Jurassic Accretionary Complex in Kaminokuni Terrane, Southwestern Hokkaido, Japan

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Abstract: The geologic unit comprising the Jurassic accretionary complex in the Kaminokuni area in the Southwestern Hokkaido is newly defined as the Kaminokuni Terrane. It is composed of the Matsumae Group which is characterized by overlying and underlying tectonic units forming the two-storied structure. The Matsumae Group of the overlying unit (unit 2) consists of the a, b and c formations in ascending order, while the underlying unit (unit 1) is composed mainly of the b formation. These three formations are tectonically repeated within both units.

The a formation is composed of the oceanic greenstone and bedded chert of Late Carboniferous through Permian age and the lower part of bedded chert includes bedded manganiferous iron oxide and manganese ore deposits, in ascending order. The nature and age of formation of these deposits are comparable to those of the Outer Zone of Southwest Japan but are dissimilar to those of the Inner Zone. The b formation consists of Middle to early Late Jurassic mudstone including olistoliths of Permain greenstone, bedded chert reworked from the a formation, and Triassic to Early Jurassic bedded cherts derived from the strata of the neighboring Kamiiso or Toi-Esan Terrane. The c formation is composed mainly of early Late Jurassic sandstone of which the provenance is regarded to be the continent or island arc.

The two-storied structure of the Kaminokuni Terrane was formed during the underplating through the duplex accretion to the South Kitakami massif in post Late Jurassic time.

1. Introduction

The Mesozoic accretionary complex collectively called the Matsumae Group is distributed in the Oshima Peninsula, southwestern part of Hokkaido, and is overlain by so-called green tuff (Tertiary volcanic and sedimentary rocks). Concerning the geologic division, this complex, newly called the Kaminokuni Terrane, has been regarded to be the northwestern extension of the North Kitakami and Iwaizumi Belts in Tohoku district occupying the outer zone of the South Kitakami Massif (Fig. 1a). The age of the Matsumae Group is thought to range from Late Paleozoic to Early to Middle Mesozoic on the basis of corals, fusulinids and conodonts from limestones, and Triassic conodonts from bedded cherts (for historical review, see Kawamura et al., 1986). Recently, Jurassic radiolarians have been found from bedded cherts and clastic rocks in the Shimamaki area, northern extension of the area of this study (Tajika et al., 1984). On the other hand, in the Oshima Peninsula, especially in and near the Kaminokuni area, several kinds of ore deposits occur; for example, the manganese vein deposits of the Jokoku and Imai-Ishizaki mines in Miocene time and the bedded manganese deposits of the Era mine in Late Carboniferous to Early Permian time. One of the authors (D.I.) has been engaged in the study of manganese-rich polymetallic (Mn, Pb, Zn and Ag) mineralizations around the Esashi and Era districts (e.g. Ishiyama et al., 1987). However, the precise geology of the mining area especially the geologic age of the rocks concerned has not been clarified because of the scarce occurrence of fossils. The studies of stratigraphy and geologic structure of the Matsumae Group in the light of the radiolarian and conodont biostratigraphy and new
scheme of the accretionary tectonics reveal the formative ages of the bedded manganiferous iron deposits and the bedded manganese deposits as well as the geohistory of the Kamino-kuni Terrane in Late Paleozoic to Jurassic time.

2. **Description of the Matsumae Group**

The Matsumae Group is distributed in the Esashi, Era and Daisengen districts as presented in Fig. 1b. The geologic unit comprising the Matsumae Group in these three districts is tentatively called the Kaminokuni Terrane. This terrane was intruded by Cretaceous granitic rocks (Fig. 1b). A detailed examination was done in the Esashi district and a preliminary study was attempted in the Era district.

### 2.1 Esashi district

**1) Kaminokuni area:** The Matsumae Group consists mainly of a complex of the Jurassic clastic rocks and Late Paleozoic greenstone and bedded chert, both of which are affected by hydrothermal activities in Miocene time. The Matsumae Group in this area is composed of two geologic units (unit 1 and 2) and the unit 2 tectonically overlies the unit 1. Both units are folded with fold axes trending in NW-SE, and form a synclinorium (Mena-zawa synform and other synform and antiform from SW to NE) which is cut by NE-SW left lateral faults. The strata of the unit 2 are distributed in the axial part of this synclinorium, while those of the unit 1 are distributed in both wings (Fig. 2).

The unit 2 consists of the a, b and c formations, in ascending order, while the unit 1 is composed of the b formation which is tectonically repeated in the unit 1. The b formation in both units has a common lithologic feature and the age is comparable as mentioned below. The a formation consists of the greenstone and red or black bedded chert, while the b and c formations are characterized by the presence of black mudstone including olistostrome and sandstone, respectively.

**a formation**

The lower part of this formation is represented by the greenstone composed of basaltic lava and hyaloclastite. Thickness of the greenstone in the areas varies, e.g. in Mena-zawa it is estimated to be about 500 m. Greenstones are usually dark green and in places purplish red in color. The greenstone shows vertical change in lithology, namely, basic tuffs overlying the pillow lava change into siliceous shale upward with a transitional zone of about 1 m thick. In turn, the siliceous shale changes upward into bedded red chert. The bedded chert is composed of alternated beds of siliceous layer of about several to 10 cm thick and muddy layer of about a few mm thick. Thickness of a single bed of the siliceous layer changes from 2 to 10 cm laterally. The color of the bedded chert changes from red to greenish or dark grey in the upper part.
Fig. 2 Generalized geologic map and geologic profile of the Esashi district.
1, Tertiary and younger volcanic and sedimentary rocks (their distribution is after M.M.A.J., 1981). 2-4, Matsumae Group (2, unit 1. 3, clastic rocks of the unit 2. 4, greenstone-bedded chert of the unit 2.). 5, synform. 6, antiform. 7, bedded manganese deposits. 8, bedded manganiferous iron oxide deposits.
Fig. 3 Route map of the Kaminokuni area.

1, granitic rock. 2, sandstone (Late Jurassic). C, conglomerate. 3, black mudstone (Middle to Late Jurassic). sil. sh, siliceous shale. 4, greenish grey siliceous mudstone (Middle to Late Jurassic). 5, grey bedded chert (Triassic to Early Jurassic). 6, grey bedded chert (Middle to Late Permian). bc, black chert. 7, red bedded chert (Late Carboniferous and Middle Permian). rc, red chert. 8, dolomite. 9, greenstone. g, greenstone. 10, localities of radiolarians and conodonts. 11, bedded manganese deposits. 12, bedded manganiferous iron oxide deposits.

This lithologic feature of the Permian bedded chert is similar to those reported from the Permian bedded chert in the Tamba Belt, Southwest Japan (e.g. Ishiga, 1983). Thickness of
Fig. 4 Geologic profile of the Kaminokuni area. For legend see Fig. 3.

Fig. 5 Geologic columns of the unit 2 of the Matsu-mae Group in the Kaminokuni area. Each number is the locality number in Fig. 4. For legend see Fig. 3.

The red bedded chert is estimated about 200 m, while that of the grey bedded chert is about 250 m along the Mena-zawa (Fig. 5). Thickness of a single layer of the grey bedded chert also varies as in the case of the red chert mentioned above. Dolomites and limestones of several meters thick are often intercalated within the bedded chert just above the greenstone. In the bedded chert above the boundary between the dolomite and the chert, many lenticular layers of ferromanganiferous parts with 1 cm thick are intercalated at Loc. 18 near the Hiyam-tetsuzan of bedded manganiferous iron oxide deposit in the Tomappu-zawa in Fig. 3. In the Esashi district, a bedded manganese deposit is known in the Hirano mine. The formative age of the deposit is discussed later in this paper.

This formation consists mainly of black to grey mudstone and intercalated greenish grey siliceous mudstone. Black mudstones are in places well bedded and laminated, where no blocks of bedded chert, greenstone and sandstone are not found. The rocks of this formation are well exposed along the forest road in the Mena-zawa and the downstream of the Tomappu-zawa. Mudstones in the latter route include blocks of Permian and Triassic bedded cherts and greenstones as olistoliths and shows foliation or scaly appearances. Judging from the evidence, the strata exposed along the Tomappu-zawa are regarded to belong to the different unit, the unit 1 of the Matsumae Group as mentioned already.

Total thickness of this formation of the unit 2 is estimated to be about 700 m along the upper stream of the Tomappu-zawa, while that of the unit 1 is calculated to be over 1500 m along the downstream of the Tomappu-zawa. The difference of thickness may be caused by tectonic repetition of the strata within the unit 1. The stratigraphic sequence of the unit 1 has not been clarified.

The relationship of the mudstone of this formation with the bedded chert of the a formation is observed at Locs. 8 and 12 in the Mena-zawa (Fig. 5). Black mudstones of the b formation conformably overlie the black bedded chert of the a formation. The age of the mudstone is regarded to be late Middle Jurassic, while that of the bedded chert is Late Permian as will be mentioned below. The b formation of the unit 2 consists of sandy mudstone which includes olistoliths of greenstone and red bedded chert. Especially, in the upper part of the b formation, characteristic olistostrome which consists of lenticular bodies of bedded red chert and greenstones within a small amount of muddy matrix is developed. This
olistostrome about 200 m thick is well observed along the Tatsumaki-zawa, and this facies continues southeastward to the Mena-zawa, and it is shown as a thick bedded red chert in the geologic route map (Fig. 3).

**c formation**

This formation consists of dark grey sandstone composed of medium- to coarse-grained feldspathic arenite. Sandstone is usually massive and partly well bedded or alternated with mudstone. This formation includes siliceous mudstone and conglomerate. The siliceous mudstones sometimes alternate with fine sandstone. Total thickness of the sandstone of this formation is estimated to be about 600 m (Fig. 5).

The sandstone of the southern wing of the Mena-zawa synform is usually massive, while that of the northern wing is bedded. Thickness of the single bed of the sandstone ranges from 10 to 50 cm thick and is alternated with thin mudstone layers with several cm thickness. Massive sandstone contains olistoliths of the red and black bedded cherts (see Fig. 3). Sandstone composition of this formation is described in the following chapter.

**(2) Assabu area**; The Matsumae Group in the Assabu area consists of the units 1 and 2 which correspond to the two units in the Kaminokuni area. The unit 2 is composed of the greenstone and bedded chert, and mudstone formations in ascending order, but these two formations are regarded to be repeated tectonically in two or three times within this unit (Fig. 2). The unit 1 is composed chiefly of the sandstone formation which is lithologically similar to the b formation of the unit 2 in the Kaminokuni area. No radiolarians have been obtained yet from the rocks in this area because of strong hydrothermal alteration in Miocene time. The greenstone and bedded chert formation in the Assabu area corresponds to the eastern extension of the a formation in the Kaminokuni area and forms the northeastern wing of the Mena-zawa synform. This formation consists of basaltic volcanics and bedded chert in ascending order. Thickness of the basaltic rocks is estimated to be 200 m in the Yabitsu-zawa. Bedded cherts are usually dark grey or black in color, while in the basal part of the bedded chert sequence just above the greenstone, the color changes to red or reddish brown. Although radiolarians have not been obtained from the bedded cherts, red and grey bedded cherts accompanied by greenstone are regarded to be lithologically correlated with the a formation and its age is Late Carboniferous to Permian. The mudstone formation of the unit 2 in the Assabu area is composed of black to grey mudstones including bedded cherts and greenstones as lenticular bodies in various scales, and this formation is regarded to be the b formation in the Kaminokuni area.

The sandstone formation of the unit 1 in the Assabu area consists mainly of alternating beds of sandstone and mudstone, and in some parts thick massive sandstone and conglomerate are intercalated in the bedded sandstone. Conglomerates are usually intercalated within the massive sandstone including a large amount of fragments of black to grey chert. The fine-grained part of the conglomerate lithologically resembles the chert arenite. Sandstone composition of this formation in the Assabu area is much alike to those of the c formation in the Kaminokuni area.

**2.2 Era district**

The Matsumae Group is distributed in Era district 15 km south of the preceding Esashi district and the authors examined the rocks in the Ishizaki area and the middle stream of the Ookamotsu river (Fig. 6). The Matsumae Group in the Era district consists chiefly of greenstones, bedded cherts and mudstones with a small amount of sandstones, and their general trends are N-S direction. Strata are gently folded with fold axis trending in nearly N-S direction and in some parts they dip steeply affected by the faulting with N-S and NNW–SSE directions. In the Ishizaki area, some polymetallic manganese (Pb, Zn and Ag) vein-type deposits in Miocene time are found near the boundary between the Matsumae Group and the Tertiary volcanic rocks, while in the middle stream of the Ookamotsu river, several bedded manganese deposits are intercalated in grey bedded cherts. Besides,
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3. Sandstone Composition and Provenance of the Matsumae Group

Sandstone of the c formation of the Matsumae Group in the Kaminokuni area is examined in order to clarify the nature and the provenance of it. Samples of coarse-grained massive sandstones, were collected from six localities in the Mena-zawa.

Mode of matrix of the sandstones ranges from 3 to 7% and the sandstone belongs to arenite in Okada’s (1968) classification. The matrix is composed of clay minerals, such as illite and chlorite, and includes Jurassic radiolarians. Sandstone composition of the Matsumae Group is plotted in the Qm–P–K and Q–F–L triangular diagrams (Fig. 7). It has been disclosed that sandstone compositions are remarkably similar throughout the six localities.

Sandstone is characterized by the presence of a large amount of quartz and alkali feldspar grains and less amount of plagioclase grains (see Qm–P–K diagram). In addition, the amount of lithic fragments is smaller than that of the total quartz grains (Q–F–L diagram).

Quartz grains are characterized by polycrystalline quartz which is regarded to be derived from quartz schists or other metamorphic rocks and some of them display mylonitic texture. Concerning the alkali feldspar grains, microcline and perthite are abundantly contained. They are well preserved compared with those of the plagioclase grains. Plagioclase grains have been altered into sericite and chlorite. As for the lithic fragments, grains of the mylonitic rocks and quartz schists are abundantly contained with a small amount of basic volcanic rocks. Zircon and biotite are contained in the matrix. Sand grains are surrounded by opaque minerals and quartz or carbonate minerals. Based on the composition of sandstone and the nature of lithic fragments, the provenance of this sandstone is regarded to be continent or island arc regions where granitic rocks were widely distributed.

4. Age of the Matsumae Group

The Matsumae Group in the study area has been locally subjected to hydrothermal activities, however the radiolarians and conodonts have been obtained from many localities.
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Fig. 8 Lists of radiolarians and conodonts from the Matsumae Group in the study area.

4.1 Esashi district

a formation

The age of the greenstone has not been determined because of the lack of the fossil evidence, but it is regarded to be Late Carboniferous to Earliest Permian on the basis of stratigraphic position under the Early Permian bedded red chert mentioned below. Detailed examination of radiolarian bio-stratigraphy was done on the bedded chert sequence about 100 m thick of the Mena-zawa in which three assemblages ranging from late Late Carboniferous to early Late Permian are discriminated.

Explanation of plate

1. Stylocapsa(? sp. cf. S. spiralis Matsukawa group
2. Stylocapsa sp.?  
3. Williriedellum sp.
4. Stylocapsa sp. cf. S. tecta Matsukawa
5. Stylocapsa sp. cf. S. robusta Matsukawa
7. 8 Triassocampe deweveri (Nakaseko and Nishimura) (Loc. 23). Both are lateral view.
10. Albaillella sp. cf. A. sinuata Ishiga and Watase (Loc. 18). Lateral view.
11. Pseudoalbaillella sp. cf. P. scalprata (Holdsworth and Jones) (Loc. 18). Apical cone is detached.
12. Pseudoalbaillella u-forma (Holdsworth and Jones) (Loc. 5). Apical cone is detached. Lateral view.
15. 17 Gondolella sp. A (Loc. 16). 15, obliquely oral and 17, obliquely aboral view.
18. 21 Gondolella sp. cf. G. bella Stauffer and Plummer (Loc. E–4). Both are lateral view.
Pseudoalbaillella u-forma morphotype II which is the characteristic species of the late Late Carboniferous to early Permian P. u-forma m. II Zone of Ishiga (1986), occurs from the bedded chert at Loc. 5. And the upper horizon of the bedded red chert at Loc. 6 yields Albaillella sp. cf. A. sinuata Ishiga and Watase and Pseudoalbaillella sp. cf. P. scalprata (Holdsworth and Jones), which are the characteristic species of the late Early Permian A. sinuata Zone (Ishiga et al., 1982, 1986). On the other side, Follicucullus scholasticus occurs from the grey bedded chert at Loc. 7, which is known from the late Middle to early Permian bedded chert in Southwest Japan (see Ishiga, 1986; Yoshida and Murata, 1985). In summarizing, the red to grey bedded chert sequence overlying the greenstone includes long time span from late Late Carboniferous through Permian time. In addition, a bedded grey chert of the a forma-

Additional data of bedded cherts occurring in the olistostrome of the b formation derived from the a formation: Concerning the conodonts, Gondolella sp. A, G. sp. B and Gnathodus sp. occur from Loc. 16 and these conodonts are regarded to be the Permian type because of having flat platform, however, whose age is not strictly determined. In conclusion, the age of the bedded chert of the a formation ranges from Early to early Late Permian including Late Carboniferous, and the bedded chert sequence overlying the greenstone includes long time span from late Late Carboniferous through Permian time. In addition, a bedded grey chert of the a formation at Loc. 18 yields Albaillella sinuata.

The former two assemblages occur continuously along the section at Mena-zawa in Fig. 3, so the mudstone of this section includes the almost whole of the Middle Jurassic.

The age of bedded cherts included as olistoliths in this formation shows wide variation: Permian bedded chert associated with the greenstone is mentioned already. As of the Mesozoic ones, a bedded chert at Loc. 23 yields early Middle Triassic Triassocampe deweveri Nakaseko and Nishimura, while that at Loc. 25 yields Late Triassic conodonts. Early Jurassic Parahsuum spp. occur from a bedded grey chert at Locs. 1 and 2. In conclusion, the age of mudstones of the b formation of the unit 2 ranges from early to late Middle Jurassic and those of the unit 1 include early Middle to early Late Jurassic.

The age determination of this formation based on microfossil is difficult, for it is mainly composed of coarse clastic materials. However the age of the c formation is regarded to be early Late Jurassic or post early Late Jurassic based on the stratigraphic position over the late Middle Jurassic b formation mentioned above. In addition, greenish siliceous mudstones included as a lenticular body within thick sandstone beds or alternating with a well bedded sandstone at Loc. 22 in the upper stream of the Mena-zawa yield early Late Jurassic radiolarians.

Judging from these lines of fossil evidence, the age of the Matsumae Group in the Kami- nokuni area ranges from Early Permian (partly Late Carboniferous) to early Late Jurassic. The Paleozoic rocks of this group are characterized by greenstone-bedded chert facies, while the Mesozoic (Jurassic) are represented by clastic rocks. In addition the Triassic to Early Jurassic bedded chert are included as olistoliths within the Middle Jurassic clastic rocks.

4.2 Era district

The Maruyama in the Ishizaki area: The bedded black chert dominantly exposed in this area which is strongly altered by polymetallic manganese (Pb, Zn and Ag) mineralizations in Miocene time. Although the radiolarians from
bedded cherts could not be identified in the specific level, late Triassic conodonts such as *Epigondolella postera*, *E. abneptis*, *Gondolella polygonathiformis* are found from well bedded grey chert at Loc. K-40 in Fig. 6. The host rock of the Pb–Zn–Cu vein deposit (Maruyama dep.) is regarded to include Upper Triassic (Carnian to Norian) bedded chert.

The Ookamotsu area: Bedded black chert is dominantly distributed in the northern side of the Ookamotsu river in which the bedded manganese deposits occur (IGARASHI et al., 1958). Serpentinite and basic igneous rocks are intruded into the bedded chert. Concerning the conodonts, Late Carboniferous *Gondolella bella* and *Streptognathodus* sp. occur from the bedded black chert at Loc. E-4 in Fig. 6. The formative age of the bedded manganese deposits in this area is regarded to be Late Carboniferous to Early Permian on the basis of conodonts.

5. Discussion

5.1 The Matsumae Group, a Jurassic accretionary complex

Recently the Meso-Paleozoic complex of the Southwestern Hokkaido has been re-examined in the light of several geologic methods (e.g. TAJIKA et al., 1984; KAWAMURA et al., 1986; MINOURA, 1985). As a result, the previously interpreted geologic age of the Matsumae Group may need to be reassessed and presumably no autochthonous Paleozoic formations are existed in this area. Furthermore, the main portion of the group is supposed to be Mesoic especially Jurassic in age.

One of the common lithology among the Meso-Paleozoic strata in Japan is the alternation of the basaltic rocks and bedded chert formation and the mudstone and sandstone formation. And the rock of the former are often reworked into the latter during the formation of the olistostrome. The basalts are mostly alkaline and are certainly regarded to have been formed at the sea-mount or oceanic islands based on the petrochemical study reviewed by KAWAMURA et al. (1986) in late Triassic time. Bedded cherts, which are closely associated with basaltic rocks, are composed of siliceous biogenic materials and detrital materials transported from a continent or an islands arc. A sedimentation rate of the bedded chert is very low, like that of recent siliceous ooze, and the bedded chert sequence with a thickness of about 100 m in the Menazawa has the long time span from Late Carboniferous through Permian time. Thus, the a formation of the Matsumae Group is regarded to have been formed at or near a sea-mount or an oceanic island. On the other hand, detritus of the b formation including the Middle Jurassic mudstone was transported from a continent or an island arc. Black mudstones generally have been suffered strong deformation showing the foliation or scaly appearance and include the fragments or blocks, which were originally olistoliths, also deformed to lenticular or to boundinage shape. These lithologic features reveal that the greenstone and bedded chert of the a formation reached the depositional basin of the b formation and they both are accreted to the continental crust, in or post-Late Jurassic time. Basaltic volcanics accompanying Triassic limestone are recognized in the Kamiiso and Toi-Esan districts further east of the Esashi district and the bedded chert of the same age is regarded to be accompanied by these basaltic rocks. These districts would represent another terranes different from the Kaminokuni Terrane. Triassic cherts recognized in this paper (see description of the b formation in the Katsuraoka area) may be derived from the strata of the Kamiiso and Toi-Esan Terranes in Middle to Late Jurassic time, because the Triassic bedded cherts are less common in the Kaminokuni Terrane than those of the neighboring terranes.

5.2 Nature and formative age of the manganese deposits in comparison with those in Southwest Japan

Two types of bedded ore deposits of pre-Tertiary time exist in the Southwestern Hokkaido, namely, the bedded manganiferous iron oxide deposits (e.g. Hiyamatetsuzan deposit) and the bedded manganese deposits (e.g. Era, Kamihata, Kenpachiryu, Hirano and Ookamotsu deposits). The host rock of the bedded manganiferous iron oxide deposits is
usually bedded red chert accompanied by greenstone mainly composed of basic lava or hyaloclastite and in some cases dolomite or limestones intercalated beneath or above the bedded deposits at the Loc. 18 in Tomappuzawa near Hiyamatetsuzan deposit. On the other side, the bedded manganese deposits are intercalated within the bedded grey or black cherts which are usually not accompanied by greenstone. The bedded manganese deposits are stratigraphically located above the ore horizon of the bedded manganiferous iron oxide deposits. Consequently, those occur in western side of the Hiyamatetsuzan and the lithologic features of host rock of these deposits are different, however, they are regarded to have been formed in Late Carboniferous to Early Permian as mentioned already. The ore of the Hiyamatetsuzan deposit is mainly composed of hematite (UMEMOTO and WATANABE, 1957). The lenticular ferromanganese sediments occur at Loc. 18 in Tomappuzawa near Hiyamatetsuzan deposit. The lenses are concordant with enclosing bedded red cherts, and the bedded red cherts warp around lens, suggesting syngenetic deposition. The contents of Fe, Mn, Ni, Co and Cu of the lens disclosed by wet chemical analysis are as follows:

$$Fe = 6.00 \, \text{wt\%}, \quad Mn = 6.90 \, \text{wt\%}, \quad Ni = 54 \, \text{ppm}, \quad Co = 82 \, \text{ppm}, \quad Cu = 48 \, \text{ppm}.$$  

The chemical composition of the lens is regarded to be depleted in trace metals such as Ni, Co, Cu relative to hydrogenous sediments. The ratio of Fe: Mn: (Ni+Co+Cu) × 10 falls in the “hydrothermal” ferromanganese field in the ternary diagram showing Fe vs. Mn vs. (Ni+Co+Cu) × 10 for manganiferous marine deposits (e.g. BONATTI et al., 1976). The mineral assemblages of the bedded manganese deposits (SAITO and MATSUMURA, 1955; IGARASHI et al., 1958; DOI and BAMBA, 1969; this study) (Fig. 6) are summarized as follows:

**Kamihata deposit**—rhodochrosite > rhodonite > quartz, spessartine, pyrite, chalcopyrite, sphalerite, alabandite, magnetite;

**Ookamotsu deposit**—rhodochrosite > penwithite, quartz;

**Era deposit**—rhodochrosite, rhodonite > pyrolusite, psilomelane > quartz, spessartine, magnetite;

**Kenpachiryu deposit**—rhodochrosite > grossularite, quartz, pyrite, chalcopyrite, bornite(?).

The bedded manganese deposits are also discriminated in Southwest Japan where many kinds of bedded manganese deposits exist (YOSHIMURA, 1952, 1967). In the Inner zone of Southwest Japan, the bedded manganese deposits are intercalated in the bedded black cherts as was observed in the Tamba Belt. While bedded manganese deposits in the Outer Zone (e.g. the North subbelt of the Chichibu Belt) occur in the bedded red cherts associated with greenstones. The formative ages of the bedded chert of the host rock at the Yumiyama and the Ashitani deposits in the Tamba Belt are Early Jurassic and Late Triassic, respectively (IMOTO et al., 1982). While the age of the bedded chert of the host rock at the Ananai deposit in the North subbelt of the Chichibu Belt is late Middle Permian (SUYARI et al., 1983), and the age falls in that of the bedded cherts in the Esashi and Era districts which host the bedded manganese deposits.

Therefore, it is possible to conclude that the formative ages, lithofacies and tectonic division of the bedded manganese deposits in the Inner Zone are different from those of the bedded manganese deposits such as the Era, Ookamotsu and the Ananai deposits in the Outer Zone.

### 5.3 Geologic structure, and its tectonic implication

Concerning the geologic structure of the Matsumae Group in the Esashi district, the essential structure before folding and lateral faulting is characterized by two-storied structure, which comprises two tectonic units. Moreover the unit 2 of the eastern wing in the Assabu area is composed of at least three subunits and the synclinorium in the Kaminokuni area is an asymmetrical folding concerning the lithology and length of each wing. This structure has not been common in the terranes of the accretionary complex in Southwest Japan, because the structure formed by accretion...
shows the dominantly imbricated structure and the polarity of age of the sedimentary rocks etc. Recent progress in the examination of continental margin or island arc indicates that not only off scraping but also underplating occur in the modern accretionary prism (e.g. Silver et al., 1985), in other words, during the duplex accretion, the sediments are transferred from the subduction slabs to overriding accretionary prism (e.g. Sample and Fisher, 1986). Through this kind of accretion, the decollement structures are growing to form duplex blocks which are composed of the underlying and the overlying tectonic units. The two storied structure in the Esashi district is regarded to have been formed as a result of the duplex accretion to the South Kitakami Massif in and post early Late Jurassic time.

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References


西南北海道，上ノ国地帯のジュラ紀付加体

石賀裕明・石山大三

要旨：西南北海道の上ノ国地帯には松前層群と呼ばれるジュラ紀の付加体堆積物が広く分布する。この地域の松前層群は構造的上部をなすユニットからなる。構造的上位をなすユニット2は下位よりa, b, c層からなり、構造的下位をなすユニット1は主にδ層からなる。

δ層はジュラ紀新世不いしベルム紀の海底性堆積の緑色岩層形成を伴い、緑色岩層層状チャートその他の構造変動を伴う。これらはグッス結核が主とする。これらの北日本地域の層序の特徴を形成年代が西南日本外帯のものと類似するが、内帯のものとは異なるものである。δ層はジュラ紀中新世不いしベルム紀の海底性堆積物の単層層を主とするが、δ層に由来する緑色層層状チャートのリアリスに由来するジュラ紀新世層群の砂岩層からなり、砂岩は大陸や鳥弧からもたらされたと思われる。

上ノ国地帯はジュラ紀新世前期に堆積した層序をもつ付加体が形成（duplex accretion）され、その後、さらに褶曲、断層により変位、变形を受けて上ノ国地帯の基本構造が形成されたと思われる。

地名 英（和）対照表

<table>
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<th>江差</th>
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<th>五勝部</th>
<th>Gokkatte</th>
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<tr>
<td>上ノ国</td>
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<td>厚沢部</td>
<td>Assabu</td>
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