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GABBROIC INCLUSION IN THE MIOCENE ANDESITE FROM ISOTAKE, OODA CITY, SHIMANE PREFECTURE, JAPAN.

By

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I. Introduction

Present author recently found gabbroic inclusion in the Miocene andesite from Isotake, Ooda city, in western most district of San'in-Hokuriku green tuff subregion of Japan.

Needless to say, it is important problem in petrogenesis to know of what materials, not only the upper mantle but also the basement of the crust, are composed.

At least some of the upper mantle must be able to yield igneous magma by partial melting ; it is not clear, however, to what depths the upper mantle must meet this requirement.

To consider these problem the study on the inclusion that the upper mantle or basement of the crust must provide a source are well worth performing, because it may provide some important knowledges on the mantle, basement of crust and origin of igneous magma.

II. Host rock and mode of occurrence of gabbroic inclusion

Gabbroic inclusion was collected at 447.3m. depth in boring core at Isotake, Ooda city, Shimane prefecture. The locality of gabbroic inclusion is shown in Fig. I.

The host rock of gabbroic inclusion at Isotake is hornblende bearing augite andesite intruded into the sandstone member of the Miocene Kawai formation and it may be that this intrusive body belong to the Miocene Kuri formation.

Phenocrysts of this andesite are plagioclase, augite and hornblende. Plagioclase phenocryst is zoned, with many dusty inclusions often arranged parallel to it. Augite phenocryst is commonly altered to chloritic clay minerals. Hornblende phenocryst occurs chiefly as euhedral form. It is commonly undergone recrystallization and corrosion. As the result of this reaction, it is rimmed by a mixture of pyroxene, magnetite and undetermined minerals.

The groundmass is fine grained texture. It carries plagioclase, augite, cristobalite, opaque minerals and cryptocrystalline minerals. Furthermore, carbonate and clay minerals as alteration minerals are formed in both phenocryst and groundmass in

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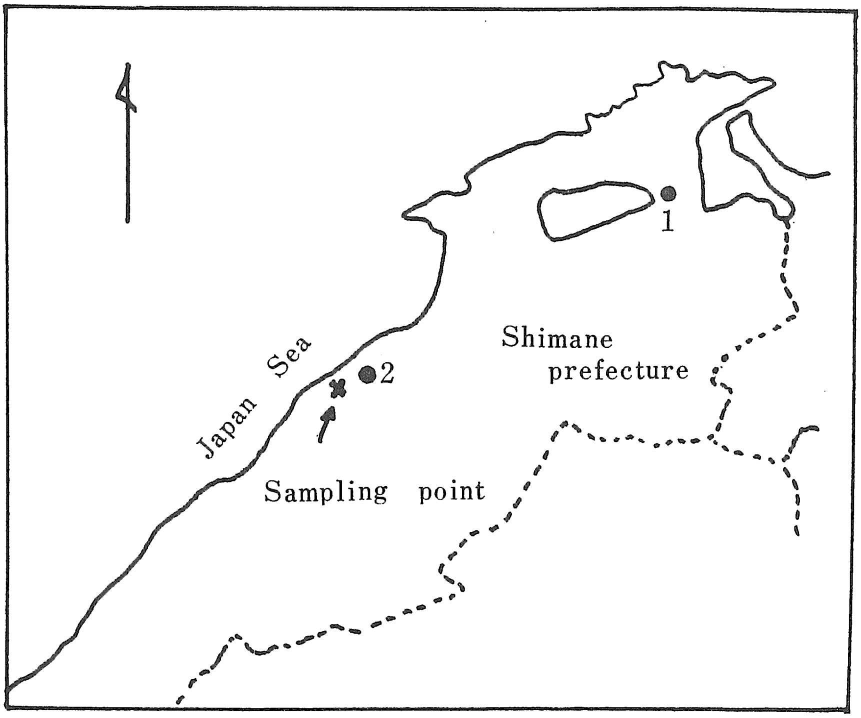

Fig. I. Locality of the gabbroic inclusion.
1 : Matsue city
2 : Ooda city

large qauntities.

The chemical composition of hornblende bearing augite andesite, which is a host rock of gabbroic inclusion at Isotake, Ooda city, together with its normative composition is shown in Table I.

Table I. Bulk and normative composition of the host rock of the hornblende gabbroic inclusion at Isotake.

Weight (%)		Norm	
SiO_2	57.10	q	15.00
TiO_2	1.09	or	5.56
Al_2O_3	12.31	ab	32.49
Fe_2O_3	5.04	an	13.62
FeO	3.21	wo	11.60
MnO	0.20	en	6.90
MgO	2.77	fs	0.16
CaO	8.71	mt	7.42
Na_2O	3.84	il	2.13
K_2O	0.98	ap	0.67
P_2O_5	0.34		
$H_2O(+)$	1.61		
$H_2O(-)$	3.54		
Total	100.74		

III. Chemical composition of gabbroic inclusion

Bulk and normative composition of gabbroic inclusion at Isotake is given in Table II. Still more, bulk composition of gabbroic inclusion in andesites from some regions in Japan reported by Yamazaki *et al.* (1966) are shown for comparison in same Table.

Table II. Bulk and normative composition of hornblende gabbroic inclusions.

	Weight (%)			Norm	
	A	B	C		A
SiO_2	41.04	40.22	41.56	or	0.83
TiO_2	0.54	1.55	1.30	ab	7.34
Al_2O_3	21.52	21.74	22.36	an	54.49
Fe_2O_3	2.97	5.50	3.32	wo	12.64
FeO	3.75	4.05	4.76	en	1.40
MnO	0.25	0.09	0.11	fs	0.53
MgO	5.15	7.08	8.36	fo	7.98
CaO	17.15	13.51	14.00	fa	3.26
Na_2O	0.85	2.07	1.27	mt	4.41
K_2O	0.14	0.49	0.61	il	1.06
P_2O_5	0.07	0.05	0.04	ap	0.17
$H_2O(-)$	1.86	1.29	0.67		
$H_2O(+)$	4.92	2.05	1.53		
Total	100.18	99.69	99.89		

A : Hornblende gabbroic inclusion from Isotake, Shimane prefecture.
B : Hornblende gabbroic inclusion from Shigarami, Nagano prefecture. (quoted from Yamasaki et al. (1966))
C : Hornblende gabbroic inclusion from Kujiranami, Niigata prefecture. (quoted from Yamasaki et al. (1966))

Although the analysed specimen from Isotake is richer in lime and poorer in alkali with compared that from Shigarami and Kujiranami, it is noticeable fact that these inclusions have similar characteristic feature in chemistry.

As it was discussed in detail by Yamazaki and his co-workers, in spite of the similarity of mineralogical composition, these gabbroic inclusions in andesitic rocks are widely different from amphibolite and appinite in chemical composition.

In short, gabbroic inclusions in andesitic rocks may be formed under different geological process compared to the amphibolites and appinites.

IV. Mineralogical character of gabbroic inclusion

The chief constituent minerals of gabbroic inclusion, except secondary minerals, are plagioclase, amphibole and clinopyroxene.

Plagioclase is very fresh and it has no zoning and C-twin by Gorai (1956) under the microscope.

The chemical composition determined by X-ray powder method adovocated by Smith et al. (1956(is nearly pure anorthite as shown by Fig. II. It is a matter of course that

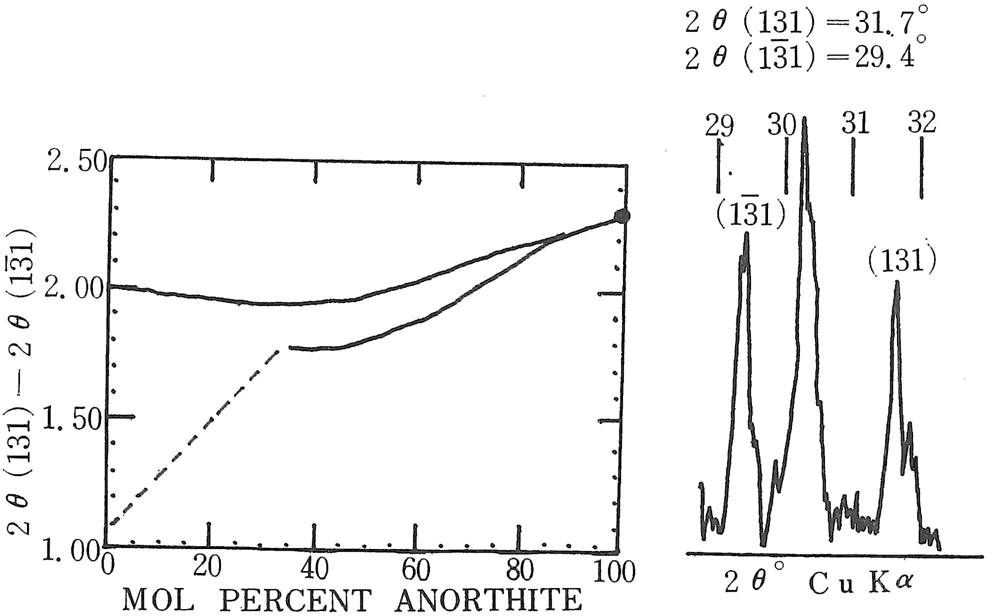

Fig. II. Anorthite content of plagioclase of gabbroic inclusion by Smith *et al.* (1956).
The symbol of circle represent the composition for plagioclase.

such highly calciferous nature of plagioclase is not expected in ordinary plutonic rocks. On the other hand, from the result of observation that it has C-twin type, it seems likely this gabbroic inclusion do not belong to the metamorphic rocks in strict sense.

Amphibole is slightly altered to montmorillonite as shown by Fig. III. It is large

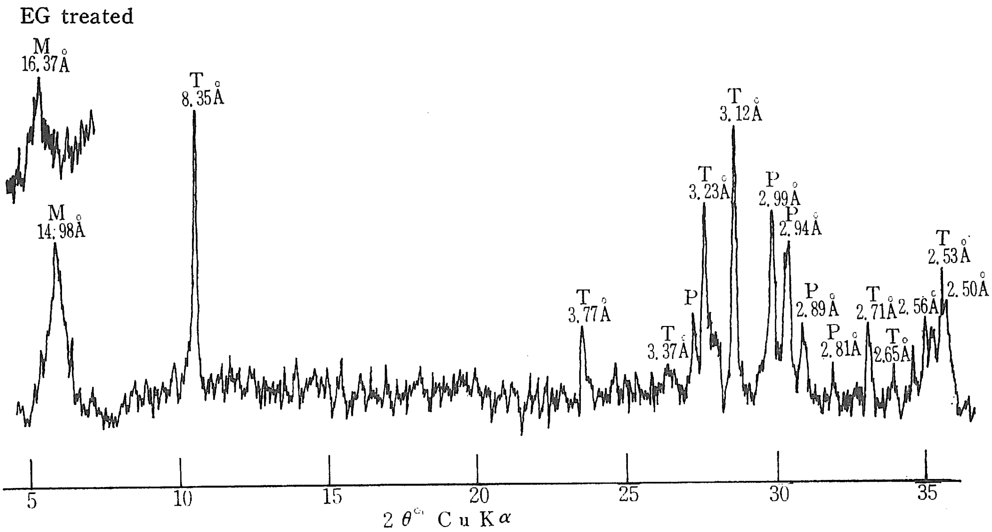

Fig. III. X-ray powder diffraction pattern for ferromagnesian minerals of gabbroic inclusion.
M : Montmorillonite
T : Tremolite
P : Clinopyroxene

crystal and has random orientation. As shown by Fig. III, amphibole of this gabbroic inclusion is tremolite.

Pyroxene is scattered between plagioclase and amphibole. Each grain of pyroxene takes random orientation. It is clinopyroxene as shown by Fig. III.

As previous mentioned, amphibole is slightly altered to montmorillonite. Furthermore, as the secondary formed minerals, sericite and chlorite are slightly formed in the boundary of the primary minerals as shown by Fig. IV.

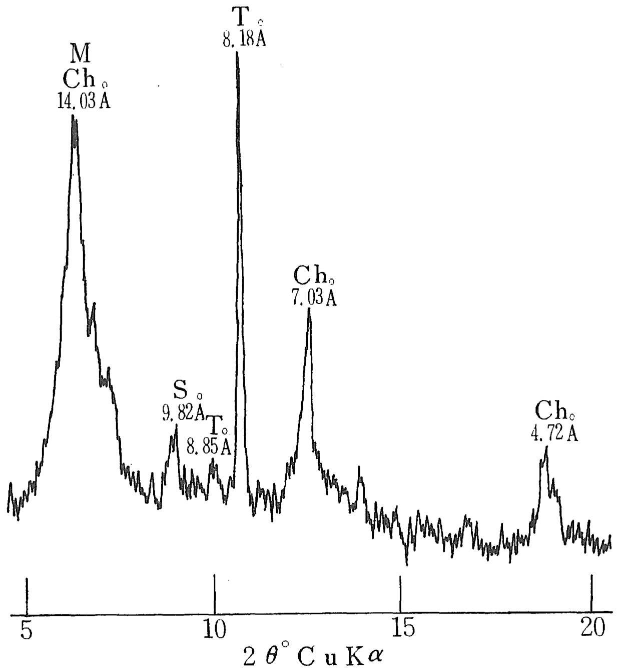

Fig. IV. X-ray powder diffraction pattern for gabbroic inclusion.
M : Montmorillonite
Ch : Chlorite
T : Tremolite
S : Sericite

V. Origin of gabbroic inclusion

As already mentioned the gabbroic inclusion at Isotake has similar characteristic feature compared with that from Shigarami and Kujiranami. Furthermore, the gabbroic inclusions associated with peridotite inclusions are often found in alkali basalt at Oki island, Shimane prefecture. From these result, it suggests the existence of similar materials to those gabbroic inclusions in considerable amounts under the Japanese island.

For consideration about the origin of gabbroic inclusion, we must pay attention to the fact that these gabbroic inclusins are not found in oceanic regions.

Kuno (1968) discussed in detail the relation between the origin of the andesite magma and gabbro connect with the growth of island arc. That is to say, the initial stage of the island arc structure was the formation of an arcuate fissure through the oceanic structure. Basalt magma first risen through this fissure. By repeated outpouring of the magma, the oceanic crust is thickened. Andesite magma is produced by fractionation in magma reservoirs which are eventually formed in this thickened crust. The extrusion of andesite magma contributes to further thickening of the crust, coupled with formation of more voluminous masses of gabbro left after the solidification of the reservoirs through fractionation of basalt magma. The thick lower layer was probably formed by addition of a voluminous gabbroic bodies to the lower crustal layer of the ocean basin, representing the complementary matrial for the Paleozoic and Mesozoic volcanic rocks. Gabbroic rocks formed through such processes should be present somewhere in the upper mantle or in the crust under the Japanese island.

The Cenozoic orogenic activity in San-in province caused buckling of the crust formed through these geological processes, and parts of it, in San-in region, were downwarped. Consequent upon this, large-scale partial melting of gabbroic crust may have occurred. Free water from the earlier breakdown of amphibole seems to be more effective for partial melting of gabbroic rock. The Miocene andesite as host rock of gabbroic inclusion is believed to have formed in this way. It may be given as a conclusion that the gabbroic inclusion contained in andesite from Isotake is cognate partial melting residua from the gabbroic lower crust representing what is left behind after extraction of a partial melting fraction. And it was brought out through the process of extraction of andesite magma as a partial melting fraction.

The concept that andesite magma as host rock was originated by partial melting of gabbroic lower crustal matrials would be consistent with volumetric predominance of acidic volcanic rocks of the Miocene in age around Ooda city. Viewed from a different angle, the experimental result that calcic plagioclase, an essential component of gabbro, is not stable at upper mantle pressure / temperature condition as showned by Kushiro et al. (1966) is moerover a factor supported this concept.

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