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A Supplement to "The Metagabbroic Rocks bearing Ferriferous Minerals in the Ryoke Zone, Japan"

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Abstract

A further study has been continued by the writer on the metagabbroic rocks bearing ferriferous minerals in the Ryoke Zone(1), even after a paper was written by him in 1952, in which these rocks were assumed as a granitized kind of such rocks as ferriferous tuff or schalstein. However, he has arrived afterwards at the more probable conclusion on their petrogenesis: These rocks are the ferriferous gabbros, contaminated by sialic materials, which were injected into the Ryoke sedimentaries as sills and then, affected by the metasomatism due to the granitic magma which, in turn, was intruding into these rocks after their consolidation.

Since the general descriptions on the geology and mineralogy of these rocks have already been given, here will be given a short statement only as to what kind of supplementary observation was carried on and to what point of his view was to be revised.

(1) These rocks are medium-grained; their plagioclase crystals are mostly subhedral or anhedral in form and show, due to the complex and parallel twinning law, the twins and seldom simple form. The feldspar is of two kinds, large and small sized; both of which frequently have irregular zoning at their peripheries, whose composition is An_{30-28}* in the Hiiruba rock, and An_{40} in the Sambonmatsu one.

In the large ones there is seen, just as in andesites, the well-shaped oscillatory zonal structure, which is different from the above mentioned irregular zoning. The well-shaped zoning is to take place in magmatic state, while the irregular one in metasomatic state.

(2) Hornblendes and biotite occur poikilitically; the latter penetrates into the formers at the portion of their contact with each other. They are crystallized, as it were, in irregular veinlets along the boundaries of plagioclase, olivine and pyroxenes, the grains of which are scattered in the hornblendes and biotite

* Revised datum.

like so many islands; all this constitutes, as described in the previous paper, a certain kind of reaction texture (PL. XII), which clearly demonstrates the metasomatic origin of the hornblendes and the biotites.

So much about the microscopic obervation. As for the field observation, it is noticeable that at or near the boundaries between these rocks and the granitic ones, there the olivine and the pyroxenes suffered much more metasomatism and, consequently, the hornblendes and biotite were increased, while the olivine and pyroxenes diminished, and also the almandine garnet was sporadically formed; the fact that this occurs in these rocks, as a porphyroblast, only at the portion rich in colourless minerals, informs us that the crystallization of the garnet was probably due to some metamorphic differentiation: Such was the formation of the melanocratic granodiorites enclosing the metagabbroic rocks as described in the previous paper.

(3) The quartz is anhedrally crystallized out between other crystals except the hornblendes and biotite, and fresh and clear due to the absence of any microcrystal in its body. In the case of the quartz coming into contact with the olivine, no kelyphytic border appears around the olivine, and therefore the quartz and the olivine can probably coexist in equilibrium. Beside the above mentioned mode of quartz occurrence, there is another mode of it, namely, of its replacement of other minerals along their cleavages and margins. These two different modes of quartz seem to represent two different stages of our rock formation.

(4) From their optical properties, as given in the previous paper, the chemical composition of the refractory coloured essentials in the Hiiruba and Sambonmatsu rocks are as follows.

	olivine	monoclinic pyroxene	orthopyroxene
Hiiruba rock	fayalite* (Fa_{95} ca.)	ferroaugite Wo_{35} En_{23} Fs_{42}	eulite En_{16} Fs_{84}
Sambonmatsu rock	none	none	ferrohypersthene En_{33} Fs_{62}

Having very few or no oriented plates of clinopyroxene in the bodies, those orthopyroxenes in the rocks seem to have been crystallized out probably at a lower temperature than the inversion point of Mg–Fe clinopyroxene and orthopyroxene.(2) As the hornblendes and biotite, in the Hiiruba rock, are generally crystallized around each crystals of the olivine and the pyroxenes due to the remarkable metasomatism caused by the granitic magma, the mutual relationship between the olivine and the pyroxenes was not explainable in the previous paper by means of their microscopical observation.

* supplementary data: $\gamma > 1.860$, $\alpha \geqslant 1.805$, $2V = 56\text{–}54°$

The following points, however, were made clear from recently acquired specimen in which the bornblendes and biotite were poorly developed. Generally the olivine and the pyroxenes, separated by feldspar, are found ophitically between the plagioclase crystals and seem to occupy the respective positions. According to the observation, however, in the portion where the olivine and the pyroxenes are rarely adjacent to each other, the fayalite and the eulite seem to coexist in the like manner as the fayalite and ferroaugite, or the ferroaugite and eulite do: According to the studies done hitherto, fayalite and eulite, respectively, stand in the relation of parallel crystallization with ferroaugite,[2][3] and the writer's observation offered him hardly anything that suggests a reaction relation between the fayalite and the eulite. As clear from the two dry melt systems ($MgSiO_3$–$FeSiO_3$, MgO–FeO–SiO_2),[3] the Fe-rich clinopyroxene and fayalitic olivine stand indeed in reaction relation at higher temperature. But their crystallization behaviour in the melt at a lower temperature than the inversion point described above remains still unknown of the orthopyroxene and fayalite, whose chemical composition is similar to those of the minerals contained in the Hiiruba rocks. From the studies on $MgSiO_3$–$FeSiO_3$ system, it is true that these three mineral: fayalite, eulite and quartz, coexist in their solid state at a lower temperature than the inversion point.

The genetical consideration of the rocks (revised)

(1) The features as described in the previous paper once led the writer to the opinion that all the said minerals contained in these rocks, have attained their crystallization in two stages. The existence of the two different stages of their crystallization is clear and plain from the supplementary data stated already in the present paper: the minerals belonging to the first stage are: olivine, pyroxenes, plagioclase represented by the inner part of its zonal structure, and also quartz having grown interstitially between the formers. The minerals belonging to the later stage are: hornblendes and biotite, feldspar as is the case with the irregularly zoned margin of its crystal, probably quartz replacing frequently other minerals and almandine garnet.

(2) A weak turbidity is seen in some calcic core portion of the feldspar crystals, owing to the inclusions of several kinds of microcrystal, and ascribed by some authors[4] to the recrystallization. At a first glance, the coexistence of fayalite, eulite, ferroaugite and quartz in the Hiiruba rock seems to be explainable by the idea of recrystallization. However, the general texture of the assemblage of the minerals belonging to the first stage is as a whole igneous, i. e., porphyritic gabbro, texture which is usually observed in ferrogabbro. And all the minerals produced in the second stage are of no recrystallization, but, as already told, of metasomatical crystallization. Moreover, except some core part of the plagioclase, all the minerals of the first stage are quite fresh and clear. Also from their

geological evidences, it can safely be said that these rocks in question occurred in igneous sills. From these facts, it can hardly be considered that these minerals were recystallized out.

(3) In the previous paper it was written by the writer that the granitization was playing a very important rôle through the two different stages of the formation of the minerals. The consideration of the data already stated in the present paper forced him to revise his former view: the minerals belonging to the first stage were formed from the basic magma: whereas, due to the metasomatism caused by the granitic magma, the minerals belonging to the second stage were brought to their crystallization.

(4) Then, what kinds of gabbro are these of the first stage? The comparatively low crystallization temperature of the pyroxenes contained in these Ryoke rocks informs the writer that they were derived from a magma rich in volatiles due to its contamination by some sialic materials. Similar kind of rocks has been reported from various districts, though few in number: The gabbro contaminated by sialic materials in Aberdeenshire(5), for example, involves Fe–rich orthopyroxene, and the gabbro contaminated by iron ore in Upper Harz(6) contains fayalite, ferroaugite and orthopyroxene. The Sambonmatsu rock and the basic xenoliths(7) in the granitic rock reported by Iwao resemble the former, and the Hiiruba rock the latter. These foreign rocks, however, seem to have not been affected by granitization after their consolidation.

Moreover, judging from the crystallization behaviour and the mineralogical properties of the pyroxenes, these rocks in the Ryoke Zone are of different origin from the ferrogabbro, e. g., those in Karroo,(8) and in Skaergaard,(9) occuring in Kratogen and being regarded as a differentiate of the later stage in the magmatic differentiation; these Ryoke rocks owe their formation mainly to magmatic contamination, and the ferrogabbros in Kratogen to the differentiation of the olivine tholeiitic magma.

Appendix

The writer received a communication from an English petrologist on the difference between charnockites and these Ryoke rocks. The writer's opinion thereof is as follows:

1) If there were the charnockite of magmatic origin having not greatly suffered regional metamorphism, it would be similar to these Ryoke rocks.

2) Charnockite may represent a kind of metamorphic rocks which have been produced under influence of high, mainly uniform pressure at great depth in the earth crust.

In these both cases, it is very remarkable that the minerals contained in the charnockite and those of the first stage of these Ryoke rocks, though similar in kind, are quite different from each other in their properties. Moreover, the recent studies on the Ryoke metamorphics offer us hardly any evidence to believe that a metamorphism of so high a degree as that of granulite facies has ever been taken place there.

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Plate XII

Explanation of Plate XII

Fig. 1. The ferriferous metagabbroic rock, Hiiruba.
p :—plagioclase. q :—quartz. h :—amphibole (the darker coloured marginal portion ....brownish green hornblende. the lighter coloured inner portion......grunnerite.) ×23. Crossed nicols.

Fig. 2. The reaction structure of the amphibole in the rock. (The mineral has the irregularly shaped patches of olivine, plagioclase, etc.)
o :—olivine. p :—plagioclase. ×23. Crossed nicols.

Fig. 3. The same structure around the rhombic pyroxene in the rock.
r :—rhombic pyroxene with the mesh structure of iddingsite. h :—amphibole. ×23. Crossed nicols.

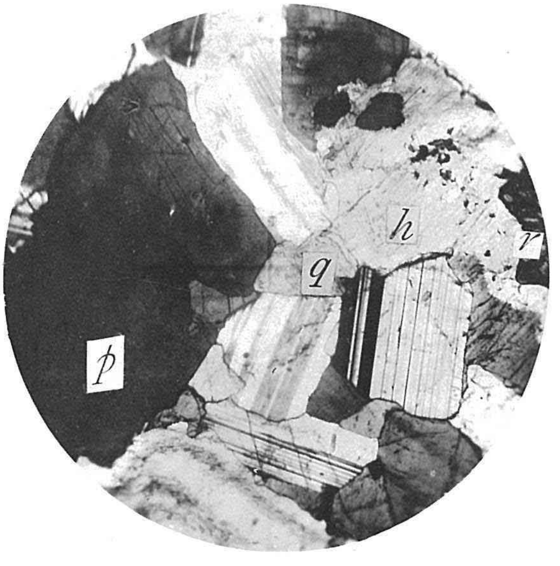

Fig. 1.

Fig. 2.

Fig. 3.

Crossed nicol ×23