Studies on the Chromites and their Occurrences in the Tari District, Tottori Prefecture, Japan (I)

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北 原 順 一： 鳥取県多里地方のクロムテツ鉱並に
産状に関する研究 (I)

Introduction

In the previous paper (Kitahara, 1957), the writer described the outlines of studies on the chromites and their country rocks in the Tari district, Tottori Prefecture.

In this paper the writer wishes give a more accurate knowledge obtained during his last one year investigation of the chromit deposits in the region.

Granite and Related Rocks

As the transitional relations among granite, granite porphyry and quartz prophyry are observed at northwestward of Tari, the writer believes that these rocks in the region were originated from same magma.

Biotite granite

Localtity: At about 1 km. south of Inazumi mountain.

The writer already mentioned the results of the megascopic and microscopic observations of the rock in the previous paper (1957).

In thin section, biotite first changes from brown to green and then changes to chlorite. As the birefringence of the green mineral is very strong, the mineral is considered still a biotite. Small amounts of epidote is produced by alteration of biotite with chlorite.

The chemical composition of the sample is as shown in Table I.

From the table of the chemical composition, the writer interprets the character of the granite as follows.

The content of silica in the rock corresponds to the average value in the Japanese granites. The alkali contents of the former are lower than those of the latter. The contents of magnesia and total iron of the former are higher than those of the latter. The content of lime of the former is lower than the latter.

Table 1.

	Wt%	Mol. props		Atom. ratios	Ditto when O=160
SiO_2	72.13	1.202	Si	1.202	62.7
TiO_2	0.44	6	Ti	6	0.3
Al_2O_3	14.53	142	Al	284	14.8
Fe_2O_3	1.38	9	Fe'''	8	0.9
FeO	2.46	34	Fe''	34	1.8
MnO	0.06	1	Mn	1	0.1
MgO	1.06	27	Mg	27	1.4
CaO	1.45	26	Ca	26	1.4
Na_2O	2.43	39	Na	78	4.1
K_2O	2.94	31	K	62	3.2
P_2O_5	0.24	2	P	4	0.2
H_2O_+	0.57	32	H_+	64	3.3
H_2O_-	0.12	6	O	3.068	
Total	99.81				

Ultra-basic Rocks

The occurrences of the serpentinite masses in the region was already described in the previous paper (1957).

The ultra-basic rocks consist largely of serpentinized dunite and harzburgite. Sertentinite associated with disseminated chromite is generally pale yellow or pale green and wall rock serpentinite is dark green or black. Serpentinite is here used as the name of a mineral aggregate composed largely of antigorite. Under the microscope, dusty magnetite is generally characteristic of the greenish black or black serpentinite and absence or scarcity in the pale yellowish green serpentinite associated with the chromite grains as mentioned in the previous paper (1957). Away from chromite body residual olivine in the ultra-basic rock is comparatively abundunt, but serpentinization increases to completion as the chromite body is approached. Talc occurs frequently in the marginal altered mass, but is also found in the unmodified ultra-basic rock. Enstatite has sometimes altered to bastite and olivine to mesh serpentine. Serpentinized olivine is ophitically held in enstatite or bastite altered from enstatite. Silica plus water must be added to an unserpentinized dunite or normal peridotite to change the chemical composition of olivine into serpentine.

$$(1)\quad 3Mg_2SiO_4+SiO_2+4H_2O=\underset{\text{(serpentine)}}{2H_4Mg_3Si_2O_9}$$

Reaction (1) accounts for all of the serpentine formed. It seems to the writer that serpentinization come from within the ultra-basic rock (autometamorphism) and serpentine is not crystallize directly from the residual liquid. Olivines uniformly distributed in the partially serpentinized ultra-basic rock are equally serpentinized in corroded form. This points that the olivine grains are serpentinized by a residual liquid present in the interstices between the grains. The residual liquid (magmatic water) thus may be the chief agent in effecting serpentinization. When serpentinization of iron bearing forsterite was taken through the action of magmatic water in the closing stages of consolidation of the ultra-basic rock, dusty magnetite is separated in serpentine derived from the forsterite as suggested following chemical reaction (2), but a part of iron still remains in the serpentine.

$$\text{(2)}\quad \underset{\text{(Fe-beaing forsterite)}}{3Mg_3FeSi_2O_8}+6H_2O+O=3H_4Mg_3Si_2O_9+\underset{\text{(magnetite)}}{Fe_3O_4}$$

Reaction (2) is further indicated that some oxygen is available and the serpentinized ultra-basic rocks have a higher Fe_2O_3/FeO ratio than the unserpentinized ultra-basic rocks. The fact as mentioned above was proved by comparing the microscopical observations and the chemical analyses of the ultra-basic rocks in the region.

Occurrences of Chromites

The chromite deposits in the region occur only within the ultra-basic masses as shown in the previous paper (1957). Ore bodies are lenticular or layered in shape and arranged in an echelon form. The strikes of the chromite bodies are generally uniform, and almost parallel to the trend of the serpentinite mass. Most of the ultra-basic rocks solidified before chromite. In a number of places the chromite is deposited along well defined fissures. Some of the fissures appear to be merely joint resulting from emplacement of the ultra-basic rocks. The fissures show almost parallel relationship to the outlines of the serpentinite masses. Although a part of chromite may crystallize at early stage, a substantial amount of the chromite at least did not crystallized until the general mass of the rock mass solid enough to fissures and then molten chromite fluid entered the fissures. In this case the chromite fluid partly replaced wall rocks of the fissures to form plate-like bodies. The chromite of these bodies has sharp boundaries against the serpentinite. It is evident by wall rock alteration of the chromite serpentinite contacts that the chromite formation is later than the first formed silicates of the host rocks. Most of the chromite deposits thus may be generally classified as a fissure filling type. On the other hand silicate bearing chromite fluid intruded in pre-forming silicates that were not completely solidified, took on irregular and vaguely shapes to wall rocks. In the case disseminated chromite gradetes in the wall rocks. As molten chromite and peridotic silicate were injected contemporaneously, the chromite forms disseminated and massive bodies according to the relative abundance of the silicates and the chromites. The chromite bodies frequently catch serpentinite blocks as xenolith. As intense serpentinization is bordered by plate-like bodies of chromite, the chromite bodies are sometimes surrounded by thin margin of pale yellow green (bleached) serpentinite. In the wall rock near the chromite body dike-like chromites sometimes occur. The chromite dikes are off shoot of the chromite body.

It seems to the writer that fluid chromite formed within the still partially fluid silicate magma that intruded in pre-solidifing serpentinite, take on an original magmatic structure. In occurrence showed in Fig. 1, irregular chromite band is curved and broken, suggesting movement of chromite within the fluid magmatic mass.

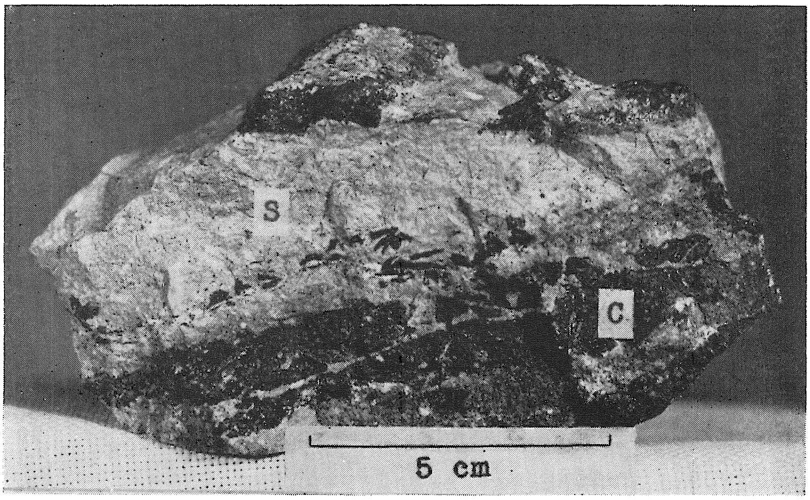

Fig. 1. Irregular chromite band suggesting movement of chromite.
C : Chromite S : Serpentinite
7th level of Wakamatsu Mine.

In case chromite-silicate molten magma intruded in fissures of pre-forming country rock, serpentinization of silicate minerals associated with chromite was more intense at the border along the wall side than at the middle of the intruded chromite-silicates.

The occurrences of the chromite bodies may belong to a hypohydrous magmatic type than hydrothermal type. These chromites are associated with serpentine of igneous origine, but not any of typical hydrothermal minerals.

Chromite Deposits of Hirose Mine

The deposits of Hirose Mine are composed of ore bodies of Hirose (sea level 775 m +0 m), 22 m (775 m+22 m), 37 m (775 m+37 m) levels, and levels for transporting filling materials (883 m). The ore bodies of the Hirose, 22 m and 37 m levels are continuous each other to a dip direction. The ore body of 22 m level is main one among the above mentioned levels. As the ore bodies of 37 m and Hirose levels are present in marginal parts near country rock, disseminated chromites are frequently observed and yet the chromites have a diminishing tendency in these bodies. The strikes of these ore bodies are N10°–20°W with a dip of 30°–70°W and almost parallel to trend of the serpentinite, but the strikes of ore series at the 22 m and 37 m levels suddenly changes from N10°W to almost eastward as shown in Fig. 2. The writer supposes that the normal strikes of these ore bodies were deformed secondarily by orogenic movement. This disturbed zone of the chromite series is continuous to the South 5th level of Wakamatsu Mine. The

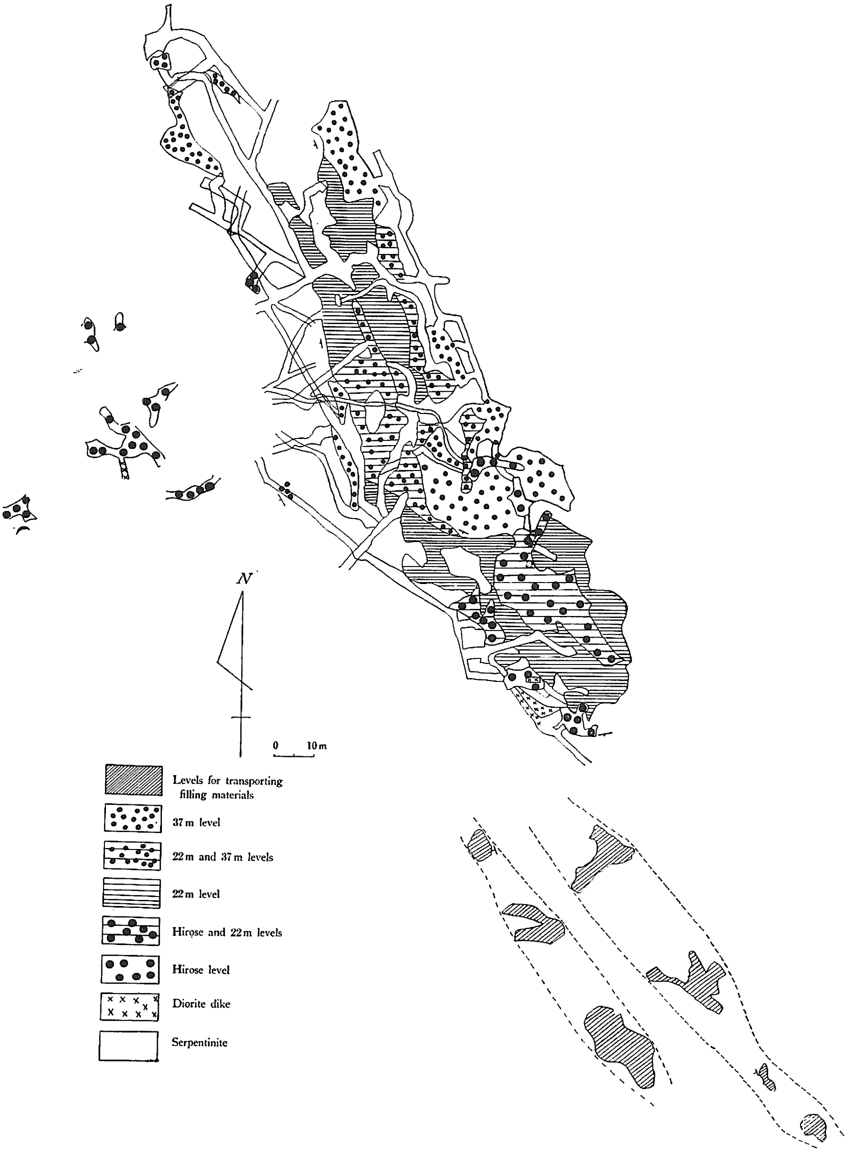

Fig. 2. Chromite deposits of Hirose Mine. (by J. Kitahara)

levels for transporting filling materials are located about 30 m. south of the 37 m. level and the ore bodies of the levels are arranged in two lines showing strike of N15°–45°W.

The description of the deposits of Wakamatsu and Hinokami Mines was excluded in the paper.

Chromites

Fractures filled by serpentine are present in most chromite. This suggests that the fractures occurred prior to serpentinization. Much of disseminated chromite is intermixed with pale yellow or pale green serpentinite. The chromite grains disseminated in the yellowish green serpentinite commonly are black or yellowish brown with black opaque borders and also cross cutting lines. The disseminated chromite is commonly less translucent than massive chromite in the same deposit. It appears that iron oxide set free with magmatic emanation such as gases, vapours, or liquids from molten silicate matrix during cooling and added to the chromite grains to form crosscutting lines and black opaque margins of the grains. Namely, the emanation from silicate magma reacts with the chromite, and gives rise to magnetite rich parts along fissures and margins of the chromite.

Fig. 3. Chromite (Analysis No. 12) surrounded by rim of uvarovite. U : Uvarovite ×30
37 m level of Hirose Mine.

Under reflected light, magnetite rich parts in chromite are light grey or white, whereas chromite parts are grey.

A chromite specimen associated with green mineral was collected from the 37 m level of Hirose Mine. In thin section, the chromite grains are surrounded by rim of isotropic, greenish mineral–uvarovite ($3CaO{\cdot}Cr_2O_3{\cdot}3SiO_2$)–with high refringence (Fig. 3). The chromite was vigorously attacked by silicate matrix and convertet into the uvarovite.

Compositions of Chromites

The location of the chromite deposits in the region is indicated on the gelogic map in the previous paper (1957).

When chromite was ground to 200 mesh and separated by the use of heavy liquids, it still contains about 1% gangue minerals. The analyses of twenty one samples of chromite separated from gangue minerals are listed in Table 2. The chromites from the deposits in the region are comparatively high in MgO and Al_2O_3 contents and low in Cr_2O_3 content as seen in Table 2. MgO content exceeds FeO except a few samples. Since disseminated chromite is enriched in iron oxide through the action of magmatic emanation from molton silicates as mentioned above, the surrounding serpentinite is left relatively iron poor. The content of iron oxide in the disseminated chromite thus has as a reverse relation to that in the serpentinite that disseminated the chromite. The

Table 2. Chemical analyses of Chromites

No.	1. D	2. D	3. M	4. M	5. D	6. D	7. D.M	8. D	9. D	10. D	11. M
FeO	6.38	10.34	13.04	7.53	14.01	8.97	15.39	9.08	12.37	10.78	9.82
MgO	19.47	17.05	16.04	20.00	15.11	18.46	15.07	18.50	15.77	17.81	16.87
MnO	0.37	0.61	0.32	0.11	0.16	0.25	0.31	0.05	0.65	0.05	0.56
Cr_2O_3	38.11	32.80	28.46	30.86	29.97	33.61	22.06	34.01	31.56	32.92	37.45
Al_2O_3	24.86	29.66	35.30	36.80	30.25	29.15	38.33	29.15	30.01	30.16	28.59
Fe_2O_3	9.27	8.02	6.50	4.27	9.13	8.12	7.28	7.97	8.90	6.50	6.51
CaO	tr	tr	tr	0.05	tr	0.27	0.20	tr	tr	tr	tr
SiO_2	1.21	1.02	0.09	0.52	0.92	1.10	0.98	1.15	0.71	1.47	0.06
Total	99.67	99.50	99.75	100.14	99.55	99.93	99.62	99.91	99.97	99.69	99.86

No.	12. M	13. M	14. M	15. M	16. M	17. D	18. D	19. D	20. D.M	21. D.M
FeO	8.49	7.17	13.58	14.17	9.01	12.07	14.79	7.21	11.25	12.39
MgO	19.43	20.10	14.12	15.24	17.92	16.72	13.12	18.66	16.99	15.16
MnO	0.10	0.20	0.63	0.21	0.36	0.20	0.91	0.40	0.67	0.63
Cr_2O_3	38.78	29.07	44.61	36.28	37.03	32.74	40.14	36.43	35.11	40.18
Al_2O_3	30.96	38.07	21.49	28.96	31.16	29.28	19.77	22.49	27.82	24.44
Fe_2O_3	2.10	4.41	4.57	4.21	4.09	8.07	9.03	11.98	3.84	5.18
CaO	0.07	tr	tr	0.08	tr	tr	0.21	tr	0.02	0.03
SiO_2	0.23	0.75	0.80	0.69	0.40	0.97	1.47	2.03	3.19	1.42
Total	100.16	99.77	99.80	99.84	99.97	100.05	99.44	99.20	98.89	99.43

D: Disseminated chromite M: Massive chromite

D. M: Either densely dissemintated or nearly massive chromite

Nos. 1, 2, 3, and 4: Chromite from the the 7th deposit of Wakamatasu Mine.
Nos. 5, 6, and 7: Chromite from the South 5th deposit of Wakamatsu Mine.
Nos. 8–13: Chromite from the deposit of Hirose Mine.
Nos. 14–19: Chromite from the Hinokami deposit of Hinokami Mine.
Nos. 20 and 21: Chromite from the Inazumi deposit of Hinokami Mine.

disseminated chromites in the leuchtenbergite rocks, found by the writer, which are rich in Al_2O_3 content and poor in FeO plus Fe_2O_3 are poor in Al_2O_3 and rich in FeO plus Fe_2O_3.

According to Bragg, the unit cells of spinel structure are seemed to contain 8 ($R''O.R''_2O_3$). The number of atoms of each metal present in the unit cell was calculated from the analyses shown in Table 2. Each of atoms per unit cell taken as 8 ($RO.R_2O_3$) of the specimens analysed by the present writer was omitted in the paper. The end member system suited to express the chemical composition of chromite is spinel, magnesiochromite, ferrochromite and magnetite within six end members. The writer calculated the end member formulae per unit cell by the following equations devised by Stevens.

$$\text{Spinel}=\text{Al}/2$$

$$\text{Magnesiochromite}=\text{Mg}-\text{Al}/2$$

$$\text{Ferrochromite}=\frac{\text{Cr}+\text{Al}}{2}-\text{Mg}$$

$$\text{Magnetite}=\text{Fe}''+\text{Mg}-\frac{\text{Cr}+\text{Al}}{2}=\frac{\text{Fe}'''}{2}$$

As a natural magma always contains abundance of Al_2O_3 and MgO, the end member ferrochromite $FeO.Cr_2O_3$ cannot produce from magma. When the analyses are expressed in terms of normative constituents as given in Table 3, the spinel content is generally higher than chromite plus magnetite. The normative magnetite content in disseminated chromites is higher than that in massive chromites.

Table 3. Norms

No.	1 D	2 D	3 M	4 M	5 D	6 D	7 D.M	8 D	9 D	10 D	11 M	12 M	13 M	14 M	15 M	16 M	17 D	18 D	19 D	20 D.M	21 D.M
Spinel ($MgO.\ Al_2O_3$)	43.7	52.5	60.6	61.2	53.7	51.3	66.3	51.3	52.5	53.1	49.4	63.7	63.1	39.4	51.9	53.1	51.9	36.3	40.0	50.0	43.7
Chromite ($(Mg, Fe)O.\ Cr_2O_3$)	46.3	38.7	32.5	34.4	36.3	39.4	25.6	40.0	37.5	39.4	43.7	34.4	32.5	55.0	43.7	42.5	38.7	53.1	46.3	45.6	50.0
Magnetite ($FeO.\ Fe_2O_3$)	10.0	8.8	6.9	4.4	10.0	9.3	8.1	8.7	10.0	7.5	6.9	1.9	4.4	5.6	4.4	4.4	9.4	10.6	13.7	4.4	6.3

Chromite of metallurgical grade is generally considered that a chrom-iron ratio by weight % is 3/1. It is said that refractory grade of chromite needs not have as high a Cr_2O_3 content as metallurgical grade and requires over 57% of total Cr_2O_3 plus Al_2O_3. The chrom-iron ratios of the chromites in the region are noted in Table 4. The chromites are adequated as a refratory use from the Tables 2 and 4.

Table 4. Cr/Fe (Wt%)

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Cr/Fe	2.8	1.6	1.3	2.4	1.2	1.8	0.9	1.8	1.4	1.7	2.1	2.6	2.3	1.3	1.8	2.6	1.5	1.5	1.8	2.2	2.1

Gabbros

Gabbros occur within the serpentinites and the chromite bodies as cognate xenolith derived from the same magma that generated ultra-basic rocks and chromites.

The optical properties of the rocks were summarized in the previous paper by the writer (1957).

Uralite was produced around the periphery and along cleavages by the alteration of clinopyroxene.

The detailed optical properties and chemical compositions of the gabbros were excluded from the paper.

Leucocratic Rocks

After the chromite body became rigid, a orogenic movement produced fractures in the ore body and the country rock. Leucocratic dikes with dioritic dikes were emplaced about this stage. Such leucocratic rocks are observed seldom and almost insignificant in volume. A leucocratic dike rock that included remants of chromite particles was seen at the 7th level of the 7th deposit of Wakamatsu Mine.

The fact that the dioritic and leucocratic dikes thus cut the ultra-basic rocks such as serpentinized peridotites and harzburgites indicates that such dike forming magmas remained as fluid after consolidation of these rocks. The true that the dikes mentioned above cut also the chromite bodies shows the position of chromite in the magmatic cycle.

The dioritic rocks are frequently occured as described in the previous paper (1957). The detailed descriptions of the dioritic rocks were omitted in the paper.

The leucocratic rocks are composed largely of quartz, felspar. The brief petrogical notes of the few specimens are as follows.

Quartz-albitite

The rock occurs as dike intruded in the serpentinite at the 9th level (open-air) of Hirose Mine.

The specimen is megascopically milky white with quartz and felspar.

Under the microscope, it shows porphyritic texture. The constituent minerals are as follows. Quartz: Abundant in matrix, sometimes as quartz aggregates, and frequently as veinlet in albite. 0.01 mm. to 0.10 mm. in size. Albite: Less common and as phenocryst of 1 mm. to 5 mm. in size. The index is low than 1.54. Twin lamellar is curved. Ratio of albite to quartz is 1/15. Hornblende: Rare. Colorless and high index. Cleavage observed. Vesvianite: Less comon. Pale brown with weak pleochroism. Vein like form. Magnesite: Less common. Lacking in lamellar twinning. Veinlet cutting vesvianite (by post igneous action).

The chemical composition of the rock is as shown in Table 5.

Quartz-plagioclasite

The rock is exposed as dike in the serpentinite at the levels for transporting filling materials of Hirose Mine.

This is megascopically grey white with felspar and somewhat green mineral.

In thin section, Quartz: Less common. Plagioclase: abundant. 0.2 mm. to 0.3 mm. in size. Almost kaolinized. n=1.538 (oligoclase) on fresh cleavage fragment. Hornblende: Scarce. Colorless with indistict cleavage. Extinction angle $c \wedge Z$=small. Zoisite: common. Product by anamorphism of plagioclase (probably under hydrothermal condition). High refringence and low birefringence (iron poor type).

The chemical composition of the sample is as indicated in Table 5.

Table 5. Compositions of Leucocratic rocks

	1				2			
	Wt %	Mols		Atom. ratios when O=160	Wt %	Mols		Atom. ratios when O=160
SiO_2	77.94	1298	Si	64.8	62.01	1033	Si	53.5
TiO_2	0.16	2	Ti	0.1	0.07	1	Ti	0.05
Al_2O_3	7.94	77	Al	7.7	19.83	194	Al	20.1
Fe_2O_3	1.04	7	Fe'''	0.7	0.04	0.3	Fe'''	0.03
FeO	0.94	13	Fe''	0.6	0.47	7	Fe''	0.4
MnO	0.04	1	Mn	0.05	0.00	0	Mn	0
MgO	1.08	27	Mg	1.3	0.82	21	Mg	1.1
CaO	5.32	95	Ca	4.7	8.52	152	Ca	7.9
Na_2O	2.27	36	Na	3.6	4.08	66	Na	6.8
K_2O	0.26	3	K	0.3	0.41	4	K	0.4
$H_2O_+(CO_2)$	3.18	177	H_+	17.7	3.44	191	H_+	19.8
H_2O_-	0.28	16	O	160.0	0.27	15	O	160.0
Total	100.45				99.96			
	1. Quartz-albitite				2. Quartz-plagioclasite			

Carbonates

Numerous calcite veins penetrated along various cracks and openings of the serpentinite and the chromite body in the region. Some of these veins include remnants of massive chromite and serpentinite. The chromite was partly altered and replaced by solutions depositing the calcite. The calcite occurs with magnesite, as patches and in veins.

Magnesite is common in the marginal parts of serpentinite near chromite body and also in the chromite body. It occurs in veins and as patches. In thin section, lamellar twinning is absent and cleavage is rare.

New Saponite

New saponites were found by the writer in researching the chromites and their country rocks in the region. The writer describes only the properties of a saponite from the 7th level of the 7th deposit of Wakamatsu Mine in the paper.

The country rocks, such as serpentinite and pyroxenite which were attacked by alkaline ground water passing through the fissures, were partly dissolved and altered into saponite filling the cracks or fissures of the serpentinite and chromite bodies. The vein forming saponites are generated after the serpentinization as one of the minerals of the latest stage of crystallization. The minerals are found as vein-like forms from microscopical one to 0.3 m. in width in the serpentinite and the chromite bodies. The saponite is sometimes associated with chalcedony or opalin silica. The chalcedony appears as small spherulites with perfect polarization crosses.

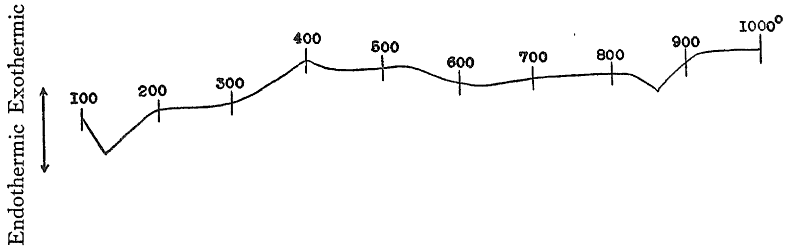

Fig. 4. Differential thermal curve of saponite.
7th level of Wakamatsu Mine.

The differantial thermal curve (Fig. 4) of the mineral from the 7th level of Wakamatsu Mine shows an endothermic reaction at low temperature, corresponding to the water loss below 110°C, and also the other endothermic reaction is suggestive of loss of OH water at about 860°C. The curve showing two kinds of the endothermic reaction denotes that the mineral is a kind of montmorillonite group. It seems probably that the exothermic peak attaind about 400°C is due to mixture. It has been argued that most normal aluminous montmorillonite shows an endothermic reaction at about 700°C. The magnesium rich montmorillonite shows an endothermic reaction at a higher temperature than the aluminous montmorillonite.

The electron micrograph (×24.000) shows the mineral to be lath or flake of varying

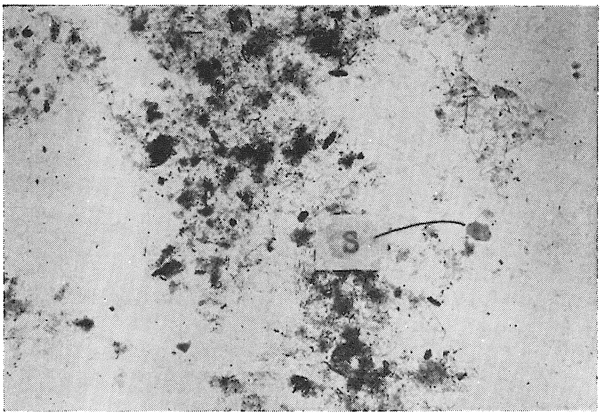

Fig. 5. Electron micrograph of saponite
S: Saponite ×24.000
7th level of Wakamatsu Mine.

size with irregular outlines as shown in Fig. 5. The length of the laths is generally about one or two times the width dimension. As magnesium rich montmorillonite shows usually lath shape, the writer believes that the mineral is saponite, judging from the shape observed in the electron micrograph.

The mineral reacts with the saturated benzidine ($H_2N.C_6H_4.C_6H_4.NH_2$), and then assumes pale blue color. The writer understood the mineral is a kind of montmorillonite owing to this characteristic change of color.

The color of the mineral is greyish white and the luster is greasy; the specific gravity is 2.27 and the hardness is 2.5.

In thin section, the mineral is colorless, and isotropic but shows weak birefringence in different parts of the same specimen. Since the flakes are very fine and aggregate irregularly, the double refraction is very low and apparently isotropic. The refractive index Nm is 1.525.

The result of the chemical analysis of the specimen is as illustrated in Table 6.

Table 6.

	Wt %	Mol. ratios		Atom. ratios	Ditto when O(OH)=2400
SiO_2	47.02	783	Si	783	716
TiO_2	0.00	—	Ti	—	—
Al_2O_3	5.54	54	Al	108	99
Fe_2O_3	0.83	5	Fe'''	10	9
FeO	0.07	1	Fe''	1	1
MnO	0.00	—	Mn	—	—
CaO	0.82	15	Ca	15	14
MgO	25.52	638	Mg	638	584
Na_2O	0.28	5	Na	10	9
K_2O	0.17	2	K	4	4
H_2O_+	4.00	220	H	440	OH 402
H_2O_-	16.04	891	O	2624	O 1998
Total	100.29				

The mineral is low in ($FeO+Fe_2O_3$) and Al_2O_3 contents, and rich in MgO content;

the montmorillonite of this sort has not been reported in Japan. The formula calculated on the basis of 20 oxygen atom can be expressed as $(OH)_{4\cdot 02}(Si_{7\cdot 16}Al_{0\cdot 93})_{8\cdot 09}(Mg_{5\cdot 84}Fe''_{0\cdot 01}Fe'''_{0\cdot 09}Al_{0\cdot 06})_{6\cdot 00}((Ca/2)_{0\cdot 28}Na_{0\cdot 09}K_{0\cdot 04})_{0\cdot 41}O_{19\cdot 98}mH_2O$ which corresponds almost to the ideal formula $((Mg_{3-\alpha}Al_{\alpha})(Al_{1/3+\alpha}, Si_{4-(1/3+\alpha)})O_{10}(OH)_2W_{1/3}.mH_2O)$ of saponite suggested by Ross and Hendricks.

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