Notes on the Banded Chromite Ore from the Akaishi Mine in the Province of Iyo, Japan.

By

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With 1 Plate.

I. Introduction.

The present paper includes the result of a study of beautiful hand-specimens of chromite ore from the Akaishi Mine⁽¹⁾ in the province of Iyo, which were recently presented to the writer by Mr. S. Ôtsu. The mine under consideration lies in the terrain of crystalline schists, called 'Sambagawan Series' by Prof. B. Kotô, forming a rugged mountainous district on the island of Shikoku. The ore-deposits of this mine are not yet thoroughly prospected, but the following statement⁽²⁾ by Ôtsu throws some light on their mode of occurrence:—

“The ore-bearing serpentine mass is intrusive in mica schists, its form and dimensions being unknown. Chromite masses are usually contained in the light green coloured portions of the country rock and show usually more or less banded texture. The largest ore mass ever found is about 50 meters in length and about 2 meters in thickness, showing a distinct banded texture resembling stratification. The location of the ore masses is not confined to the borders of the serpentine mass.”

1) 伊豫國宇摩郡關川村赤石鑛山.

2) Communication by letter.

II. Country Rock.

The country rock is a medium-grained dunite varying in colour from yellowish green to dark green. Under the microscope it is composed essentially of small grains of olivine, with chromite crystals as an accessory component. The olivine is usually highly serpentized along the irregular cracks in which it is very rich, often being almost entirely altered to serpentine showing a typical mesh-structure with minute cores of fresh olivine. The accessory chromite occurs in small well-defined crystals and is always of the earliest crystallization. Minute particles or dusty aggregates of secondary magnetite are developed in the serpentine, sometimes being accumulated along the margins of the accessory chromite crystals.

In places, cloudy patches and veinlets of a strongly double-refracting carbonate, highly probably magnesite, in association with occasional patches of pellucid calcite characterized by the perfect cleavage and gliding planes, are developed in the serpentized dunite, often replacing and enclosing the serpentine and the olivine cores.

In some places, the country rock is represented by a coarse aggregate of flaky, pale green talc mingled with flecks and masses of fibrous, light green to light gray actinolitic amphibole, in association with more or less magnesite. Separate crystals and crystal-aggregates of chromite are scattered through it, sometimes in abundance. This is an altered peridotite. As can be revealed under the microscope, the colourless actinolitic amphibole in fibrous aggregates is surrounded by confused aggregates of talc and serpentinous matter commingled with magnesite. It is highly probable that the talc, serpentine and magnesite were formed by alteration of olivine. Along the chromite, flakes of light rosy kämmererite are characteristically developed.

III. Banded Ore.

According to the statement by Ôtsu, the chromite ore appears to assume a banded texture on a large scale, as observed in the field. The hand-specimens of the ore, on the other hand, shows a beautiful banded texture on a very small scale as shown in Fig. 1 (Pl.).

The banded ore in question consists of an irregular alternation of black layers and light yellowish green ones, each layer ranging in thickness from a few millimeters to several centimeters, rarely even to several decimeters. The black layer consists chiefly of minute crystals of chromite, associated with a small quantity of olivine or serpentine; the light yellowish green layer is composed essentially of olivine or serpentine with insignificant quantity of scattered crystals of chromite. The lines of division between the layers is usually sharp, but in some instances one layer passes into another gradually.

The banded ore sometimes shows a typical fluxion-structure, the bands being intricately contorted (Fig. 1, (Pl.)).

IV. Microscopic Study of Banded Ore.

Chromite is always of the earliest crystallization. When it occurs as separate crystals imbedded in the light yellowish green layer, it is commonly well crystallized, with sharply-defined crystal-outlines or more or less corroded forms (Fig. 3 (Pl.)), and is surrounded by grains of olivine. Olivine is generally highly altered to serpentine.

The black layer is an aggregate of large and small crystals of chromite, the interstices between them being filled with grains of highly serpentized olivine. It is very characteristic that the chromite individuals of *this layer* are usually accompanied by clusters

of small grains of the same mineral along their margins, indicating that a phenomenon of "crushing" has occurred along the borders and cracks of the larger crystals. The crushed-off-grains as well as the original larger crystals are usually more or less rounded, indicating a *later magmatic resorption* (Fig. 2 (Pl.)) On the other hand, olivine, which fills up the interstices between the crystals and grains of chromite and is commonly highly altered to serpentine, shows no sign of granulation. *It is thus suggested that the granulation along the margins and cracks of the chromite crystals has occurred prior to the crystallization of olivine.*

V. Summary and Conclusions.

It has been observed that, (1) the beautiful, well-defined banded texture of the chromite ore under consideration is due to the alternation of black layers rich in chromite and light yellowish green layers consisting essentially of olivine with insignificant quantity of chromite, (2) the banded ore sometimes shows a fine fluxion-structure, (3) the chromite is always of the earliest crystallization in the dunite magma, being usually more or less rounded in form owing to magmatic corrosion, (4) the chromite crystals in the chromite-rich layers are crushed or granulated along the margins and cracks, (5) the crushed-off-grains as well as the original crystals are magmatically corroded, indicating that the granulation has occurred prior to the crystallization of olivine.

From these observations, it is highly probable that the banded ore was formed by a flowing motion of the crystallizing dunite magma, in which settling of the chromite crystals was going on.⁽¹⁾

1) ~~It is~~ It is hardly conceivable that so typical a banded ore consisting of layers of olivine and those of chromite, sometimes in fluidal arrangement, can develop by crystal-settling and filter-pressing (N.L. Bowen: "Crystallization-Differentiation in Igneous Magmas," Journ. Geol., XXVII, p. 411) or by intrusion of a heterogeneous magma (A. Harker: Memoirs, Geol. Survey, United Kingdom, Glasgow, 1904, p. 90 and p. 119).

The motion of the magma must have been strong, if very slow, to cause so remarkable a granulation along the margins and cracks of the already formed chromite crystals by collision and friction of the individuals as well as of the torn fragments. As to the origin of the magmatic motion in question, the idea of convection after the intrusion, as fully discussed by F. F. Grout¹⁾ with special reference to the Duluth gabbro, seems most attractive.

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1) F. F. Grout, "Internal Structures of Igneous Rocks; Their Significance and Origin, with Special Reference to the Duluth Gabbro," Journ. Geol., Vol. XXVI, 1918, pp. 439-458; "Two-Phase Convection in Igneous Magmas," Journ. Geol., XXVI, 1918, pp. 481-499; "Movements in Crystallizing Magma," Journ. Geol., Vol. XXVIII, 1920, pp. 255-264.

Explanation of Plate.

Fig. 1.—A handspecimen of the banded chromite ore from the Akaishi mine, showing a fluxion-structure. About $\frac{1}{2}$ natural size.

Fig. 2.—Photomicrograph of the black layer of the banded ore. Note the granulation along the margins and cracks of the chromite crystals, and the corrosion of the crushed-off-grains. Magnified 50 diameters. Ordinary light.

Fig. 3.—Photomicrograph of the yellowish green layer of the banded ore. Note the mesh-structure of the serpentized olivine with sporadic rounded crystals of chromite. *It is also to be noted that the serpentine shows no sign of dynamo-metamorphism, notwithstanding that it occurs in the terrain of highly schistose rocks. It is thus suggested that the intrusion of the serpentine in question has taken place after the formation of the schistose structure of the surrounding rocks.* Magnified 50 diameters. Ordinary light.

S, serpentized olivine; O, olivine core.