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# Comparative Characteristics of the Samarka (Sikhote-Alin) and Ultra-Tamba (Japan) Terranes as Grounds for Correlating Fragments of the Jurassic Accretionary Prism in Two Regions

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**Abstract**—Comparative data on tectono-stratigraphic complexes of the Ultra-Tamba terrane (Inner Zone of Japan) and upper structural level of the Samarka terrane in the Jurassic accretionary prism of Sikhote Alin are considered. Structural, lithological, petrographic data and age constraints characterizing rock associations of the terranes show that the latter are similar to a great extent, and consequently the Ultra-Tamba terrane can be regarded as an element of the Tamba–Mino–Ashio accretionary prism of the Jurassic but not Permian age, as it was thought earlier. The considered data substantiate confident structural correlation of both fragments of the Jurassic prism and of two regions in general.

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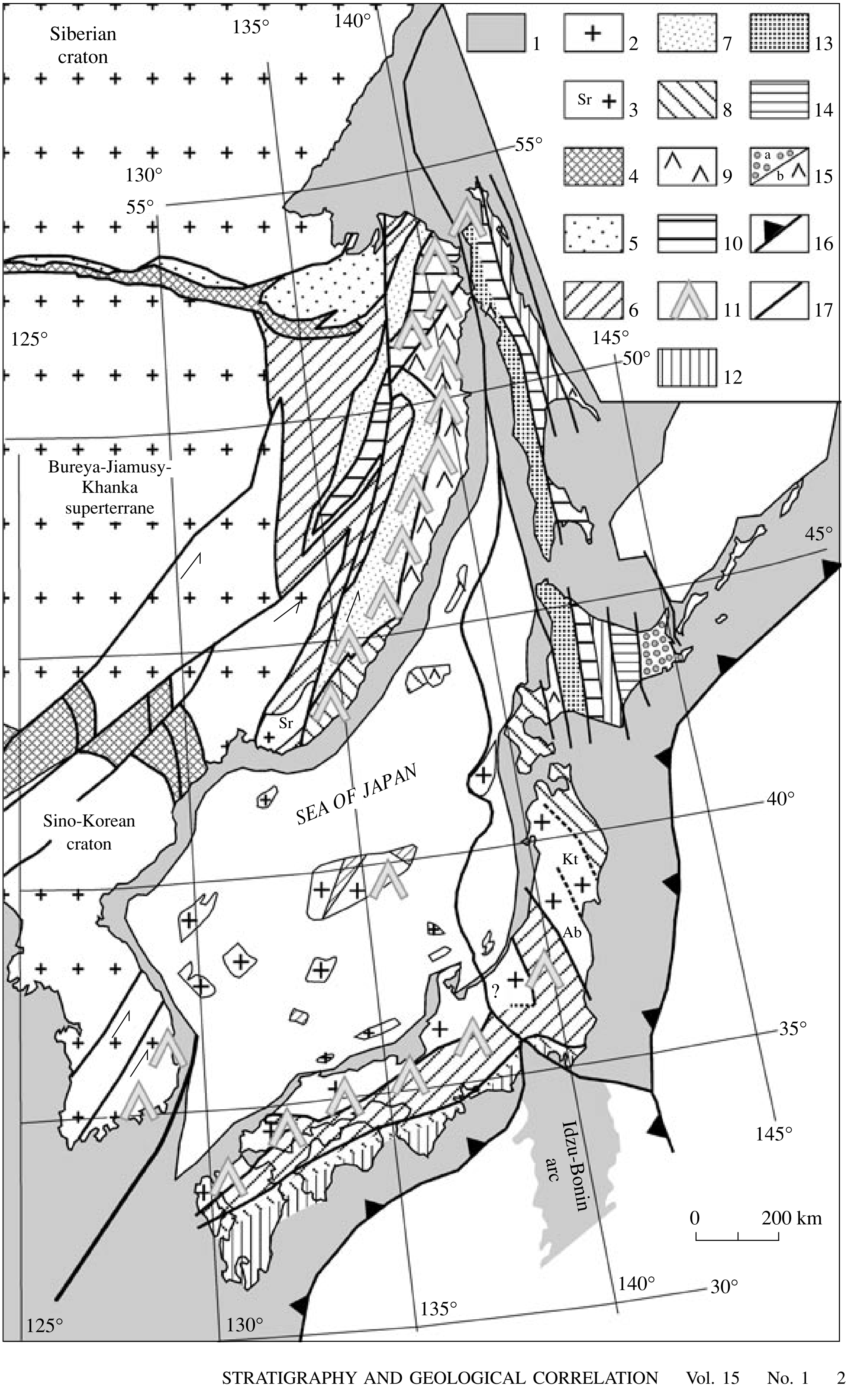
*Key words*: accretionary prisms, terranes, tectono-stratigraphic units, accretion, subduction, oceanic sediments, subduction-related melange, Sikhote Alin, Japan.

## INTRODUCTION

Numerous fragments of old accretionary prisms are main structural elements (Fig. 1) of the Sikhote Alin and Japan (Kemkin and Filippov, 2002; Khanchuk and Kemkin, 2003; *Pre-Cretaceous…*, 1990; and others). The prisms represent tectono-stratigraphic complexes of an intricate imbricated structure being composed of complicatedly alternating tectonic slices and blocks of oceanic (pelagic to hemipelagic sediments and fragments of seamounts and underwater rises), marginal oceanic (sandy–shaly sediments), and chaotic (melange and olistostromes) deposits. An example is the Jurassic accretionary prism that includes the Samarka, Nadan'khada–Bikin, Khabarovsk, and Badzhal terranes in Sikhote Alin and the Tamba, Mino, and Ashio terranes in the Inner Zone of Japan. A comparative study of these terranes showed their similarity and stimulated some researchers (Kemkin and Khanchuk, 1993; Mazarovich, 1985; Khanchuk et al., 1988; Khanchuk and Kemkin, 2003; Kojima, 1989; Mizutani and Kojima, 1992) to suggest that an integral subduction–accretionary system extended in the Jurassic along the Pacific margin of Asia. Similarity of the terranes is evident from a complete structural analogy of particular prism sections, which are of comparable lithology in both regions, and from concurrent ages of pertinent rock associations in paleoceanic fragments and overlying terrigenous rocks, which contain microfossils of identical taxonomic composition.

On the other hand, there are certain differences as well. For example, the uppermost structural level of the Samarka terrane (the best-studied fragment of the Jurassic prism in Sikhote Alin) is composed of accreted paleoceanic fragments representing a dismembered ophiolitic association (Kemkin and Khanchuk, 1993; Kemkin and Filippov, 2002; Khanchuk et al., 1988, 1989; and others). These are tectonic sheets and blocks composed of the following rocks (Fig. 2): (1) Middle Paleozoic gabbro and ultramafics (Kalinovka Formation); (2) basalts, frequently associated with overlying Carboniferous–Permian carbonate and siliceous rocks and Upper Permian black silty argillites (Sebuchar Formation); (3) greenish gray and tobacco–green sandstones alternating with similarly colored Upper Permian siltstones (Udeka Formation).

Paleoceanic fragments of this kind are unknown in the Jurassic prism of the Inner Zone of Japan, except for blocks of basalts associated with Paleozoic cherts and


Siberian craton
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2
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5
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14
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a
b
16
17
55°
130°
55°
125°
145°
50°
50°
Bureya-Jiamusy-Khanka superterrane
45°
45°
Sr
SEA OF JAPAN
Sino-Korean craton
40°
40°
Kt
Ab
?
35°
35°
Idzu-Bonin arc
0
200 km
145°
140°
30°
135°
125°
130°

**Fig. 1.** Principal structural elements of the Japan Sea region (after Khanchuk, 2000 with additions): (1) present-day continental and island shelf; (2, 3) old crystalline massifs with the continental development regime: (2) Bureya–Jiamusy–Khanka superterrane, Sino-Korean, and Siberian cratons, (3) Sergeevka (Sr), Southern Kitakami (Kt), Abukuma (Ab), and Kurosegawa continental blocks; (4) Permian–Triassic accretionary prisms; (5) Jurassic turbidite basin (Ul'ban and Un'ya-Bom terranes); (6) Jurassic accretionary prism (Samarka, Nadan'khada–Bikin, Khabarovsk, Badzhal, Mino, Tamba, Ashio, Rioke, Sambagawa, and Northern Chichibu terranes); (7) Early Cretaceous turbidite basin (Zhuravlevka–Amur terrane); (8) Tithonian–Hauterivian accretionary prism (Taukhe, Oshima, Northern Kitakami, Southern Chichibu, and Ryukyu terranes); (9) Hauterivian–Albian island arc (Kem, Kamyshov, Shmidt, Moneron, and Rebun-Kabato terranes); (10) Hauterivian–Albian accretionary prism (Kiselevsk–Manomin, Aniva–Gomon, and Western Hidaka terranes); (11) Late Cretaceous volcanic arc (Eastern Sikhote Alin volcanogenic belt); (12) Late Cretaceous accretionary prism (Nobil, eastern Hidaka, and Shimanto terranes); (13) Late Cretaceous fore-arc basin (Western Sakhalin and Sorachi-Ezo terranes); (14, 15) subduction–accretionary complexes of the Paleo-Okhotsk subduction zone: (14) Late Cretaceous accretionary prism (Tokoro terrane); (15a) Late Cretaceous fore-arc basin (Nemuro terrane), (15b) Late Cretaceous island arc (Terpeniya terrane); (16) present-day subduction zone; (17) faults.

limestones in the subduction melange.[1] Rocks close in age and lithology are know however in the neighboring Ultra-Tamba and Maizuru (partly) terranes, which are referred to the Permian accretionary prism and Permian–Triassic continental margin, respectively, bordering the Tamba-Mino terrane in the northwest (*Pre-Cretaceous…,* 1990).

In this connection, I examined in the field the most typical sections of the Ultra-Tamba terrane in order to compare and correlate them with corresponding formations of the Samarka terranes. The results obtained are considered below.

## BRIEF CHARACTERIZATION OF THE ULTRA-TAMBA TERRANE

In the southwestern part of the Inner Zone of Japan (Fig. 3), the narrow NE-trending Ultra-Tamba terrane is clamed between the Maizuru and Tamba terranes. This is individualized based on lithostratigraphic, structural, paleobiofacial, and age constraints of its rock associations (Caridroit et al., 1985; Ishiga, 1986). Being different in structure and composition from the coeval Maizuru and Tamba terranes, the terrane in question is largely composed of Permian rocks bearing microfossils indicative of specific paleogeographic settings. The Ultra-Tamba terrane is bounded by thrust faults thus being in tectonic relations with neighboring structures: it is thrust over the Tamba terrane and overridden by the Yakuno ophiolite that is a structural element of the Maizuru terrane.

According to recent data (Ishiga, 1990), the Ultra-Tamba terrane consists of three tectono-stratigraphic units thrust one over another and differing in lithology and structure. The lower structural unit is the Hikami Formation largely composed of green to greenish gray sandstones alternating with greenish siltstones and, less common, black silty argillites.[2] The latter yielded radiolarians of the terminal Middle–initial Late Permian (Kurimoto, 1986).[3]

The middle structural unit corresponding to the Oi Formation rests upon the previous one with the tectonic contact and is subdivided into three members: (1) bedded cherts grading into siliceous argillites; (2) turbidites composed of rhythmically alternating sandstones and siltstones, and (3) chaotic deposits represented by siltstones with blocks and fragments of sandstones and cherts. An assemblage of Late Permian radiolarians has been extracted from cherts and siliceous shales. There are also data on single finds of Permian radiolarians in black shales of the second member (Ishiga, 1986).

The upper structural unit is the Kozuki Formation consisting largely of black aleuropelites with radiolarians of the terminal Middle–initial Late Permian age and also of basic volcanics associated with Permian cherts and Carboniferous limestones (Pillai and Ishiga, 1987).

## TECTONO-STRATIGRAPHIC COMPLEXES OF THE ULTRA-TAMBA TERRANE

During field works, I examined most typical sections of all three structural units distinguished in the Ultra-Tamba terrane. The objective was to specify their composition, structure, age, and relations between them and with neighboring terranes.

**Hikami Formation.** The type section of the lower structural unit is located 5 km southwest of the Fukuchiyama City. Outcrops are observable in numerous steep cliffs along the Hikami–Ebara highway, in the Anaura pass area, and in the quarry 300 km southward of the pass. The Hikami Formation consists of green to greenish gray medium- to fine-grained sandstones with interbeds of yellowish green to tobacco–green siltstones and subordinate black silty argillites. Sandstones

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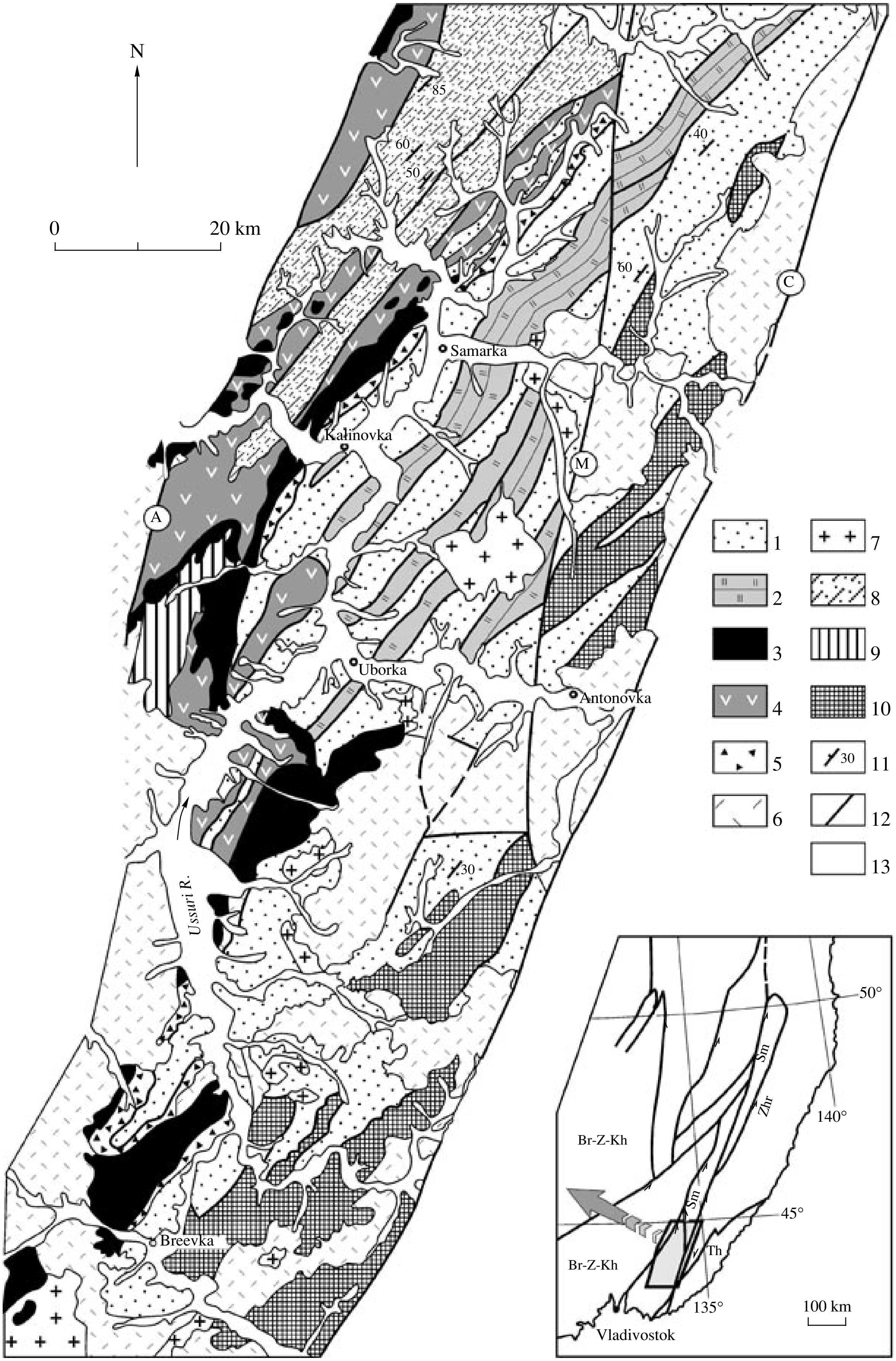
[1] The subduction melange is clastic rock with chaotic structure and aleuropelitic to aleuropsammitic matrix that encloses irregularly scattered size-variable blocks, fragments and small sheets of heterogeneous rocks different in age (usually older than matrix). The subduction melange originates when subducting oceanic plate experience faulting and successively younger parts of the plate become thrust under its older segments. Being destructed at the trust-fault plane, rocks of the upper slab collapse as blocks and smaller clasts into incoherent sediments of the lower slab and, being cemented by sedimentary material, form a chaotic mixtite (Kemkin and Filippov, 2002).

[2] Inasmuch as the term "formation" is understood differently in Russia and abroad, I use original terms in order to avoid confusion when describing rock associations of the Ultra-Tamba terrane.

[3] In Japan, the three-member subdivision of the Permian System is accepted.


N
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20 km
85
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Samarka
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Antonovka
30
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Breevka
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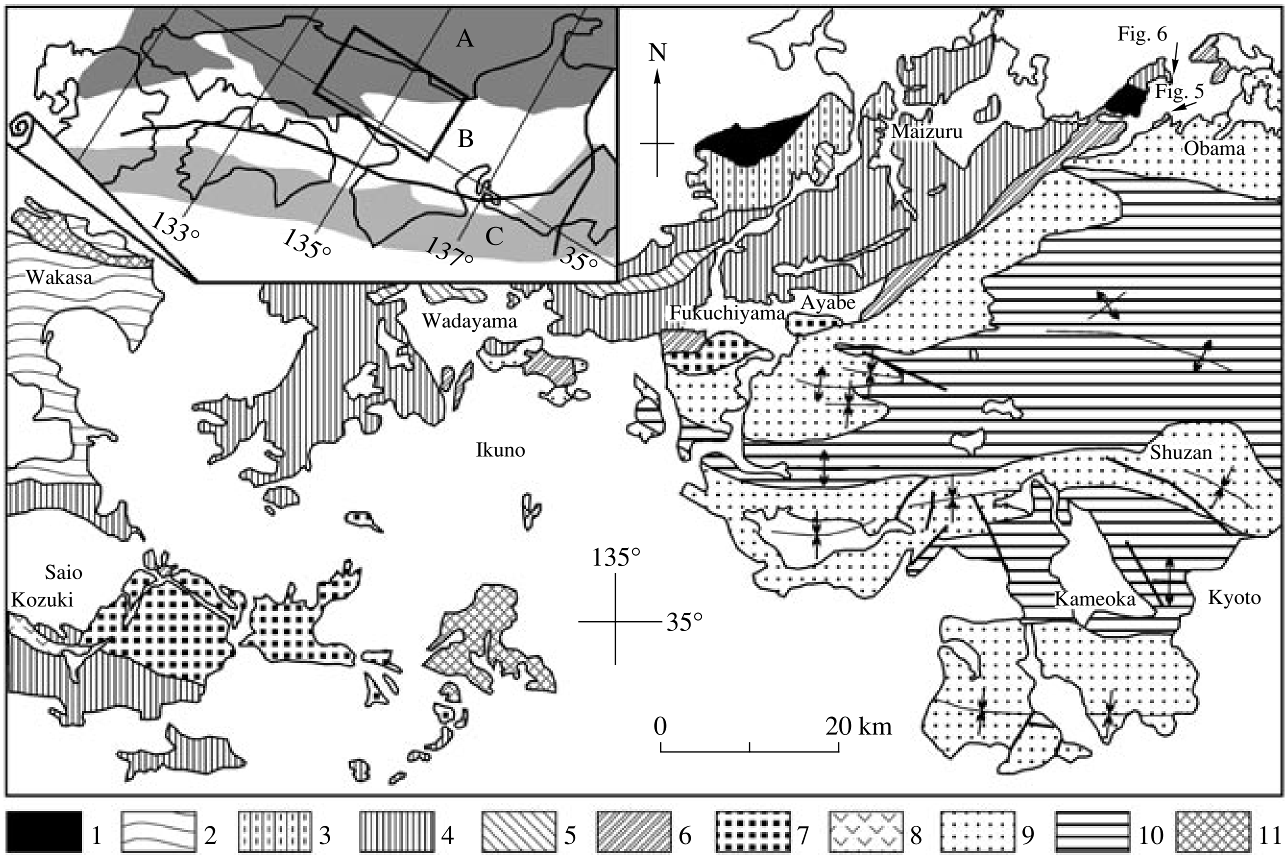

**Fig. 3.** Schematic geological structure of the Ultra-Tamba and neighboring terranes (after Ishiga, 1986 with insignificant additions): (1) ultramafic rocks of the Chugoku terrane; (2) metamorphic rocks of the Sangun terrane; (3) Shimomidani Complex; (4) Permian shallow-water marine (shelf) sediments of the Maizuru terrane and Yakuno ophiolites; (5) Triassic shallow-water marine sediments of the Maizuru terrane; (6–8) Ultra-Tamba terrane: (6) Oi Formation, (7) Hikami Formation, (8) Kozuki Formation; (9–11) Tamba terrane: (9) Lower–Middle Jurassic part of the Tamba terrane, (10) Middle–Upper Jurassic part of the Tamba terrane, (11) undivided sediments of the Tamba terrane. Letters in the inset map denote terranes accreted in the Triassic (A), Jurassic–Early Cretaceous (B) and Cretaceous time (C).

usually massive are bedded sometimes. They are composed of chlorite–hydromica matrix (30–35%) and clastic components (65–70%). Clastic material is represented by angular poorly sorted grains, 80–90% of which are mineral clasts and 10–20%, rock fragments. Mineral clasts include quartz (30–45%), plagioclase (basic, intermediate, and, rarely, acid) and K-feldspar (35–50% in sum). The latter amounts to 15–20% of total quantity of feldspars. Rock fragments are usually represented by granite, felsite, volcanic glass, and metamorphites. In the classification diagram (Shutov, 1967), sandstones of the Hikami Formation plot between feldspar–quartz graywackes and graywacke arkoses (Fig. 4). Siltstones alternating with sandstones are of similar composition. Thickness of siltstone interbeds ranges from 2–10 to 15–30 m. The integral thickness of the Hikami Formation is estimated to be 640–1000 m (Ishiga, 1986). Like in the other two complexes of the Ultra-Tamba terrane, rocks of the formation are intensely deformed that is evident from foliation of siltstones and variable degree of sandstone cataclasis. Deformations are most intense at the contacts with

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**Fig. 2.** Schematic geological map of the southern Samarka terrane (after Khanchuk, 2000 with additions): (1) Lower–Upper Jurassic turbidite–melange rocks of the Samarka terrane; (2) sheets of Permian, Triassic, and Lower Jurassic cherts; (3) Middle Paleozoic gabbroic–ultramafic rocks of the Kalinovka Complex; (4) basalts associated with Permian silty argillites and Carboniferous–Permian cherts and limestones of the Sebuchar Complex; (5) Permian sandstones with siltstones interbeds of the Udeka Complex; (6) Late Cretaceous volcanics; (7) Late Cretaceous granites; (8) Early–Late Jurassic turbidites of the fore-arc trough; (9) Permian–Triassic shallow-water marine (shelf) sediments of the overlying Bureya–Jiamusy–Khanka superterrane; (10) pre-Devonian gabbro–gneisses and overlying Permian–Triassic shallow-water marine (shelf) sediments of the Sergeevka terrane; (11) elements of rock attitude; (12) faults; (13) Quaternary sediments. Encircled letters designate faults: (A) Arsen'ev, (M) Meridional, (C) Central Sikhote Alin. Letters in the inset: (Br–Z–Kh) Bureya–Jiamusy–Khanka superterrane, (Sm) Samarka terrane, (Zhr) Zhuravlevka terrane, (Th) Taukhe terrane.

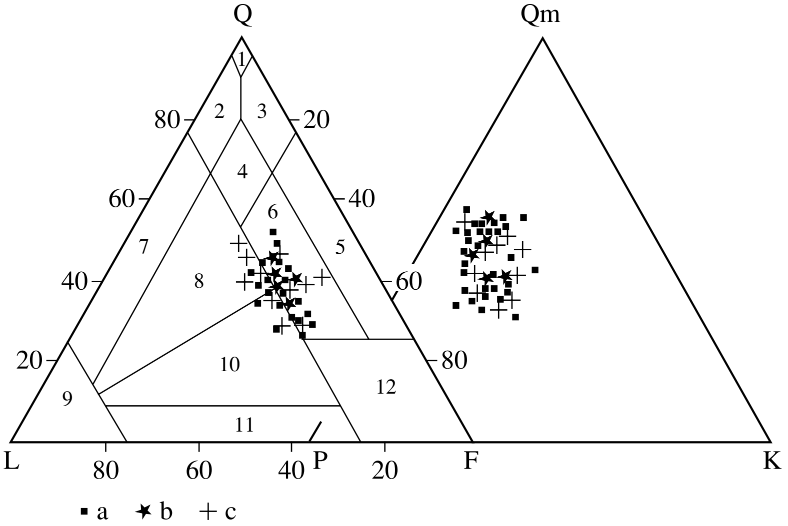

**Fig. 4.** Diagrams characterizing composition of sandstones from the Hikami and Udeka formations: (Q) quartz; (F) feldspars; (L) lithoclasts; (Qm) monocrystalline quartz; (K) K-feldspar; (P) plagioclase. Classification fields: (1) monomictic quartz, (2) siliceous-clastic quartz, (3) feldspar–quartz, and (4) mesomictic quartz sandstones; (5) arkoses proper, (6) graywacke arkose, (7) quartz graywacke, (8) feldspar–quartz graywacke, (9) graywacke proper, (10, 11) quartz–feldspar graywackes, (12) crystalline tuffs. Other symbols: (a) Hikami Formation (after Ishiga, 1986); (b) Hikami Formation (original data); (c) Udeka Formation.

other structural units, where rocks are frequently transformed into mylonites. The Hikami Formation is separated by tectonic contact from "underlying" rocks of the Tamba terrane. According to Japanese geologists (Ishiga, 1986; Kurimoto et al., 1993), "green" sandstones of the Hikami Formation are universally thrust over chaotic deposits (subduction melange) of the Tamba terrane. At the same time, my observations show that immediately below the contact with sandstones of the Hikami Formation (Fig. 5) melange includes size-variable blocks and fragments of "green" sandstone identical to the same rocks above the contact and associated with blocks of cherts (in the outcrop under consideration), basalts, and limestones (in other areas). The contact proper is represented by a fracture 1–2 cm thick oriented parallel to bedding planes in the chaotic matrix. Similar situation was observed also in the right side of the Kambayashi River 20 km northeast of the Ayabe City, where the Hikami Formation is in analogous relations with the Tamba terrane melange (Caridroit et al., 1985). Presence of size-variable fragments of "green" sandstones in the subduction melange of the Tamba terrane indicates that the Hikami Formation represents a large tectonic sheet (as well as sheets of cherts, basalts, and other rocks) in the Tamba accretionary prism of Jurassic age. Tectonic contacts between the sheets could result from various processes. For example, it could be the intraformational detachment along boundary between differently competent rocks during folding or younger tectonic deformations. It is most likely, however, that tectonic contacts are of initial origin, since accretionary prisms increase in volume when new (younger) slabs of oceanic lithosphere thrus under relatively older slabs. It this case, we should speak about underthrusting rather than thrusting to characterize the origin of contacts. Sandstones of the Hikami Formation are tectonically overlain by either the Oi Formation (turbidite–melange and cherty rocks) or serpentinized gabbroids of the Yakuno Formation.

The Hikami Formation age (terminal Middle–initial Late Permian) is established based on radiolarians found in black argillite beds occasionally present among sandstones (Kurimoto, 1986).

**Oi Formation.** The type section of the middle structural unit is located 15 km west of the Obama City, where the middle and, partly, upper parts of the formation are exposed. The most representative sections of all three parts has been observed near the Ayabe City (Caridroit et al., 1985) and in the eastern extremity of the Oura Peninsula 10 km northwest of the Obama City (Ishiga, 1985, 1986). In addition, some fragments of this structural unit are studied in numerous isolated outcrops in the Fukuchiyama City area.

The Oi Formation is divisible into three parts of different lithology. In the Oura Peninsula, the lower part of the visible section (Fig. 6) is represented by pinkish red flaggy cherts approximately 16 m thick. Splitting of the rocks is determined by alternating chert (2–4 cm) and siliceous argillite (2–5 mm) beds. Higher in the section, cherts are replaced by thin alternation (a few millimeters) of siliceous and siliceous-argillaceous laminae grading into siliceous argillites. The member is slightly over 6 m thick. It is overlain by a member of terrigenous turbidites (thin alternation of silty sandstones, siltstones, and silty argillites) 14 m thick. The visible section is crowned by a member of chaotic deposits approximately 45 m thick, composed of black silty argillites with blocks and fragments of sandstones,

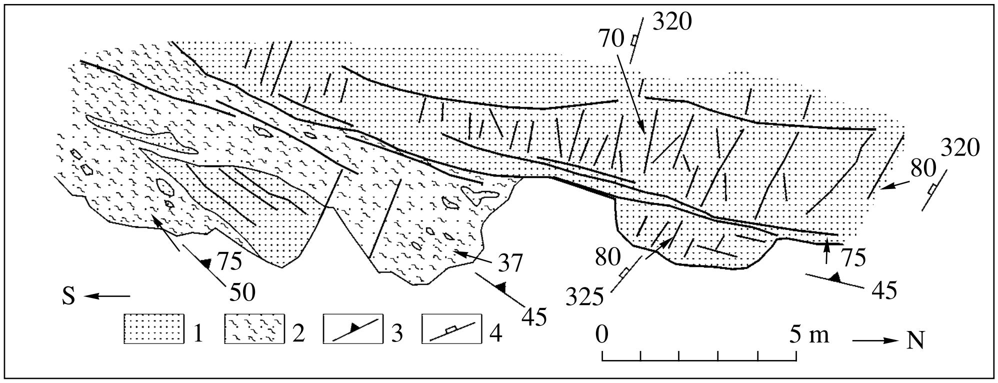

**Fig. 5.** Sketch of the riverbank outcrop illustrating relationships between the Hikami Formation and melange of the Tamba terrane (after Ishiga, 1986): (1) "Green" sandstones from the Hikami Formation; (2) subduction-related melange of the Tamba terrane; (3) elements of rock attitude; (4) orientation of fractures.

cherts, and siliceous argillites. It should be noted that all the rocks are intensely altered: siliceous rocks are recrystallized, while terrigenous rocks are transformed into phyllite-like varieties. The remarkable deformation degree of rocks from this part of the Oi Formation is a result of their proximity to the thrust plane, along which they are overridden by ophiolites. The contact zone approximately 15 m thick is composed of foliated serpentinites with blocks and smaller fragments of basalts, dolerites, cherts, and siltstones. As for the age of the Oi Formation, there is the following information. Siliceous rocks, as well as terrigenous varieties in occasional localities, the section under consideration included (Fig. 6), contain radiolarians of the uppermost Middle–basal Upper Permian (Caridroit et al., 1985; Ishiga, 1985). I have sampled turbidite and chaotic sediments of the Oi Formation in different areas as well. Many of these rocks contain radiolarians. Their preservation is unfortunately insufficient due to intense deformation of rocks. Fossils are represented by recrystallized flattened spheroids and ellipsoids, which cannot be identified even at the order level. At the same time, several samples yielded rare radiolarian remains of slightly better preservation. An assemblage in the sample taken from phyllite-like rock in the eastern extremity of Oura Peninsula (Fig. 6) near the contact with the Yakuno ophiolites appeared to be most representative, although of the mixed composition. On the one hand, it includes poorly preserved forms (representatives of the families Hsuidae, Eucyrtidiellidae, and others) of the Jurassic age. Besides, some forms of better preservation, identifiable even at the species level, point to the Permian age of host rocks. E.S. Panasenko identified the following species: *Follicucullus bipartitus, F. scholasticus, F. monocantus, F. dactylinus, F. dilatatus, Albaillella triangularis, Pseudoalbaillella globosa, P. corniculata, P. fastigata, Pseudoalbaillella* sp., *Nazarovella gracilis, Ishigaum trifustis, Phaeniocosphaera* cf. *mamilla, Pseudotormentus kamigoriensis*, and others. This assemblage of radiolarians characterizes at least four intervals of the Upper Permian corresponding to the lower part of the Kubergandian Stage, middle part of the Murgabian Stage, lower part of the Midian Stage, and middle–upper part of the latter stage. Thus, a single sample contains five radiolarian assemblages of different age. Examination of thin sections and etched surface of the sample clarified the situation to some extent: the rock relatively uniform by visual examination consists of foliated silty argillite matrix and flattened fragments (from a few millimeters to a few centimeters) of cherts and siliceous argillites (melange) (Fig. 7). Examination of etched surface under binocular microscope showed that Permian radiolarians are from inclusions, while forms of the Jurassic affinity are from the foliated matrix. This explains better preservation of Permian radiolarians (more plastic matrix experienced stronger deformation) and diversity of their ages (melange encloses fragments of siliceous rocks from different stratigraphic levels).

Taking into consideration all these data, one can conclude that the terrigenous part of the Oi Formation is most likely of the Jurassic age. It is appropriate to mention here unidentifiable Nassellaria forms found in the turbidite part of the formation westward of the Ayabe City (Caridroit et al., 1985) and indicating the Mesozoic age of the Oi Formation middle part as well.

**The Kozuki Formation.** The upper structural unit is of a limited distribution. Rocks of the formation have been observed within the SE-trending narrow area 4–5 km wide and approximately 20 km long near the Kozuki City (Igi and Wadatsumi, 1980). Isolated fragments of the formation section are observable in numerous rocky outcrops along road in the forest between the Hogan and Kamiakisato cities. In the examined outcrops, the Kozuki Formation is largely represented by black silty argillites and basalts. Two rock types are usually separated by faults or by zones of younger quartz porphyry, diorite, and andesite dikes. In areas, where tectonic dislocations do not complicate the contact, the boundary between basalts and sedimentary rocks is conformable. Prevalent in the section are massive, sometimes vaguely bedded silty argillites. They

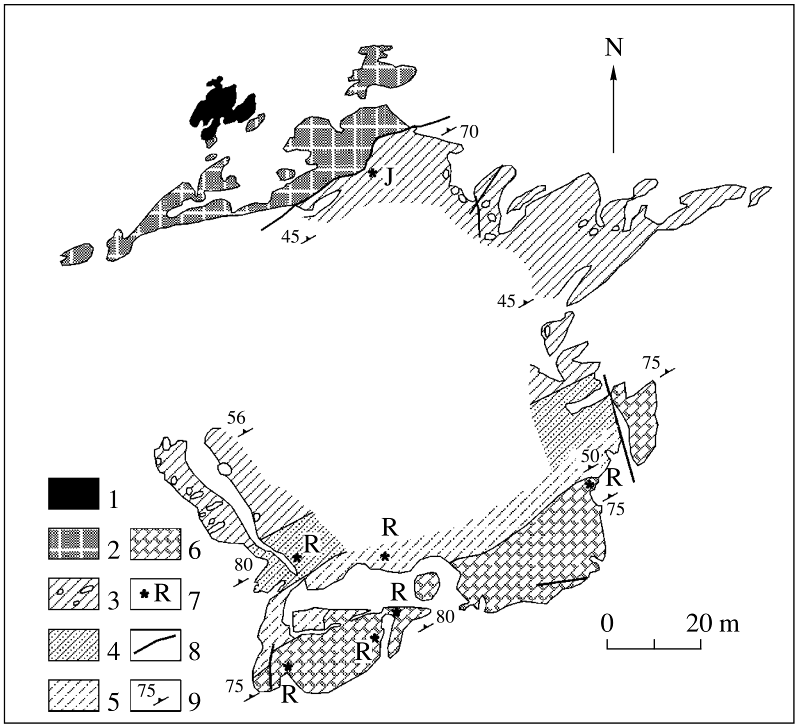

**Fig. 6.** Geological structure of the easternmost Oura Peninsula (after Ishiga, 1985 with insignificant additions): (1) Yakuno gabbroic–ultramafic rocks; (2) brecciation zone; (3) black phyllite-like schists with inclusion of chert and sandstone fragments; (4) turbidites; (5) greenish gray siliceous argillites; (6) pinkish red cherts; (7) radiolarian finds and their age; (8) faults; (9) elements of rock attitude.

are composed of sericite–chlorite–hydromica matrix with rare silt-sized quartz grains. Argillites enclose lenticular interbeds of acid tuffs from 0.2–0.5 to 2–4 m thick. Greenish gray to brownish green basalts of the Kozuki Formation are intensely altered. They are intercalated with bodies of massive and bedded pinkish to reddish cherts and limestones. The latter contain the Late Carboniferous fusulinid fauna and corals (Igi and Wadatsumi, 1980), while cherts and silty argillites bear Permian radiolarians (Goto and Hori, 1980; Ishiga, 1990; Pillai and Ishiga, 1987). The Kozuki Formation is thrust onto turbidite–melange rocks of the Oi Formation and "green" sandstones of the Hikami Formation, being overridden in turn by a sheet of gabbroids representing the Yakuno ophiolites. The thickness of the unit under consideration is estimated to be 130 m (Ishiga, 1990).

## CORRELATION BETWEEN TECTONO-STRATIGRAPHIC FORMATIONS OF THE ULTRA-TAMBA TERRANE AND UPPER STRUCTURAL COMPLEX OF THE SAMARKA TERRANE

Based on lithologic, petrographic, structural data and age constraints, formations of the Ultra-Tamba terrane can be correlated with rock associations in the upper structural level of the Samarka terrane. The lower structural unit (Hikami Formation) resting upon turbidite–melange rocks of the Tamba terrane is correlative with the Udeka Formation that is 600–1000 m thick. Outcrops of the latter are traceable within a narrow NE-trending band for over 120 km from the Breevka Settlement in the south to the Otkosnaya River head in the north (Fig. 2). The Udeka Formation includes peculiar greenish gray inequigranular (fine- to medium- and coarse-grained) sandstones with interbeds of tobacco–green silty argillite, which are a few to 20–30 m thick, and occasional thin interlayers of black silty argillite. By composition, the sandstones are intermediate between feldspar–quartz graywackes and graywacke arkoses (Fig. 4). They are composed of angular, poorly sorted grains of quartz, basic, intermediate, and acid plagioclases, K-feldspar and rock clasts represented, like in the Hikami sandstones, by granite, volcanic glass, felsite, and metamorphites. Percentages of main clastic components are as follows: quartz 25–45%, feldspars 30–50% (up to 15% of K-feldspar included), and rock clasts 10–25%. Matrix (25–35% of the rock volume) is composed of chlorite and hydromica.

The Udeka sandstones are thrust everywhere (Fig. 2) over chaotic deposits of the middle structural complex of the Samarka terrane (Golozubov and Mel'nikov, 1986). Clasts in the latter consists of basalts, Carboniferous–Permian limestones, Triassic cherts, "green" Udeka sandstones, and other rocks. The Udeka Formation is overridden in turn by either gabbroids of the Kalinovka Complex or volcanogenic–siliceous rocks of the Sebuchar Complex corresponding to the upper structural level of the Samarka terrane. The Udeka Formation rocks contain the Late Permian microfossils (Kemkin and Khanchuk, 1993). Thus, the analogy between rock associations of the Hikami and Udeka formations is evident from lithology, age, structure, and, even, similar thickness of the units.

The Kozuki Formation is correlative with the Sebuchar Complex of the Samarka terrane, which represents a system of thrust sheets composed of basalts with intercalations of sedimentary rocks. Some sheets are up to 20 km long. In their basal parts, basalts corresponding in geochemical characteristics to oceanic tholeiites (Khanchuk et al., 1989) are usually brecciated and intensely altered (spilitized). Basalts are overlain by either cherts or limestones replacing laterally each other, or by black silty argillites. Some sheets demonstrate more intricate lateral variations of lithology, when basalts are overlain by cherts grading into black silty argillites. Contacts between basalts and sedimentary rocks are conformable (when they are not disturbed by subsequent tectonic dislocations). For example, between basalts and cherts there is a bed 15–20 cm thick, composed of material eroded from basalts and cemented by siliceous and hydromica–chlorite–siliceous material. Contacts between limestones and basalts are marked by brecciated material consisting of small angular and subangular limestone and basalt fragments, which are cemented by either carbonate or products of underwater erosion of basalts. Some sheets of uniform composition are composed either basalts or aleuropelites and cherts.

Flaggy, sometimes massive cherts are pinkish red, brown–cherry or yellowish gray in coloration. In separate sheets, they are rather thick (10–20 to 35–50, rarely 100 m). In most cases, chert slices are multiply (2–4 times) imbricated by tectonic movements, and it is difficult to estimate the original thickness of sediments. Cherts bear remains of Carboniferous conodonts and Permian radiolarians (Belyanskii et al., 1984; Rybalka, 1987; Khanchuk et al., 1988). Limestone bodies associated with basalts are a few to 20 m thick, containing Carboniferous and Permian foraminifers and algae (Belyanskii et al., 1984). Black silty argillites, massive or vaguely bedded sometimes, are up to 60–100 m thick in separate sheets. They are composed of clay–chlorite material with rare quartz clasts and aggregates of organic matter. The radiolarian assemblage dominated by representatives of the genus *Follicucullus* indicates the Late Permian age (Belyanskii et al., 1984) of silty argillites, which often enclose thin lenticular interbeds (10–30 cm and thicker) of greenish gray silicic tuffs.

According to age constraints, the Oi Formation characterizes matrix of the Jurassic accretionary prism, which cemented sheets and size-variable blocks and clasts of Permian cherts and siliceous–clayey rocks. Similar turbidite–melange deposits with sheets of Permian and Carboniferous cherts occur in the upper part of the middle structural level in the Samarka terrane (Kemkin and Filippov, 2002). They are also typical of separate slices sandwiched between larger sheets of the Kalinovka gabbroid complex and Sebuchar Complex of basalts intercalated with cherts or black silty argillites. Chert sheets of the Oi Formation represent most likely fragments of corresponding rocks characteristic of the Kozuki Formation. In the Sikhote Alin and Japan, radiolarian assemblages from chert sheets and from sediments associated with basalts are identical in composition (Belyanskii et al., 1984; Ishiga, 1986; Pillai and Ishiga, 1987).

**Fig. 7.** Photograph of the phyllite-like schist etched surface. White corresponds to cherts, light gray to siliceous argillites, and dark gray to foliated matrix.

The Samarka terrane encloses sheets of Middle Paleozoic ophiolites (Kalinovka Complex) as well (Kemkin and Filippov, 2002). In the present-day structure of Sikhote Alin, ophiolites are thrust over turbidite–melange deposits of the middle structural level: either on "green" sandstones of the Udeka Formation or on volcanogenic-siliceous rocks of the Sebuchar Complex (Fig. 2). According to geochemical and mineralogical characteristics, the Kalinovka ophiolites originated in intraplate oceanic settings, presumably at the base of an oceanic plateau formed under influence of mantle plume (Khanchuk and Panchenko, 1991). The basal interval of ophiolite section is composed of serpentinized harzburgite and dunite (Khanchuk et al., 1988). These rocks are overlain by plagioclase dunite, wehrlite, clinopyroxenite, troctolite, and olivine gabbronorite. The gabbroic part of ophiolite succession is represented by two-pyroxene, clinopyroxene, and amphibole gabbro. The basaltic–sedimentary portion of the succession is attributed to the Sebuchar complex (Khanchuk et al., 1988). Similar situation is also observable in the Ultra-Tamba terrane. Practically everywhere, rock associations of this terrane are tectonically overridden by the Yakuno ophiolites, which are composed of harzburgites, dunites, gabbroids, and basalts (*Pre-Cretaceous…*, 1990). In their petrologic and geochemical characteristics, these rocks resemble the Kalinovka ophiolites of the Samarka terrane (Ishiwatari and Hayasaka, 1992; Ishiwatari, 1994). Being of similar composition, structure, and age, they can be considered as rocks derived from Middle–Late Paleozoic oceanic plateau.

## CONCLUSIONS

The comparative study of rock associations in the Ultra-Tamba terrane and upper structural level of the Samarka terrane reveals their complete identity. The similarity of corresponding tectono-stratigraphic units in both terranes is evident from their structure, lithological–petrographic composition, and age constraints, which are substantiated by the identical taxonomic composition of microfossils species in relevant rocks. Admitting that the tectono-stratigraphic units of Sikhote-Alin represent elements of the Jurassic accretionary prism, it is possible to conclude that the Ultra-Tamba terrane, the Yakuno ophiolites included, is also a part of the Jurassic prism composed of paleoceanic plateau fragments in the Inner Zone of Japan. Presumably Jurassic radiolarians found in matrix of turbidite–melange deposits of the Oi Formation represent additional evidence in favor of this inference. Thus, the regional structural position of studied complexes, which augment northwestward the Jurassic prism of the Inner Zone in Japan, and new data obtained suggest that the Ultra-Tamba terrane characterizes the upper structural level of the Tamba–Mino–Ashio accretionary prism. Consequently, it is necessary to revise traditional views on structure of the Inner Zone in southwestern Japan and its geological evolution.

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