On the Kitaôshima Granite Gneiss Complex

By

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with 1 Table, 5 Text-figures, and 5 Plates

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ABSTRACT: In the Yanai-Yashirojima (Oshima) district, Yamaguchi Pref., in the Ryôke metamorphic belt, a composite mass consisting of granite gneiss (orthogneiss) and basic gneiss occurs surrounded by the layered syntectic granodiorite. Various features, especially such as agmatitic behaviour in granitization, the presence of metamorphic dyke and granitized "fault", strongly suggest that the granite gneiss complex had been brought up to the tectonic level of brittle fracturing in the state of gneiss before the metamorphism and granitization of the Ryôke age began. It is suggested that the Kitaôshima granite gneiss complex would represent a fragment of the basement under the Upper Palaeozoic geosyncline in the innerside of Southwest Japan. Furthermore, the possibility of pre-Permian land between the innerside and the outerside of Southwest Japan is suggested.

CONTENTS

I. INTRODUCTION

In the early days of Japanese geology, gneissic rocks, including the Ryôke gneiss, were assigned to the Precambrian in age. In these three decades, especially after the paper of KOBAYASHI (1941) on the Sakawa orogenic cycle, in which the Ryôke metamorphism was assigned to the Early Cretaceous, no one has insisted the presence of Precambrian gneiss in the Ryôke belt, but the gneissic rocks in this belt have been believed to be the metamorphic derivatives from Palaeozoic rocks in the innerside of Southwest Japan. Discussions were diversified only with respect to the age of metamorphism. In the recently published laborious monograph, "*The Geologic Developments of the Japanese Islands*" (1965), the Ryôke metamorphism and plutonism were viewed to have been occurred in some age between the Permian and the Late Triassic, accompanying the Honshû tectogenetic movement, which roughly corresponds to the Akiyoshi orogenic cycle by KOBAYASHI. However, data of radiometric age determination, increasing in number recently, indicate the age of the Upper Cretaceous for the rocks in the Ryôke belt.

It has been known in the Ryôke belt that there are various kinds of granitic rocks having planar structures, such as layering, trains of mafic clots, and schistosity, but, in most cases, they were lumped together in such terms as gneissic granite or gneissose granodiorite. The senior author published a paper (1966), emphasizing the geological significance of foliated metamorphic rocks derived from plutonic rocks of granitic composition, and suggested the presence of a granite gneiss complex before the Ryôke metamorphism in the Yanai-Yashirojima (Oshima)[1] district, Yamaguchi Pref.

II. GEOLOGICAL SITUATION

Along the northern boundary of the Ryôke belt, there are several districts where we can trace progressive metamorphism of Palaeozoic rocks from the north to the south. In the Yanai district, complete succession of petrographic as well as petrofabric changes of Palaeozoic rocks is observed (KOJIMA and OKAMURA 1952, NUREKI 1960, OKAMURA 1960, OKAMURA and NUREKI 1962).

To the north of the metamorphic belt of the Yanai district, there occur Palaeozoic rocks, consisting of slate, sandstone and banded chert, with minor amount of limestone. KOJIMA (1953) named them the Kuga group. After Fusulinid fossils found in the limestone, the age of the group is believed to be Permian, presumably Middle to Upper Permian in the main. The Kuga group presents a remarkable contrast to the other Permian groups in Southwest Japan in that no product of basic vulcanism is inserted into the sedimentary formations.

From the region of non- or least metamorphic rocks can be traced toward the south successive changes by metamorphism, which are arranged by NUREKI (1960) into three zones, namely, the zone of schistose hornfelses, the zone of transitional rocks, and the zone of migmatites. Lithological characters of the original formations are quite consistent throughout these metamorphic zones. The area shown in Fig. 1 belongs to the zone of migmatites.

The basement of the Yanai-Yashirojima district, now under consideration, is occupied by the Palaeozoic sedimentary gneiss, syntectic layered granodiorite, massive granodiorite, and a complex composed mainly of granite gneiss and amphibolite or basic gneiss. The sedimentary gneiss is represented by banded mica gneiss, consisting of biotite, muscovite, almandine, cordierite, sillimanite, plagioclase, K-feldspar, and quartz, associated with siliceous banded gneiss of chert origin. The sedimentary gneiss often shows various features of anatexis, such as formation of plagioclase porphyroblasts, metatexis, and injection by quartzo-feldspathic veinlets. In some parts, especially near the layered granodiorite, the sedimentary gneiss grades into coarse-grained, igneous-looking rocks of granodioritic composition with nebulitic structure, in which the ghost of folded structure of the Palaeozoic rocks can be perceived. The distribution of the sedimentary gneiss is arranged into two discrete belts: one from Yanai to Obatake, Maeshima, and Kuroshima, and another from Hikari to Atsuki and Oki-

1) 柳井・屋代島 (大島)

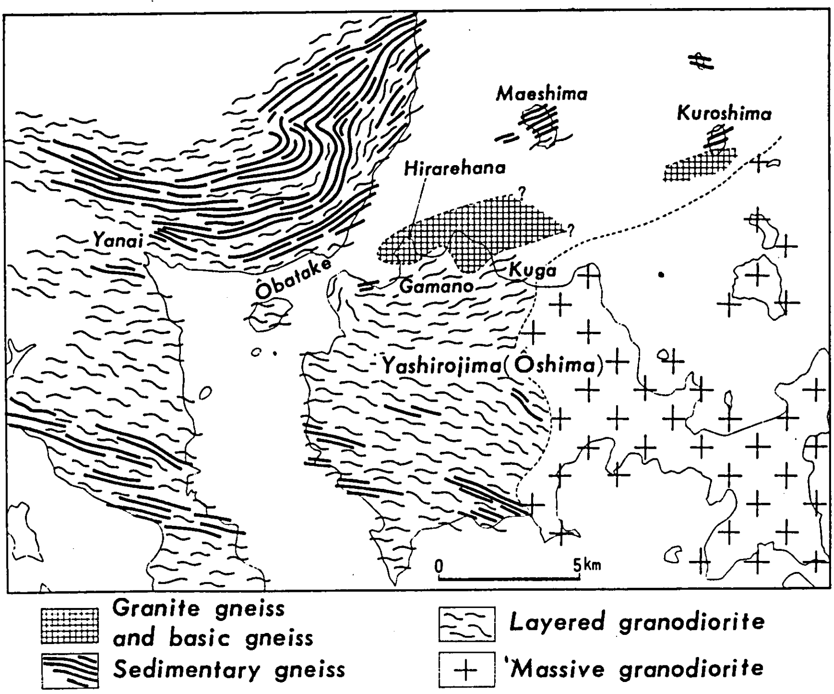

FIG. 1. Geological sketch map of the basement rocks of the Yanai-Yashirojima (Oshima) district

ura, which is represented by the distribution of sedimentary gneiss in the lower third of the map, Fig. 1. In the former belt, named **the Obatake gneiss belt** tentatively, formations of gneiss can be traced rather continuously, while in the latter belt, **the Okiura gneiss belt**, gneiss beds are distributed intermittently. This difference would reflect that of intensity of granitization between the two belts.

Most part of the map area, Fig. 1, except for the southeastern part, is occupied by the syntectic layered granodiorite, which includes the Obatake, Okiura and Gamano gneissic granodiorites after OKAMURA. In this paper, they will be named **the Gamano layered granodiorite** as a whole, because no significant difference can be detected between them. The granodiorite is medium- to coarse-grained, with heterogeneous appearance, consisting of biotite, plagioclase, quartz, and lesser amount of K-feldspar. The quantity of K-feldspar is highly variable from place to place. In the specimen with small amount of it, K-feldspar can be observed only interstitially. In this case, the rock should be named quartz-diorite. While, in other cases, K-feldspar occurs as porphyroblastic megacrystals, attaining to several centimeters in length. Banding or layering is predominant throughout the mass. In the melanocratic bands, biotite is enriched. The part enriched with K-feldspar megacrystals also forms band. Often the rock shows nebulitic appearance, and basic inclusions, either foliated or massive, are ubiquitous. These features suggest that the Gamano granodiorite represents a highly contaminated variety. OKAMURA (1960) reported that biotite, plagioclase, and quartz of the granodiorite show distinct preferred orientation, that being probably related to the differential stress during the emplacement of the granodiorite. The trend of the layering is harmonic with that of the sedimentary gneiss, as shown in Fig. 1. At least some part of the Gamano granodiorite mass would represent the anatexite formed by in situ granitization from the Palaeozoic gneiss.

The Gamano granodiorite is the oldest one in the Ryôke belt in the western part of the Inland Sea (Setonaikai). In the map area, it is intruded discordantly by massive granodiorite, named **the Tôwa granodiorite** by OKAMURA, a member of the younger intrusives in the Ryôke belt.

A complex consisting of granite gneiss and amphibolite or basic gneiss, which appear to be extraneous to the layered granodiorite and the Palaeozoic sedimentary gneiss, forms a mass extending from the northwest coast of Yashirojima to Kuroshima. The detail of the outline of the mass cannot be determined owing to the sea, but the longest axis of the mass seems to coincide with the regional structural trend defined by the foliation and layering of gneiss and granodiorite. In this paper, the complex in question will be named **the Kitaôshima granite gneiss complex.**[1)]

III. THE KITAOSHIMA GRANITE GNEISS COMPLEX

A. PETROGRAPHICAL CHARACTERS

The complex consists of quartzo-feldspathic gneisses derived from granitic rocks and basic gneisses or amphibolites, either foliated or massive, in the main. Features of anatexis are ubiquitous, related to the Gamano granodiorite. The relation between the complex and the Gamano granodiorite can be ascertained at several places, e. g. on the east of Yamashitahama and on the southern part of Kuroshima, where the granite gneiss and basic gneiss are penetrated by granodiorite in the network fashion, showing features of granitization. This fact indicates that the gneisses were present before the emplacement of the granodiorite.

In this paper, the authors intend to use the term "*granite gneisses*" in the sense of coarse-grained metamorphic rocks derived from plutonic rocks of the granitic family, ranging from granite to quartz-diorite in composition. They can be named "*orthogneisses*" after the continental nomenclature. Most of the granite gneisses of the Kitaôshima complex are quartz-dioritic in composition. They consist of plagioclase, quartz, and biotite, with minor amount of K-feldspar interstitially. Hornblende is found sporadically, sometimes including clinopyroxene. Plagioclase crystal shows zonal structure with calcic core, and various stages of disintegration of plagioclase single crystal into an aggregate of finer-grained crystals owing to metamorphic crystallization can be traced. The grain-size ranges mostly from 2 to 5 centimeters. Near the promontory west of Kuga, garnet-bearing granite gneiss exists. It is coarse-grained and true granitic in composition, with much K-feldspar.

1) 北大島花崗片麻岩（または正片麻岩）体

In the granite gneiss, biotite forms thin layers or trains of clots, arranged parallel to each other. This feature must be related to metamorphic differentiation as is the case for the banding of sedimentary gneiss.

Basic gneisses show two kinds of mode of occurrence: one as parallel layers, alternated with granite gneiss, and the other as blocks. The former is foliated, while the latter granoblastic. Sometimes, the train of small blocks of amphibolite runs across the layered amphibolite and granite gneiss. This suggests that at least some of blocks of non-foliated amphibolite would represent remnants of older basic dykes intruded before the metamorphism. If this suggestion could be granted, layers of foliated amphibolite should be derivatives from older basic materials than the "older basic dykes" just mentioned. The occurrence, that foliated amphibolite and granite gneiss are intimately alternated, suggests the existence of migmatitic gneiss complex before the Ryôke metamorphism. This suggestion will be confirmed by the presence of a granitized basic dyke in the following pages.

There are no fundamental differences in mineralogy between foliated and non-foliated basic gneisses. They consist of hornblende, biotite, and plagioclase. Clinopyroxene or quartz is sometimes observed. The grain-size ranges from 0.5 to 2 millimeters in diameter. There are found porphyroblastic as well as blastoporphyritic crystals of plagioclase, attaining to 4 centimeters.

B. Structure

Rocks of the Kitaôshima granite gneiss complex are well exposed along the northwestern coast of Yashirojima. As the type area, the route map of the Hirarehana[1] peninsula is shown in Fig. 2. Poles of the foliation of gneisses are plotted on the lower hemisphere of equal-area projection (Fig. 3). Mostly, the dip of the foliation is small, and wavy fold on a mesoscopic scale is reflected on the diagram. From the distribution of poles, the π-circle (dashed curve) and the π-axis (cross) can be estimated, as shown on the diagram. The π-axis points to N65°E, plunging at 12°. This direction roughly coincides with the regional structural trend in this part of the Ryôke belt. It must be noticed, however, that the dip angle of the layering of the Gamano granodiorite neighbouring the granite gneiss complex is much higher.

Okamura made microfabric diagrams of quartz, biotite, and plagioclase of granite gneiss from the Hirarehana peninsula (Okamura 1960, Figs. 58, 59, and 60), although, in that paper, he described the granite gneiss as a member of the Gamano gneissic granodiorite. All the microfabric diagrams are characterized by the orthorhombic symmetry with respect to the foliation surface and also by a tendency of incomplete girdle around an axis lying on the foliation surface.

C. Agmatite

As mentioned in the preceding pages, anatexis is predominant in the Yanai-Yashirojima district. The anatexis of the Palaeozoic sedimentary gneisses is characterized by

1) 平連鼻.（5万分の1地形図「柳井」山下浜西方の岬）

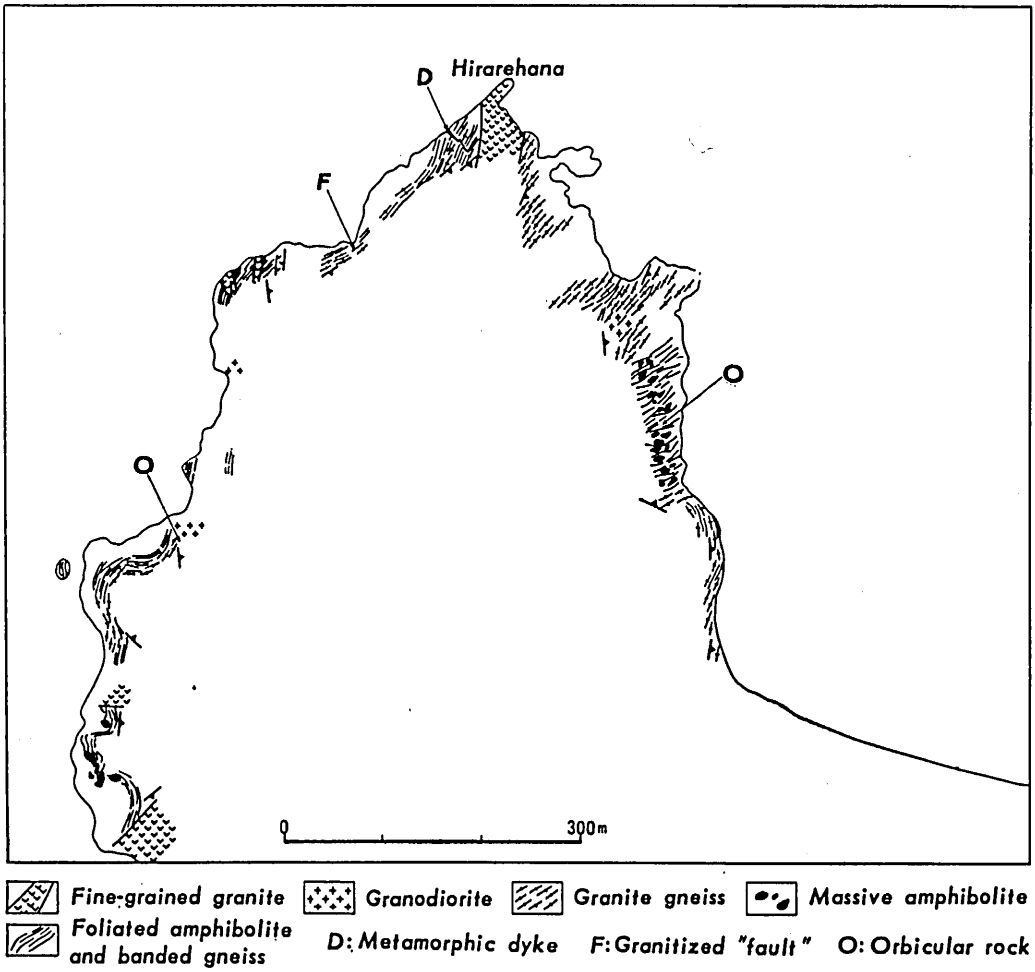

FIG. 2 Route map of the Hirarehana peninsula

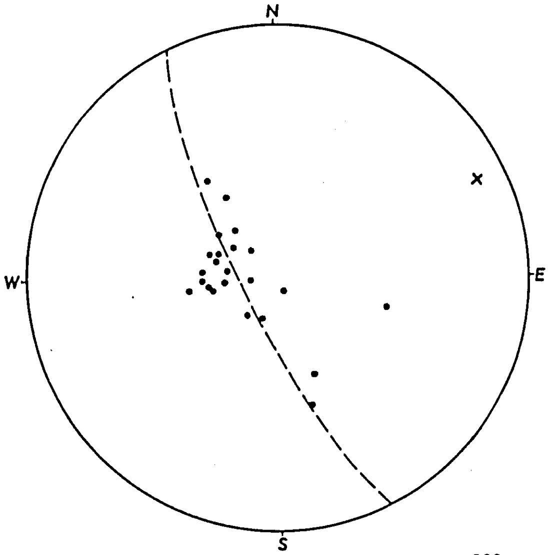

FIG. 3. π-diagram of the foliation of gneisses in the Hirarehana peninsula.

the formation of plagioclase porphyroblast, metatexis, diatexis or obliteration of gneiss structure by permeation, and injection with quartzo-feldspathic veinlets. In the Kitaôshima granite gneiss complex, these features of anatexis are also observed everywhere, but, in addition to these, the prevalence of agmatitic anatexis is very impressive (Plate 19). In the layered gneiss, granitization proceeds along the layering as well as through the fracture surface, along which the gneiss layers show displacement. In the massive amphibolite, granitization occurs almost exclusively along the fracture surface in the network fashion, and pegmatitic veinlets with large crystals of hornblende are observed.

The difference in the behaviour of anatexis between the Palaeozoic gneiss and the granite gneiss complex can be ascribed to the difference in history before the Ryôke metamorphism. The granite gneiss complex must have passed through a certain condition of lower temperature and/or pressure, under which fracturing occurred. On the other hand, the Palaeozoic sedimentary gneiss has suffered progressive metamorphism under increasing temperature, and the nature of material remained ductile.

Orbicular rock is known on the east side of the Hirarehana peninsula (Ishioka 1953). We found another locality of it on the west side of the peninsula, where it remains in embryonic stage of development. The orbicular rocks occur in intensely granitized part of basic gneiss.

D. Metamorphic Dyke

Wegmann (1947, 1948; Wegmann and Schaer 1962) emphasized the significance of metamorphic basic dyke for the "synchronisation" in the history of tectonic development as well as for clarifying the change in nature of material in that part of the crust, or the change of "*étage tectonique*".

Near the promontory of Hirarehana (Fig. 2), a basic dyke was found cutting discordantly across the layered gneiss (Fig. 4 and Plate 21). The trend of the dyke is nearly perpendicular to the foliation of layered gneiss, and the latter was displaced slightly along the dyke. Aplite develops along the selvage of the dyke, and offshoots of aplite penetrate the dyke and neighbouring gneiss. No foliation is observed in the dyke.

The main part of the dyke consists of compact, medium-grained, dark-gray rock. The bulk of the rock consists of plagioclase and hornblende, accompanied with biotite and quartz. The mean size is 1 to 2 millimeters, but plagioclase and biotite attain to 4 millimeters. Plagioclase megacrystals contain calcic cores, which show the Carlsbad, Acline and Pericline twins, that suggesting igneous origin, but porphyroblastic outgrowth is also observable. Hornblende is greenish-brown in colour, partly changed to cummingtonitic amphibole. Biotite grows to poikiloblastic plates. The matrix consists of panidiomorphic plagioclase and hornblende, with accessory apatite and ore. Quartz is sometimes found interstitially. In the dyke, there are coarser-grained, more leucocratic pools, where develop poikiloblastic biotite and quartz.

These features indicate that the dyke had been intruded into the gneiss complex

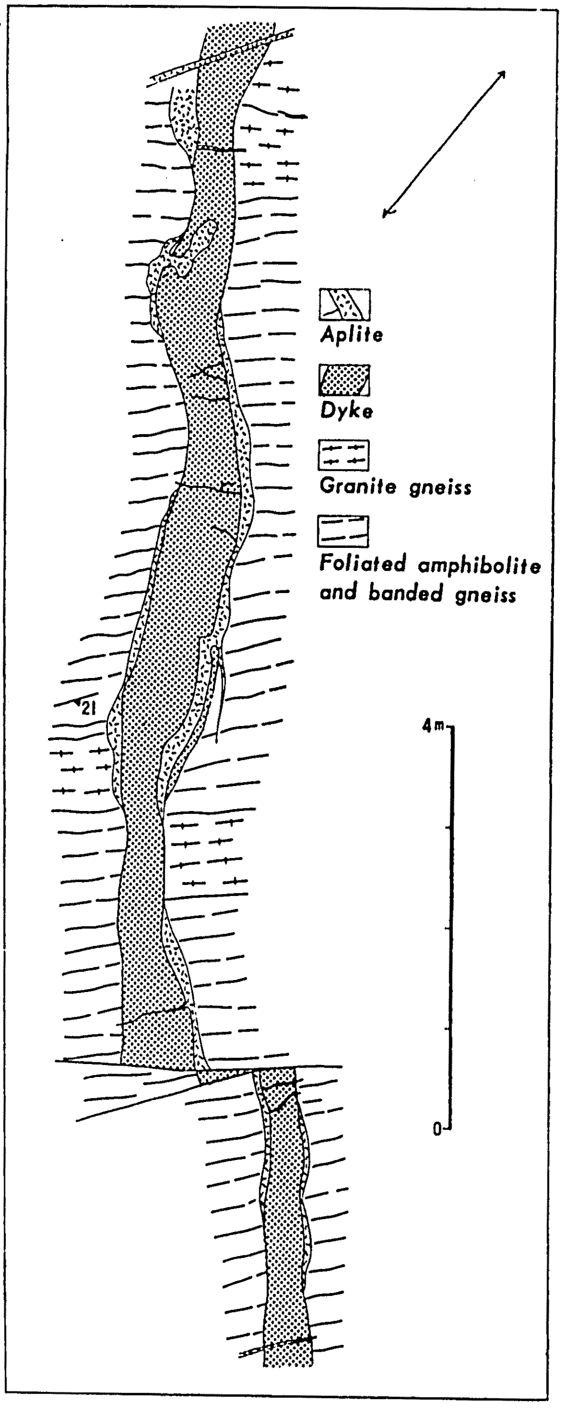

FIG. 4. Metamorphic basic dyke near the promontory of Hirarehana.

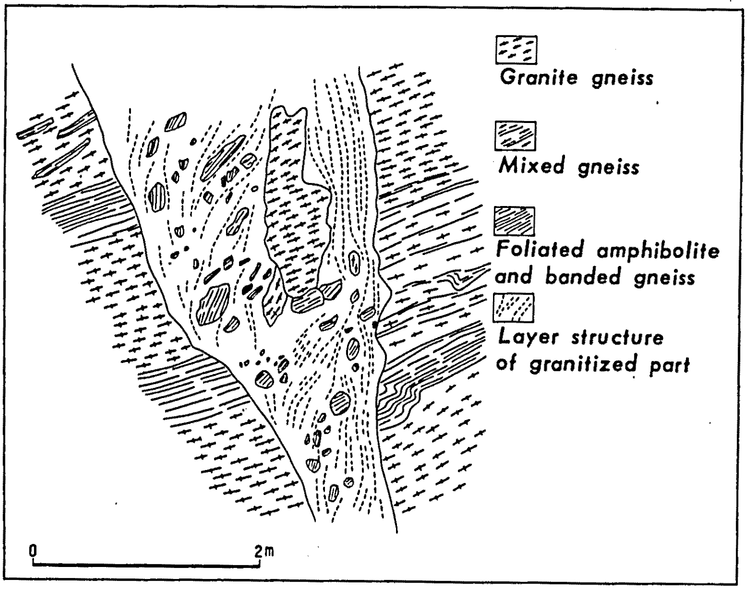

FIG. 5. Sketch of the granitized "fault"

before the Ryôke metamorphism began. In other word, before the Ryôke metamorphism, the granite gneiss complex had been brought up to the tectonic level or *étage tectonique* characterized by brittle fracturing. Aplite along the selvage of the dyke and cutting across the interior of the dyke would have been developed along the fracture surface at the time of regional anatexis of the Ryôke metamorphism.

E. GRANITIZED "FAULT"

An exposure of peculiar appearance has been found near the promontory of Hirarehana (Fig. 2). A kind of chaotic structure develops within a zone, 1 to 2 meters in width, cutting across the granite gneiss complex (Fig. 5 and Plate 22). The zone consists of angular to subangular blocks of various size and granitic matrix. The blocks are composed of granite gneiss, banded gneiss and foliated amphibolite, all of which are represented in the neighbouring gneiss complex. In the granitic matrix, weak layering can be traced, which winds around included blocks. The layering of the gneiss complex does not continue across the zone. Therefore, this zone represents one of displacement or fault. The foliation surface of included gneiss blocks in the zone is oriented at random, indicating rotational movement.

From these features, it seems most probable that this zone would have been developed from a fault, which had been formed when the granite gneiss complex had been situated on a tectonic level of brittle fracturing, as suggested by the agmatitic behaviour and the metamorphic dyke. After this interpretation, the gneiss blocks in the zone correspond to the brecciated blocks in the fault zone, and the granitic matrix to the fine-grained rock flour.

One may ask, however, if these features could be interpreted as intrusion breccia. But, in this part of the Ryôke belt, no intrusion breccia has been observed related to the Gamano granodiorite, the emplacement of which occurred probably under the regional condition of plastic flow.

IV. DISCUSSIONS

Above described features, especially such as the agmatitic behaviour in granitization, the metamorphic dyke and the granitized "fault", strongly suggest that the Kitaôshima granite gneiss complex had been brought up to the tectonic level of brittle fracturing in the state of gneiss before the metamorphic recrystallization and anatexis of the Ryôke age began. The history of development of the granite gneiss complex would be arranged in the following scheme.

Stage 1: Plutonometamorphism. Formation of amphibolite and banded gneiss. Injection of granitic rocks.

Stage 2: Regional metamorphism. Formation of foliation in the granitic rocks.

Stage 3: Fracturing and faulting. Intrusion of basic dyke.

Stage 4: Metamorphism and anatexis of the Ryôke age.

The geochronological age of each stage cannot be determined at present, except for the Ryôke age, which is suggested to be Cretaceous from recent data of radiometric determination. Because the Palaeozoic sedimentary gneiss represents progressive metamorphism under increasing temperature and no evidence of repeated metamorphism is detected, the stages 1 and 2, and presumably the stage 3, would have preceded the sedimentation of the Palaeozoic groups in the innerside of Southwest Japan. Since the oldest sedimentary formation so far known in the innerside of Southwest Japan is Devonian in age, it is most probable that at least the stages 1 and 2 are pre-Devonian. In other word, the Kitaôshima granite gneiss complex would represent a fragment of the basement under the Upper Palaeozic geosyncline in the innerside of Southwest Japan.

Recently, NOZAWA (1967) summarized the data of radiometric age indicatng about 400 m.y. by the K-A and Rb-Sr methods. The data are reproduced on Table 1. These data, though insufficient at present, suggest the presence of regional metamorphism and plutonic activity of about 400 m.y. in age in Southwest Japan. One may assign the stage 2 to this age provisionally.

KOJIMA has noticed other two localities of gneisses of granitic origin in the Ryôke belt in Southwest Japan. In Nara Pref., a complex of granite gneiss, named the Sagawa granite by HARA (1962), exists on the south of the Palaeozoic sedimentary gneiss in the Kasagi district. At Momodaira, Komagane City, Nagano Pref., anatectic granite gneiss has been found, which belongs to the gneissic granite mass, named the Tenryûkyô granite (Geological Map of Kamiina). At this locality too, the granite gneiss occurs just on the south of the Palaeozoic sedimentary gneiss area.

These two localities were visited by the senior author only cursorily, and detailed

TABLE 1. ROCKS OF 400 M. Y. RADIOMETRIC AGE FROM SOUTHWEST JAPAN

LOCALITY		ROCK	AGE	COMMENTS
Dai	(山口県豊浦郡豊田町西市台)	Garnet-bearing muscovite granodiorite, gneissic	424 m.y.	K-A method (muscovite) by KONO et al., 1966. Inclusion in serpentinite in the Nagato Tectonic Zone.
Kiyama	(熊本県上益城郡益城町木山)	Garnet-white mica-chlorite-albite schist (pelitic)	319± (mean) 429	K-A method (white mica) by MILLER et al., 1963. Rb-Sr method(white mica)by HAYASE et al., 1967.
Komine	(熊本県上益城郡清和村小峯)	Hypersthene-hornblende-biotite granodiorite, medium-grained	372	K-A method (biotite) by KONO et al., 1965. The Kurosegawa Tectonic Zone.
Mitaki	(愛媛県東宇和郡城川町三滝山)	Granite	419	Rb-Sr method (biotite) by HAYASE et al., 1967. The Mitake Igneous Rocks of the K. T. Z.
Tomioka	(徳島県阿南市富岡)	Granite	412	ibid.

(Summarized by NOZAWA, 1967)

study is hoped in future from the viewpoint of this paper. Therefore, it seems premature to infer any opinion from these observations, but it may be allowed to note some common facts among these occurrences. The Palaeozoic, probably Permian formations show progressive metamorphism increasing in grade from the north or northwest toward the south or southeast, and the granite gneiss complex occurs within the highest grade zone, characterized by anatexis, just on the south of the Palaeozoic gneiss belt. This fact may suggest that, at the beginning of the Ryôke metamorphism, the granite gneiss complex was situated on a level lower than the Palaeozoic sediments, and that it was brought up to a higher level by the upward movement accompanied with granitic plutonometamorphism. It seems probable that the granite gneiss complex was covered unconformably by the Permian sediments. In this connection must be noticed the finding by the authors of granitized conglomerate (Plate 20) at the southernmost of the Obatake gneiss belt on the west of Obatake. It is a polymictic conglomerate, so intensely granitized that the matrix was transformed to granite.

Lastly, it may be pointed that there is a possibility of pre-Permian land between the innerside and the outerside of Southwest Japan, which is now largely hidden under granitic intrusives, or missed from the surface between the Ryôke and the Sambagawa belts.

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Explanation of Plate XVIII

Granite gneiss

Explanation of Plate XIX

A: Granitization of basic gneiss near Hirarehana. The granitization proceeds along fracture and foliation surfaces, showing agmatitic appearance.

B: Granitization of banded gneiss, near Hirarehana. ibid.

Explanation of Plate XX

A: Orbicular rock, near Hirarehana.

B: Granitized conglomerate, west of Obatake.

Explanation of Plate XXI

B: A metamorphic dyke of basic composition, penetrating gneiss complex. Note aplitic selvage.

A: A portion of the metamorphic dyke, permeated by salic materials.

Explanation of Plate XXII

A: Granitized "fault".

B: A portion of the granitized "fault". Lower right of the photograph A.


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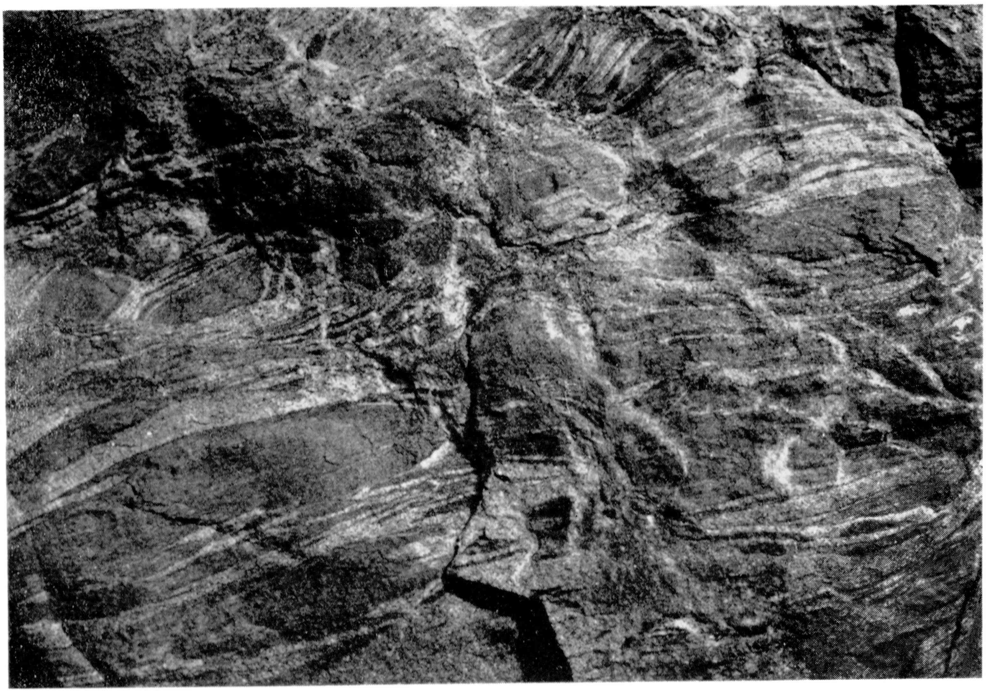

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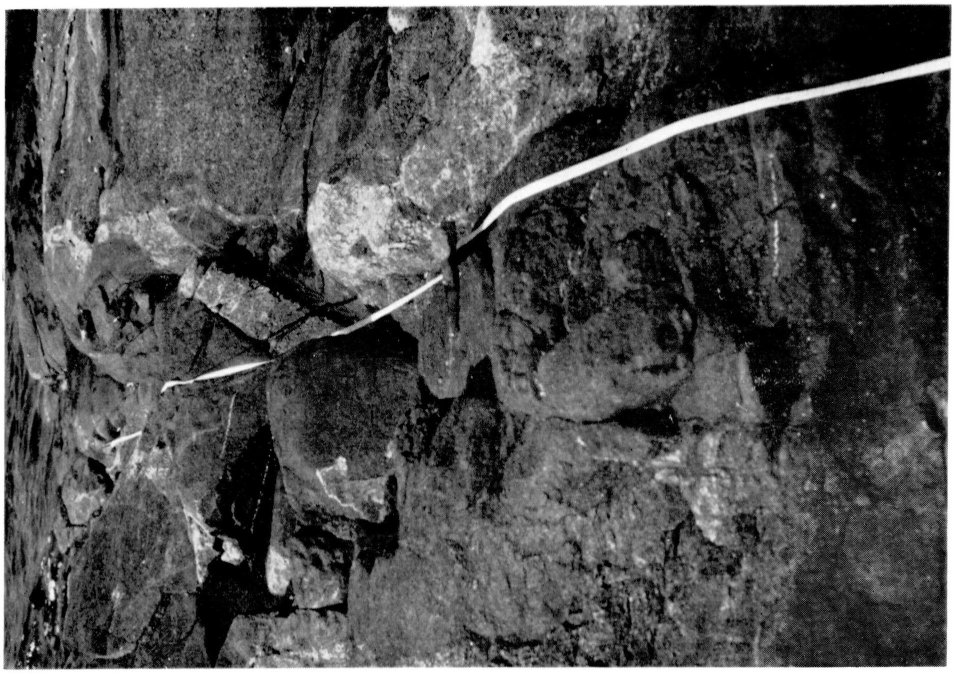

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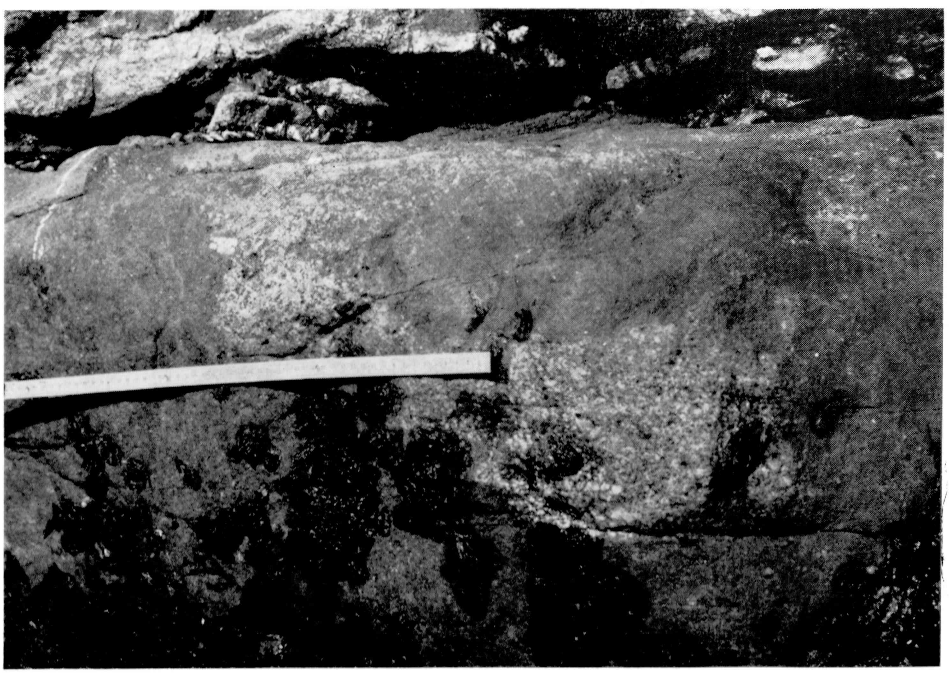

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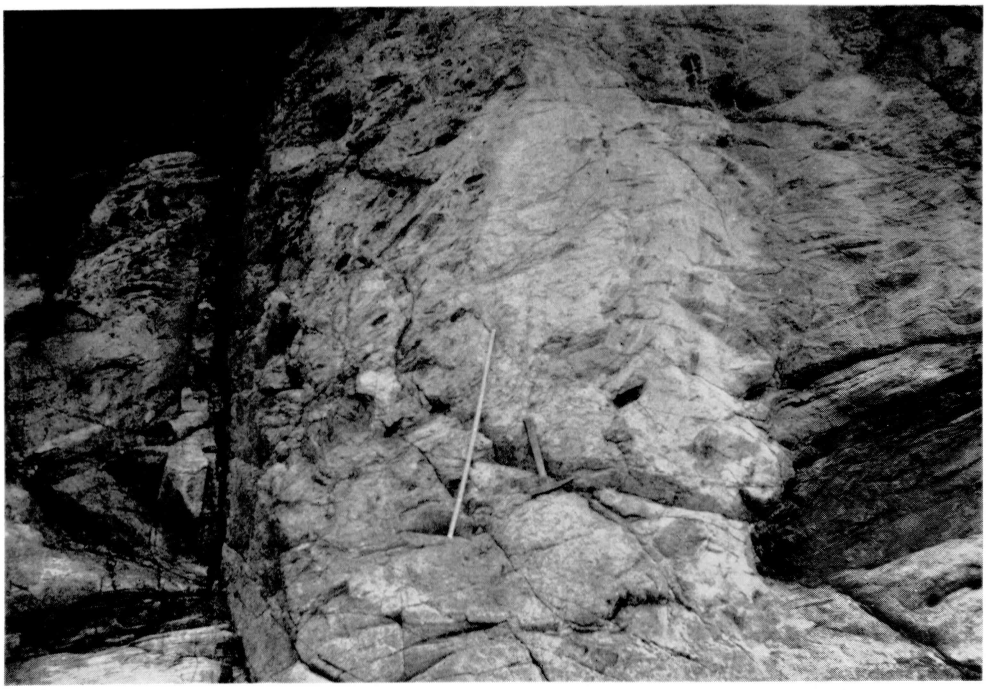
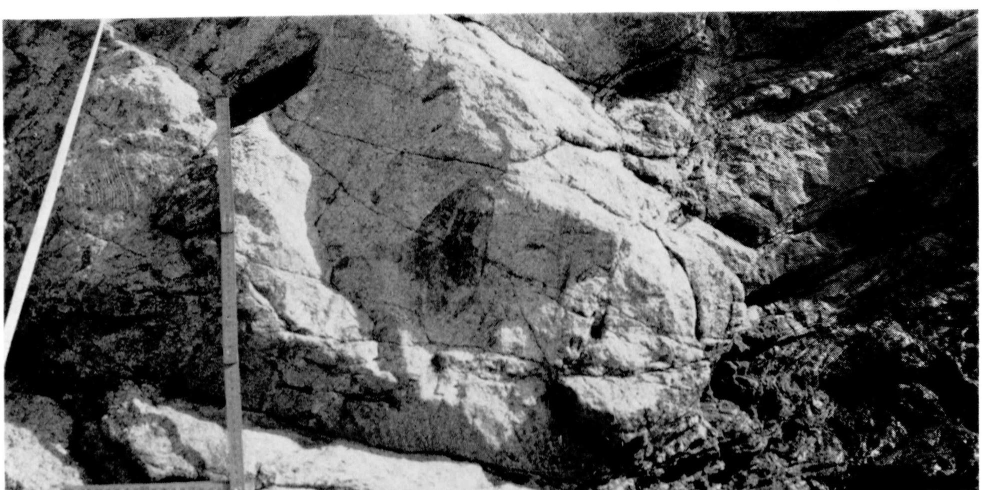


A



B