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Finding of Inverted Pigeonite from the Gabbro in the Mikabu Zone at Kamiyama, Eastern Shikoku, Japan.*

By

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Abstract

The authors have found inverted pigeonite from the gabbro in the Mikabu zone at Kamiyama, Tokushima Prefecture.

This paper contains a brief description of the gabbro, and the results of chemical analyses using E.P.M.A. for pyroxenes. The chemical composition of the pyroxenes of the gabbro is nearyly equal to that of the pyroxenes from the Bushveld intrusive body. Their conclusion is that the gabbro in this area is a hypabyssal intrusive rock derived from the tholeiitic magma.

Introduction

In the course of the geological and petrological studies of the Mikabu zone, the authors have recently found inverted pigeonite in the gabbro at Kamiyama, Tokushima Prefecture.

This is the first finding of inverted pigeonite in the gabbro of the Mikabu zone.

The Mikabu zone occupies a characteristic position in the process of the tectonic movement of the Sambagawa metamorphic zone.

It is the "igneous activity area" in the Sambagawa metamorphic zone in the geosynclinal stage and also in the conversion stage from geosyncline to geoanticline.

Namely, the zone is characterized by submarine volcanism at the geosynclinal stage and hypabyssal basic and ultrabasic intrusions at the conversion stage (Nakayama, 1960).

The gabbro carrying the inverted pigeonite in this area is one of these basic intrusive rocks.

Geological Setting

The results of the geological survey on the extensive region including this area have been published by the Kenzan Research Group (the Collaborative Research Group for the Sambagawa metamorphic zone of Shikoku) (1963).

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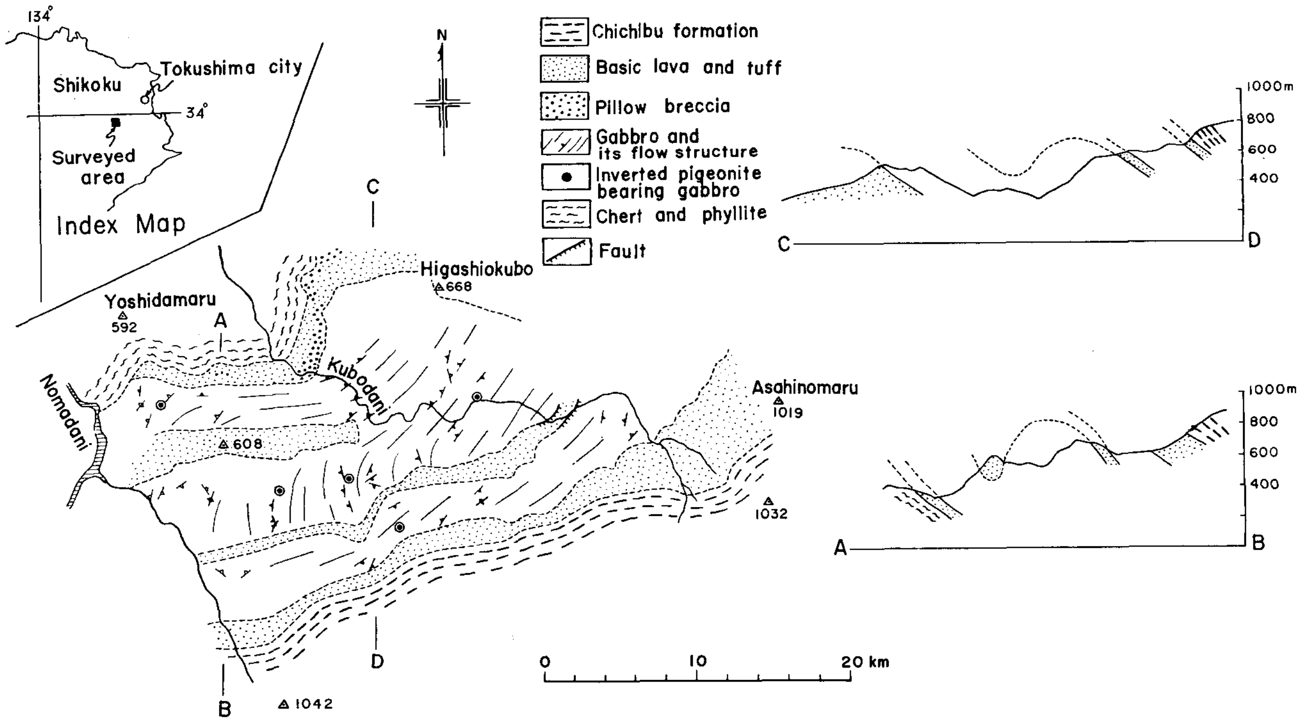

Fig. 1. Geological sketch map of the Mikabu zone at Kamiyama.

Table 1. Stratigraphical succession

Red chert and red "schalstein".
Gabbro
Basic tuff and lava
Gabbro
Basic tuff, lava, and pillow breccia
Chert and pelitic phyllite

In that paper, the rocks in the Mikabu zone of eastern Shikoku are named Koyadaira formation as a whole.

However, by further observation made since 1967, more detailed data concerning the geology of the area have been obtained by the authors. The geological map of the area is shown in Fig. 1. The stratigraphical succession of the area is shown in Table 1.

The uppermost strata in the area are overlain conformably by strata belonging to the so-called non-metamorphic Chichibu formation which may be correlated to the Middle Permian system.

The authors have surveyed the occurrence of the gabbro, and have found it to be exposed as two sheets. The relations between the sheet and surrounding strata are conformable.

The whole strata bearing the sheets have been folded and have suffered the regional metamorphism of glaucophane type. The direction of the folding axes is east-west with plunging to 10° to 15° to the west.

In several parts of the gabbro masses flow structure due to the dimensional parallelism of plagioclase or trends of schlieren are found (Plate 4, Fig. 2). The trends of flow structure are shown in the geological map. The trends in places forming monoclinal structure are in harmony with the shape of the gabbro masses, although those in the gabbro mass forming anticlinal structure have in places crossing directions to the shape of the gabbro mass.

In the gabbro masses ultrabasic or ultramafic intrusive body is not found.

Brief note on the gabbro

The gabbro consits of various lithologic facies, in which fine-grained melanocratic gabbro with ophitic texture, medium and coarse-grained gabbro are found.

These gabbros contain clinopyroxene, plagioclase, hornblende, quartz, magnetite, ilmenite, apatite and rarely chalcopyrite as primary minerals, and pumpellyite, chlorite, serpentine, glaucophane and aegirine augite as secondary minerals.

The inverted pigeonite-bearing gabbro is found in several parts of these gabbro masses and is characterized by ophitic texture. The primary minerals it contains are augite, plagioclase, hornblende, inverted pigeonite and magnetite in general, but sometimes it also contains quartz and olivine as primary minerals.

The augite of forms an irregular crystal plate in thin slice and has in places striation of the diallage type or of the salite type. The augite from the inverted pigeonite-bearing gabbro has striation of latter type.

The hornblende occurs in long shaped prism or as chadacryst in the clinopyroxene of host crystal. The colour is brown or sometimes green. Frequently, brown hornblende in core is mantled in green hornblende.

The plagioclase occurs in appearance in the next three types.

The plagioclase of the first type is idiomorphic crystal and has suffered intense saussuritization (Plate 5, Fig. 3). The second type is characterized by micrographic intergrowth with quartz and has also suffered saussuritization (Plate 5, Fig. 2). The third type is represented by fresh albite and occurs as albite vein and surrounding of the plagioclase of the second type.

The most usual occurrence of plagioclase is in the first type, although the latter two types are sometimes found in the slices of the gabbro.

Besides the occurrence mentioned above, quartz grains occur in irregular form. Whether quartz grains are original or decomposition products are sometimes difficult to decide, but when the mineral forms a part of micrographic intergrowth with feldspar, its primary nature may be safely assumed.

Table 2. Modal composition of the inverted pigeonite-bearing gabbro (volume ratio).

Sample	6782501-c	6782501-q	7082502
Pigeonite	4	2	5
Augite	32	17	30
Hornblende	12	16	8
Plagioclase	47	56	49
Magnetite	5	9	8

The modal composition of the inverted pigeonite-bearing gabbro in the samples from three localities is shown in Table 2. As a matter of course, the various metamorphic minerals are recognized, but they were restored to their original minerals.

Inverted pigeonite and co-existing pyroxene

POLDERVAART and HESS (1951) summarized the exsolution lamellae in different pyroxenes. BROWN (1957) reported on his detailed study of the inverted pigeonite of the Skaergard intrusive body.

The inverted pigeonite in the gabbro in this area is in appearance in agreement with the inverted pigeonite recognized by the investigators mentioned above.

Namely, the inverted pigeonites in the gabbro are characterized by "herring bone" structure and augite lamellae exsolved from pigeonite is parallel to (001) and is preserved in the orthopyroxene of the host (Plate 1, Figs. 2, 3). Also, exsolved augites are found as blebs or patches elongated parallel to (001) of the original pigeonite (Plate 4, Fig. 4; Plate 5, Fig. 2). However, at present the orthopyroxene of the host is converted into bastite.

The optical constants of lamellae augite in inverted pigeonite cannot be exactly

Table 3. Chemical composition of lamellae augite and co-existing augite.

	Lamellae augite	Augite*
SiO_2	52.9	52.1
TiO_2	0.4	0.6
Al_2O_3	1.5	2.0
$\sum FeO$	11.8	12.4
MgO	13.4	13.1
CaO	20.7	19.8
NaO	0.3	0.4
Total	101.0	100.4

* Whole analysis of augite containing "striation part".

Atomic proportion for 6 oxygen atoms.

	Lamellae augite		Augite*	
Si	1.964	2.000	1.953	2.000
Ti	0.010		0.056	
Al	0.026		—	
Al	0.040	1.997	0.027	1.972
Fe	0.366		0.387	
Mg	0.747		0.735	
Ca	0.822		0.796	
Na	0.022		0.027	
Ca	42.7		41.5	
Mg	38.5		38.4	
Fe	18.8		20.1	

Analyst: M.Komatsu

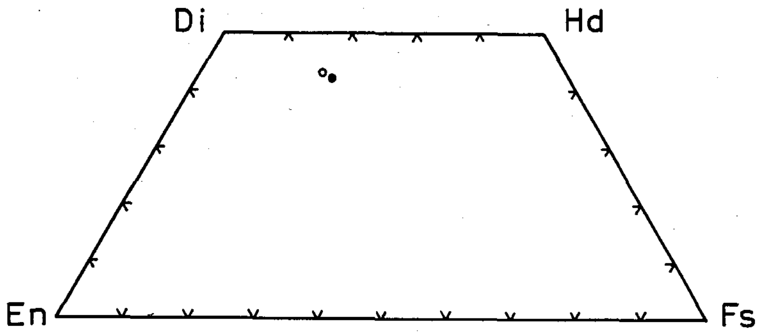

Fig. 2. Analytical results in the pyroxene quadrilateral.
Open circle: Lamellae augite Closed circle: Co-existing augite

determined due to the thinness of plate (0.01–0.03 mm). The optical constants of co-existing clinopyroxene are mentioned below.

2Vz : 52°

β : 1.693$\pm$0.003

The analytical results obtained by E.P.M.A. of the lamellae augite and oc-existing augite are shown in Table 3.

The results occupies positions near that of Bushveld (BOYD and BROWN, 1969) in the pyroxene quadrilateral (Fig. 2).

Petrological significance of the finding of inverted pigeonite

Two types of parent magma have been distinguished by KENNEDY (1933) such as the tholeiitic and olivine basalt magma types. According to KENNEDY two distinctive criteria of the tholeiitic basalts, as contrasted with olivine basalts, are prevalence of pigeonite and common presence of an acid residum.

POLDERVAART (1951) discriminated several types of the exsolution phenomena of pyroxene, and concluded that in volcanic rocks pigeonite is preserved by quenching as a metastable phase, and that in intrusive rocks it exsolves augite plates parallel to the (001) plane and is subsequently inverted to orthopyroxene.

These rules based on experiences have been generally accepted in current literatures.

The authors conclude, therefore, that the gabbro in this area is an intrusive rock derived from tholeiitic magma.

Acknowledgement

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Explanation Plates

Plate 4.

Fig. 1. Flow structure in the inverted pigeonite bearing gabbro. ×7/10

Fig. 2. Inverted pigeonite having "herring bone" structure. Crossed nicol. ×100

Fig. 3. Ditto Crossed nicol. ×35

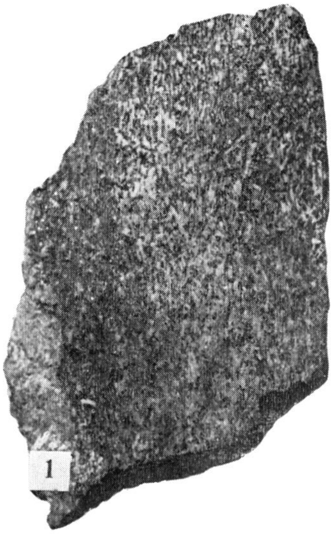
Fig. 4. Exsolved augite occur as blebs and patches. Crossed nicol. ×35

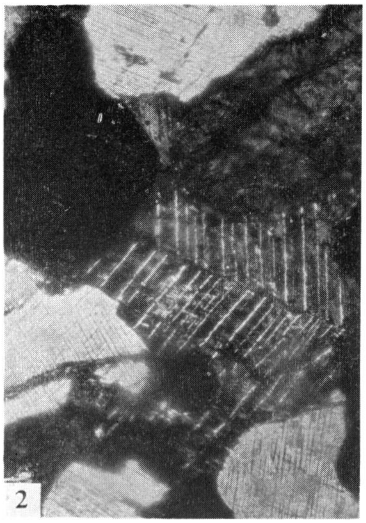
Plate 5.

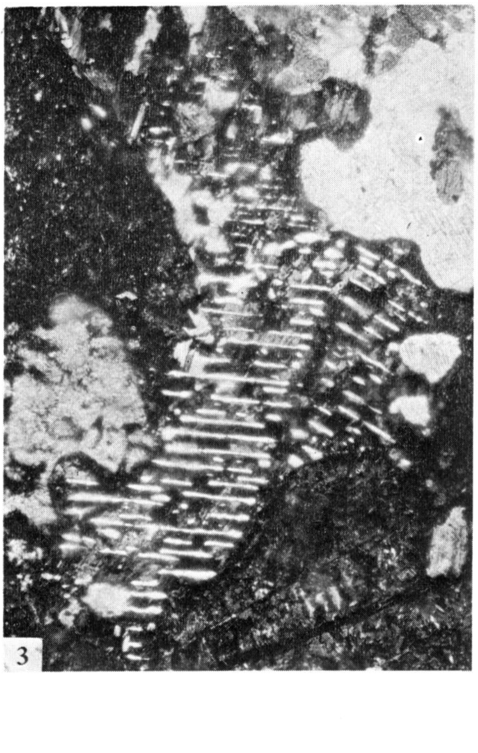
Fig. 1. Inverted pigeonite and co-existing augite with salite striation. Crossed nicol. ×35

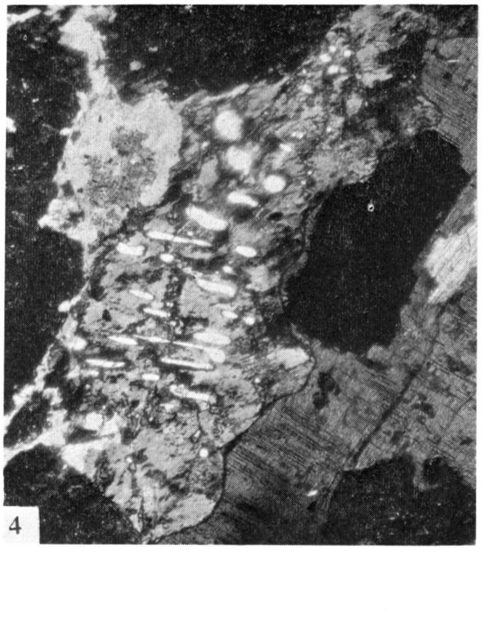
Fig. 2. Micrographic intergrowth of quartz and saussurized plagioclase. Crossed nicol. ×35

Fig. 3. Inverted pigeonite, augite and oriented saussurized plagioclase. Crossed nicol. ×35









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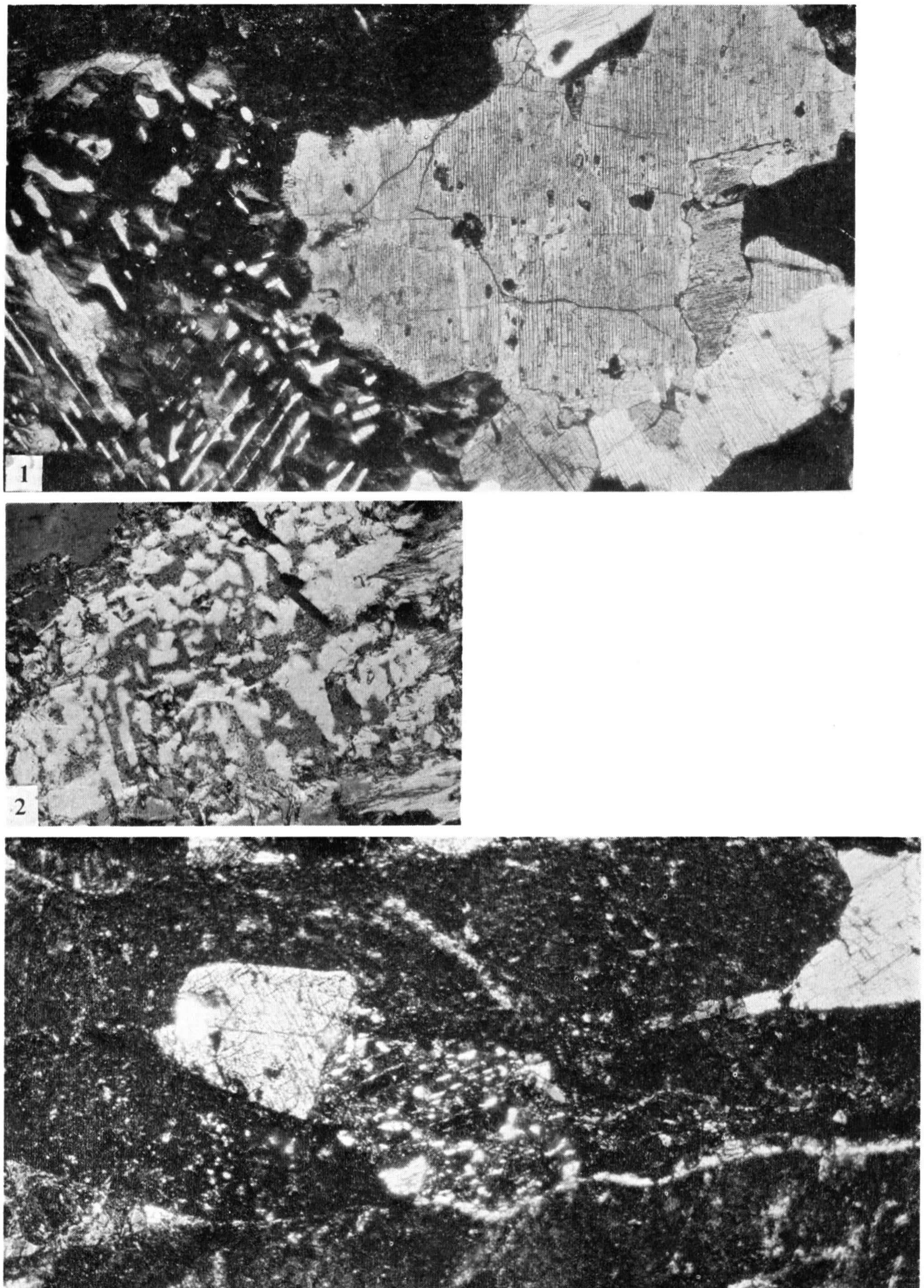

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