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Two Kinds of Glaucophanite Terrane in Japan and the Environs

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Introduction

MIYASHIRO (1961) discussed in his well-known synthesis of the evolution of metamorphic belts that a high-pressure glaucophanitic terrane is commonly paired with a low-pressure high-temperature terrane, both extending side by side in the direction of orogenic zones of the circum-Pacific regions. The most well-known pair in Japan consists of the high P/T Sambagawa glaucophanitic and the low P/T Ryoke andalusite-sillimanite type metamorphic belts. But there are some isolated small or narrow glaucophanitic terranes which appear not to be paired with any low P/T ones. The Motai metamorphic district in the south Kitakami region, northeast Japan (KANISAWA, 1964), the Kiyama district in Kyushu (BANNO, 1963; YAMAMOTO, 1964) and the Kurosegawa fault zone (ICHIKAWA *et al.*, 1956; NAKAJIMA and MARUYAMA, 1978a) are a few examples (Fig. 1).

Including these small-sized areas, a number of metamorphic terranes which are underlain by glaucophanites and related rocks have been known to us in Japan and the surrounding regions (MIYASHIRO, 1967; HASHIMOTO *et al.*, 1970; DOBRETZOV and KURODA, 1970; YEN, 1975). But, when we examine in some details the areal extent, internal geologic structure and rock association, we may be led to the conclusion that there are at least two geologically different kinds of glaucophanitic terrane in Japan and the environs, although it does not matter whether the terrane is apparently paired with a low P/T terrane or not.

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First Type

Terranes of the first type are exemplified by the Sambagawa belt in southwest Japan. This belt has a large areal extent. It starts at the Kanto Mountains area and extends longitudinally on the Pacific Ocean side of the Japanese islands, through Akaishi Ranges, Kii peninsula, Shikoku to the eastern part of Kyushu. The length of this belt exceeds 1000 km and the maximum width reaches 50 km. Many studies have been made on the geologic structure of the Sambagawa belt and have revealed the existence of large-scale recumbent folds particularly in Shikoku (*e.g.*, HIDE *et al.*,

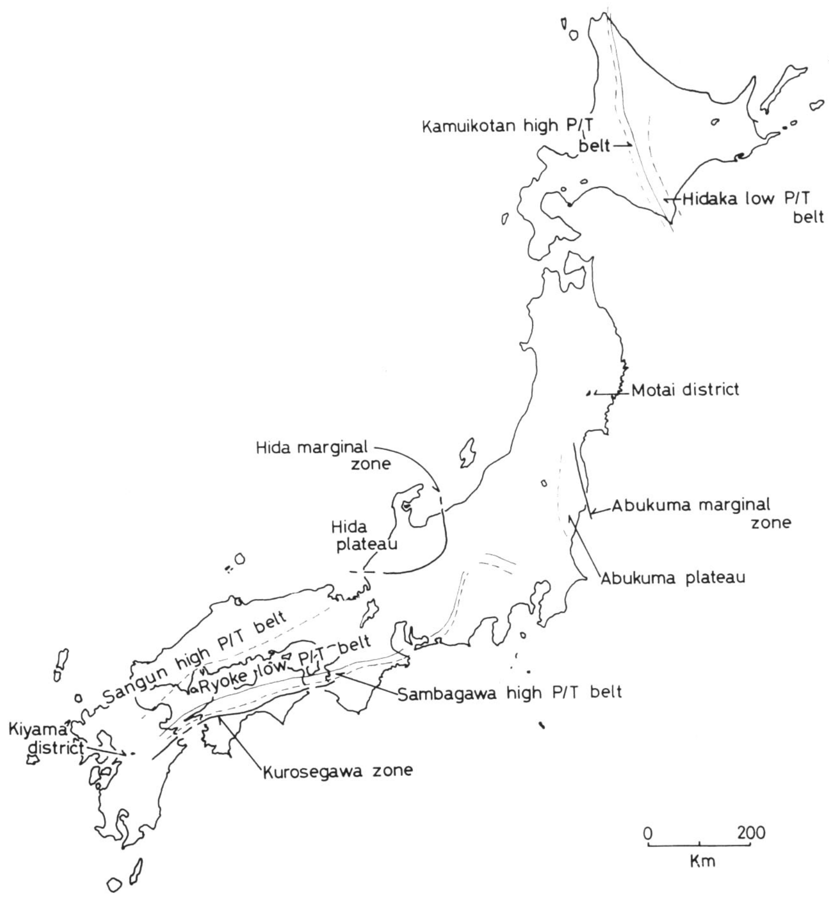

Fig. 1. Index map of Japanese regional metamorphic terranes.

1956; HIDE, 1961; KAWACHI, 1968; ERNST *et al.*, 1970; HARA *et al.*, 1977). The structure have been analysed by highly detailed mapping in the fields, by tracing some well-defined marker beds, *e.g.*, beds of piemontite-quartz schist derived from manganese chert, and by analysing styles of foldings and overturned graded-bedding preserved in sandstone schist (KAWACHI, 1966, 1968). The strata of the Sambagawa metamorphic terranes are usually traceable for long distance. In the Mishima district, Shikoku, for example, a piemontite-quartz schist bed has been traced for about 25 km in the field (DOI, 1964) without any large disruption by dislocation.

A number of ultrabasic rock masses have been emplaced in the Sambagawa belt. But their amount is not so large, and the ratio exposed of ultrabasic to metamorphic rocks is rather low. There is no close spatial relationships between ultrabasic rocks and glaucophanites. The petrogenesis of glaucophane schists in this belt has been interpreted that the higher pressure metamorphic conditions have favored the formation of alkali amphiboles in some rocks of basic and silisic compositions particularly rich in ferric iron (MIYASHIRO and BANNO, 1958; SEKI, 1958; IWASAKI, 1963; BANNO, 1964). No soda metasomatism is considered to have taken place in connection with the emplacement of ultrabasic rocks. The rocks of the ultrabasic masses are chiefly dunite, wehrlite, clinopyroxenite and serpentinite and frequently associated with metagabbros.

To sum up, the following geologic features are characteristic of the first group of glaucophanitic terranes such as the Sambagawa: 1) large areal extent, 2) traceable and analysable geologic structures, and 3) low proportion in volume of ultrabasic rocks to metamorphic rocks.

Another example of the first type terrane is the Sangun metamorphic belt equally in southwest Japan (HASHIMOTO, 1968, 1972). This belt does not look like a "belt", but it consists of many separated fragmental areas distributed in the Chugoku and northern Kyushu provinces. However, the original areal extent of this metamorphic belt is considered to have been large, the estimated length and width being respectively about 500 km and 80 km. Although the geologic structure of this belt has been not so well studied, it is analysable by ordinary geologic mapping in the fields.

Second Type

A typical example of another kind of glaucophanite terrane is the Kamuikotan belt in Hokkaido. It extends in a meridional direction through central part of this island. The length is about 300 km, but the width is rather narrow, being less than 20 km. Considering the northern extention of this belt in Sakhalin, its length reaches about 800 km, the width being still less than 20 km (DOBRETZOV and KURODA, 1970). The geologic structure is highly complicated and no reasonable solution has not yet been obtained. Recent studies (BANNO *et al.*, 1978; ISHIZUKA, 1978) revealed that two types of metamorphic rocks are there in this belt. One is the high-pressure Kamuikotan metamorphics and the other is the low-pressure metamorphic rocks with ophiolite succession of the Sorachi Group. In the central Hokkaido a large-scale anticlinal structure has been inferred to exist, the axial part being occupied by the high-pressure Kamuikotan metamorphic rocks which in turn is overlain by dunite-harzburgite and ophiolite successions on both flanks. However, beds of metamorphic rocks are highly deformed, fragmented and disrupted by many faults and are not traceable for long distance unlike to the case of the Sambagawa belt. The Kamuikotan belt is the greatest serpentine belt in Japan and very rich in ultrabasic rocks. The ratio in volume of ultrabasic to metamorphic rocks is very high. A rough estimate gives the ratio of the exposed areas of the former to the latter rocks as about 0.6. It means that more than a third of the area of this metamorphic belt is occupied by ultrabasic rocks. Masses of ultrabasic rocks enclave frequently various kinds of glaucophanitic and related rocks along with the associated metagabbros. This close spatial relationships is the reason why some petrologists (*e.g.*, SUZUKI and SUZUKI, 1959) erroneously concluded that glaucophane schists and related rocks would have been formed by alkali metasomatism associated with the emplacement of serpentinites. Accordingly, the following geologic features are characteristic of the Kamuikotan belt in contrast to those of the Sambagawa and Sangun: 1) relatively small areal extent, especially narrowness in width, 2) geologic structure is highly complicated and not easy to analyse by ordinary mapping in the field. The strata of metamorphic rocks are usually not traceable for long distance due to disruption by faults, 3) high proportion of ultrabasic rocks to metamorphic rocks, and 4) close, if merely in appearance, relationships between ultrabasic rocks and glaucophanites. Furthermore, minerals or mineral assemblages indicating truly high-pressure metamorphism such as lawsonite, metamorphic aragonite (GOUCHI and BANNO, 1974; SHIBAKUSA, GOUCHI and IMAIZUMI, 1977) and jadeite plus quartz (SEKI and SHIDO, 1959; SHIDO and SEKI, 1959) have been reported from this belt, although they are quite rare in the Sambagawa and Sangun terranes.

We have many other glaucophanitic and serpentinite-rich terranes of this kind in Japan and the environs. The examples other than the Kamuikotan are as follows, although the geologic features mentioned above as characteristic of the Kamuikotan belt are not always revealed completely in these other terranes.

a) The Kurosegawa zone, which is a fault zone running in the east-west direction through the Chichibu terrane of southwest Japan, is probably of this type of glaucophanite terrane (ICHIKAWA *et al.*, 1956; HADA, 1974; NAKAJIMA and MARUYAMA, 1978a). The main part of this zone is exposed in Shikoku and is represented by trains of lens-shaped complexes which consist of the following various kinds of rocks: 1) Terano metamorphic rocks, which are high-grade and considered to be of the granulite facies (HAYAMA, 1976; MARUYAMA, 1976; KARAKIDA, 1977), 2) highly sheared Mitaki granites, 3) limestone containing Silurian fossils, which are amongst those of the oldest organic remains reported from Japan (HAMADA, 1959; KUWANO, 1976), 4) acid volcanic and pyroclastic rocks and ordinary sedimentary rocks of the Okanaro Group (HASHIMOTO *et al.*, 1976), and 5) strongly serpentinized ultrabasic rocks. The internal geologic structure of this zone is highly comlicated. All the rock units are mixed up, and the boundaries between masses consisting of each unit are always faulted. Recently, MARUYAMA (in prep.; NAKAJIMA and MARUYAMA, 1978a, 1978b) published a detailed geologic map of the Ino district of the Kurosegawa zone in central Shikoku. According to the study, serpentinite intrudes pervasively throughout the whole complexes. Furthermore, serpentinites of the Kurosegawa zone include xenolithic masses of various kinds of metamorphic rocks such as glaucophanites and associated quartz-jadeite schist, hornblende-bearing schist and psammitic schist.

b) The Wariyama, Matsugadaira-Yamagami and Yaguki districts (SEKI and OGINO, 1960; KURODA and OGURA, 1963). They are fragmental small areas of glaucophanitic metamorphic rocks and associated serpentinite, intermittently distributed along the eastern border of the Abukuma plateau and constitute the eastern Abukuma marginal zone. The Motai district (KANISAWA, 1964) in the southwestern part of the Kitakami region is also considered to be of this zone.

c) The Hida marginal zone (BANNO, 1958; SEKI, 1959; ITO, 1975). A few relatively small areas all underlain by glaucophanitic metamorphic rocks are distributed intermittently in a narrow zone extending along the southeastern border of the Hida plateau schist, gneiss and granite terrane. The areas are, from north to south and southwest, the Omi, Asahidake, Gamata, Naradani and Ise districts. Serpentinite is initimately associated with the metamorphic rocks, and in some places garnet amphibolite has been found to occur.

d) The Kiyama district of central Kyushu (BANNO, 1963; YAMAMOTO, 1964) is underlain by glaucophanitic rocks and associated serpentinite and seems to be of the second group of glaucophanite terrane. But, this district is small in area and surrounded completely by the Lower Cretaceous sediments so that its geologic and tectonic relations with other glaucophanitic regions in Japan is obscured.

e) Glaucophane schists and epidote amphibolites occur as tectonic blocks, being accompanied with serpentinites, in the Juisui district of the Yuli metamorphic belt of east Taiwan (LIOU, HO and YEN, 1975). The geologic structure is complicated in the blocks, the foliation of rocks being highly variable in strike and dip. However, the foliation of the country rocks is rather uniform and the dip is commonly gentle. Rocks of the blocks are much coarser grained than the surrounding feebly metamorphosed schists. The mineral assemblages also indicate the higher grade facies in rocks of the blocks in contrast with the low-grade quartz-graphite-sericite association in the country schists. It is suggested that the tectonic blocks are allochthonous and constitute a glaucophanite terrane of the second type defined here.

Discussions

MIYASHIRO (1961) stated that a glaucophane schist terrane is usually paired with a low P/T metamorphic terrane, particularly in the circum-Pacific orogenic regions. From this standpoint, he considered the Kamuikotan glaucophanitic belt to be paired with the Hidaka low P/T metamorphic terrane, the Abukuma marginal zone with the central Abukuma andalusite-sillimanite type terrane, and the Hida marginal zone, which was considered to be the eastern extention of the Sangun glaucophanitic belt, with the Hida plateau gneiss and granite region.

But, when we examine the radiometric age data from those pairs of metamorphic belts, it appears that the high P/T metamorphic rocks are usually distinctly older than those of the respective associated low P/T terranes, as shown in Table 1 (NOZAWA, 1975, 1977). The differences in age are too large to regard the respective groups as the paired metamorphic belts which must have been formed in one and single orogenic event. Furthermore, some second type glaucophanite terrane appear not to be paired with any low P/T metamorphic terranes as in the case of the Kurosegawa zone.

Consequently, the glaucophanite terrane of the second type are not always and not necessary to be paired with any low P/T ones, so far we observe the present-day

Table 1 Average radiometric ages of the apparently paired metamorphic belts in Japan (data from NOZAWA, 1977).

Belt	P/T	Averaged age in m.y.
Kamuikotan	high	120
Hidaka	low	30
Abukuma marginal zone	high	300
Abukuma plateau	low	110*
Hida marginal zone	high	310
Hida plateau	low	190**

* At least a part of the Abukuma plateau metamorphic rocks seem to have suffered from two metamorphic events. A few geologists consider the older metamorphism to be Precambrian. But most of the radiometric age data range from 90 to 120 m.y.

** Hida metamorphic rocks have given widely diversing age data ranging from 350 to 130 m.y. But most of them fall in a narrow range of 200–170 m.y.

geologic situations. It is not certain if this type of glaucophanite terranes would have been paired with low P/T ones in ancient geologic times. The geologic features mentioned in the foregoing pages on the second type glaucophane schist terranes suggest that they are of melange formed along the boundary between different geo-tectonic blocks.

On the other hand, the Sambagawa metamorphic belt, which is a typical glaucophanite terrane of the first type, is clearly paired with the Ryoke low P/T terrane. The difference in radiometric ages between the two belts is not large. The Sambagawa rocks have been dated as about 70 m.y. old, while the Ryoke rocks as 90 m.y. (NOZAWA, 1975, 1977). The Sangun high P/T belt whose rocks have been dated as about 180 m.y. is similarly to be paired with the Hida plateau gneiss and granite terrane of about 190 m.y. The truly paired metamorphic belts are to be those consisting of a glaucophane schist belt of the first type and a low P/T terrane, both being similar in their ages of metamorphism.

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