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Mineralogical Study on Tungsten Deposit of the Eiwa Mine, Yamaguchi Prefecture, Japan

By

Toshiyuki HABARA

With 7 Text-figures, 7 Tables and 2 Plates

ABSTRACT: To find the least requisite for genesis of radioactive anomaly recognized in the galleries of the related mine was taken into account as an aim of this research in the light of mutual relation to other similar or different kinds of ore deposits. As a result that particularity of the ore-bearing or barren veins and veinlets has been mineralogically pursued by means of various procedures so far applied, certain views concerning the subject in question might have been successfully obtained.

CONTENTS

I. INTRODUCTION AND ACKNOWLEDGEMENTS

The present paper is closely related to a part of the studies under the heading of "Über die pegmatitischen Mineralien" (UMEGAKI et al, 1954, 1957), which have hitherto been executed and are still being made by Prof. Dr. Y. UMEGAKI of Hiroshima University and his co-workers.

The Eiwa Mine located about 1 km north of the Nishiube-chō, Ube City, Yamaguchi Prefecture has recently become famous for higher radioactivity derived probably from wolframite-bearing quartz veins accompanying bulk of clayey veinlets within the related area. With special reference to the radioactive anomaly, detailed investigations of the mine are yet remained to be dealt with.

For the purpose of gaining a clue to solving the problem as well as of enlightening the genesis of mineral assemblages together with wall-rock alterations and so on, either geological surveys of the region concerned or some laboratory examinations have been made by the writer.

The results partly reported at the general meeting of the Society of Exploration Geophysics of Japan at Ube City in November, 1957 and the data added to sequently will hereunder be described and inspected in more details.

The writer here wishes to express his sincere thanks for kind guidance and continuous encouragement suffered from Prof. Dr. Y. UMEGAKI throughout this research and

is indebted also to some members of Hiroshima University, that is: Prof. Dr. T. MATSUURA of the Chemical Institute, giving all conveniences for studing the infrared absorption, Messers. S. HAMAMURA and K. IZUI of the Physical Institute, giving the benefits of both spectrographic and electron-microscopic inspections, and to Shimadzu Seisakusho Ltd. offering the röntgenographic data.

It is to be noted that this study has been made partly by the Scientific Grant attained from the Ministry of Education of Japan.

II. OUTLINES OF GEOLOGY AND ORE DEPOSITS

The field dealt with in this paper includes the area of about 0.5 square kilometers in the northern part of Nishiube-chō, where the hills from 20 meters to 70 meters in the height above sea level are found scattered.

The region concerned composes mainly of the lower Ube group covering the pre-Tertiary basement (ref. Fig. 1).

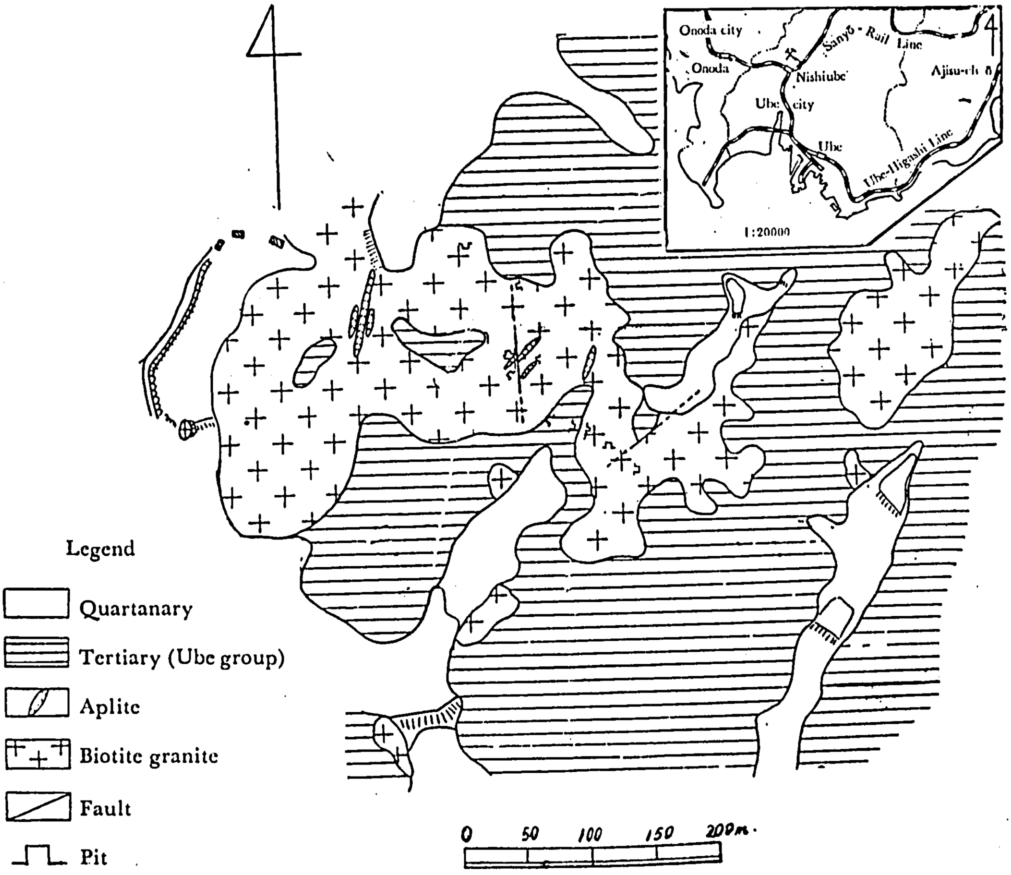

Fig. 1 Geological Map of the Eiwa Mine District

Basement rocks

The rocks lying unconformably over the Ube group are composed mostly of coarse- or medium-grained biotite granite apparently pertaining to a part of those intruded in Cretaceous and injected partly by some aplite veins.

The granite contains chiefly quartz, microcline, perthite, plagioclase, biotite with accessories such as zircon, garnet and fluorite, and the aplites consisting mainly of quartz, orthoclase, plagioclase and biotite occur as dikes penetrating into the former intrusive, both being cut through by amounts of quartz veins, partly greisenized and partly hydrothermally altered, and of clayey lodes.

Ube group

This group including the coal seams of economic importance has already been divided into the Kotō-gawa conglomerate formation (lower) and the Ube coal-bearing formation (upper) by Mr. K. KIYOHARA (1956).

The part distributed in the mapped area is composed mainly of conglomerates comprising the pebbles of chert, quartz-porphyry, crystalline shist, shale, sandstone and rarely of granite. The trend shown by shales and sandstones in parts intercalating between, or lying over, the conglomerates seems to be controlled by topography of the basement granite and is generally NW–SE with dip of less than 20° SW in the neighborhood of the main ore bodies, excepting the special locality where sandstone is in vertical contact with granite.

Ore deposits

Scarce amounts of wolframite ores are deposited irregularly in the fissure-filling veins consisting mainly of massive quartz associated with various kinds of minerals.

All the lodes found merely in the biotite granite show general strikes of nearly N 5° W and the dip of 80–90° E. There are about fourty principal veins, among which some broader ones can be traced for more than 100m along the strike in the outcrop, others are comparatively shorter and a lot of tiny veinlets are considerably irregular and macroscopically hard to ascertain. In general, the veins indicate the variation from 1 cm to 30 cm in width and those showing the range from 5 cm to 15 cm are most abundant.

The regularity in the strikes and dips of the main lodes seems to suggest that the formation of ore-bearing fissures probably have a relation to common origin or have been subjected to certain regional stresses. Another noticeable fact is that the large crystals of pinkish feldspar become more and more predominant in the lower horizons of the veins.

As ore minerals, wolframite accompanied with small quantity of scheelite, molybdenite, bismuth-bearing minerals, pyrite, chalcopyrite, arsenopyrite and fluorite are to be taken into account. Molybdenite, sulfide minerals and fluorite are found appeared at several places in the lowest galleries such as Minami-Ōgiri-kō and Higashi-Ōgiri-kō.

It must be particularly remarked that numerous fissure-filling clayey veinlets are appeared both in the granite and in the ore veins especially between the contact zones of one with the other. Detailed studies regarding to these clays will be stated in the other paragraph.

The biotite granite representing the country rock of these veins and veinlets are greisenized or rather sericitized along the contact ranging from 1cm to 5 cm in width. It is a matter of course that the grade of these alterations in wall rock increases with approaching the veins. The apparently greisenized parts are microscopically composed merely of quartz accompanying sericite or muscovite but are lacking in any other pneumatolytic minerals. Feldspars and biotites included in the outer zone of greisenized granite are partly replaced by sericite presumably derived from the reaction with low-temperature hydrothermal solution.

III. MINERALOGICAL RESEARCHES

In expectation of solving the problem in question mineralogically, chemical analyses, röntgenometric inspections, differential thermal analyses and some examinations by means of the electron microscope and of infrared absorption and ordinary spectroscope have been put into operation.

The major constituents comprised in the specimens of bismuth carbonates and clayes were quantitatively analysed with ordinary procedures generally applied for silicates, while the amount of CO_2 merely was separatedly determined through the increase of absorbent in weight.

Röntgenographs were numerically measured with "Norelco" and Shimadzu GX-1 recording X-ray difractometer. The experimental condition is as follow: Filter: Ni,

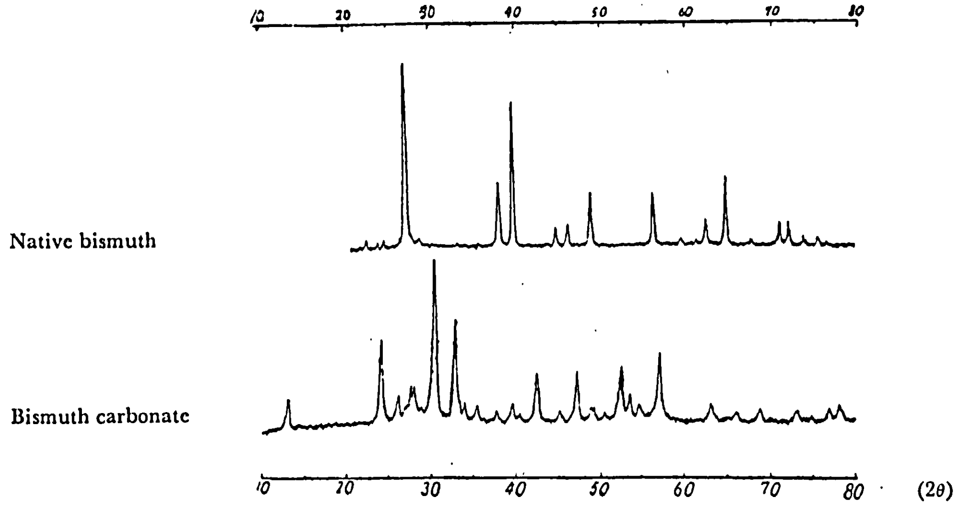

Fig. 2. Röntgenographs of some minerals obtained from the Eiwa Mine

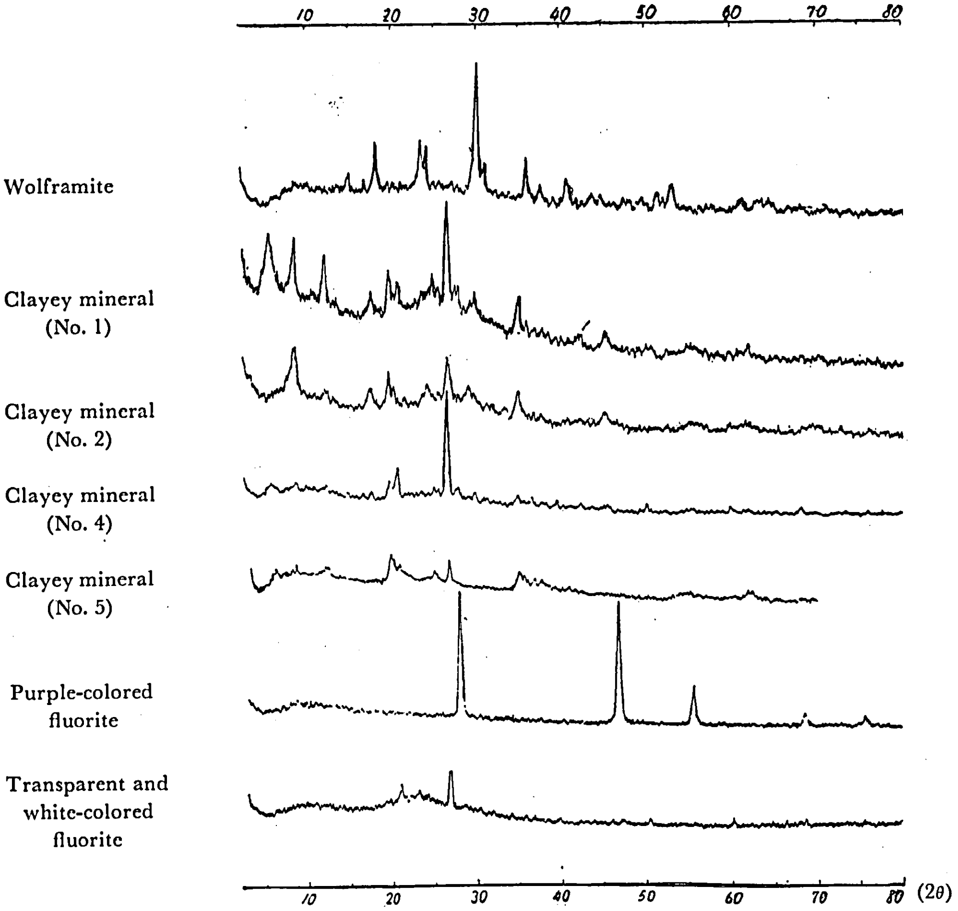

Fig. 2. (Continued). Röntgenographs of some minerals obtained from the Eiwa Mine

CuKα radiation, 35 kV, 15 mA, scale factor: 4-8, time constant: 4 sec, multiplier: 1.0, scanning speed: 2°/min, chert speed: 2cm/min, divergency: 1°, receiving slit: 0.4mm (ref. Fig. 2).

The thermograms obtained from differntial thermal analyses were drawn by the T. SUDO's apparatus (SUDO's et al, 1952, etc.) somewhat modified in our laboratory. Heating-rate in each experiments was ca. 10°C per minute (ref. Fig. 3).

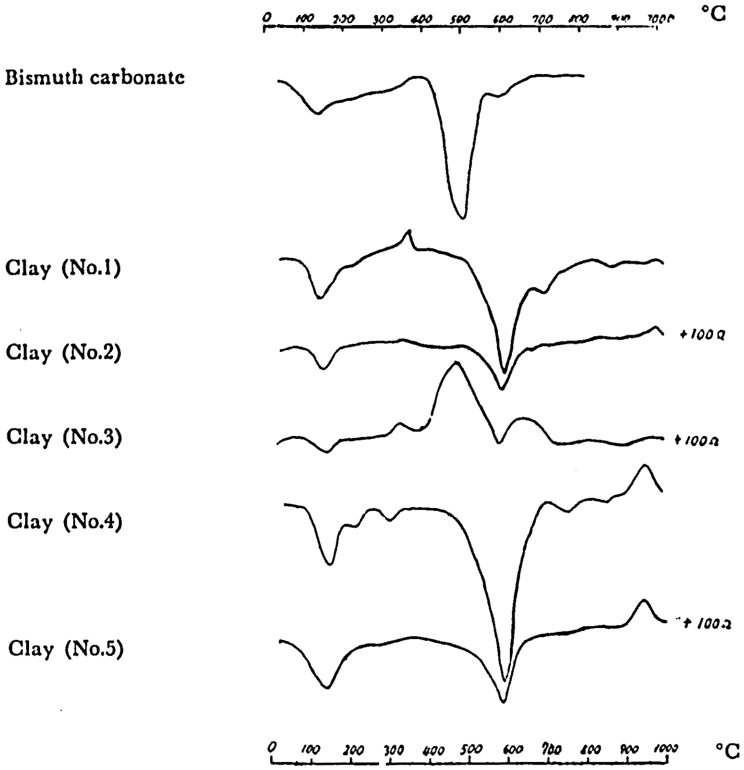

Fig. 3. Differential thermal analysis curves of some minerals obtained from the Eiwa Mine

As the electron microscope was used the TRS-50B designed by Akashi Co. Ltd. (DWORNIK et al, 1955). The standard-mesh covered with a thin film of collodion coated with carbon in high vacuum was provided for mounting the sample powders. The specimen was dispersed on the mesh by water suspension method. After evaporating the water the mounted matters were provided for examination (ref. PL. 15).

The infrared absorption spectra were obtained on the Hilgar H-800 infrared spectrometer equipped with a sodium chloride prism. The scale of the wave-length was standardized by using polystyren oil. The thin tablets used for inspection were prepared through mixing 1.0–2.5 mg of KBr with 1.0–2.5 mg of the finely pulverized minerals at the compressed state, and the experiments were carried out at 20°C and 40% in humidity (ref. Fig. 4).

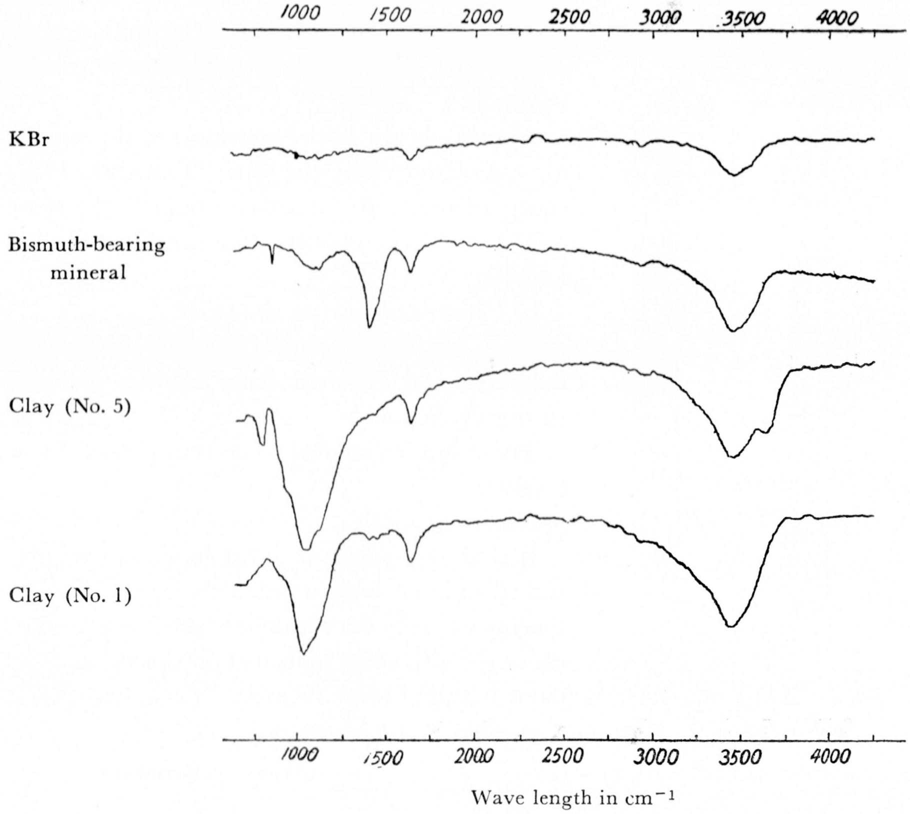

Fig. 4. Infrared absorption spectrograms of some minerals obtained from the Eiwa Mine

Ordinary spectroscopic analysis was made with the spectrometer of Carl Zeiss Jena. Nr. 51743. Specimen pulverized as fine as possible was held on the carbon electrodes, previously boiled in aqua regia and washed thoroughly, between which the electric current of 4.5–5.5 amperes was given for 10–15 seconds. The arc spectra thus obtained were taken on the photoplates attached to the spectroscope (ref. PL. 16).

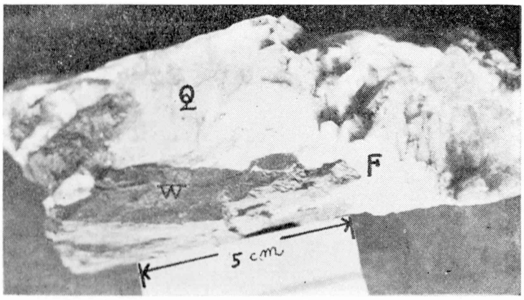

Fig. 5. W: wolframite Q: quartz F: feldspar

a) Wolframite

Wolframite (Ke-Chin Hsu, 1943; Ishibashi 1948, 1950; Kinosaki. 1952; Ball, 1954; Umegaki et al, 1954) is the only tungsten mineral occurring almost merely within the veins in somewhat workable scale. Well-crystallized specimens (ref. Fig. 5)

Table. 1 X-ray diffraction data for wolframite

(Eiwa Mine)

I	d	hkl
1.5	5.74	(010)
4	4.79	(100)
4	3.76	(011)
3	3.68	(110)
10	2.96	(111)
2	2.86	(020)
4	2.49	(002)
1.5	2.39	(200)
1	2.29	(012)
2	2.20	(121)
1	2.06	(112)
1	2.02	(211)
1	1.911	(030)
1	1.879	(022)
1	1.838	(220)
1.5	1.779	(130)
1	1.726	(202)
2	1.717	(221)
1	1.507	(113)
1	1.468	(311)
1	1.442	(231)
1	1.432	(040)
a_0 4.79	b_0	5.74
c_0 4.97	β	nt. dt.

are tabular and enclosed with the elongated orthopinacoids. Short columnar crystals and irregular cleavable lumps of this mineral are also common.

Scrutiny of the lattice constants of this mineral, calculated from the data (TAKANO, 1957) röntgenometrically obtained, suggests the more amouts of Mn component contained (ref. Tab. 1 and Fig. 5).

b) Bismuth-bearing minerals

They are found occurred in particular parts of the veins and often in drusy cavities included in the veins.

Those so far clarified to certain extent are as follows:

Native bismuth

It is always enclosed in earthy carbonate presumed to have been secondarily produced. The specimens taken out commonly show silver-whitish or greyish color with metalic luster, and are massive in form. Their diameter is about 0.5 mm on an average. Their hardness is

Table. 2 X-ray diffraction data for native bismuth

(Eiwa Mine)	a)		(Altenberg, Germany)	b)
I	d	hkl	I	d
1	3.95	(003)		
1	3.74	(011)		
10	3.28	(102)	3.0	3.21
4	2.30	(014)	1.0	2.34
8	2.273	(110)	2.0	2.245
2	2.030	(105)	0.5	2.015
2	1.976	(006)		
2	1.970	(113)	0.5	1.955
0.5	1.941	(201)		
4	1.868	(022)	1.0	1.850
4	1.639	(204)	1.0	1.625
1	1.556	(017)	0.5	1.545
1	1·515	(025)		
2	1.491	(116)	2.0	1.480
4	1.443	(212)	3.0	1.435
0.5	1.386	(108)	0.5	1.378
2	1.330	(124)	2.0	1.325
0.5	1.319	(009)		
2	1.312	(300)	1.0	1.304
1	1.284	(207)	0.5	1.278
1	1.261	(215)	0.5	1.254
0.5	1.246	(303)	0.3	1.240
				⋮

a) Writer. b) Frondel (1943).

2–2.5 and the specific gravity is $9.70\left(\frac{8^\circ C}{4^\circ C}\right)$. The röntgenometric inspection of a specimen indicates it to be a native bismuth, as is shown in Table 2.

Bismuth carbonates

Bismuth carbonates (FRONDEL, 1943) enclosing the metallic bismuth are supposed to be the alteration products. They are used to occur as the earthy hard granules varying from deep gray to black in color, as the radially fibrous crusts showing straw yellow in color or partly as the spheroidal aggregates (ref. Fig. 6). Their hardness is ca. 4 and the specific gravity is $7.42\left(\frac{8^\circ C}{4^\circ C}\right)$.

The results obtained from chemical analysis (ref. HARADA, 1948) indicate that the substance concerned is certainly a sort of bismuth carbonate containing small amounts of iron, alluminium, silica and antimony, etc. as impurities, together with a small amount of water ranging ordinarily from 1 to 3.5% (ref. Tab. 3).

Table 3. Chemical analysis of bismuth carbonate obtained from the Eiwa Mine

Chem. Comp.	Wt. %
Bi_2O_3	91.08
CO_2	4.80
PbO	tr.
Sb_2O_3	0.25
Fe_2O_3	0.69
Al_2O_3	0.13
MnO	0.04
SiO_2	0.83
$H_2O^{+)}$	0.94
$H_2O^{-)}$	0.45
Total	99.21

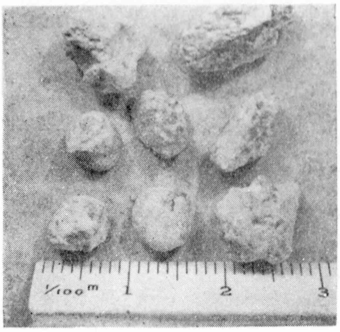

Fig. 6. Bismutosphaerite

X-ray powder diffraction study of the specimens proves their identity with bismutite or bismutosphaerite already cited in the literature (ref. Fig. 2 and Tab. 4). Röntgenographically the min-

Table 4. X-ray diffraction data for bismuth carbonate

(Eiwa Mine) a)		(Altenberg, Germany) b)	
I	d	I	d
2	6.828	7	6.903
5	3.708	7	3.708
2	3.361	3	3.402
2	3.234		
2	3.202		
10	2.941	10	2.943
6	2.728	8	2.724
1	2.642		
1	2.531	1	2.527
1	2.392		
2	2.280	4	2.276
1	2.235	1	2.225
3	2.135	8	2.134
1	2.014		
3	1.931	7	1.936
1	1.840	2	1.857
3	1.748	9	1.745
2	1.714	4	1.715
1	1.683	3	1.681
4	1.615	9	1.616
2	1.475	5	1.473
1	1.416	6	1.413
1	1.366	5	1.366
		1	1.336
1	1.287	5	1.284
1	1.270	1	1.268
1	1.238	4	1.237
1	1.224	1	1.222
			· · ·

a) Writer.
b) Frondel (1943).

eral bismutite is considered to be identical rather completely with anhydrous Bi_2CO_5 artificially synthesized as well as with bismutosphaerite. The name of bismutite appears to have been conveniently given to the bismuth carbonates containing an apparently significant amount of non-essential water. Whereas bismuth carbonate containing little or no water is, according to C. FRONDEL, considered to be bismutosphaerite, one is hardly distinguishable from the other in their characteristics.

The differential thermal analysis curve is similar to that given for the Willimantic, Connecticut bismutite (ref. Fig. 3). The diagram drawn from the specimen shows one larger, and two smaller endothermic peaks. In the diagram the first endotherm appeared between 50°C and 120°C is naturally related to the loss of non-essential water. The second one appeared between 400°C and 500°C is to be connected with the release of CO_2. The smaller one appeared at ca. 570°C probably represents an undeterminable inversion, as to which BECK (1950) stated that the röntgenograph shown by the samples heated at 525°C and 700°C was identical with γ-Bi_2O_3. The second endotherm given by him is corresponding to the writer's third peak and also seems to represent an inversion appeared on cooling. SILLEN (1938) reported that this inversion was facilitated by the presence of silica impurities.

Bismutites are used to show another inversion concerning the formation of β-Bi_2O_3 or of mixture of β-Bi_2O_3 and γ-Bi_2O_3 at ca. 725°C. From both the experiments and the data mentioned above, the bismuth carbonate in question is possibly identifiable with bismutite or bismutosphaerite or their mixture.

The infrared spectra attained from the mineral have several absorption bands, with reference to which pending questions are remained to be solved in their connection with the crystal structure of the specimen (ref. Fig. 4). Spectroscopically (ref. PL. 16), the major elements contained in the mineral are given as follows:

Fe, Bi, Al, Mn, Cu, Pb, Sb, Sn, Ca, and Si.

c) Clayey minerals.

Suspensions of clayey minerals, previously crushed and dispersed in distilled water, were, after removing heavier materials precipitated in the beaker and standing for 12 hours or longer, decanted out by means of syphon and dried up in the air. The specimens thus prepared have been provided for various kinds of experiments, since more detailed inspection relating merely to earthy matters was considered to be necessary in the light of their close relation to why or where somewhat higher radioactivity recognized generally in the galleries of this mine might come from.

Sampling positions, and macroscopic characteristics of each specimen are as follows:

No. 1, obtained from the contact zone of the lode with wall rock in the southern drift of the eastern gallery; showing pale yellowish green color with silky luster.

No. 2, collected from a fault cutting cross the lodes in the same drift as the former; white yellow in color.

No. 3, sampled from dull bluish black-colored clayey veins including certain amount of sulphide minerals in the same drift as the former.

No. 4, picked up from brownish yellow-tinged veinlet included in the lode of the southern gallery.

No. 5, attained from lighter brownish clayey matter in the lodes of the old eastern gallery.

In the röntgenographic data obtained for the earthy specimens mentioned above are observable the spacing for 7.1–7.3Å, 10Å, and 15Å probably concerning the basal

Table 5. X-ray diffraction data for clayey specimens obtained from the Eiwa Mine

No. 1			No. 2			No. 3			No. 4			No. 5		
I	d		I	d		I	d		I	d		I	d	
7	15.28	M							2	15.17	M	1	14.26	M
7	10.09	S H	10	10.25	S H				2	10.09	S H	1	10.16	S H
5	7.22	HK	2	7.14	K	w	8.72		2	7.19	HK	2	7.30	HK
									1	5.97				
									1	5.31				
2	5.02	S	3	5.02	S				2	5.00	S			
4	4.48	SMHK	6	4.48	SMHK	w	4.45	S	3	4.49	SMHK	5	4.46	SMHK
			3	4.35	S									
			1	4.29								3	4.25	Q
			3	3.67	S									
3	3.57	S HK							1	3.55	S HK	2	3.57	S HK
2	3.49	S H												
10	3.35	S Q	9	3.35	S Q	w	3.35	S	10	3.35	S Q	4	3.34	S Q
2	3.24	SM							2	3.21	SM			
2	3.20	SM				w	3.14	Py						
			3	3.07										
1	3.04	S K	1	3.01	S									
2	2.99	S							2	2.99	S			
			1	2.86	S									
			1	2.68	S	s	2.72	Py						
3	2.57	SMHK	4	2.56	SMHK	vw	2.58	S	2	2.57	SMHK	3	2.57	SMHK
1	2.50	SMHK										2	2.53	SMHK
						s	2.43	Py				2	2.45	M KQ
			1	2.38	S HK							2	2.40	S HK
1	2.25	S HK				m	2.21	S Py						
2	2.01	S												
2	1.99	S HK	2	2.00	S HK	m	1.92	S Py						
1	1.80	S Q				vw	1.82	S Py						
1	1.67	SMH												
1	1.66	SM K				s	1.64	S Py						
						w	1.57	Py						
1	1.50	SM	1	1.50	SM	w	1.51	S Py						
1	1.49	S HK				m	1.45	S Py				2	1.49	SHK
			1	1.42	K									
			1	1.32										
			1	1.28	H	vw	1.22	Py						
						vw	1.19	Py						
						vw	1.11	Py						
						m	1.05	Py						
						vw	1.01	Py						

d : spacing in Å.
I : intensity. w : weak. vw : very weak. m : medium. s : strong.

S representing sericite.	K representing kaolinite.
M representing montmorillonite.	Q representing quartz.
H representing halloysite.	Py representing pyrite.

planes of kaoline group, halloysite, and montmorillonite respectively, together with those for sericite, though the specimen No. 2 merely is lacking in the spacings for montmorillonite and No. 3 is specifically different from the other fours in mingling of those for pyrite ores (ref. Fig. 2 and Tab. 5).

The results from thermoanalysis (ref. Fig. 3) are in good accordance with those from X-ray diffraction. As for No. 1, 1) the endothermic peaks appeared at 130°C and 200°C may be interpreted to be mixed with montmorillonite, 2) that recognized at ca. 600°C may be deduced to have come from overlapping of those for sericite, kaoline group, and halloysite as well as transformation of quartz, 3) the smaller one shown at 700°C is ascribable to mixing of sericite and montmorillonite, 4) that observed at 850°C may represent the third one for montmorillonite, and 5) the scarcity of kaolinite group or halloysite, while the exotherm observed at 350°C seems to be derived from carbonaceous matter. It thus follows that No. 1 is essentially composed of montmorillonite and sericite, and No. 2 is surely related to sericite. In the case of No. 3, some questions are yet remained to be persued but the exotherm appeared between 400°C and 500°C may be produced from presence of pyrite ore and that confirmed at 570°C is believed to imply the mingling of sericite with quartz. The diagram given for No. 4 suggests the coexistence of montmorillonite, kaolinite, halloysite and sericite, excepting that the endotherm at 300°C is assumed to be in rela- tion to limonite and the one observed at 750°C seems to imply the deviation toward the side of higher temperature owing to the scarce amount of sericite. General tendency of the diagram obtained from No. 5 are similar to that appeared in the former caseand the peak of symmetrical larger dimension at 130°C is deducible from the increaseof halloysite in amount, suggesting the sampling position situated near the groundsurface and accordingly its genetic condition. Basing on the previous description that the endotherm appeared at 580°C is symmetrical in the case of kaolinite and it shows steeper inclination toward the side of higher temperature in the case of halloysite, the amounts of the latter included in Nos. 4 and 5 are probably scarce (MCCONNEL, 1950; SUDO et al, 1952, 1953, 1954, 1957 etc; TAKUBO et al, 1954; KINOSHITA et al, 1954, 1956; KAKITANI, 1957; TSUZUKI, 1957; TOKUNAGA, 1957). This assumption is probable from inspection of the result, obtained by means of electron microscope, where the grains representing kaolinite of hexagonal tabular form and acicular halloysite are few in amount and those showing irregular platy forms are abundant (ref. Fig. 4).

The data obtained from chemical analysis indicate the identity of the specimen No. 2 with sericite (MINATO et al, 1952; MINATO, 1954), and that of No. 4 with kaoline group excepting the slight excess of silica in quantity (ref. Tab. 6).

Table 6. Chemical analyses of clayey specimens obtained from the Eiwa Mine

	No. 2		No. 4	
Chem. Comp.	Wt. %	Mol. prop.	Wt. %	Mol. prop.
SiO_2	47.78	0.796	49.94	0.832
Al_2O_3	37.20	0.365	31.47	0.309
Fe_2O_3	0.45	0.003	1.26	0.079
FeO	0.75	0.010	1.25	0.017
MgO	0.21	0.005	0.99	0.025
CaO	0.47	0.008	0.55	0.010
K_2O	5.93	0.063	0.81	0.009
Na_2O	0.62	0.010	0.54	0.009
$H_2O^{+)}$	5.25	0.292	10.77	0.598
$H_2O^{-)}$	1.10	0.061	2.48	0.138
Total	99.76		100.06	

The results of the infrared absorption spectra given for the specimens No. 1 and No. 5 are still rich in problematical regards concerning their relations to the inner architecture of the specimens in question. Only in the case of No. 5, it seems clear that the absorption at 2.7μ indicates the correspondence to OH radical comprised in halloysite. It must here be emphasized that in the case of examination for clay minerals the procedure with nujol (ref. KELLER et al, 1950; LAUNER, 1952; FRONDEL, 1953; KAKITANI, 1956; UMEGAKI et al, 1957) is better for use than that with KBr tablet (ref. Fig. 4).

d) Fluorite

The purple-colored massive specimen paragenized with sulphide minerals in the eastern main gallery and the white transparent one, closely attached to the sheared zone of the southern gallery in tiny lamellar form were röntgenographically scrutinized(ref. Fig. 2 and Tab. 7, SAITO, 1950, 1951). The former shows conspicuous diffraction related to its higher crystallinity, while on the contrary the latter has, probably because of its genetic condition or of a sort of metamictization originated by radioactivity, almost no peaks in the spacings and gives yellowish green-tinged fluorescence with radiation of mineralight (TWENHOFEL. 1947; KULP et al, 1952; PABST, 1952; HURLEY, 1953; UEDA et al, 1954; BERMAN, 1955; HOLLAND, 1955; SHELDON, 1957). From this facts and the data for paragenized clayey minerals it is deduced that the former is an ordinary kind of specimen produced from the condition generally intermpreted but the latter may be precipitated specifically from low temperature hydrothermal solution in the stage later than the formation of wolframite or other kinds of pneumatolytic minerals. As for this regard, BERMAN's work (1957) showing that röntgenographs of fluorite coexisting with radioactive substances are used to be broaden and to be decreased in their intensity, culminating in producing purplish one, is surely of significance compared to the specimen here cited.

Table 7. X-ray diffraction data for fluorite

Purple-colored specimen a)			b)		Ttransparent and white-colored specimen a)		
I	d	hkl	I	d	I	d	
					2	4.26	Q
			mw	3.772			
			m	3.483	3	3.36	Q
10	3.157	(111)	s	3.162			
					1	2.47	Q
			w	2.275	1	2.29	Q
			ms	2.136			
			m	2.016	1	1.98	Q
9	1.932	(220)	ss	1.933			
			w	1.827	1	1.82	Q
			w	1.712			
3	1.648	(311)	s	1.646			
			ww	1.526	1	1.54	Q
					1	1.41	Q
1	1.365	(400)	ms	1.359	1	1.38	Q
			w	1.296			
1	1.254	(331)	ms	1.248			
			w	1.164			
			s	1.113			
			w	1.050			

a) Writer.
b) Kubo et al. (1955).
Q representing quartz.

IV. CONSIDERATIONS ON RADIOACTIVITY

With development of exploration methods for uranium- and thorium-bearing ores various kinds of the related deposits have hitherto been successively found out and miscellaneous opinions concerning their genetic origins or their characteristics have been frequently made public by a large number of investigators and mining engineers (MCKELVEY et al, 1950, 1956; STEVENSEN, 1952; FRONDEI, 1953, 1956; ROSENZWEIG et al, 1954; STERN et al, 1955; BREGER et al, 1955; GROSS, 1956; GRUNER, 1956; MATHESON et al, 1956; OLSON, et al, 1956; STIEFF et al, 1956; VIKERS et al, 1956; WALKER et al, 1956). It is of course that wide-spread distribution of uranium in various geologies through the world as well as all types of its deposition originated from complicated sources are evidently attributable to its physico-chemical properties specifically such as its polyvalency, scale of atomic radius, chemical activity, facility of oxydation from tetra- to hexa-valent ion, solubility of the latter into aqueous media and so forth (ABBERMAN et al, 1949; PHAIR et al, 1953; MOORE, 1954; GARRELS, 1955; KOCZY et al, 1957). From this point of view radioactivity appeared in the galleries of this mine has been inspected somewhat detailedly as to its genesis. The data obtained by counting with Geiger counter per meter in the lowermost levels of the eastern and southern galleries and by radiation of mineralight on special parts of walls have

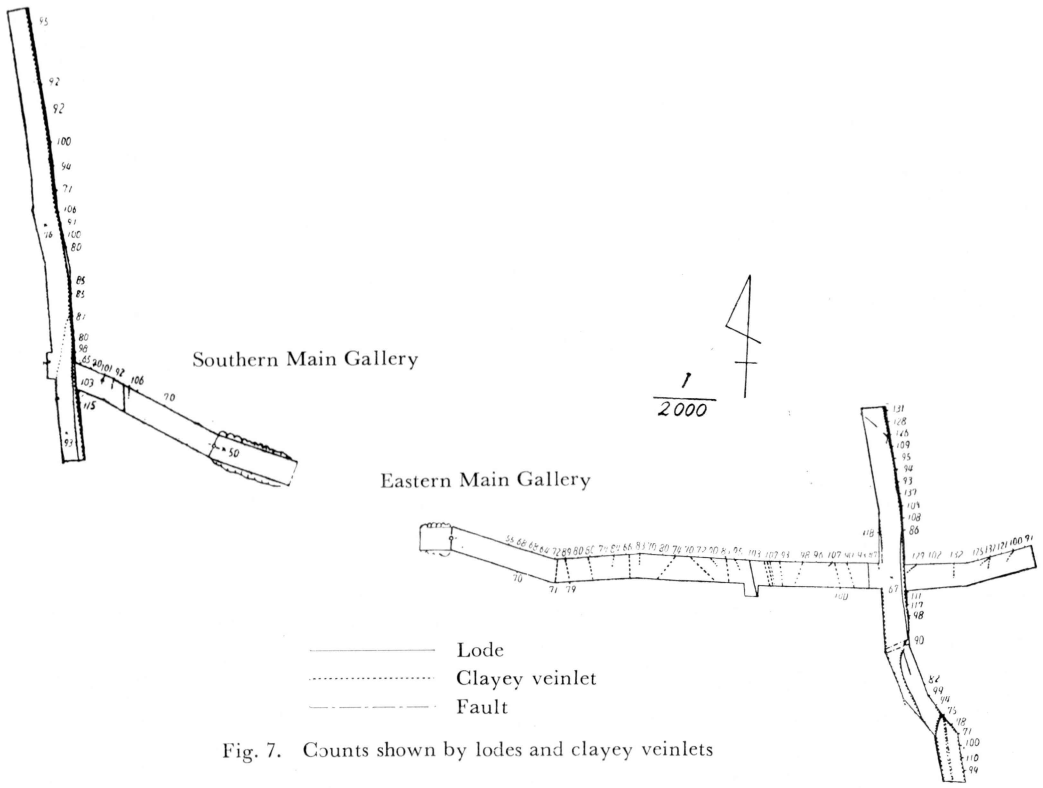

Fig. 7. Counts shown by lodes and clayey veinlets

given some noteworthy and interesting suggestions, as are plotted on Fig. 7. According to the conclusion thus attained, it becomes clear that the values for counting have not always a proportional connection with the contents of W- or Bi-bearing minerals but are rather more closely related to the networks of clayey veins cutting cross the lodes and wall rocks. For example, the specimen No. 1 indicates 100 cpm even in laboratory and No. 5, 88 cpm higher than the values for country rocks ranging from 50 to 65 cpm. Autoradiographs taken for these specimens after standing for more than four days also have shown the alpha tracks (STIEFF et al, 1952), and the contents of radon dissolved in the running water poured out from the western galleries have been radioscopically estimated as about 12 Mache when it was completely clear and as more than 40 Mache when it was somewhat turbid with clayey suspensions (ref. GILETTI et al, 1955). Although the rare occurrence of Bi-bearing clayey parts showing higher values such as 500-800 cpm may be mistaken to have affinity with radioactive substances, it must again be noted that the purified bismuth minerals are hardly observed to be radioactive and the clayey veins without traces of the former, however, indicate the anomaly though to a slight extent.

The example of radioactivity found in absence of primary uranium minerals has been alluded to by BARTON JR. (1956) believing the fixation of uranium absorbed on the colloidal substances on the basis of his experimental data and taking into account the trace of radioactive hydrothermal minerals together with absorption by bismuth carbonate. LOVERING (1955) also has established an absorption theory for radioactive limonite, while RANKAMA and SAHAMA (1950) have suggested the absorption of soluble compounds of uranium on the gels of hydroxides of Al, Fe, and Mn etc. as well as of silica. On the other hand, the stability of uranium in the solution of various pH was researched by MILLER (1955) proving its solubility of $2-4 \times 10^{-5}$ mol/L in pH ranging from 6 to 8, which is corresponding to that recognized in the water descending along the fissure-filling veins commonly found in the Eiwa Mine and is suggestive for their radioactivity.

MCKELVEY et al. (1956) stated the possibility of derivation of uranium from the residual solution considered to be a part of the differentiate in the later stage because either of difficulty of its concentration into ordinary kinds of rock-forming minerals owing to larger radius and to higher valence or of insolubility of tetravalent compounds into aqueous solution.

In consequence, it appears that inspection executed by the writer with various means becomes valid in the light of the views proposed already by some authors and may play an important role in solving the origin of radioactivity recognized everywhere in the galleries. In other words it results in that uranium might have been brought out in certain later stage with comparatively lower temperature hydrothermal solution ascending from the same source related to wolframite or other minerals and absorbed in the lodes hydrothermally altered as well as simultaneously in various veins and veinlets deposited from hydrothermal solution and partly affected by latest weathering.

CONCLUSION

The ore veins occurring in this mine seem to have dualistic characters concerning their genesis from the standpoint so far established, since it is believed that wolframite, associated rarely with molybdenite especially in the lower levels, were pneumatolytically or hydrothermally at higher temperature deposited along the fissures appeared in biotite granite lying under the conglomerates of Tertiary formation in the earliest stage of ore mineralization and certain kinds of low temperature hydrothermal minerals produced in far later stage are more predominantly observable in the fissures, quite similar to, or cutting across the former. That the greisenized portions macroscopically recognized on the wall rocks along the lodes are subjected to sericitization and almost lacking in their primary characteristics may prove severe alteration originated mainly from hydrothermal solution together with subsequent weathering agency, and in a sense suggested already by KE-CHIN HSU (1943), greisenization hitherto considered as a result of pneumatolysis may have closer relation to hydrothermal effect in certain case. The fact that the main bodies of ore veins become more abundant in potash feldspars as gangues with increase of depth is of significance in the meaning of suggesting the rapidity of their vertical variation of from lower to higher temperature mineral assemblages and, at the same time, in considering either their source or the characteristics of their country rocks distributed widely in Chûgoku province.

Generally, clayey veinlets, whatever they may be macroscopically recognizable or not in the related wall rocks, is apt to be mistaken genetically as barren ones on account of mere coherence to special mineral such as bismuth carbonate in prospecting uranium ores but the opportunity absorbing or including the element concerned seems, though in more or less amount, equal over all the veins and veinlets scattered within this mine. It is here to be added that waltherite named for bismutite or bismutosphaerite including certain amount of uranium by FRONDEL (1946) may not be the case with the specimens obtained from this mine because of absence of uranium in themselves, though clayey matters injecting into or covering them are considerably radioactive. At any rate, parts of the hidden granite under conglomerates or other sedimentaries in the vicinity of this mine must, for the reason of expecting the similar kinds of veins possibly continued from this region, be considered as an important subject for exploration of radioactive minerals.

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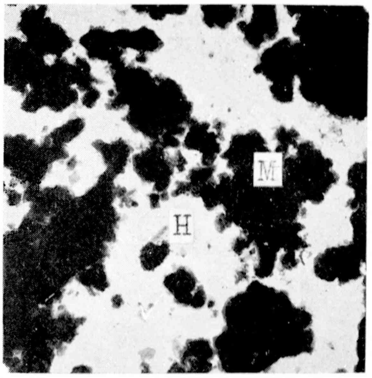
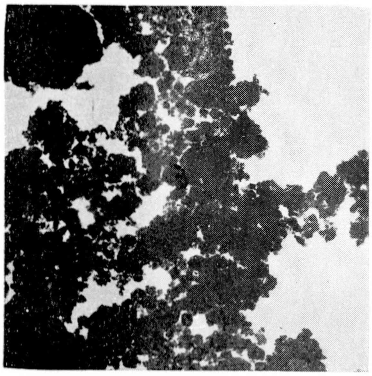
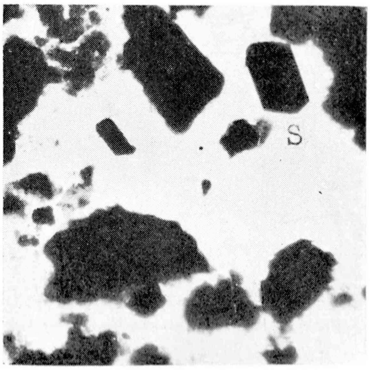
Electron photomicrographs of clayey specimens obtained from the Eiwa Mine.



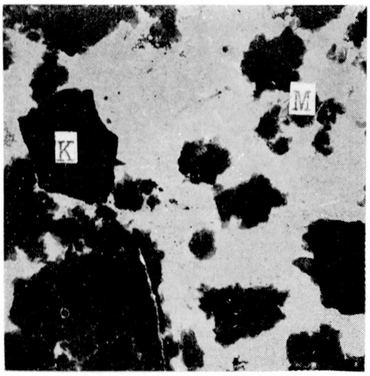
Spcimen. No. 1 ×3000
M : Montmorillonite
H : Halloysite



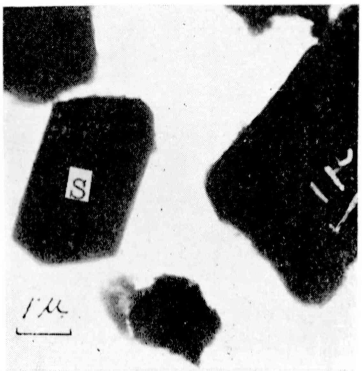
Specimen. No. 3 ×3000



Specimen. No. 2 ×3000
S : Sericite



Specimen. No. 4 ×3000
K : Kaolinite
M : Montmorillonite



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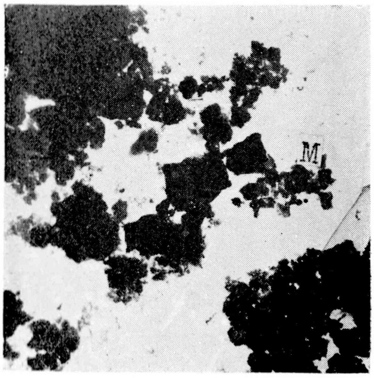
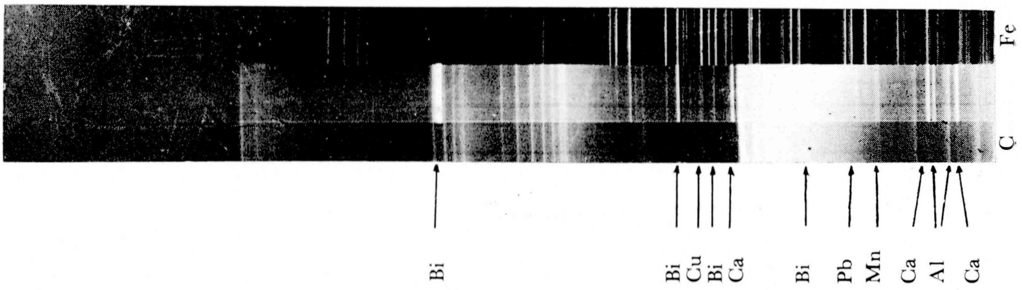


Specimen. No. 4 ×3000

Spectrographs of bismuth carbonates obtained from the Eiwa Mine.

1.



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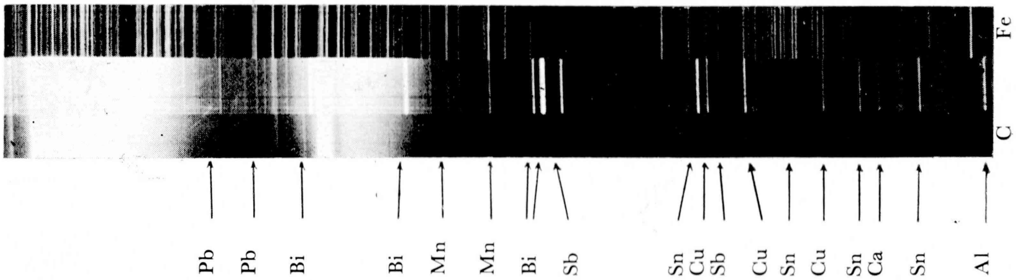

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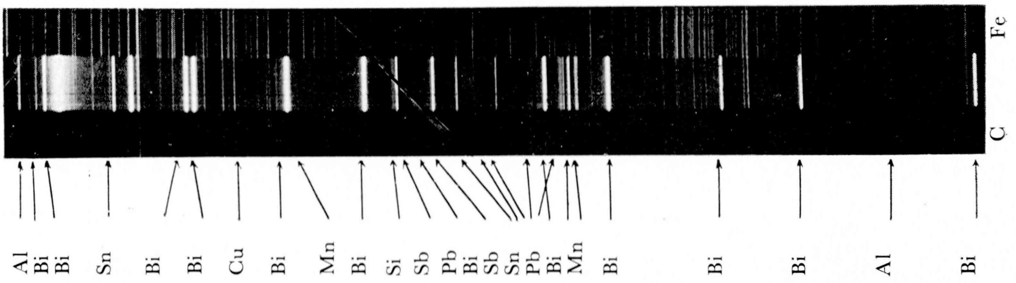

4.