-freibergite-andorite-gold-stibnite-cinnabar.

According to his view, mineralizations represented by M_1 and M_2 are regarded to have continuously taken place for such reason that, in spite of its intervention, the breccia dike might have been formed in the course of mineralization.

On the basis of interrelation between the lodes and their country rocks, trend of the lodes relating to geologic structures and mineralogical constituents included in the lodes, the writer (1961) has independently grouped the periods of mineralization recognized in this mine into the main four ones. The results comprising some data obtained subsequently are shown in Table 2.

Table 2

Period	Group and stage	Ore mineral
P I		Pyrite, marcasite, and ullmannite.
P II	*G 1*	Arsenopyrite, sphalerite, pyrrhotite, pyrite, marcasite, chalcopyrite, and galena.
	G 2	Pyrite, pyrrhotite, arsenopyrite, chalcopyrite, bismuthinite, native bithmuth, and marcasite.
P III	*S 1*	Pyrite, arsenopyrite, galena, sphalerite, chalcopyrite, berthierite, freibergite, stibnite, native gold, and jamesonite.
	S 2	Pyrite, arsenopyrite, sphalerite, berthierite, freibergite, andorite, stibnite, native gold, marcasite, and cinnabar.
P IV		Pyrite.

In the table the denomination *G* is given for the case in that the sequence is hardly distinguished from each other though it be distinctly different on the whole.

P I: The mineralization in this period is represented by deposition of the 'blue ore' named by the miner in this mine. The ores accompanying ullmannite reported by T. MATSUKUMA (1950, 1953) are surely in accordance with the so-called blue ore in their mineralic constituents. T. KITA (1950) defined it as the ore formed by silicification of micro-drusy, gold-, silver-, and antimony-bearing quartz-vein derived from serpentinite. As was demonstrated by the writer (1961), it however seems more

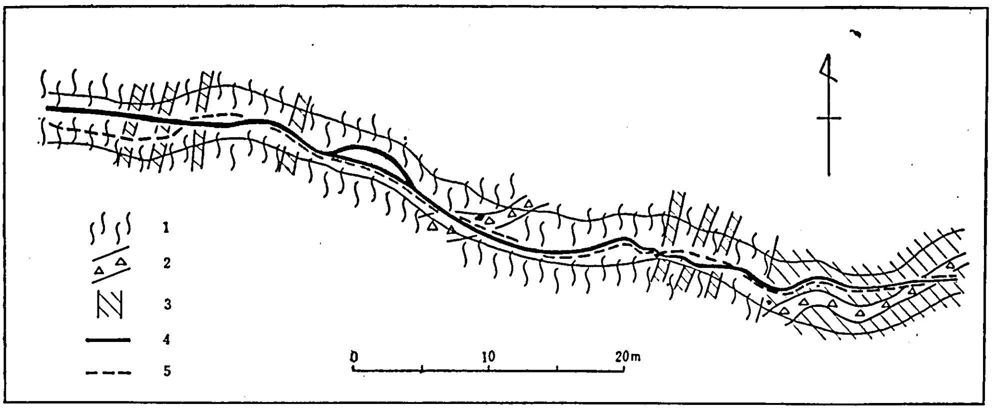

FIG. 2 Relation of the lode formed in *P I* to that formed in *P III*, appeared on the hanging wall of the lower No. 3 level of the Gingiri gallery

1 Sangun metamorphics indicating their trend of schistosity 2 Breccia dike
3 Lode formed in *P 1* 4 Lode formed at *S 2* 5 Lode formed at *S 1*

accurate to consider that the ores are composed mainly of pyrite and marcasite indicating characteristic in their bluish or greenish color derived certainly from traces of nickeliferrous components as well as in severe silicification and furthermore to refer to their characteristic occurrence shown in the following:

(a) The ores are found embraced only in the Sangun metamorphics and serpentinite but not in the later rocks; (b) The ores are included in the lodes running along the schistosities of the metamorphics, while the later lodes are deposited in the fissures displaying almost no relation to the schistosities; (c) The lodes are cut across by all kinds of the later lodes; (d) The lodes are penetrated by the acidic dikes earlier than the other lodes; (e) The lodes are found not only in the neighborhood of the later ones but also in any places revealing no connection with the latter; and (f) In spite of severe and comparatively large-scaled alteration given on the country rocks by the lodes in question, the effects of the later lodes are represented by nothing other than pyritization, sericitization, and carbonatization in slight grade.

In view of the facts mentioned above the mineralization during this period is reasonably considered to have been kept apart from the other later ones and to have brought about at certain stage earlier than Miocene, whereas the upper limit is hardly determinable now that the acidic dike cutting the lodes concerned are chronologically not correlated to other members. Morever, serpentinite comprising nickel ores of the Natsume and Ôya mines is located about 6 Km southeast of the Nakase mine and accountably to be connected with that appeared in the latter district. Considering the content of nickel, the blue ore seems to have been related to, or formed contemporaneously with, those of the former district at certain stage later than Jurassic.

P II: The lodes formed in this period are certainly included in the Sangun metamorphics, serpentinite, and quartz porphyry, and found cut across by one of porphyrite and breccia dike. This kind of lodes is supposed to have been deposited at a temperature higher than in the case of all others in an intimate relation to those formed in *P III* and bears a trend of EW in good accordance with the direction revealed in the structure of the Kinosaki subgroup within this region. These facts may indicate the lodes concerned to have connection with those formed at the initial stage in Miocene or at any other earlier stage and to have certain relation to a part of the deposits appeared in the Ikuno and Akenobe mines. The lodes produced in *P III* are mineralogically subdivided into two groups denoted as *G 1* and *G 2*, the interrelation of which is not confirmable on account of being isolated from each other.

P III: The main body of the lodes is developed not in the Tentaki lava but in the fissures traversing through the rocks from the Sangun metamorphics to micro-quartz-diorite and penetrated across by basaltic dike. Trend of the lodes is apt to point mainly to NW–SE and partly to EW in accordance with that indicated by the Teragi group (H). The antimony deposit located at Yagidani about 4 Km NNE of the Nakase mine seems to be grouped into the lode produced in this period and is embraced in the fissure cutting through shale of the Kinosaki subgroup. As was already stated in the previous report, this kind of the lodes is reasonably considered to have been produced in Plio-Pleistocene (H∼I).

In consequence, it may be deduced that mineralizations taken place during *P II* and *P III* are essentially to be distinguished from each other because of intervention of breccia dike and porphyrite dike between the lodes representing each period.

P IV: The lodes formed in *P IV* are found in the fissures of minor faults intersecting obliquely or perpendicularly to those of *P III* and may be regarded as a sort of post mineralization of the latter, resulting in calcitization of phenocrysts of basaltic dike.

Gold-, silver-, and antimony-bearing lodes deposited during *P III* grouped into *S 1* and *S 2* are regarded as the main objective for mining in this mine. In particular, *S 2* lodes and accordingly the galleries along the lodes concerned are well-excavated, while on the coutrary there appears inconvenience for discerning the preceding state of lodes other than the now excavating parts on account of being digged out at all.

Nine lodes which are now being worked are found running parallel to one another in a zone with width of about 1 Km from north to south, revealing general trend of NW–SE with northward inclination in high angle, and respectively named Ishimabu, Gingiri, Gingiri No. 2, Sasakura, North No. 2, North No. 1, Manju No. 2, Manju, and Hommabu-Kijimabu, in that mineralizations representing *S 1* and *S 2* are observed separately, solitarily and as composite veins. In general, *S 1* seems to have been less active than *S 2* and is merely found in the Sasakura and the easternmost part of the North No. 2 lodes accompanying no traces of *S 2* therein.

The Ishimabu lodes bearing the strike of nearly N70°W with the dip of 60°~80°N are developed about 700 m along strike-side and about 400 m along dipe-side. Though on the upper level the lodes seem at a glance to be well-continued along a straight line, detailed inspection indicates that they are composed of some lodes with different trend dislocating slightly from one another, as are the cases with other lodes in this mine. On the southernmost side of the deposit three lodes such as Manju

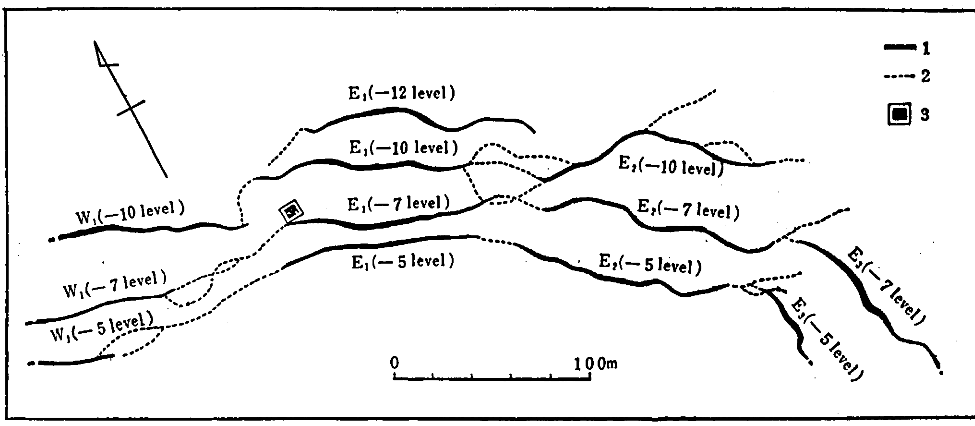

Fig. 3 Projection of each lode in the eastern part of Ishimabu gallery, showing discrepancy with one another.

1 Lode formed in *P III* 2 Adit 3 Shaft

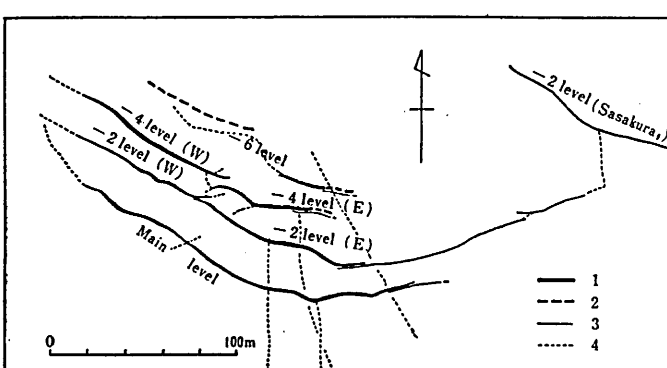

Fig. 4 Projection of each lode in the North No. 2 gallery, showing discrepancy with one another

1 Lode formed in *P III* 2 Lode formed in *P III* (presumed)
3 Lode formed in *S I* 4 Adit and cross-cut

No. 2, Manju, and Hommabu-Kijimabu are independently named and arranged roughly in direction of NW-SE, while mutual discrepancy between the lodes is more conspicuous than in the case of Ishimabu lodes. A lode regarded as a branch of Manju No. 2 in the part extended northwest from the latter has recently been ascertained as a different one. This kind of the lodes is for the present separable into four parts of échelon-like structure. On the lower No. 4 level of North No. 2 lode similar relation is evidently discernible in two places.

Difference in the mode of occurrence seems to be similarly reflected on mineralizations. As will later be referred to in detail, the respective lodes revealing discrepancy in arrangement are mineralogenetically somewhat different, whereas variation is recognized not in characteristic of a single lode along strike- and dip-side but in width.

To be noted in this deposit is that as gangues dolomite is far more predominant than calcite. This may be ascribed to much more supply of Mg component from the passage of serpentinite.

Alteration given by the lodes in *P III* on the country rock is not worthy mentioning. Effects of *S 2* lodes on black-colored semischist are hardly recognizable but those of *S 1* lodes are more or less remarkable than in the former case, resulting in formation of so-called 'red slate' implying coloration of country rocks into greyish white to pale brownish tint derived synthetically from sericitization, carbonatization, and silicification in slight grade. Besides, pyrite also is found impregnated in the country rocks. Zone of alteration, $5 \sim 50$ cm or ordinarily about less than 20 cm in width, seems in no relation to the scale of the lodes and is considered to have been originated by the fore-running solution concerning the deposition of *S 1* lodes.

As for the temperature controlling the ore genesis, the lode formed in *P I* might have been deposited in epithermal state. On the basis of some data illustrating the exsolution of sphalerite in chalcopyrite, that of pyrrhotite and chalcopyrite in sphalerite, and that of vallericite in chalcopyrite, *P II* lodes are believed to have been precipitated at somewhat higher temperature. As will be described, *P III* lodes seem also to have been derived from a sort of low-temperature hydrothemal solution.

III. Mineralic Constituents

Various kinds of ore minerals have ever often been collected from the lodes appeared in the Nakase mine and some of them have been researched in detail by many investigators. The representative ones are shown in Table 3, where some are included universally in all of the lodes and others are found simply in special lodes. Minerals listed in Table 3 are hereunder scrutinized to certain extent.

Andorite: This mineral is found always accompanied with freibergite, sphalerite, berthierite, and stibnite in the same lode and shows an intimate relation of intergrowth to the former two. It is comprised abundantly in the lode formed in the beginning of the later substage of *S 2* in the Ishimabu lodes. Certain specimen has recently been named "Nakaséite" by T. Itô and H. Muraoka (1960) on the basis of difference from ordi-

TABLE 3 List of Ore Minerals Obtained from the Nakase Mine

Nomenclature \ Investigator	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Period of deposition	Remarks
Andorite		‡		+						+			‡	+	*‡	+	+	III	d.
Arsenopyrite						+	+					+		+		+	‡	II III	d.
Barite (negative mold)											‡						‡	III	
Berthierite		‡	+	‡	‡	+	‡			+		+		+		+	‡	III	d.
Bismuthinite														+		+	+	II	m. i., n. d.
Chalcopyrite						+	+							+		+	+	II III	d.
Chalcostibite																+		II?	n. d.
Cinnabar									‡							+	‡	III	d.
Freibergite			**+	**+			**+			+		**+	‡	+		+	‡	III	d.
Galena						+	+					+		+		+	‡	II III	d.
Jamesonite														+		+	‡	III	d.
Magnetite														+		+		II	n. d.
Marcasite										+							‡	I II III	d.
Metacinnabarite									‡									III	m. i., n. d.
Native bismuth														+		+	+	II	m. i., n. d.
Native gold							+			+		+		+		+	+	III	d.
Pyrargyrite														+					n. d. ⊙
Pyrite						+	+			+		+		+		+	+	I II III IV	d.
Pyrrhotite						+								+		+	+	II	d.
Semseyite																+		II?	n. d.
Sphalerite			+			+	+					+		+		+	‡	II III	d.
Stibnite	‡			+		+	+	‡		+		+		+		+	‡	III	d.
Tetrahedrite																+		II?	n. d.
Ullmannite										‡							+	I	m. i., n. d.
Wittichenite														+		+		II	m. i., n. d.

Abbreviation for the list

- + Merely mentioned.
- ‡ Referred to mineralogically in more or less detail.
- * Denominated as nakaseite.
- ** Denominated as tetrahedrite.
- d. Röntgenographically determined by the writer.
- m. i. Microscopically identified by the writer.
- n. d. Röntgenographically not determined by the writer.
- ⊙ Doubtful.

Investigator

1 M. Kimura (1937)
2 T. Itô & K. Sakurai (1947)
3 T. Tatsumi (1948)
4 K. Sakurai & E. Tanda (1948)
5 H. Muraoka (1949)
6 T. Kita (1950)
7 T. Tatsumi (1951)
8 K. Muda (1952)
9 K. Sakurai & E. Tanda (1953)
10 T. Matsukuma (1953)
11 K. Masutomi & K. Takaoka (1953); K. Takaoka (1954)
12 T. Tatsumi (1956)
13 K. Kinoshita (1957)
14 T. Kita (1960)
15 T. Itô & H. Muraoka (1960)
16 T. Kita (1961)
17 K. Akatsuka (1961)

nary andorite in chemical composition and inner structure. Since it however is extremely difficult or rather impossible to separate it completely from coexisting freibergite or sphalerite, and M. Fleischer (1960) has also pointed out that the material should be called andorite XXIV, it seems for the present better to identify it as a sort of ordinary mineral.

Arsenopyrite: This mineral is found included in the lodes formed in *P II* and *P III*. In the *P II* lode, it seems to be of higher-temperature type deposited at a comparatively earlier stage. In the *P III* lode, it is comprised characteristically and universally in each lode at *S 1* but in small quantity in the lode formed at the earlier substage in *S 2* and seems to be of low-temperature type. On the other hand, it is not included in the main veinlet containing berthierite and stibnite worked as the objective in this mine. The specimens are small-sized, short prismatic, acicular and pulverous in habit. Röntgenometrical data relating to this mineral have already been published.

Barite: This mineral is occurred as negative mold embraced in chalcedonic quartz at the later substage in *S 2* but nothing is remained in the present cavity. It is, as was reported by K. Masutomi and K. Takaoka (1953), morphologically identifiable.

Berthierite: This mineral, predominant in content following that of stibnite, is included characteristically in the lodes deposited at the later substage in *S 1* and at the intermediate substage in *S 2* but lacking in certain lodes and associated with pyrite, arsenopyrite, sphalerite, freibergite and stibnite in the same lode. Röntgenometrical date have already been given.

Bismuthinite, native bismuth, and wittichenite: These minerals are microscopically found contained in the lodes at the later stage of *P II* but, on account of scarcity in content, remained yet to be röntgenometrically identified.

Chalcopyrite: The specimens including the exsolution-stars of sphalerite are found deposited at somewhat higher temperature principally in the lodes produced in *P II* (especially in *G 1*), and those without remarkable characteristics are in a slight amount in the lodes deposited in *S 1* of *P III*.

Chalcostibite, semseyite, and tetrahedrite: These minerals are, in spite of the oral publication made by T. Kita* (1961), remained yet to be strictly assured. According to his view chalcostibite seems included in tetrahedrite distinguished essentially from freibergite and semseyite covering galena formed in his M_1 (corresponding to *P II*) is regarded as a part of the product derived secondarily with the effects of mineralizer in M_2 (corresponding to *P III*) on the core mineral. Nevertheless, it is questionable whether such an inactive solution as merely filled the druses appeared in *S 2* lodes might have caused the formation of crust in question or not. If any, the mineral under consideration is rationally considered to have been primarily deposited in special parts of *S 1* lodes since there are, as will later be alluded to, certain reasons to suggest its formation because of contents of some elements such as Cu, Pb, and Sb etc. in the lodes formed at *S 1*. On the other hand, if it were related to the mineralization

* Read at 11th general meeting of Soc. Min. Geologist, Japan, Feb. 3.

in *P II* occurrence of schapbachite is therein to be expected in connection with native bismuth and bismuthinite.

Cinnabar: This is rarely obtained from the veinlets deposited in tiny cracks at the last step in *S 2*.

Freibergite: This is found mainly but less abundantly in *S 1* than in *S 2* in the Ishimabu lodes, and always accompanied with andorite and sphalerite in the lodes formed in *S 2*.

Galena: Its occurrence is common in the lodes produced in *P II* but generally poor in *S 1* excepting the case appeared in the western part of Ishimabu lower No. 7 level.

Marcasite: The specimens are included in the lodes deposited in *P I*, *P II* and *P III*. It is particularly to be noted that a sort of mineralization precipitating marcasite scatteredly on the surface of drusy dolomite formed nearly at the last step in *S 2* on the uppermost of the main level in North No. 2 gallery corresponding to the uppermost part of North No. 2 lode might have caused the deposition of pyrite similarly in the same lode appeared on the lower No. 6 level situating 200 m lower than the former. Excepting such a slight variation as is illustrated in the relation of marcasite to pyrite with depth the mineralization in question is, despite of its inactivity, considered to have been continued throughout 200 m along the passage concerned.

Jamesonite: Wooly specimens are developed in the druse formed at the last substage in *S 1* and, as are observed only in the Sasakura lodes, happen to be enclosed in the drusy quartz.

Magnetite: This is found included in the lodes deposited at a comparatively later stage of *P II*, whereas the specimens are remained yet to be röntgenometrically identified.

Pyrargyrite: The reason why the mineral is here mentioned is in that T. Kita (1960) once reported on its occurrence and the writer also found out certain red-colored specimens which has later been identified as a sort of sphalerite, but it is still now pending whether it may occur or not.

Pyrrhotite: The specimens are obtainable from the lodes formed at a higher temperature in the beginning of *P II*.

Sphalerite: Striking is that the mineral are included in almost all lodes formed from *P II* up to the last substage in *S 2* of *P III* accompanying stibnite. The specimens obtained from the lodes formed in *P II* are used to involve the exsolution-blebs of pyrrhotite and of chalcopyrite exsolving further vallerieite, suggesting their formation at a comparatively higher temperature. Those occurring in the lodes produced in *P III* however reveal nowhere such exsolution as be recognized in the former case and are regarded as the products at low temperature. With descending stage their color becomes more pale, while those accompanied with stibnite at the last substage in *S 2* are, though it is pending to clarify whatever origins may be related, too reddish to be mistaken as pyrargyrite.

Stibnite: This is contained mainly in the lodes deposited in *S 2* and also in those formed at the later substage in *S 1*.

Ullmannite: Its occurrence is microscopically recognizable in the lodes produced in *P I* though it is remained yet to be röntgenometrically scrutinized in detail.

IV. Mineralogenesis.

As was frequently stated, the lodes deposited in this mine are essentially and genetically grouped into four kinds assumed to have been formed in such different periods as are represented by *P I*, *P II*, *P III*, and *P IV*, each of which is furthermore subdivided into various mineralizations distinguished from one another and repeatedly overlapped.

Of all periods, *P III* is of most importance and the main one relating to formation of mineable ores included in the deposits under consideration. In particular, the lodes produced at *S 2* stage in *P III* is being actively excavated because of their conspicuous mineralization and higher content of gold.

The lodes formed during *P III* are used either to bear the width of less than 50 cm even in the part where *S 1* and *S 2* coexist with each other and run along a seemingly simple passage or to reveal variation in width. In common, the lodes formed at *S 2* stage have already been digged out almost at all and nothing other than the part remained scarcely in the adits under excavation or on the lowermost level of the gallery is recognizable. Moreover, workable parts are not remained in the Manju and Hommabu-Kijimabu galleries, and the remainder, if any, indicates only some trace of feeble mineralization or low contents of ores. In consequence, it seemes at present very much difficult to pursue every lode laterally or vertically.

The lodes formed at *S 1* and *S 2* stages ordinarily occur in an intimate relation to each other but each happens to be solitarily appeared. In the cases of Sasakura gallery and of the easternmost part on the lower No. 2 level of North No. 2 gallery, for example, the *S 2* lodes are not found appeared even in the similar passage. It is difficult to discriminate macroscopically one from the other in the lodes in that *S 1* and *S 2* coexist and one is far weaker than the other in its grade of mineralization. Macroscopic inspection simply indicates that the lodes deposited at *S 1* stage are composed of pyrite, arsenopyrite, galena, sphalerite, chalcopyrite, berthierite, freibergite, stibnite, and jamesonite in descending order, accompanying little amount of native gold. Nevertheless, either contents or states of the lodes concerned are not so much simple but rather extremely complicated, as are so also in the case of the lodes formed at *S 2* stage. *S 1* lodes characterized with content of pyrite, arsenopyrite and sphalerite are accompanied with a sort of brecciation at the earlier substage of their deposition. It results in that the ores formed at the initial stage were brecciated and embraced together with the fragments of country rocks in, or captured by, those produced subsequently, thus forming a sort of 'brecciated ore'. In the part wherein *S 1* and *S 2* coexist in the same passage, the former is always traversed by the latter.

On the other hand, in spite of macroscopically obtained results illustrating that the lodes formed in *S 2* are consisted of pyrite, arsenopyrite, sphalerite, berthierite, freibergite, andorite, stibnite, and cinnabar etc. together with megascopically identifiable grains of native gold in descending order, their mineralic assemblages and mineralogenetic sequence are not simple though to less extent than in the case of *S 1* lodes. Most parts of the lodes under consideration are particularly characterized with content of berthierite, freibergite and stibnite as well as with their occurrence seemingly filling the druses of the earlier lodes.

With all the fact enlightened in the preceding, each lode representing *S 1* and *S 2* is of course considered to have been originated not from a simple mineralizer but through repetition or overlapping of mineralization, culminating in respective formation of a sort of composite vein. Relations of mineralogenetic sequences and their characteristics are schematically and synthetically shown in Tables 4~15, wherein andorite is, because of its intimate coexistence with freibergite and of being usually included in the latter, not referred to but represented in the term of freibergite.

As far as the lodes belonging to *S 1* are concerned, they are found most actively and complicatedly in the lodes of the Sasakura, Gingiri, and western Ishimabu galleries. The lodes concerned are developed in form of fissure-filling veins with width of 20 cm in maximum and of 5~10 cm in common in the above-mentioned galleries, while with width of 10cm in maximum and of less than 5cm in common in the cases of being embraced in other lodes. They are used to be appeared as composite veins including bulk of veinlets, some of which happen to be found branched isolatedly from the main bodies into wall rocks. Almost all these veinlets are composed mainly of quartz with a little amount of ore minerals. In particular the lodes appeared in the Sasakura gallery are consisted of a great number of veinlets in which remarkable regularity in mineralic species is not recognizable. It however seems on the whole that galena might have been derived from the earlier mineralization, chalcopyrite from the intermediate and antimony-bearing minerals represented by berthierite and stibnite from the later, while on the other hand quartz-grains composing each veinlet are, as are observed similarly in other kinds of lodes, apt to reveal somewhat distinct tendency of variation from fine to medium size with descending sequence of mineralization. Such tendency as is recognized in ore mineral as well as in gangues appeared on certain level of a lode is appeared almost similarly in other lodes and on other levels. Though vertical difference in height between the lower No. 6 level and the main level included in the Manju No. 2 gallery is estimated about 170 m and that between the lower No. 6 level and the uppermost of the main level included in the eastern part of the North No. 2 gallery about 230m, remarkable variation in temperature or property of mineralizer is not discernible merely on the basis of mineral assemblages. This may suggest each mineralization to have been taken place in the similar passage at a temperature too low to be distinguished from one another and to have formed a number of veinlets containing certain resembling assemblages of mineralic constituents, whereas decrease of arsenic as well as increase of antimony are, though to a slight extent, generally ascertainable in each veinlet with descending sequence.

Far more important is that instability appeared in mineral assemblages belonging to each veinlet formed repeatedly at the earlier to intermediate substages in *S 1* is to be ascribable to the effects of brecciation, overlapped ascension of mineralizers, and mingling of mineralizers with one another, as to which decisive conclusion can at present not be reached.

In the lodes formed after the intermediate substage in *S 1* it appears general that traces of brecciation have gradually been abated, and deposition of berthierite and stibnite together with formation of druses have become conspicuous. The veinlets produced at this stage are used to bear a tendency revealing not so much complicated structures as are observed in the lodes formed at the preceding stage and, on account of similarity in structure and in composition appeared in different parts or on different levels, easily correlative to one another. On the other hand these veinlets containing berthierite and stibnite associated with or without arsenopyrite are, because of their similarity to the lodes formed at the intermediate substage of *S 2* in compositions, hardly distinguished from each other. In the case where *S 1* and *S 2* are appeared in the same place both are easily distinguishable from the relation to other lodes, whereas it is extremely difficult to determine them independently. As for the sequence recognized in the eastern part of North No. 2 gallery, each one is found on the lower No. 2 level and *S 1* is solitarily developed on the uppermost while it is questionable to whether group the lodes observed on other levels may belong.

Moreover it seems also a sort of characteristic appeared at *S 1* that content of galena formed prior to jamesonite is more conspicuous in the lodes of the Gingiri and Sasakura galleries and western part of Ishimabu gallery including the latter in more amount than in other lodes. At any rate, spacial difference of mineralization confirmed in flock of veinlets formed at *S 1* is much less than that appeared in *S 2* lodes.

As for *S 2* lodes, alteration afforded on their wall rocks is hardly observed. The lodes in question are rich in variation of width but reveal the width of less than 20 cm in common and of 10 cm in average. Subdivision of the lodes concerned as well as scrutiny of their interrelation are considerably easier than in the case of *S 1* lodes, inasmuch as veinlets composing *S 2* lodes are less in number and less complicated than in the latter. Almost all veinlets grouped into *S 2* are found deposited in druses formed at the preceding stage and further contain bulk of druses of their own. Significant is that a single kind of mineralization concerning *S 2* lodes demonstrates a remarkable continuity within a range from the lowermost to uppermost level and mineralic constituents together with formation sequence of veinlets indicate almost no noticeable difference throughout all levels. On the other hand it seems general that content of silver i. e. freibergite is more abundant in the Ishimabu lodes than in the Manju lodes and that of berthierite appeared in the former is also more abundant than that of stibnite and *vice versa* in the latter, while difference in gold content is not recognized in both lodes. Inspection of ore minerals in relation to their sequence points to that, subsequent to formation of veinlets composed of arsenopyrite and pyrite earlier produced, berthierite, freibergite and stibnite might have been precipitated in descending order, while sphalerite merely are found included continuously in veinlets formed at earlier stage to later stage whereat stibnite was deposited. Nevertheless, it is sure that each lode is essentially distinguished from one another concerning respective mineralization.

As was referred to already, each lode formed at *S 2* stage represents either discrepancy in distribution or difference in mineral assemblage and in mineralogenetic sequence. In the eastern part of the Ishimabu gallery three lodes named E_1, E_2, and E_3 for convenience by the writer are appeared as seemingly continued but actually separated veins (see Fig. 3). In E_1 lode berthierite is only included rarely in the veinlet formed at the earlier substage while freibergite is found conspicuously in those produced at the later substage (ref. Table 5). In E_2 lode formation of berthierite is observed distinctly in the veinlet deposited at the intermediate substage, while deposition of the veinlet containing freibergite is intervened between earlier berthierite and later stibnite (ref. Table 6). In E_3 lode freibergite is nowhere recognizable but repeated depositions of stibnite-bearing veinlets are strikingly obvious (ref. Table 7). Although characteristics of the lodes named E_1, E_2, and E_3 in tables surely represent respectively those appeared on the specific levels such as the lower No. 12, No. 5, and No. 7, each one is characterized with similar property throughout its own lode. In consequence any lodes developed on certain level are identifiable with one another or grouped even if some part situated on specific level has already been excavated at all and almost nothing is therein remained. As a matter of fact vertical variation in mineralogenetic sequence or order of deposition of veinlets is not observable on each level.

It seems general that the veinlets, which are composed of fine- to medium-grained, scaly quartz and contain a remarkably slight amount of berthierite and stibnite associated with arsenopyrite, might have been produced at the earlier substage, bearing either the width of about 1cm in maximum or inactive property. Subsequent veinlets are found contained in the fissures formed at the preceding stage, composing of quartz which are observed developed from the walls of fissures toward their central parts including druses. In these druses later deposition of hypidiomorphic or idiomorphic berthierite of short-prismatic or acicular form associating almost always a little amount of sphalerite with medium-grained, scaly quartz are involved while crystalline dolomite is also recognized embraced among the quartz grains. And then, either variation of mineralizer in property during the deposition of these veinlets or other sort of mineralizer ascending succeedingly in the same passage with slight interval might have brought the successive precipitation of somewhat larger-grained quartz bearing such a form as is similar to that mentioned above as well as formation of subhedral or euhedral, short-prismatic, larger-sized stibnite which however is smaller than that formed in the subsequent veinlets, instead of berthierite shown above, accompanying dolomite enclosed among quartz grains. Mineralization forming the druses accompanied with deposition of this kind of stibnite seems to have not completely filled the druses associating the earlier berthierite, so that it is commonly observed at the intermediate substage that berthierite or stibnite developed on the druses included in this veinlet is complicatedly mingled with each other and on the whole berthierite is abundant along the outer zone, while stibnite is concentrated in the central part of the veinlet. At the following later substage opening of fissures, growth of quartz forming the druses in the manner similar to the above-mentioned, and then deposition of quartz and stibnite associating always a little amount of sphalerite and dolomite seem to have taken place. Stibnite formed at this stage is long-prismatic, larger than that appeared in the former case and bears the length of 1∼3cm, protruding on the druses. The lodes characterized mainly with Sb contents are used to be appeared in such manner as fill the druses and, in consequence, to reveal a remarkable variation in scale. It happens in fissures formed at the initial stage of Sb veinlet that grains of quartz protruding from the walls of fissures are not observed and finer-grained quartz, instead of scaly, medium-sized occurrence, is appeared. As a sort of post-mineralization, that is to be distinguished from those relating to *P IV*, deposition of veinlet composed mainly of carbonate is certainly discriminated. Well-developed crystals of dolomite filling the fissures opened in the preceding lodes are found protruding toward the center of the druse, on which crystals of pyrite are scattered and further covered sporadically with those of calcite. The facts stated above are referred to all observed in the lodes formed at *S 2* stage, particularly in the Manju No. 2 lode in which the relation to freibergite observed in a small quantity on the lower level is, because of being excavated at all, now of obscurity on the upper level (ref. Tables 8–11), as are similarly observed in the North No. 2 lode (ref. Table 12–15).

Noteworthy is that in the eastern part of the North No. 2 gallery crystals of pyrite are found scattered on dolomite protruding into druses appeared on the lowermost No. 6 level while on the other hand those of marcasite are observed in the similar occurrence on the uppermost of the main level. Excepting such a slight variation in constituents as is represented in the case of iron sulfide, to be noticed is that all kinds of mineralization, even if they may be extremely inactive or small-scaled, demonstrate a splendid continuity throughout all levels.

V. Consideration

The lodes deposited in the Nakase mine have so far long been classified into those belonging to an ordinary kind of vein type or recently into a sort of subvolcanic or xenothermal vein. The reality is however that they are not to be grouped according to a common category of the previous concept concerning ore deposit, since the lodes concerned are surely believed to have been formed at low temperature through various processes or complicated overlapping of mineralizations without their mutual interaction. In view of this, analyses of the lodes into each mineralogenetic series and of its sequence have been schemed in addition to scrutiny on the whole. On the basis of an idea that each veinlet might have been uniquely derived from a simple mineralizer careful efforts have been made for separation of each veinlet traversed with one another. It is comparatively easy to discriminate each veinlet revealing specific characteristic in mineral assemblage or lateral and vertical continuity in many places, whereas there are many difficulties and obscurities in the case of the lodes appeared in the Nakase mine since each lode corresponding individually to respective mineralization is in many parts appeared in extremely small scale, rich in variation of width, nearly similar to one another in mineralogical characteristic and affected through severe brecciation especially at the earlier stage, causing impossibility of megascopic identification on the actual spot. In the light of this circumstance, specimens have been collected as many as possible concerning each lode pursued for long interval and microscopically or röntgenometrically inspected. It has thus become clear that some of the megascopically traceable veinlets revealed respectively a good accordance in mineralogical constituents and texture with the results obtained from microscopic examination for their own polished and thin sections. The results indicate also that a single veinlet is intermittently but continuously extended vertically or horizontally according to such a rule as pinches out in some parts but is reappeared in other parts along the similar passage. Accordingly characteristics of respective veinlets have been microscopically scrutinized in detail with respect to species, assemblage, combination, grade and sequence of crystallization, form and size and so forth, of all minerals contained.

Determination of sequence of each veinlet has been based on some phenomena. First, one is regarded as was formed earlier than the other in stage, if the latter is traversed across by the former. This relation is, because of being disturbed through a sort of brecciation, hardly recognized in the veinlets formed at the stages earlier than the intermediate of *S 1* but easily applicable to the case concerning the later ones. On the other hand the lodes related to *S 1* stage are characterized with formation of brecciated ores but continuously developed veinlets are scarcely obtainable in the lodes concerned. As the second step, therefore, the fact that brecciated veinlets are captured in the later ones is considered to give an important clue to determining the stage. It however seems to happen that, if certain kinds of ores were precipitated from a mineralizer and then others were subsequently deposited from the residual solution, either mineralizations are taken as different ones. As was referred to already, these relations are hardly discernible similarly to the case where certain veinlets might have been produced in the residual solution squeezed out from a mineralizer depositing already a part of ores. As for brecciation, it has been regarded as was derived from different mineralization when brecciated parts are well-defined and evidently distinguishable from their surroundings both in mineralogical constituents and in texture. Nevertheless, two individuals coming into contact with each other have been grouped into those produced through a simple mineralization when microscopically both illustrate either similar kinds of mineralic components or resembling forms, their boundaries are extremely obscure, and grains of quartz, their gangue mineral, reveal gradual variation in characteristic and in habit. The third step for determination of mineralogenetic sequence has been based on the facts in that some of mineralizations were distinctly related to formation of druses and others to deposition in such earlier druses. In this case forms and disposition of drusy quartz are intrinsically of due significance, demonstrating such occurrence that fine grains of quartz are arranged in many parts along the walls, found enclosing the extremely fine-sized fragments of wall rocks at the base, become coarser in size, and protrude out into the inner parts of druses. There are also the cases in that fragments of wall rocks are not contained. These grains of quartz are apt to indicate not only the elongation almost perpendicular to the walls but also the fun-shaped occurrence with pyramidal top toward the druses. These characteristics appeared along the walls of veinlets have been taken as the last product of certain mineralization, while on the other hand finer-grains of quartz deposited in the druses mentioned above are considered to have been produced later in stage. Remarkable interval however seems to have not intervened between these two kinds of mineralization. It may be a pertinent example that almost all of antimony-bearing veinlets are apparently regarded as were precipitated in certain mineralizer filling the druses and consequently associated with drusy quartz along the walls. It happens that some parts of druses are remained as cavities containing no traces of the later minerals and certain veinlets cutting the drusy quartz are found isolatedly branching from the inner parts into the wall rocks. The veinlets belonging to the latter case seem to represent a facies of mineralization appeared later in druses. Veinlets composed of druse-forming quartz are ordinarily accompanied with no ore minerals, whereas the similar ones are found including abundance of freibergite and sphalerite together with few of pyrite and arsenopyrite as are appeared in the Ishimabu E_1 lode formed at the middle of *S 2* stage (ref. Table 5). It is of course dangerous to dispute the formation of druses merely on the basis of forms and arrangement of quartz, since the seemingly formed druses sometimes display a gradual variation into nothing other than ordinary veinlets (see Figs. 3 and 4, Pl. 2). These facts have carefully been taken into account so as to avoid the confusion expected. Furthermore, in the parts where minerals are radially disposed from walls toward the drusy cavities and there are the later druses covering the former, the related mineralizations have separately been distinguished one from the other and at the same time difference in mineral assemblage and in species also have been taken as was derived from different mineralizations. These relations have been effectively applied to the cases concerning the lodes formed at the later *S 1* and all *S 2* stages. As for mineral assemblage, attention has been paid particularly to whether the minerals formed in the preceding mineralization might have been captured or not by those deposited in the subsequent mineralization and the earlier textures are remained or not in the later ones or to their arrangement in the veinlets concerned.

A part of the results thus obtained are carefully compiled and summarized in Tables 4∼15. Inspection of the tables clearly points to that some, for example, the Sasakura lode, were subdividable into many steps and others were not so for various reasons. In the Sasakura lode, mineralizations concerning *S 1* with a larger width is considered to have been more active and numerous than other lodes and to include overlapping of precipitations, some of which however might have been ascribed to seeming repetition resulted from squeezing-out of the similar mineralizer. It seems questionable whether repetition of mineralogenesis might have, on account of inactivity, been actually few or not in other lodes; discontinuity of the latters resulted from splitting into a number of extremely minute veinlets might have brought on difficulty in discrimination or not; and active mineralizations at *S 2* stage might have caused obscurity in their own individuals or not.

At the earlier to intermediate substages in *S 1* mineralogeneses in nearly similar grade are believed to have been repeated and accordingly conspicuous variation in mineralic assemblage are not confirmable on each level of respective veinlets. This seems to suggest that these mineralizations might have been taken place at similar temperature and such a slight difference as is shown in mineral assembage, for example, presence or absence of arsenopyrite, might have probably been attributed to partial or instantaneous variation in property of mineralizer. On the whole, however, *S 1* lodes reveal a tendency pointing to that variation in characteristics of mineralizations is evidently affirmable either in decrease of arsenic or in increase of antimony.

The relation confirmed in the lodes mentioned above holds good similarly in the case of the lodes precipitated at *S 2* stage. There are some reasons to consider that *S 2* might have been larger in scale and more powerful than *S 1*. In general veinlets formed at the earlier substage in *S 2* are used to contain arsenopyrite and pyrite with a few amount of berthierite and of stibnite; those deposited at the intermediate substage to include abundance of berthierite, stibnite and a little quantity of sphalerite; those originated at the later substage to involve freibergite and bulk of stibnite together with a few amount of sphalerite; and those produced as a sort of post-mineralization at the last substage to enclose merely carbonates. Nevertheless, there are more or less differences in characteristics even on the same level of each lode indicating discrepancy with one another. In other words, each lode in dislocated échelon-like arrangement is distinguishable one from another in respective facies of mineralization, while vertical variation is hardly discernible in mineralogical constituents, their quantitative ratios and their characteristics at least with respect to the same lode.

This seems to illustrate either the general features or formation temperature of *S 2* lodes almost similar to those produced at *S 1*, while it is reasonably supposed that properties of mineralizers might have gradually varied during repeated depositions and been different to a slight extent on each échelon.

On the other hand, the main lodes in this mine are ordinarily found developed in the Sangun metamorphics but the Ishimabu E_3 lode is included in serpentinite at least merely on the lower No. 7 level, most parts of the Manju lode are situated in the Manju volcanics, and the eastern half of the Sasakura lode is in micro-quartz-diorite. Striking is that states of mineralizations are similarly appeared no matter where the lodes might have been contained. This certainly indicates that mineralizations appeared during *P III* are considered to have not been affected through, or rather to have been indifferent to, the surrounding geology. If any, difference in competence of country rocks might have taken part in opening of fissures and thus yielded convenience or spaces for mineralogenesis.

TABLE 4. Mineralogenetic sequence appeared on the lower No. 2 level of the Sasakura lode.*

Stage	*S 1*																			
Substage	Fore-running	Earlier								Intermediate							Later			
Step / Mineral	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Galena		—	—																	
Chalcopyrite											—									
Pyrite	—	—	—	—	—	—				—	—	—	···	—		—		···		
Arsenopyrite			—	—				—		—	—		—	—						
Sphalerite		—	—	—	—			—		—	—	—	—	—				···		
Berthierite											—	—	—					▬		
Stibnite														—	—	—		▬		
Jamesonite																			—	
Native gold																		—		
Quartz	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Dolomite											-							—		
Calcite																				—

▬ abundunt, — ordinary, ··· rare. Used similarly in all tables.

* This part is composed simply of *S 1* lode representing the most active mineralization of all.

1. These are used to run along the main lode with width of 2~5mm. Pyrite included, larger in size, is continuously developed.
2. Quartz reveals comb-like development and obscurely undulatory extinction. See Figs. 1 and 2, Pl. 2.
3. Quartz is extremely fine-grained. Arsenopyrite is poor in amount. Pyrite, rich in amount, is coarse-grained and idiomorphic in habit.
4. Quartz is tiny-grained. Arsenopyrite and sphalerite are less abundant. Pyrite is unevenly needle-shaped and surrounded with arsenopyrite.
5. Quartz is fine-grained. Pyrite with characteristic similar to the above-mentioned is mingled with idiomorphic, cubic one.
6. Quartz is fine-grained. Pyrite is pulverous and found disseminated.
7. Quartz indicates the growth from the wall into the center and is found forming the druses.
8. Quartz is fine- to medium-grained. Short-prismatic arsenopyrite is exuberant and sphalerite is few in amount.
9. Quartz reveals obscurely undulatory extinction, bearing a sort of Liesegang's zoning.
10. Quartz is fine- to medium-grained. Pyrite is coarse-grained and idiomorphic in habit. Arsenopyrite is short-prismatic in form.
11. Quartz is fine- to medium-grained and somewhat stained, partly disclosing a sort of comb-like texture. Dolomite is abundant in the central part of veinlet.
12. Quartz is fine- to medium-grained. Ore minerals are enclosed particularly in the part of medium-grained quartz. Pyrite is a little more abundant compared with others. Berthierite is acicular in form and small-sized. Sphalerite is somewhat blackish in color. See Figs. 1 and 2, Pl. 2.
13. Quartz is fine- to medium-grained. Pyrite is hardly observed. Arsenopyrite is slender-shaped and predominant. Sphalerite is poor in amount and somewhat reddish in color. Berthierite is acicular in form and small-sized. See Figs. 1 and 2, Pl. 2.
14. Quartz is fine- to medium-grained. Ore minerals are very few in amount.
15. Brecciated fragments are buried in reticulate, slender-prismatic quartz.
16. Quartz is fine-grained. Very few amount of stibnite is included. Other ore minerals are hardly observed.
17. Quartz revealing its growth from the wall-side into the center is found forming the druses. See Figs. 1 and 2, Pl. 2.
18. Quartz, medium- to coarse-grained, is found sticking out into the drusy space in form of pyramid and stained with clouds of inclusions around its margin. Dolomite intervenes among the coarser-grained quartz. Slender crystals of stibnite also protrude into the druses. Berthierite is abundant. See Figs. 1 and 2, Pl. 2.
19. Quartz is found forming the druses. Jamesonite is observed either in the druses or as inclusions in quartz.
20. Calcite vein are observed deposited at the last stage.

TABLE 5. Mineralogenetic sequence appeared on the lower No. 12 level of the Ishimabu E_1 lode.

Stage	*S 1*									*S 2**										
Substage	Fore-running	Earlier			Intermediate			Later		Earlier				Later				Last		
Step / Mineral	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	10	11
Pyrite	—	—	—	·	—	—	—	—	—		…	—	—	…		…	··			
Arsenopyrite			—		—	—	—	—				—	—	—						
Sphalerite			…			—	…	—	—		…	—	—	—	—	—				
Berthierite								—			—	—								
Freibergite							—		—			—	—	▬	—	▬..				
Stibnite								—	—		—	—	—			▬	—			
Native gold				·																
Quartz	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	–	—
Dolomite												…							—	

* Intermediate substage has not been discriminated concerning this lode.

S 1 lode

1. Quartz indicates comb-like development. Pyrite is continuously developed. Veinlets, 1～5mm in width, are found formed prior to the main vein and affecting on the wall rocks.
2. Quartz is minute-grained. Pulverous pyrite is predominant.
3. Quartz is fine- to somewhat larger-grained and scaly in form, capturing breccias. Pyrite and arsenopyrite are abundant, pulverous or granular, and idiomorphic in habit. See Figs. 3 and 4, Pl. 3.
4. Quartz covers the druses.
5. Quartz is fine-grained and reveals reticulate appearance. Pyrite and arsenopyrite are small-grained.
6. Quartz indicates an occurrence similar to that in the above case.
7. Quartz, fine in size, bears an appearance of mozaic texture and is reticulately occurred. See Figs. 3 and 4, Pl. 3.
8. Quartz stained with inclusions is fine- to medium-grained, and prismatic or scaly in form. Pyrite is a little larger-size (2mm in diameter). Sphalerite is minute in size. Arsenopyrite is short-prismatic. Berthierite and stibnite, comparatively abundant in amount, are small-grained and subhedral in habit.
9. Quartz protrudes from the walls into the center of druses, becoming more finer in size. Pyrite is small in size and euhedral in habit. Arsenopyrite reveals needle-like occurrence. See Figs. 1 and 2, Pl. 3.

S 2 lode

1. Quartz is found forming the druses. See Figs. 1 and 2, Pl. 3.
2. Quartz, prismatic and scaly in form, is found splitting into the wall rocks as dissemination.
3. Quartz is fine- to medium-grained and prismatic or scaly in form. Ore minerals are small in size.
4. Quartz bears an appearance similar to that in the above case. Kinds of ore minerals are similar to, but distinguished from, one another in the cases of 2, 3 and 4. See Figs. 1 and 2, Pl. 3.
5. Quartz is found protruding from the wall-side into the center of druses and encloses freibergite in its interstices. Freibergite is used to include andorite and to be accompanied with sphalerite. Arsenopyrite, few in amount, is small in size and short-prismatic in form. See Figs. 3 and 4, Pl. 2 and Figs. 1, 2, 3, and 4, Pl. 3.
6. Beside the facts shown in 5, freibergite is found predominantly near, or in, the druses.
7. This is the main part containing stibnite. Stibnite is closely crystallized among quartz grains. Quartz is medium- to coarse-grained, scaly and in parts like grains of rice. The latter case is frequently recognized near the druses, into which acicular stibnite is found sticking out. Freibergite and sphalerite are exuberant near the wall. Some of freibergite are more than 1 cm in length. Druses formed in the case of 5 are almost always filled with the veinlets deposited in the case of 7. See Figs. 1, 2, 3, and 4, Pl. 3.
8. Quartz, bluish milky white in color, is extremely fine-grained, minute-needle-like or chalcedonic and found forming the druses, revealing partly spherulitic texture. See Figs. 3 and 4, Pl. 3.
9. Quartz is found protruding out into the druses. See Figs. 3 and 4, Pl. 3.
10. The surface of druses are covered with petal-like crystals of dolomite, beneath which minute grains of quartz happen to be developed.
11. Crystals of dolomite are found grown on the surface of druses.

Table 6. Mineralogenetic sequence appeared on the lower No. 5 level of the Ishimabu E_2 lode.

Stage	*S 1*							*S 2**						
Substage	Fore-running	Earlier		Inter-mediate		Later		Ear-lier	Inter-mediate		Later			
Mineral \ Step	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Pyrite	—	—		—	—	—	—			—				
Arsenopyrite			—	—		—								
Sphalerite							…			—	…	—		
Berthierite						—				━				
Freibergite												—		
Stibnite								…		-		…		━
Native gold										—				
Quartz	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dolomite										—				

* Last substage has not been distinguished in this lode.

S 1 lode

1. The veinlets concerned are composed of quartz showing comb-like texture, and pyrite running continuously through the lodes and play an important role in alteration of wall rocks.
2. Quartz is fine-grained. Pyrite is larger in size (2mm in diameter), granular and euhedral in habit.
3. Quartz is minute in size. Arsenopyrite is pulverous.
4. Quartz is fine-grained. Pyrite is predominant in amount larger in size (2mm in diameter) and idiomorphic. Arsenopyrite is pulverous and few in amount.
5. Quartz is tiny-grained. Some of pyrite are pulverous and bear inky-flow texture while others, enhedral and about 1mm in diameter, are disseminated.
6. Quartz is fine-grained. Pyrite is few in amount, and small in size (0.2mm in diameter). Arsenopyrite, about 0.4 mm in diameter, is subjected to brecciation and frequently captured in 7.
7. Quartz is fine-grained. Pyrite is few in amount and small in size. Stibnite is small in size, acicular and subhedral in habit, filling up the spaces among brecciated minerals such as arsenopyrite.

S 2 lode

1. Quartz is fine in size. Stibnite is few in amount and acicular. The veinlets concerned are faint in property and captured along the margins of, or in, the later ones.
2. Quartz is found forming the druses and growing from the wall into the center of the lode.
3. The related veinlets often fill up the druses formed in 2 or happenly penetrate into fissures lacking in quartz belonging to 2. Quartz, medium-grained and scaly in form, is somewhat stained with dusty inclusions, indicating such habit as becomes finer near the walls and coarser in the center. In the parts where druses are found formed, it appears like grains of rice. Stibnite, slender-prismatic, is larger in size and less in amount, than berthierite, both being idiomorphic or hypidiomorphic in habit and protruding like needles. Pyrite is small in size (about 0.1mm in diameter) and euhedral. Sphalerite is faint-colored. See Fig. 2, Pl. 3.**.
4. Quartz is found producing the druses. Freibergite happens to crystalize in this quartz.
5. Quartz is fine- to medium-grained and scaly in form. Stibnite is sometimes acicular in form. Freibergite is used to include andorite in itself and to be associated with faint-colored sphalerite. See Fig. 2, Pl. 3.
6. Quartz is found constructing the druses.
7. The related veinlets are found filling up the druses of 6 or the fissures lacking in quartz and forming the druses into which large-sized stibnite, more than 1cm in length, is recognized sticking out. Quartz is, in the main, coarse-grained and partly fine- to medium-grained. See Fig. 2, Pl. 3.

** Fig. 2, Pl. 3 is corresponding not to the specimen obtained from the lower No. 5 level but to that sampled from the lower No. 11 level.

TABLE 7. Mineralogenetic sequence appeared on the lower No. 7 level of the Ishimabu E_3 lode.

Stage	*S 1**				*S 2*								
Substage	Inseparable				Earlier	Intermediate		Later		Last			
Step / Mineral	1	2	3	4	1	2	3	4	5	6	7	8	9
Chalcopyrite		—											
Pyrite	—	—	—		—		-						
Arsenopyrite		—										—	
Sphalerite	—	—					···		—	—		—	
Berthierite		—			—		▬						
Stibnite	—				···		—		▬		▬		
Native gold							—		—		—		—
Quartz	—	—	—	—	—	···	—	—	—	—		—	
Dolomite							···		···		—		—

* Because of inactive mineralization, it is not subdividable into several steps but considered to have been produced at the intermediate to later substage.

S 1 lode

1. Quartz is very minute- to fine-grained. Pyrite is generally pulverous but contains dissemination of idiomorphic microlites.
2. Quartz is tiny- to fine-grained and the last one is observed forming the druses.
3. Quartz is fine-grained. Pyrite, idiomorphic and about 2mm in diameter, is disseminated.
4. Quartz is medium-grained and found producing the druses.

S 2 lode

1. Quartz is fine-grained.
2. Quartz is observed forming the druses.
3. The related veinlets are found traversing across the druses produced in 2 with protrudent berthierite or into the fissures involving no druses. Berthierite is 0.1~5mm in length, slender-prismatic and anhedral, subhedral or euhedral in habit. Anhedral stibnite is few in amount. Quartz stained with dusty inclusions is fine-grained and accompanied with little quantity of pyrite at the initial stage but becomes coarser in size, scaly or tortoise-shell-like in form.
4. Quartz is found forming the druses.
5. The related veinlets are found filling up the druses produced in 4 and forming furthermore other druses. Stibnite is prismatic, about 5mm in length, subhedral to euhedral in habit, and protrudes into the druses. Quartz is fine- to medium-grained and somewhat stained with dusty inclusions.
6. Quartz is found producing the druses.
7. The related veinlets are observed filling up the druses formed in 6 and producing furthermore other druses, on which petal-like crystals of dolomite are found. A few amount of long-prismatic stibnite are included.
8. Quartz is found producing the druses. Microlites of long-prismatic arsenopyrite are observed in a few amount.
9. Dolomite formed at last is found filling up the druses or cutting through the lodes as veinlets. Native gold is found in an extremely few amount.

Table 8. Mineralogenetic sequence appeared on the main level of the Manju No. 2 lode.

Stage	S 1											S 2											
Substage	Fore-running	Earlier						Inter-mediate		Later		Earlier		Inter-mediate			Later		Last				
Step / Mineral	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	8	9	10	11	12
Galena				—	—			—															
Chalcopyrite								—	—														
Pyrite	—	—	—	—	—	—		—		—		—	—		—							—	
Arsenopyrite		—		—	—	—		—	—			—	—										
Sphalerite					—	—		—	...	...		—	—			—		—					
Berthierite				...					...	—		—	—		—	▬							
Freibergite																							
Stibnite										—		—	—			▬		▬		-			
Native gold																—							
Quartz	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..		
Dolomite										-						..					—		
Calcite																							—

S 1 lode

1. The related veinlets, as a sort of forerunner for mineralization, are found running in the wall rocks along the main vein. Quartz reveals a comb-like occurrence. Pyrite is found running continuously in the central part of the vein.
2. Quartz is minute in size.
3. Quartz is tiny in size. Pyrite is pulverous.
4. Quartz is minute-grained. Pyrite and arsenopyrite are comparatively predominant, and idiomorphic in habit. See Figs. 1 and 2, Pl. 4.
5. Quartz is fine in size.
6. Quartz is fine in size.
7. Quartz is found producing the druses.
8. Quartz is fine in size.
9. Quartz is fine- to medium-grained and scaly in form. Arsenopyrite is short-prismatic in form, and predominant in amount.
10. Quartz is fine or somewhat coarser in size and becomes medium-grained in the central part of the vein, terminating in formation of the druses. A little amount of dolomite are found filling up the spaces among quartz. Berthierite is acicular in form and tiny in size. Pyrite is euhedral in habit.
11. Quartz bears dusty inclusions looking like Liesegang's zoning, and is found protruding into the druses. See Figs. 1 and 2, Pl. 4.

S 2 lode

1. Quartz is very fine in size and extremely stained. Ore minerals are minute in size and scarce in amount. See Figs. 1 and 2, Pl. 4.
2. Quartz is fine- to medium-grained and scaly in form. Ore minerals are very small in size and few in amount. See Figs. 3 and 4, Pl. 4.
3. Quartz is found producing the druses.
4. Quartz is fine-grained and stained with dusty inclusions. Berthierite is very small in size and acicular in form. See Figs. 1 and 2, Pl. 4.
5. Quartz is medium- to coarser-grained and scaly in form. Berthierite is slender-prismatic and some reveal variation into those in 5. Stibnite is a little larger in size than berthierite, and some are observed including dolomite along their cleavages. See Figs. 1, 2, 3, and 4, Pl. 4.
6. Quartz is found forming the druses.
7. Quartz is fine- to medium-grained and scaly in form. Stibnite is long-prismatic and found sticking out into the druses.
8. Quartz is found constructing the druses. See Figs. 3 and 4, Pl. 4.
9. Quartz is coarse in size but finer at the contact with quartz formed in 8, protruding into the druses. Some indicates variation from those in 8. Acicular stibnite is contained in the interstices of quartz. See Figs. 3 and 4, Pl. 4.
10. Dolomite is found composing the veinlets, and its petal-like crystals cover the surface of druses and are found protruding into the druses. Some involve fine grains of quartz along the walls. See Figs. 3 and 4, Pl. 4.
11. Pyrite is found scattered on the drusy dolomite.
12. Crystals of dolomite are found covering pyrite on the drusy dolomite.

Table 9. Mineralogenetic sequence appeared on the lower No. 2 level* (situated 60m lower than the main level) of the Manju No. 2 lode.

Stage	*S 1*					*S 2*				
Substage	Earlier			Inter-mediate	Later	Earlier	Intermediate		Later	Last
Step / Mineral	1	2	3	4	5	1	2	3	4	5
Galena										
Chalcopyrite										
Pyrite	—	—		—	—	—				
Arsenopyrite	—	—		—	—					
Sphalerite	—	—			—	—		—		
Berthierite						—		━		
Freibergite										
Stibnite					—			━	━	
Native gold					—				—	
Quartz	—	—	—	—	—	—	—	—	—	
Dolomite										—
Calcite										

* Sequence in this case has, though much more complication was actually to be expected, been extremely simplified on account of being compiled merely on the basis of minerals obtained from the parts remained from complete excavation.

S 1 lode

1. Quartz is fine-grained. Pyrite is somewhat acicular in form and reveals uneven surface.
2. Fine grains of quartz are found mingled with coarse ones. Arsenopyrite is predominant.
3. Quartz is found forming the druses.
4. Quartz is fine- to finest in size. Arsenopyrite is abundant.
5. Quartz is medium-grained and scaly in form, or coarse-grained. Arsenopyrite is exuberant. Native gold is contained.

S 2 lode

1. Quartz is finest-grained. Berthierite and stibnite are comparatively predominant, and extremely minute in size or dusty.
2. Quartz is found producing the druses.
3. Quartz is scaly in form. Berthierite is particularly abundant.
4. Quartz is fine in size. Stibnite is long-prismatic in habit.
5. Dolomite is found forming the druses, and its petal-like crystals protrude into the druses.

Table 10. Mineralogenetic sequence appeared on the lower No. 4 level (situated 110m lower than the main level) of the Manju No. 2 lode.

Stage	*S 1**								*S 2*										
Substage	Fore-running	Earlier				Later			Earlier			Inter-mediate		Later		Last			
Step / Mineral	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	9	10	11
Galena																			
Chalcopyrite														…?					
Pyrite	—	—	—	—		—			—	—	—				—				
Arsenopyrite			—																
Sphalerite	—	—	—	—		—			—	—	—		—	—	—				
Berthierite				—		—			…	—	—		▬						
Freibergite														—	-				
Stibnite						—	—		—		—		▬	—	▬		—		
Native gold													—		—				
Quartz	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
Dolomite			-	-		-				-			-		-			—	
Calcite																			—

* Intermediate substage has not been discriminated concerning this lode.

S 1 lode

1. The related veinlets regarded as forerunner for mineralizations are found running in the wall rocks along the main vein and yielding alteration on the wall rocks. Pyrite is found continued in the central part of the veinlets concerned.
2. Quartz is minute in size.
3. Fine-grains of quartz are observed mixed with medium-ones, revealing clear styles with scarce amount of inclusions. Dolomite is found intervening among the interstices of quartz. See Figs. 1 and 2, Pl. 5.
4. Quartz is medium-grained and bears only a few amount of dusty inclusions. Pyrite is found continued.
5. Quartz is found constructing the druses.
6. Quartz is fine- to medium-grained and partly scaly in form. Dolomite is bnried among the grains of quartz somewhat stained with dusty inclusions. Pyrite is found running continuously. Stibnite is acicular in form. See Figs. 1 and 2, Pl. 5.
7. Quartz is fine- to medium-grained. Stibnite is acicular in form. See Figs. 1 and 2, Pl. 5.
8. Quartz is found forming the druses or on their surface in fine-crystalline state.

S 2 lode

1. Quartz is very fine in size. See Figs. 1 and 2, Pl. 5.
2. Quartz is fine- to medium-grained, scaly in form and somewhat stained with dusty inclusions. Berthierite is extremely minute in size and disseminated as dusts.
3. Quartz is fine-grained and stained with dusty inclusions.
4. Quartz is found constructing the druses. See Figs. 1 and 2, Pl. 5.
5. Quartz is medium-grained and scaly in form. Dolomite is contained among the grains of quartz. Berthierite is acicular in form and rich in amount. Stibnite, long-prismatic in form, is larger in size, and less in amount than berthierite. See Figs. 1 and 2, Pl. 5.
6. Quartz is found protruding out from the walls to form the druses and, in parts, indicates variation into scaly form. In certain specimens freibergite is observed coming into contact with chalcopyrite. Stibnite is acicular in form.
7. Quartz is fine- to medium-grained and, in parts, contains freibergite, varying into those formed in 6. Stibnite is large in size and long-prismatic in form. See Figs. 1 and 2, Pl. 5.
8. Quartz is found forming the druses.
9. Quartz is medium- to coarse-grained. Stibnite is acicular in form and poor in quantity.
10. Dolomite is found constructing the druses, looking like petals.
11. Crystals of calcite are recognized scattered on the druses of dolomite.

TABLE 11. Mineralogenetic sequence appeared on the lower No. 6 level (situated 170m lower than the main level) of the Manju No. 2 lode.

Stage	*S 1*									*S 2*									
Substage	Fore-running	Earlier					Inter-mediate	Later		Earlier			Inter-mediate		Later		Last		
Step / Mineral	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	10
Galena																			
Chalcopyrite							—												
Pyrite	—	—	—	—	—			—		—	—	—							
Arsenopyrite			—	—	—		—	—											
Sphalerite	—			—	—			—		—		—		—		—		—	
Berthierite								—			—	—		▬					
Freibergite																▬			
Stibnite				—			—	—		—		—		▬		▬		—	
Native gold																—			
Quartz	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..
Dolomite					..			-		-				...		...			
Calcite																			—

S 1 lode

1. The related veinlets assumed as forerunner of mineralizations are found running in the wall rocks nearly along the main vein and yielding alterations on the wall rocks.
2. Quartz is very fine in size. Pyrite is pulverous.
3. Quartz is very fine in size. Pyrite and arsenopyrite are euhedral in habit and granular in form.
4. Quartz is fine-grained. Sphalerite is a little blackish in color.
5. The veinlets concerned are megascopically found brecciated.
6. Quartz is found forming the druses.
7. Quartz is very fine in size.
8. Quartz is fine-grained and scaly in form. A little quantity of dolomite are discernible in the intergranular spaces of quartz. The veinlets concerned are allied to, but less active than, those formed in 5 of *S 2* and different in abundance of pyrite and arsenopyrite and in finer grain-size of quartz. Pyrite indicates variation into arsenopyrite around its margin. Sphalerite is faint in color. See Figs. 3 and 4, Pl. 5.
9. Quartz reveals abnormally undulatory extinction, ill-defined crystals and is found constructing the druses.

S 2 lode

1. Quartz is minute-grained. Ore minerals are also very small in size.
2. Quartz is fine-grained and stained with dusty inclusions. Berthierite is acicular in form.
3. Quartz is fine-grained.
4. Quartz is observed producing the druses. See Figs. 3 and 4, Pl. 5.
5. Quartz is medium-grained and scaly in form. Dolomite is included in the interstices of quartz. Sphalerite is absent or present. Berthierite is acicular in form. Stibnite is long-prismatic, and larger in size and later in stage, than the former. Some of stibnite involve dolomite merely within their cleavages. Quartz at last becomes finer in size. See Figs. 3 and 4, Pl. 5.
6. Quartz is found forming the druses.
7. Quartz is fine-grained and somewhat stained with dusty inclusions. Some are medium-grained and scaly in form. Dolomite is partly contained in the interstices of quartz. With increase of sphalerite freibergite becomes more predominant.
8. Quartz is found constructing the druses.
9. Quartz is fine-grained and clear because of scarcity in inclusions, revealing no trace of undulatory extinction. Stibnite is acicular in form and poor in amount. Sphalerite is scarce in amount.
10. Petal-like crystals of dolomite are found covering, and sticking out into, the druses.

Table 12. Mineralogenetic sequence appeared on the uppermost of the main level (situated 50m upper than the main level) in the eastern part of the North No. 2 lode.

Stage	S 1							S 2*						
Substage	Fore-running	Earlier	Intermediate		Later			Later			Last			
Step / Mineral	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Pyrite	—	—	—								···			
Arsenopyrite	···	—												
Sphalerite	—		—			—			—					
Berthierite						—								
Stibnite			—			-	-		▬					
Marcasite													—	
Native gold			—			—			—					
Quartz	—	—	—	—	—	—	—	—	—	—	—			
Dolomite		-				-	—					—		
Calcite														—

* The lodes formed at the earlier to intermediate stages have already been excavated at all.

S 1 lode

1. Pyrite is found continued in the central parts of the veinlets, running in the wall rocks nearly along the main vein and giving effects on the wall rocks.
2. Quartz is fine-grained and comparatively clear on account of poverty in inclusions. Pyrite is massive. Arsenopyrite is short-prismatic, and rich in amount.
3. Quartz is fine in size. Native gold is contained.
4. Chalcedonic quartz is found forming the druses.
5. Quartz is found forming the druses and protruding from both walls into the center.
6. Quartz is fine-grained near the walls but becomes coarse and scaly in the central parts. It is found forming the druses around which it becomes to look like grains of rice. Both berthierite and stibnite are acicular in form, sticking out into the druses, and the latter is a little larger in size than the former.
7. Quartz is very minute in size. Stibnite is long-prismatic and larger in size than that observed in 6, some varying gradually into the latter.

S 2 lode

1. Fine-grained quartz is used to have been produced and captured in the vein produced at the initial stage of 2 and accordingly both are not to be distinguish from each other.
2. Subsequent to the former 1, the veinlets concerned seem to have been successively deposited. Quartz is fine- to medium-grained and scaly in form.
3. Subsequent to the former 2, the veinlets might have been successively precipitated. Quartz is very fine in size, and found traversing across stibnite formed in 2, being separated from the latter in stage.
4. Quartz is chalcedonic and bears a spherulitic texture. Some are found covering the druses, and commonly associated with a little quantity of stidnite.
5. Petal-like crystals of dolomite cover, and protrude into, the druses.
6. Dolomite is observed scattered on the druses.
7. Crystals of dolomite are found covering marcasite on the drusy dolomite.

TABLE 13. Mineralogenetic sequence appeared on the main level* in the eastern part of the North No. 2 lode.

Stage	*S 1*		?		*S 2*			
Substage	Fore-running	Inter-mediate	?		Later		Last	
Mineral \ Step	1	2	A	B	1	2	3	4
Pyrite	—	—	—					
Arsenopyrite	—							
Sphalerite		—	—					
Berthierite			▬					
Stibnite		—	-	-	▬			
Marcasite								
Native gold								
Quartz	—	—	—	—	—	-	—	
Dolomite								—
Calcite								

* Grouping of this part into substage is almost impossible because of no lodes remained.

S 1 lode

1. The related veinlets are found producing the druses.
2. Stibnite is acicular in form, and very scarce in amount.

A Quartz is fine- to medium-grained, and scaly in form. Ore minerals are mainly consisted of acicular stibnite with a slight amount of stibnite. Difference between the vein formed at the later stage of *S 1* and that produced at the intermediate stage of *S 2* are hardly discriminated.

B Quartz is fine-grained and believed to have been continuously deposited subsequent to A.

S 2 lode

1. Quartz is fine in size. Stibnite is larger in size and long-prismatic in form.
2. Quartz is very fine in size and believed to have been successively formed subsequent to A, traversing across stibnite formed in 1.
3. Quartz is chalcedonic in property.
4. Petal-like crystals of dolomite are found covering the druses.

Table 14. Mineralogenetic sequence appeared on the lower No. 2 level (situated 50m lower than the main level) in the eastern part of the No. 2 lode.

Stage	S 1													S ?*							
Substage	Fore-running	Earlier					Intermediate				Later			Inter-mediate		Later			Last		
Step / Mineral	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	5	6	7	8
Pyrite	—	—	—	—	—	—	—	—		···									···		
Arsenopyrite						—															
Sphalerite					—			—				—					—				
Berthierite							—					▬			—						
Stibnite								—	—	···?		▬	-		▬		▬				
Marcasite																					
Native gold												—					—				
Quartz	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	···	
Dolomite		-			-			-				-	-				-			—	
Calcite																					—

* Earlier substage has not been confirmed.

S 1 lode

1. The veinlets are observed running in the wall rocks along the main vein and yielding alteration on the wall rocks.
2. Quartz is very fine in size. Pyrite is granular, and euhedral in habit.
3. Quartz, very fine in size, is found forming the druses. Pyrite is pulverous.
4. Quartz is fine-grained. Pyrite is observed running continuously in the central part of this veinlets.
5. Quartz is fine-grained.
6. Ditto
7. Ditto
8. Quartz is fine-grained. Pyrite bears uneven, acicular form.
9. Quartz is fine-grained.
10. Quartz is chalcedonic in property, and reveals spherulitic texture, covering the druses.
11. Quartz is found constructing the druses.
12. Quartz is fine- to medium-grained and scaly in form. A little amount of dolomite are included in the intergranular spaces of quartz.
13. Quartz is minute in size. Stibnite is extremely small in size and acicular in form.

S 2 lode

1. Quartz is found forming the druses.
2. Quartz is medium-grained, and scaly in form. Ore minerals are chiefly consisted of berthierite. Stibnite is a little larger in size and less in amount than the former, displaying prismatic form. See Fig. 1, Pl. 4.
3. Quartz is found forming the druses.
4. Stibnite is large in size (less than 1cm in length), and long-prismatic in form. See Fig. 1, Pl. 4.
5. The veinlets are considered to have been successively deposited subsequent to 4 and found cutting across stibnite formed in 4.
6. Quartz is very fine in size. Pyrite, extremely minute in size, is sometimes contained in a few quantity.
7. Petal-like crystals of dolomite is found protruding out into the druses.
8. Crystals of dolomite are observed disseminated on the drusy dolomite.

TABLE 15. Mineralogenetic sequence appeared on the lower No. 4 level (situated 110m lower than the main level) in the eastern part of the North No. 2 lode.

Stage	*S 1*								?		*S 2**			
Substage	Fore-running	Earlier		Intermediate					?		Later	Last		
Mineral \ Step	1	2	3	4	5	6	7	8	A	B	1	2	3	4
Pyrite	—	—	—	—	—		—	...			—		—	
Arsenopyrite		—												
Sphalerite		—		—	—		—			—				
Berthierite				—						━				
Stibnite					—	—			—	━				
Marcasite														
Native gold														
Quartz	—	—	—	—	—	—	—	—	—	—	—	..		
Dolomite				-	-					-		—		
Calcite														—

* The lode formed at *S 2* stage seems to have been excavated at all.

S 1 lode

1. The veinlets are observed running in the wall rocks along the main vein and yielding alteration on the wall rocks.
2. Quartz is very fine in size.
3. Quartz is fine-grained. Pyrite is found running continuously in the central part of this veinlet.
4. Quartz is fine- to a little coarser-grained, and found constructing the druses.
5. Quartz is fine-grained. Pyrite bears an acicular form with uneven surface.
6. Quartz is fine-grained.
7. Quartz is medium-grained and stained with dusty inclusions.
8. Quartz is milky-white in color and spherulitic in texture, covering the druses.

A. Quartz is found producing the druses. Acicular stibnite is observed in a few quantity in the interstices of quartz.

B. Quartz comprised in the druses of A is medium-grained near the wall-sides and fine-grained in the center, and scaly in form. A few of dolomite are contained among the grains of quartz. Acicular berthierite is predominant. It is pending to decide whether both A and B may belong to the vein formed at the later *S 1* stage or to that produced at the intermediate *S 2* stage.

S 2 lode

1. Quartz is very fine in size and milky-white in color.
2. Dolomite is found protruding out as petal-like crystals on the druses.
3. Dolomite is observed scattered on the druses.
4. Crystals of calcite covered with dissemination of pyrite are found scattered on the drusy dolomite.

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EXPLANATION FOR PLATE I

FIG. 1. Antimony ore deposited at *S 2* in *P III* (obtained from the lower No. 2 level in the eastern part of the North No.2 lode). Ref. Table 14.

A. Wall rock unaltered (black-colored semischist).

B. Quartz veinlet bearing berthierite, produced at 2 in *S 2*.

C. Quartz veinlet containing stibnite, produced at 4 in *S 2*, cutting across that comprising berthierite.

FIG. 2. Antimony ore deposited at *S 2* in *P III* (obtained from the lower No. 11 level of the Ishimabu E_2 lode). Ref. Table 6.

A. Breccia dike.

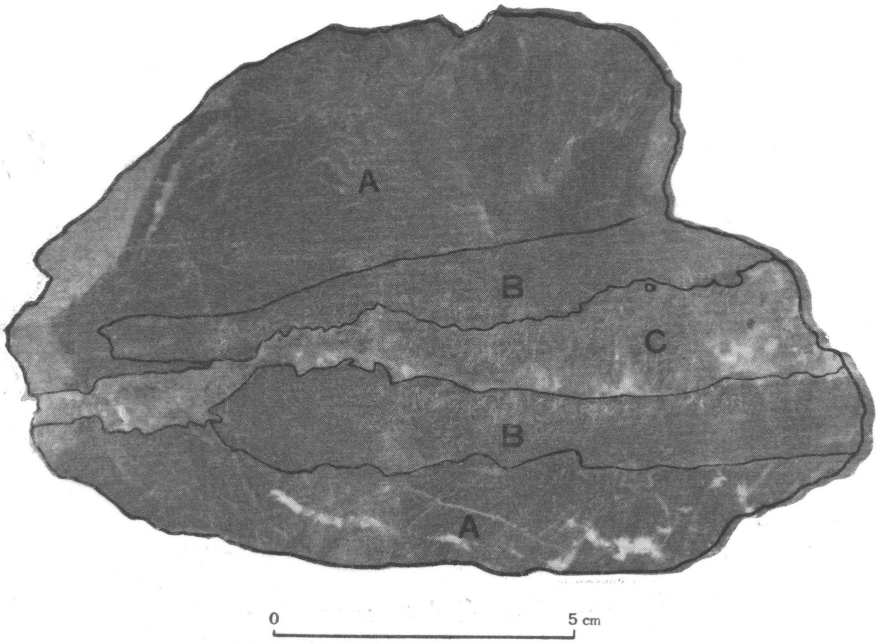
B. The part formed at *S 1*.

C. Quartz veinlet accompanying berthierite, produced at 3 in *S 2* within the interstices of drusy quartz.

D. Quartz veinlet associating freibergite and sphalerite, precipitated at 5 in *S 2*.

E. Quartz veinlet including stibnite, deposited at 7 in *S 2* within the interstices of drusy quartz.

These specimens have been collected from the lower No. 11 level and the results indicated in Table 6 have been compiled concerning the lower No. 5 level, whereas remarkable variation or difference in mineralogenetic sequence be not recognizable on each level.



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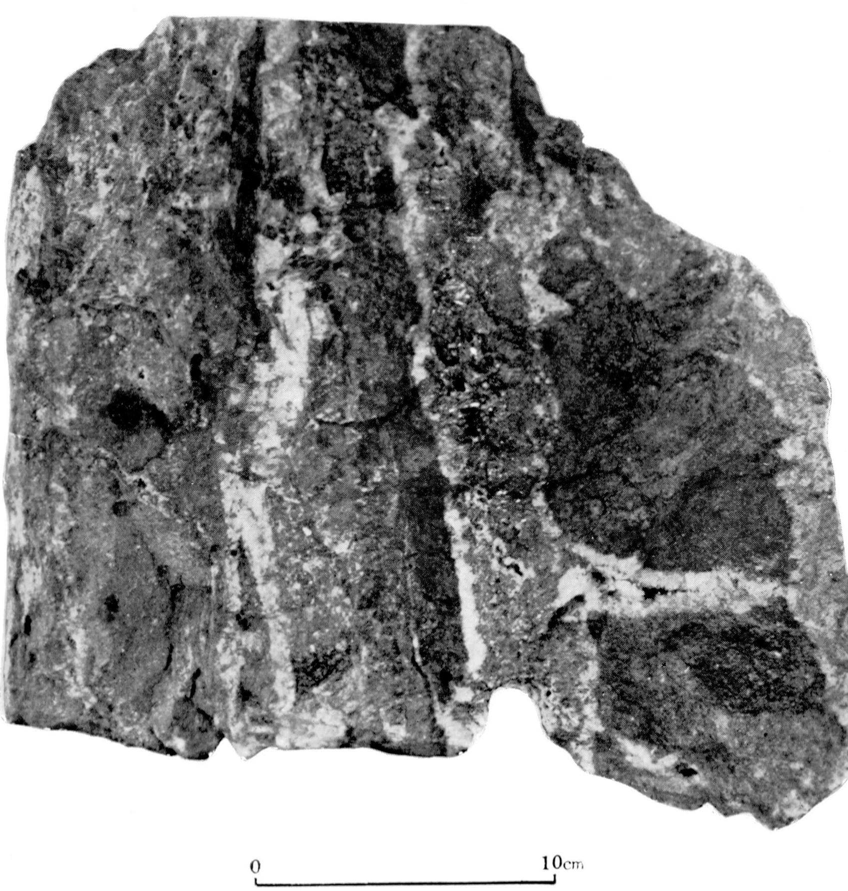
2

1

0 5 cm



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0 10cm

Explanation for Plate II

(All figures × 2.5)

Fig. 1. Relation of each veinlet deposited in *P III* (obtained from the lower No. 2 level of the Sasakura lode). Ref. Table 4. Only with lower nicol.

Fig. 2. *ibid.* With crossed nicols.

A: Quartz veinlet containing galena, pyrite, and sphalerite, formed at 2.

B: Quartz veinlet including pyrite, sphalerite, and berthierite, produced at 12.

C: Quartz veinlet bearing arsenopyrite, sphalerite, and berthierite, originated at 13.

D: Quartz veinlet comprising an extremely few amount of pyrite and stibnite, precipitated at 16.

E: Drusy quartz obtained at 17.

F: Quartz veinlet involving berthierite, stibnite, and an extremely few quantity of pyrite and sphalerite, confirmed at 19.

Fig. 3. Relation of each veinlet deposited in *P III* (obtained from the lower No. 12 level of the Ishimabu E_1 lode). Ref. Table 5. Only with lower nicol.

Fig. 4. *ibid.* With crossed nicols.

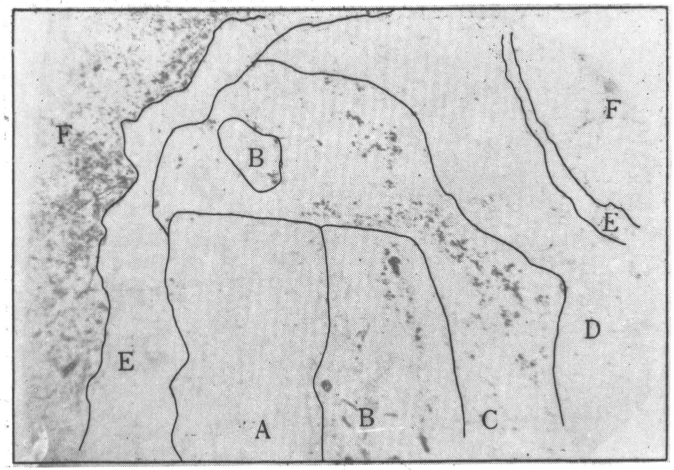
A: Wall rock.

B: Quartz veinlet embracing pyrite and arsenopyrite, formed at 3 in *S 1*.

C: Quartz veinlet enclosing pyrite, arsenopyrite, freibergite, and a few amount of sphalerite, produced at 7 in *S 1*.

D: Drusy quartz originated at 5 in *S 2*.

E: Quartz veinlet representing the seemingly formed druses appeared to be filled up with that belonging to C, precipitated at 5 in *S 2*. It involves freibergite and sphalerite.



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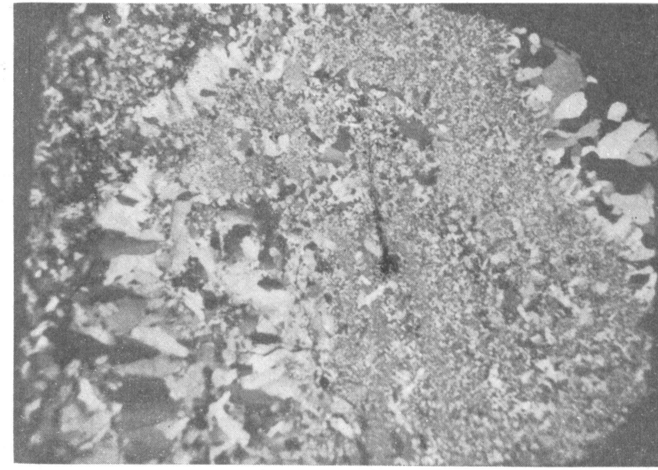
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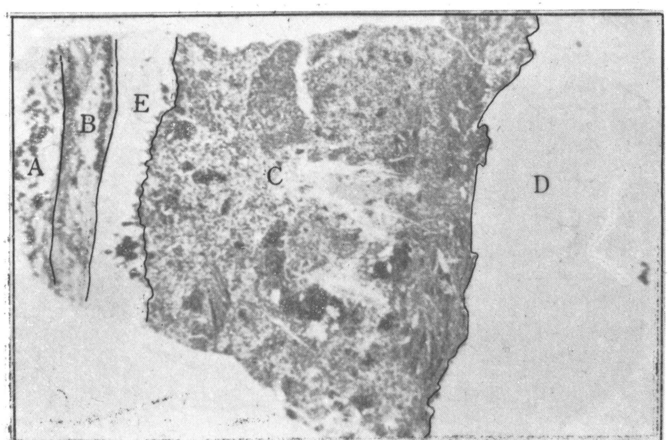

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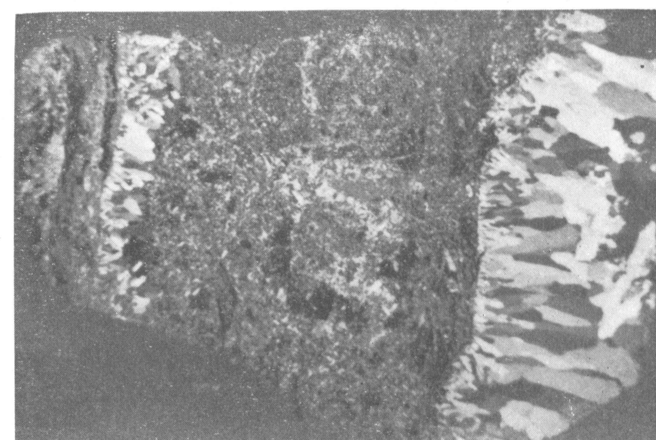
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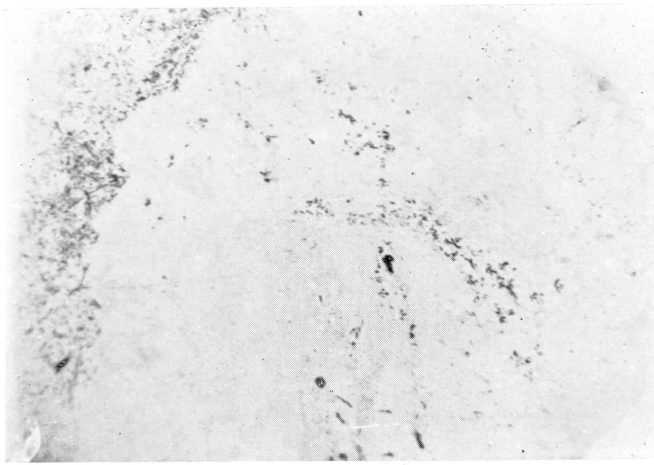

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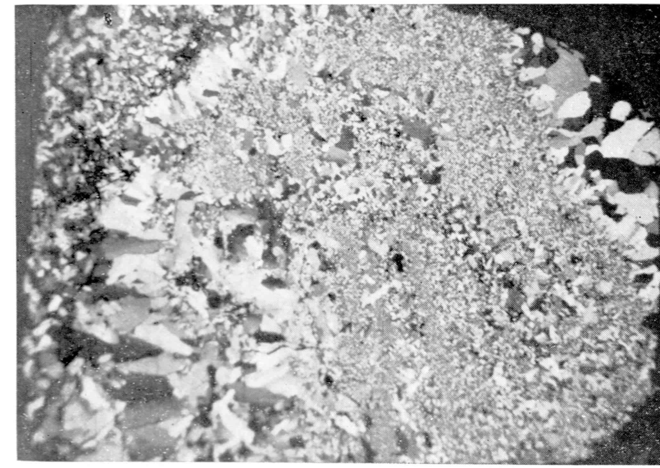

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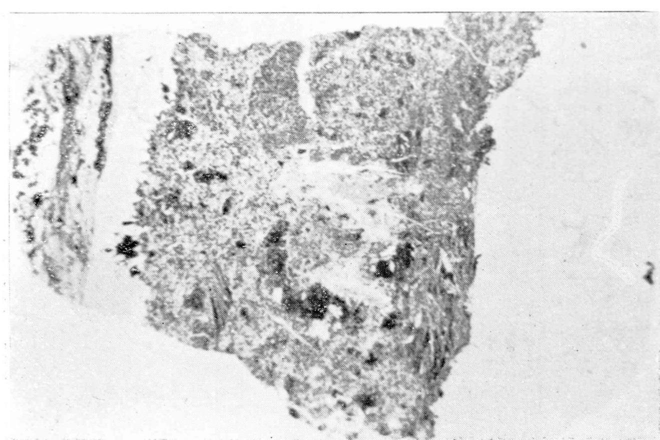

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Explanation for Plate III

(All figures × 2.5)

Fig. 1. Relation of each veinlet deposited in *P III* (obtained from the lower No. 12 level of the Ishimabu E_1 lode). Ref. Table 5. Only with lower nicol.

Fig. 2. *ibid.* With crossed nicols.

A: Quartz veinlet containing pyrite and sphalerite, formed in *P II*.

B: Quartz veinlet including sphalerite, pyrite, stibnite and freibergite, produced at 9 in *S 1*.

C: Drusy quartz originated at 1 in *S 2*.

D: Quartz veinlet bearing pyrite, arsenopyrite, sphalerite, freibergite and stibnite, precipitated at 4 in *S 2*.

E: Drusy quartz enclosing freibergite and sphalerite, obtained at 5 in *S 2*.

F: Quartz veinlet comprising stibnite and sphalerite, observed at 7 in *S 2*.

Fig. 3. Relation of each veinlet deposited in *P III* (obtained from the lower No. 12 level of the Ishimabu lode). Ref. Table 5. Only with lower nicol.

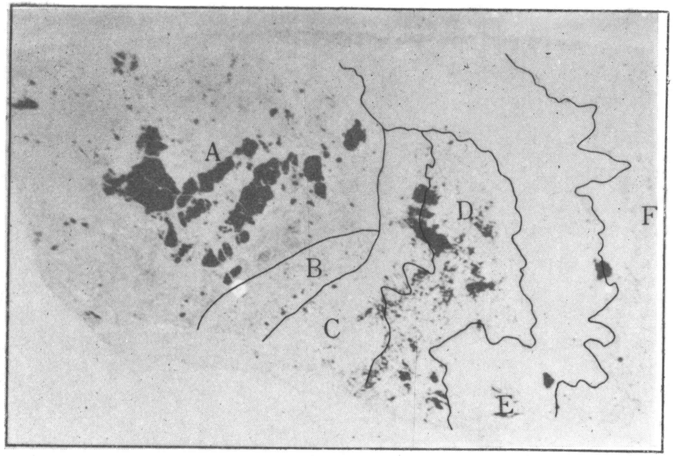
Fig. 4. *ibid.* With crossed nicols.

A: Drusy quartz accompanying freibergite, sphalerite, and arsenopyrite, formed at 5 in *S 2*.

B: Quartz veinlet associating stibnite and sphalerite, produced at 7 in *S 2*.

C: Chalcedonic quartz veinlet bearing stibnite, originated at 8 in *S 2*.

D: Drusy quartz precipitated at 9 in *S 2*.



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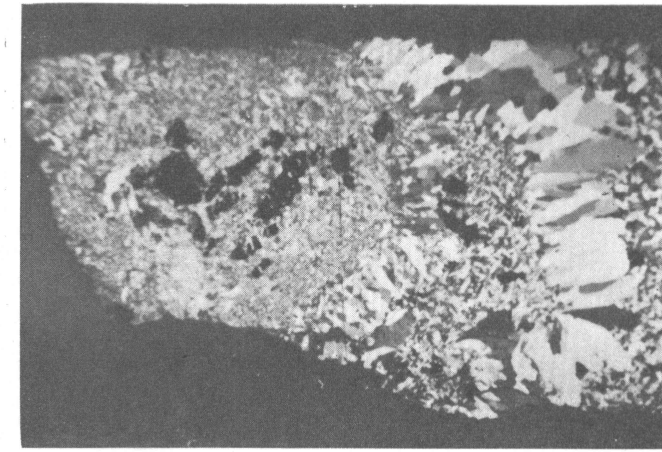

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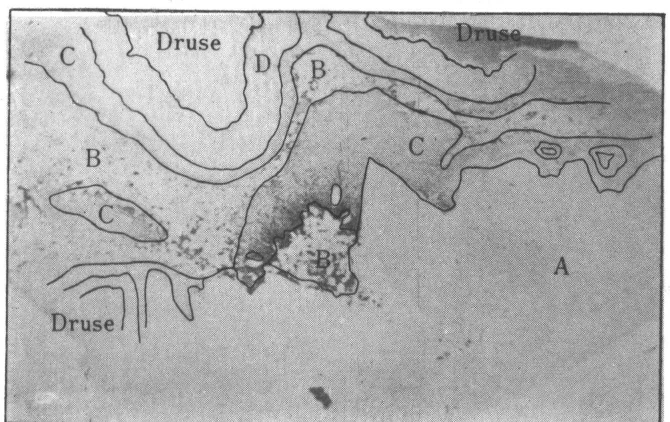

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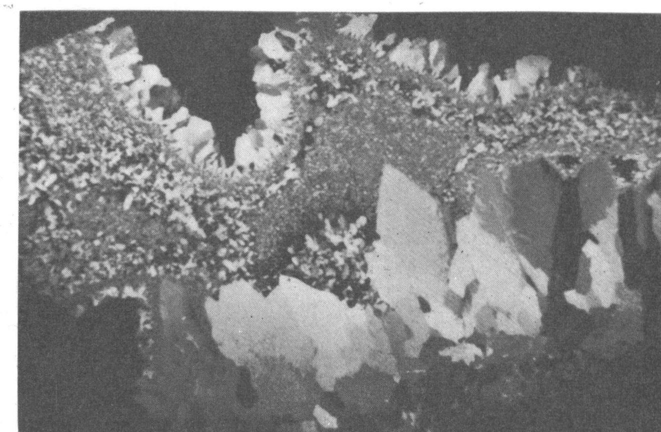

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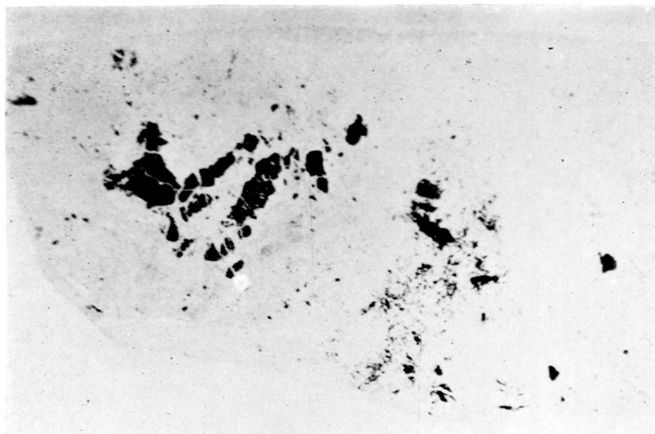

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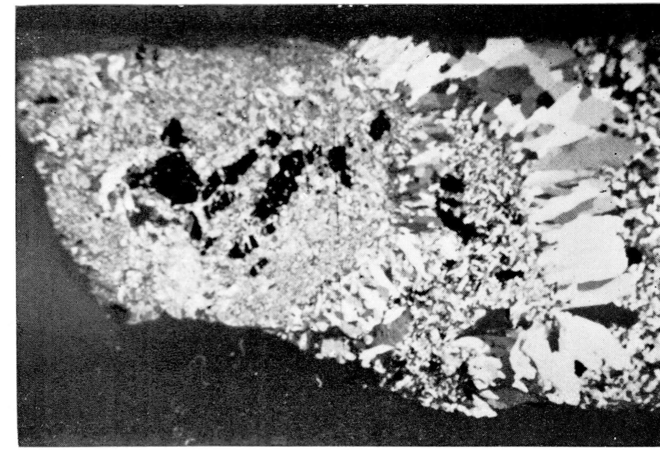

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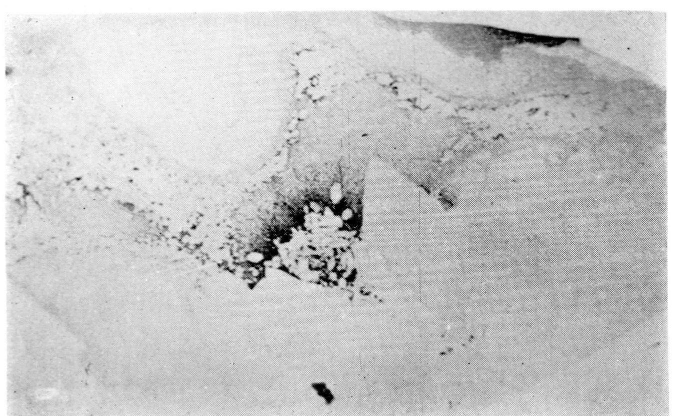

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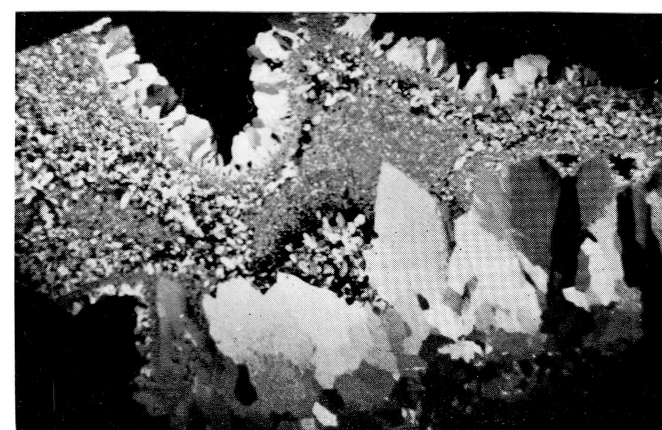

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Explanation for Plate IV

(All figures × 2.5)

Fig. 1. Relation of each veinlet deposited in *P III* (obtained from the main level of the Manju No. 2 lode). Ref. Table 8. Only with lower nicol.

Fig. 2. *ibid.* With crossed nicols.

Fig. 3. *ibid.* (Continued from Fig. 1). Only with lower nicol.

Fig. 4. *ibid.* (Continued from Fig. 2). With crossed nicols.

A: Quartz veinlet containing galena, pyrite and arsenopyrite, formed at 4 in *S 1*.

B: Quartz veinlet including chalcopyrite, arsenopyrite, sphalerite and berthierite, produced at 8 in *S 1*.

C: Milky-white-colored quartz with Liesegang's zoning, originated at 11 in *S 1*.

D: Micro-grained quartz veinlet bearing pyrite, arsenopyrite, sphalerite, berthierite and stibnite, precipitated at 1 in *S 2*.

E: Medium-grained quartz veinlet embracing pyrite, arsenopyrite, sphalerite, berthierite and stibnite, deposited at (2) in *S 2*.

F: Fine-grained quartz veinlet enclosing pyrite and berthierite, found at 4 in *S 2*.

G: Quartz veinlet involving berthierite, stibnite and sphalerite, observed at 5 in *S 2*.

H: Drusy quartz recognized at 8 in *S 2*.

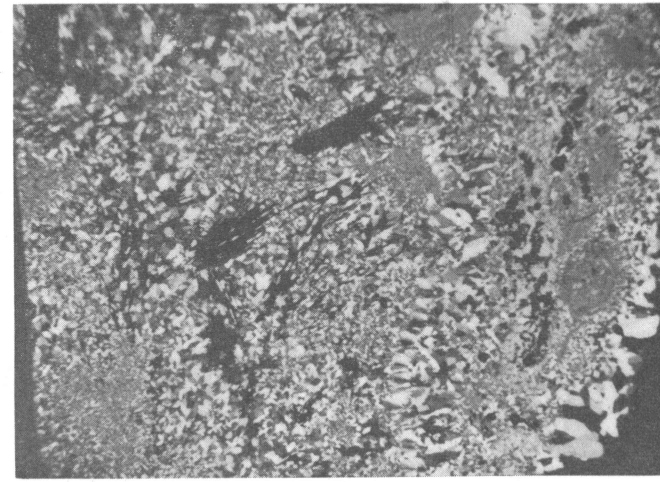
I: Coarse-grained drusy quartz comprising a few quantity of stibnite at its base, obtained at 9 in *S 2*.

J: Drusy dolomite formed at 10 in *S 2*.

St: Stibnite

Do: Dolomite

1



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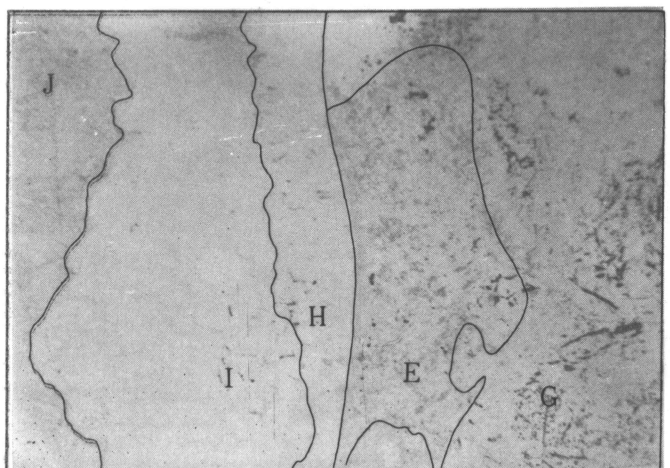

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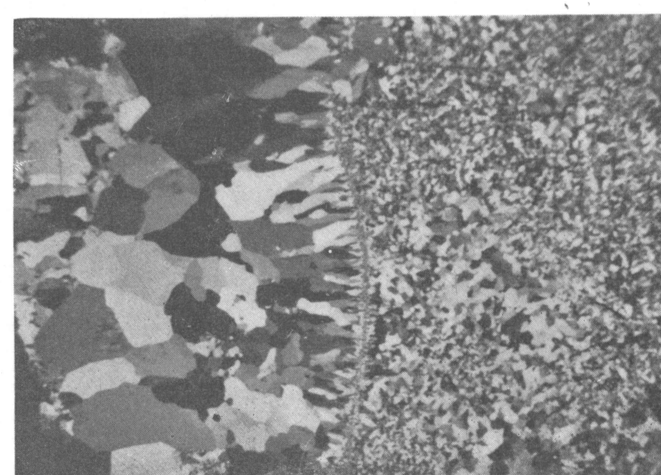

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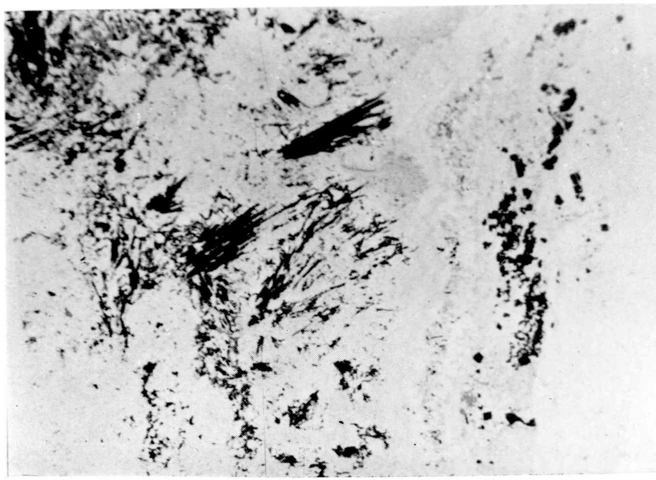
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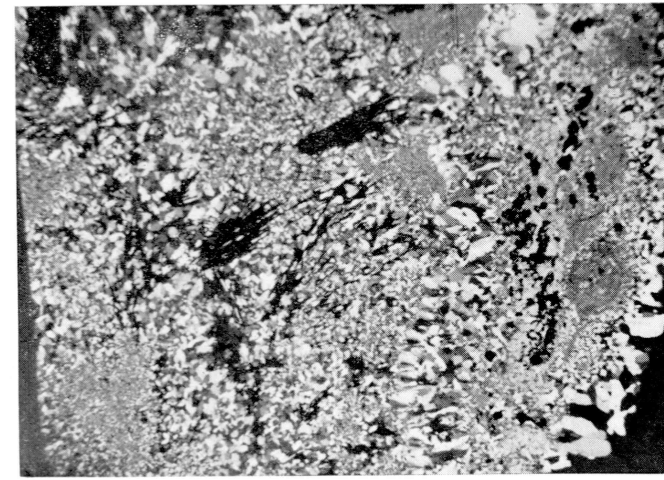
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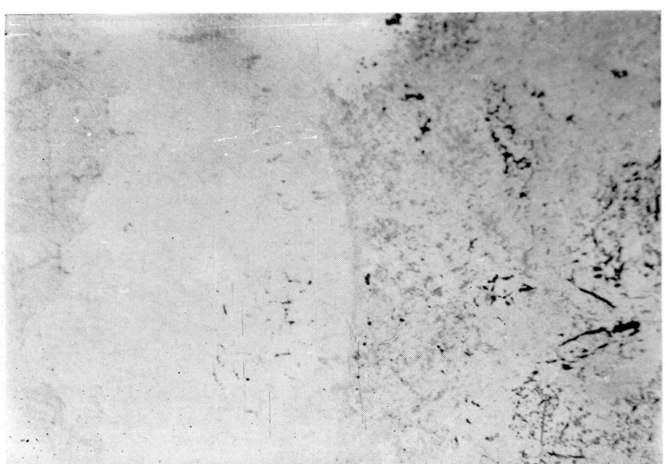
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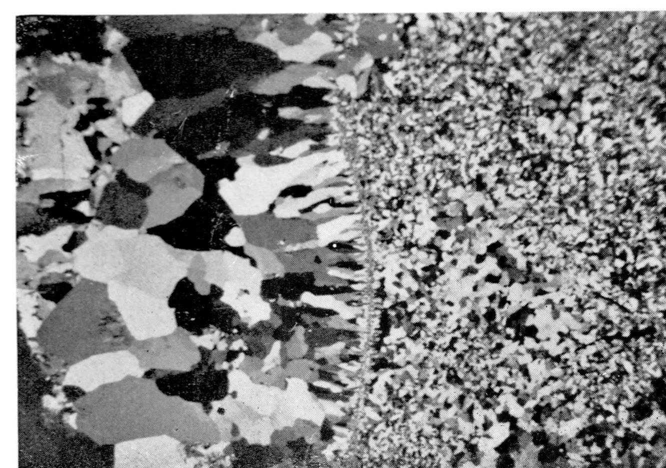
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Explanation for Plate V

(All figures × 2.5)

Fig. 1. Relation of each veinlet deposited in *P III* (obtained from the lower No. 4 level of the Manju No. 2 lode). Ref. Table 10. Only with lower nicol.

Fig. 2. *ibid.* With crossed nicols.

A: Wall rock.

B: Quartz veinlet containing pyrite, arsenopyrite and sphalerite, formed at 3 in *S 1*.

C: Quartz veinlet including pyrite, sphalerite, berthierite and stibnite, produced at 6 in *S 1*.

D: Quartz veinlet bearing stibnite, originated at 7 in *S 1*.

E: Quartz veinlet embracing pyrite, sphalerite and stibnite, precipitated at 1 in *S 2*.

F: Drusy quartz deposited at 4 in *S 2*.

G: Quartz veinlet involving berthierite, stibnite and a very few quantity of pyrite and native gold, found at 5 in *S 2*.

H: Drusy quartz accompanying freibergite, sphalerite and stibnite, observed at (6) in *S 2*.

I: Quartz veinlet associating stibnite, obtained at 7 in *S 2*.

Fig. 3. Relation of each veinlet deposited in *P III* (obtained from the lower No. 6 level of the Manju No. 2 lode). Ref. Table 11. Only with lower nicol.

Fig. 4. *ibid.* With crossed nicols.

A: Wall rock.

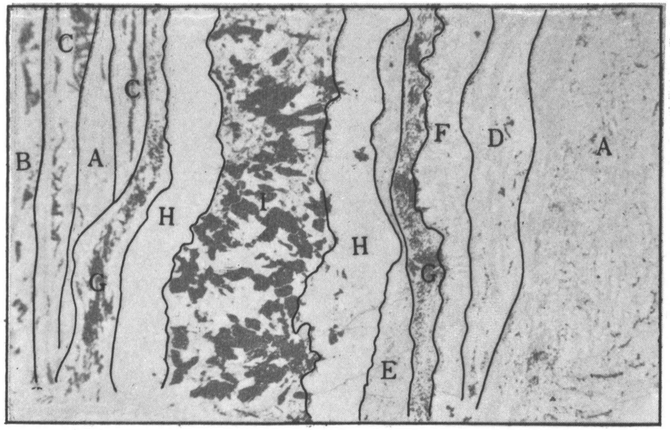
B: Fine-grained quartz veinlet containing pyrite, arsenopyrite, sphalerite, berthierite and stibnite, formed at 8 in *S 1*.

C: Drusy quartz produced at 4 in *S 2*.

D: Quartz veinlet including berthierite captured in stibnite, originated at 5 in *S 2*.

Be: Berthierite

St: Stibnite



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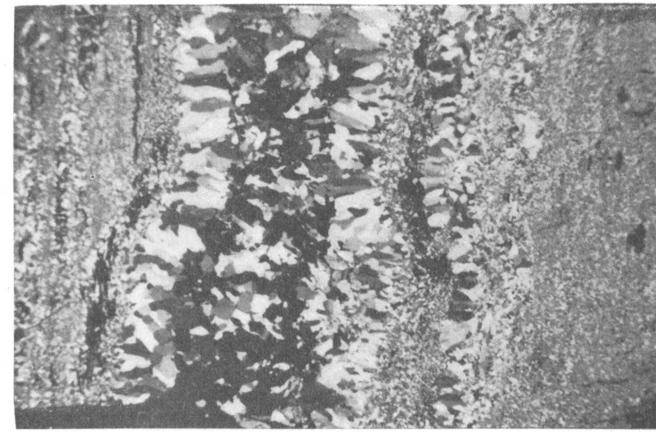

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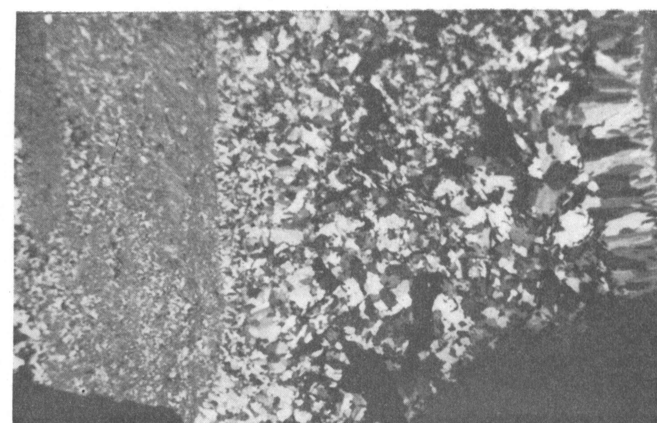

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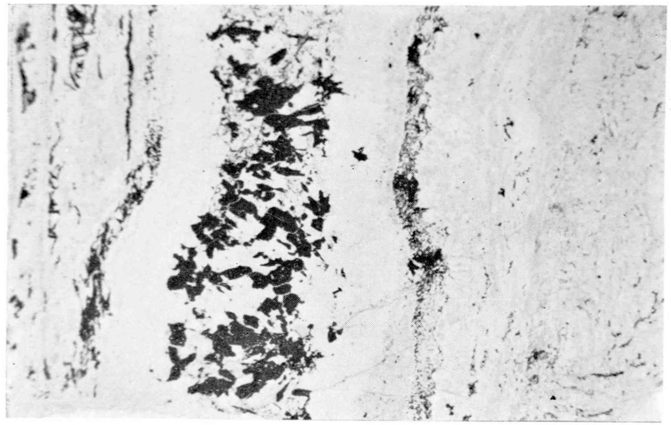

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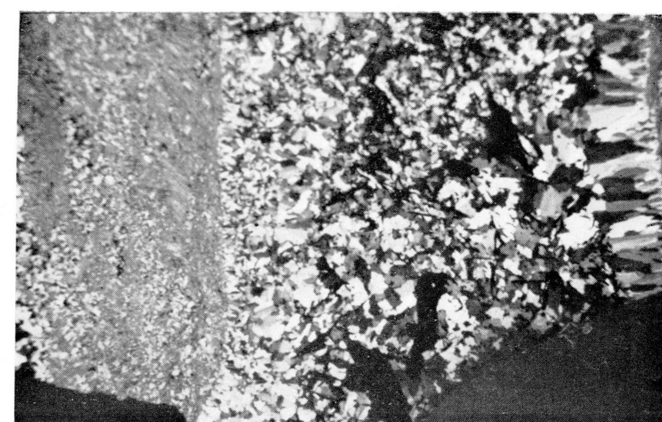

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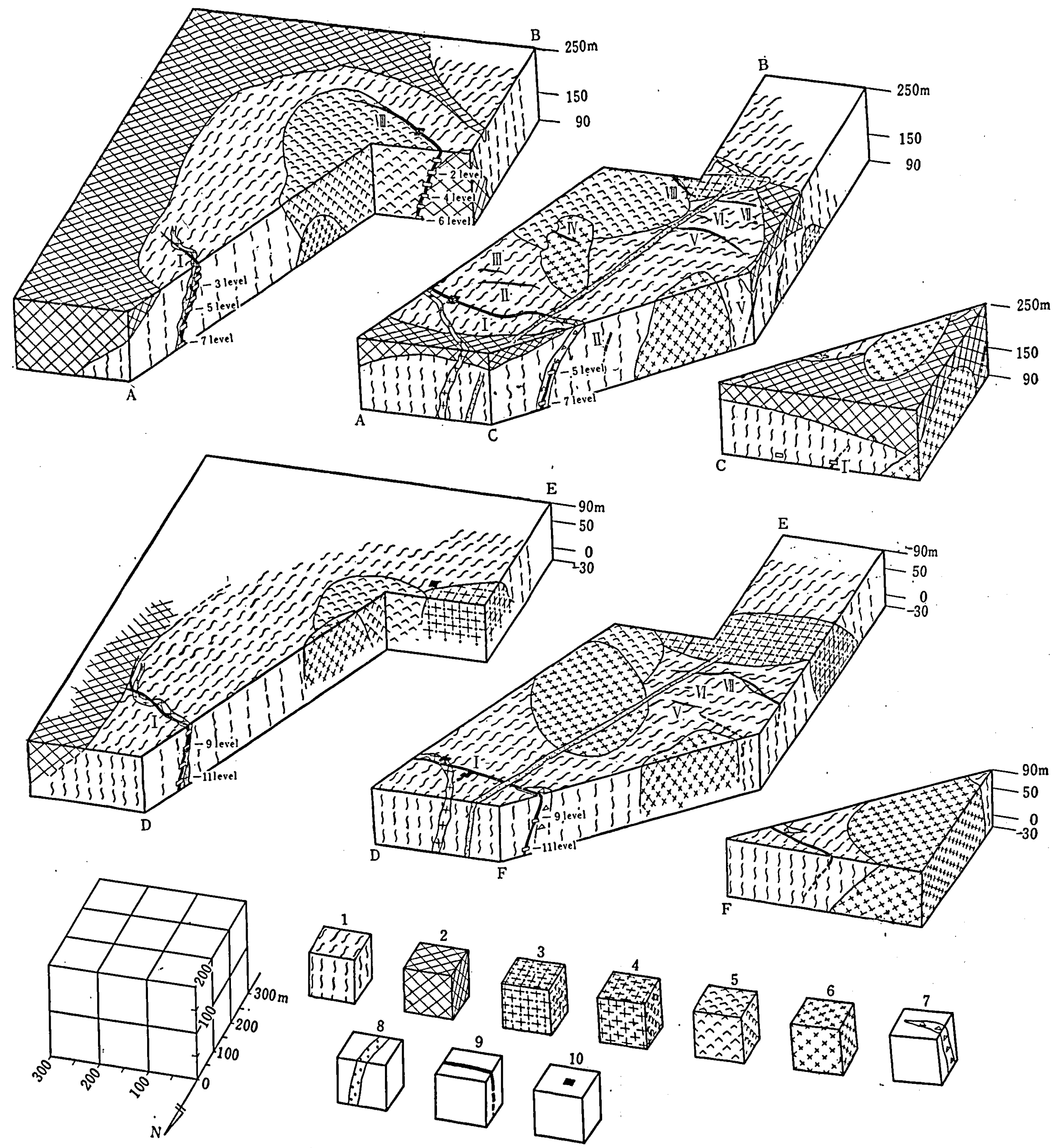

Block-diagram of the Nakase Ore Deposit

1 Sangun Metamorphics 2 Serpentinite 3 Quartz-diorite 4 Quartz-porphyry 5 Manju volcanics
6 Micro-quartz-diorite 7 Brecciated rhyolitic rock 8 Basaltic dike 9 Lode 10 Shaft
I Ishimabu II Gingiri III Gingiri No. 2 IV Sasakura V North No. 2 VI North No. 1
VII Manju No. 2 VIII Manju