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ULTRA-BASIC ROCKS OF THE CHUGOKU DISTRICT, SOUTH-WESTERN PART OF JAPAN

By

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(With 1 Table and 5 Figures)

Contribution from the Department of Geology and Mineralogy, Faculty of Science, Hokkaido University. No. 440

1. Introduction

Chromite bearing pyroxene peridotites mostly serpentinised are rather common along the ridge of the Chugoku mountain range, in the inner zone of south-western Japan. Serpentinites in the ridge between Okayama and Tottori[1][2][7][8] prefectures are the biggest occurrence in this zone, and the others which are found in Sekinomiya[4] of Hyogo prefecture and in Yakuno of Kyoto prefecture are of rather small occurrence.

It is characteristic in this zone that these ultra-basic intrusives occur in Palaeozoic sediments and associated with chromite deposits and gabbroic rocks.

In 1918, T. OGURA,[8] former member of the Geological Survey of Japan, made a geological map (1/75,000 Shobara sheet) with explanatory text. In his map the southern end of the serpentinites has been introduced. In 1921, S. KITAMURA studied chromite deposits of the Wakamatsu mine in Torrori prefecture, and in 1938, T. ISHIKAWA,[2] Department of geology and mineralogy, Hokkaido University made an investigation and introduced the geology of the Tari district, Tottori prefecture. The present author has made investigations in the area several times during the recent four years since 1946. In this paper will be described the serpentinites and the associated chromite deposits in the ridge between Okayama and Tottori prefectures. In conclusion, the relation between gabbros and serpentinites will be touched upon.

I wish to express my gratitude to Professors J. SUZUKI and T. ISHIKAWA for their kind encouragement, and also to Assistant Professor M.

Hunahasi for his advices in the preparation of this report.

2. Geology

There are two main series of rocks in this region. The sedimentary rocks of the older series are phyllite, schalstein and slate with limestones, which are believed to be of Palaeozoic age. The series has been closely folded and shows N 70° W strike and a prevailing southward dip between 40° and 70°. Into this series of sedimentary rocks, many kinds of igneous rocks intruded. The most abundant igneous rocks are granitic rocks and serpentinites with gabbros.

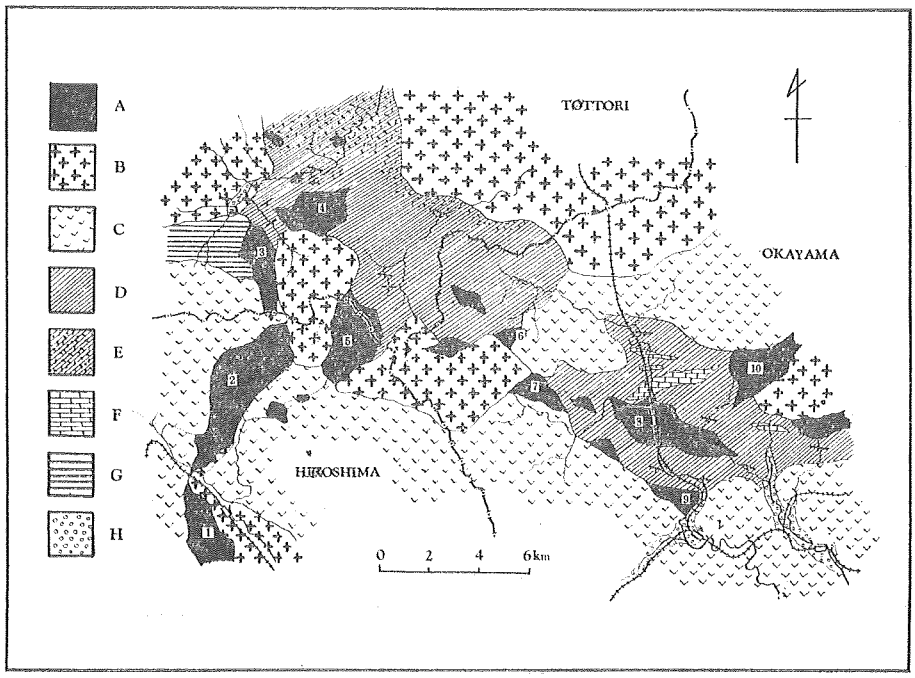

Fig. 1. Geological map of the western part of the range between Tottori and Okayama prefectures.

(A) Serpentinite, (B) Granite, (C) Quartz porphyry,
(D) Palaeozoic sediments, (E) Hornfels, (F) Limestone,
(G) Tertiary sediments, (H) Quarternary sediments,
(1) Shirataki-yama serpentinite mass (2) Neko-yama serpentinite mass
(3) Hirose serpentinite mass (4) Inazumi-yama serpentinite mass
(5) Mikuni-yama serpentinite mass (6) Takase serpentinite mass
(7) Mimuro serpentinite mass (8) Yuno serpentinite mass
(9) Yufune serpentinite mass (10) Yamomine serpentinite mass

Gabbroic rocks are found only in serpentinites showing xenolithic block and have never been seen in the other igneous masses.

The younger of the two series of rocks are Tertiary sedimentary rocks associated with liparitic lavas.

The intrusive age of quartz porphyry has not been known.

The distribution of the igneous rocks and the sedimentary rocks in the region are shown in figure 1.

3. Serpentinites

Serpentinites occur in small lens-shaped outcrops, often in long strings or as sworms. The long axis of each of serpentinites are usually parallel to the general direction of the folding of the surrounding rocks. Some of the serpentinite masses appear around the grantitic rocks. The foot walls of the serpentinites are often Palaeozoic sediments and the roofs are either Palaeozoic sediments or granitic rocks. Ultra-basic rocks in this area are generally seldom quite fresh, and more or less serpentinized. Even when the olivine is completely altered to serpentine, the characteristic texture of the peridotite often remains.

The olivines remained in the Serpentinite, are forsterite molecules rich in composition, averaging 6 mol. % of Fe_2SiO_4 and its variation limits are observed less than 5 mol. %. The proportion of MgO and FeO in the rhombic pyroxene associated with the olivine is similar.
A small percentage of chromite grains coated with magnetite occur in the rocks. Such crystals of chromite are mostly euhedral and are often included in the crystals of olivine ; their diameter is between 0.5 mm and 1 mm. Judging from the relics of minerals, the primary rocks seem to be of chromite bearing saxonite.

4. Chromite deposits

Many chromite deposits have been reported in the region. Almost all of them occur in the central parts of each serpentinite mass. The form and size of these chromite deposits have been determined since 1920 with the advance of the working of the Wakamatsu, Hirose and many other mines. The country rocks are usually massive serpentinite and rarely foliated.

Some main deposits among them will be described. The outlines of chromite deposits of the Wakamatsu and the Hirose mines in Tottori

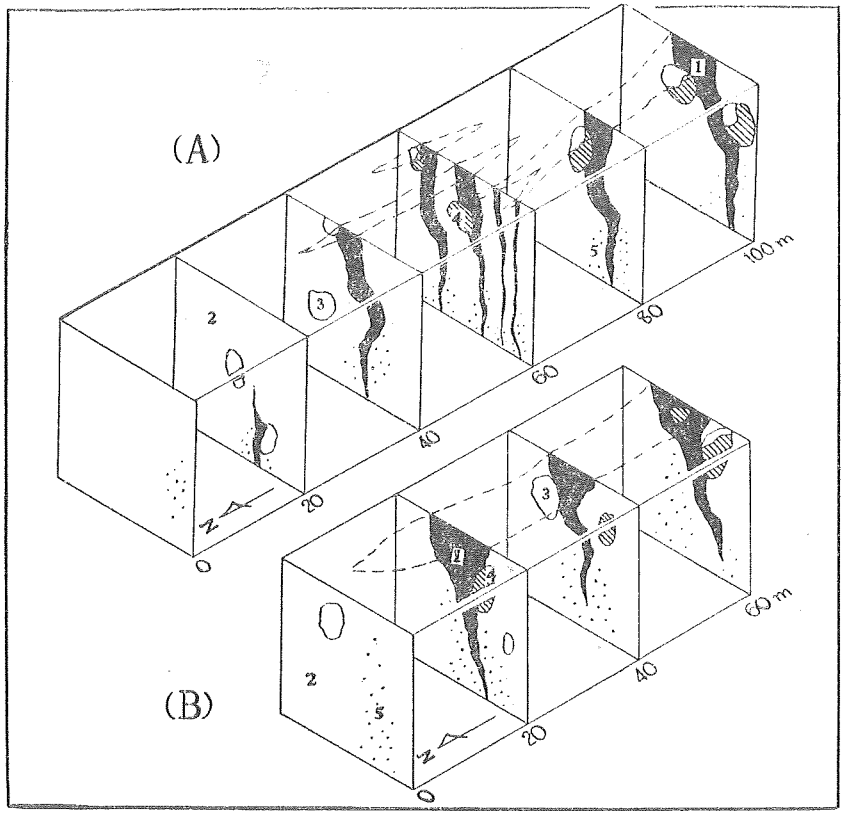

Fig. 2. Stereogram illustrating the chromite deposits of the Hirose mine (A) and the Wakamatsu mine (B).
(1) Massive chromite deposits, (2) Massive serpentinite,
(3) Gabbroic rocks, (4) Metasomatised part of gabbroic rocks,
(5) Disseminated chromite deposits.

prefecture are summarized in figure 2.

These chromite deposits are situated in the central part of the Hirose serpentinite mass showing veinlike forms, and composed of both massive ore and disseminated ore, they often accompany each other, but the boundary between them is usually very distinct.

The size of crystals of chromite in massive ore or disseminated ore from the mine averages 5 mm in diameter, and it is by far the larger compared with the chromite as rock forming mineral. The small crystals of chromite widely disseminated in serpentinites as rock forming mineral are usually euhedral, but large chromites which form ores are anhedral. In the center of the large xenomorphic crystal of chromite, many

patches of olivine are included, which are often quite fresh and not effected by serpentinization.

The colour of chromite in thin section is usually reddish brown. The chromites in the disseminated ores are often covered with magnetite film at the surface of the crystal, but large crystals of chromites in massive ores include small amount of hematite and are scarcely accompanied with magnetite.

It is hardly possible that the massive ores are the product of the accumulation of the disseminated crystals of chromite.

The chromite deposit of the Takase mine, in Okayama prefecture, is situated at the central part of the Takase serpentinite mass. Three ore bodies are known. Each of them occurs in kidneylike mass associated with foliated serpentinite. They are very samll, 10 meters in length and 5 meters in width at the largest. Two of them situated in the upper part are vertical, and the other is flat; the ore deposit is devided into three ore bodies by the faults, and along the irregular cracks of the ores, crushed uvarovites and kämmererites are found.

The Cr_2O_3 content of the ore from the Takase mine is 40% or more,

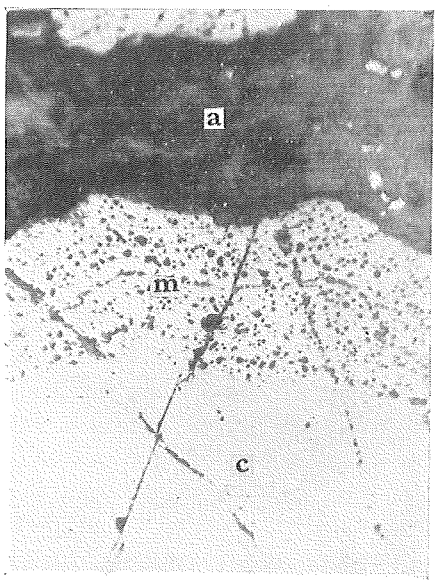

Fig. 3. Photomicrograph of polished section of disseminated ore from the Yosekura mine. One nicol, ×100
(c) chromite, (m) magnetite,
(a) antigorite

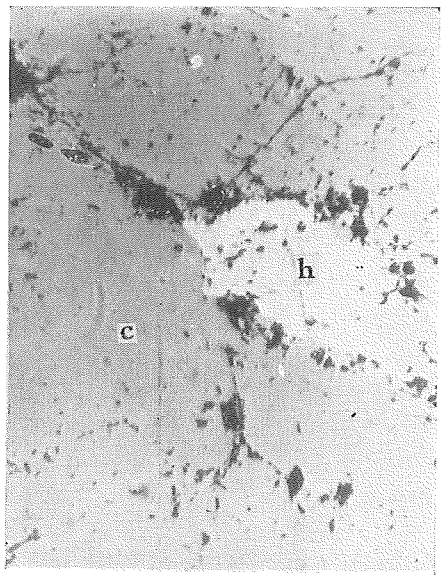

Fig. 4. Photomicrograph of polished section of massive ore from the Wakamatsu mine, One nicol, ×100
(c) chromite, (h) hematite

compared with the other mines in the region where it is usually less than 30%.

Chromite deposit of the Yosekura mine in Okayama prefecture, is situated at the south-western part of the Yuno serpentinite mass. The ore from the Yosekura mine is constituted from only disseminated ore, the size of the crystal of chromite in the ore is 1 mm or less, and the form is idiomorphic. Each of them is coated with thin magnetite film at the surface of the crystal and they show chain stracture,[9] therefore this deposit may be the product of the accumulation of small chromites as rock forming mineral. Such chromite deposits are uncommon in the region.

The relation between chromite and magnetite in the disseminated ore from the Yosekura mine is shown in figure 3, and the relation between chromite and hematite in the massive ore from the Wakamatsu mine is shown in figure 4.

5. Gabbros

Many irregular xenolithic patches of gabbroic rocks, ranging from 1 meter to 30 meters in size are contained in every serpentinite body. It is interesting that such gabbroic rocks are found only in serpentinite bodies and have never been seen in any other igneous mass in the region.

The mineral constituents of these gabbros are commonly brown hornblende with a core of augite, plagioclase and ilmenite ; occasionally, spinel, pargasite and chlorite associations which are regarded to be caused by Mg metasomatism are observed in them. The typical spinel pargasite chlorite rock facies are found in the Takase mine surrounding the chromite ore mass. Similar rock facies are seen in other mines surrounding the chromite ore mass, but the proportions of these minerals are different at every mine. The variations of proportions and components of the minerals in the metasomatised parts are confined within narrow limits ; they show a serial relation to each other.

Such metasomatised rock facies occur only in the surroundings of the chromite deposits, and this is characteristic of addition of Mg, Ca and decrease of Si compared with non-metasomatised part. The chemical relation between them is shown in table 1, and the serial relation of the mineral assemblages in each rock facies are given in figure 5.

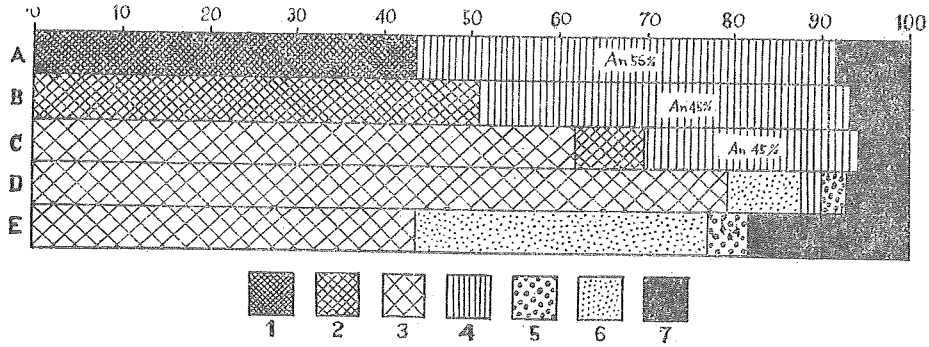

Fig. 5. (A) Volume relation in the non-metasomatised part of the gabbros. (B) and (C) are its varieties.
(E) Volume relation in the metasomatised part of the gabbros and (D) is its variety.
(1) augite, (2) hornblende, (3) chlorite, (4) plagioclase, (5) green spinel, (6) pargasite, (7) ilmenite.

	(A)	(E)
SiO_2	50.05	36.28
TiO_2	1.49	1.55
Al_2O_3	16.26	17.77
Fe_2O_3	0.90	4.06
FeO	10.67	11.67
MgO	4.73	8.89
CaO	8.81	14.30
Na_2O | K_2O	n. d.	n. d.
H_2O (+)	1.44	3.02
H_2O (−)	0.50	0.52
Total	94.85	98.06

Table. 1. (A) Main portion of chemical components of the non-metasomatised gabbro, near the Takase mine. Analyst. T. Bamba.
(E) Main portion of chemical components of the spinel pargasite chlorite rock in the Takase mine. Analyst. T. Bamba.

6. Summary

The chromite deposits, serpentinites and the associated gabbroic rocks along the ridge between Okayama and Tottori prefectures have been described in outline. Some of the main problems in the region are concerned with the origin of the two types of chromite and the relation between chromite deposits and the associated metasomatised

gabbros. The auther's views upon these problems can be summarized as below.

From the modes of the occurrence and the properties of ores, the chromite deposits in the region may be classified into two types; these types have already been illustrated by the typical four deposits of the Wakamatsu, Hirose, Takase and Yosekura mines.

Almost all of the chromite deposits in the region occur in veinlike, lens-like or kidney-like masses in serpentinites. These deposits are composed of large anhedral crystals of chromite. On the other hand, some of the disseminated chromite deposits are composed of small euhedral grains of chromite which are widely disseminated in serpentinites showing local irregular distribution as rock forming mineral.

The widespread chromite grains in serpentinites are regarded as a product of eariest crystallization. The olivines and rhombic pyroxenes follow after. Perhaps this early crystallization of chromite may have been a fractional crystallization in an early stage of the differentiation of the peridotitic magma.

The large anhedral crystals of chromite in massive and disseminated chromite deposits showing the interferent crystallization prevented the development of a complete regular crystal form may be regarded as product of more complete differentiation having solidified later than the chromite, olivine and pyroxene of an earlier stage.

Gabbros and serpentinites in the region are both derived from the same magma. The gabbros solidified earlier than the serpentinites, and were caught by the rest magma in the deep zone. The gabbros were dispersed and settled with the advance of the solidification of the magma. In the process, some of these gabbros were metasomatised and at last, spinel pargasite chlorite rock facies were formed.

It is supposed that the study of the spinel pargasite chlorite rocks will be very important to explain the origin of the two types of chromite in the region.

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