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GEOLOGY

New Data on the Structure of the Khabarovsk Terrane of the Jurassic Accretionary Prism (Sikhote-Alin)

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The heterogeneous different-aged terranes constituting the Pacific margin of Asia include numerous fragments of ancient accretionary prisms. One of these is the Jurassic prism, exposed over more than 5000 km from the left bank of the lower reaches of the Amur River via Sikhote-Alin, Nadanhada-Alin (northeastern China), Japan, and Taiwan Island to Palavan Island (the Philippines). Accretionary prisms are developed in zones of direct interaction between lithospheric plates. Consequently, they bear information on the succession and character of relevant events in the region. In this connection, the study of ancient accretionary prisms is important for specifying the structure of corresponding regions and their geological evolution. Such studies also provide data for understanding specific features of accretion in various areas of the convergent boundary, as well as the correlation of geological events at the junction of lithospheric plates.

The accretionary prisms are characterized by a complicated imbricate–thrust structure. They represent tectonic slices composed of repeatedly alternating different-age fragments of oceanic plate cover characterized by a peculiar succession (oceanic plate stratigraphy [1]). This succession consists of pelagic cherts overlain by hemipelagic siliceous–clayey and terrigenous sandy–silty rocks. The most informative among them are the hemipelagic rocks (siliceous siltstones and mudstones). On the one hand, they register the arrival of the oceanic plate to the convergence zone and, thus, their age corresponds to that of the accretion of oceanic structures. On the other hand, knowing the age of these rocks in different tectonic slices of the prism, one can determine the time of accretion of particular oceanic fragments and divide the prism into tectonostratigraphic units that characterize corresponding stages of its formation. Based on the correlation of subsequently defined units, the researcher can easily reconstruct the succession of the accretionary process and, thus, specify the structure of the entire prism, the history of its formation, and the geological evolution of the continental margin where this prism formed. It was precisely the biostratigraphic study of hemipelagic rocks that provided the opportunity to reconstruct the primary sections and structure of several terranes of the Jurassic prism in both its central part (southern Sikhote-Alin and Japan) and southern flank (Ryukyu island system and the Philippines) [2–4]. The northern flank of the Jurassic prism (Khabarovsk and Badzhal terranes) has been insufficiently studied in this respect. This gap is filled by our new data on the age and structure of the southern part of the Khabarovsk Terrane (western spurs of the Khekhtsir Ridge).

The Khabarovsk Terrane located along the eastern margin of the northern Bureya–Jiamusi–Khanka Superterrane extends as a 200- to 230-km-wide band in the northeastern direction from the Naolihe River valley in the south via the Khekhtsir Ridge and Khabarovsk Heights to the Vandan, Gorbylyak, and Sagdayan ridges in the north. Initially, it was defined as the Khabarovsk Complex of the Early Cretaceous accretionary prism of the Khingan–Okhotsk active continental margin [5, 6]. A recent revision of the age of terrigenous rocks [7, 8] and new data (see below) indicate, however, that it represents a fragment of the Jurassic prism and is similar to the Samarka Terrane of the southern Sikhote-Alin.

The terrane studied in exposures along the Amur River bank (near Khabarovsk and the Voronezhskoe-2 Settlement) consists of numerous alternating tectonic slices of variable thickness. They are composed of cherts, siliceous–clayey rocks, sandstones, siltstones, metasandstones, shales, volcanics, and chaotic rocks [5, 9, 10, and others]. According to these lithologic–biostratigraphic works, the primary succession was the following: Lower Triassic (upper Olenekian)–Lower Jurassic cherts, phtanites, jaspers, and clayey cherts (up to 80 m); Aalenian–Bajocian siliceous mudstones (at least 8 m); Bathonian–middle Callovian silty mudstones (up to 40 m); Oxfordian–Tithonian (after [7, 8]) siltstones with tuffite interbeds, clayey–carbonate–manganese concretions, members of finely alternating

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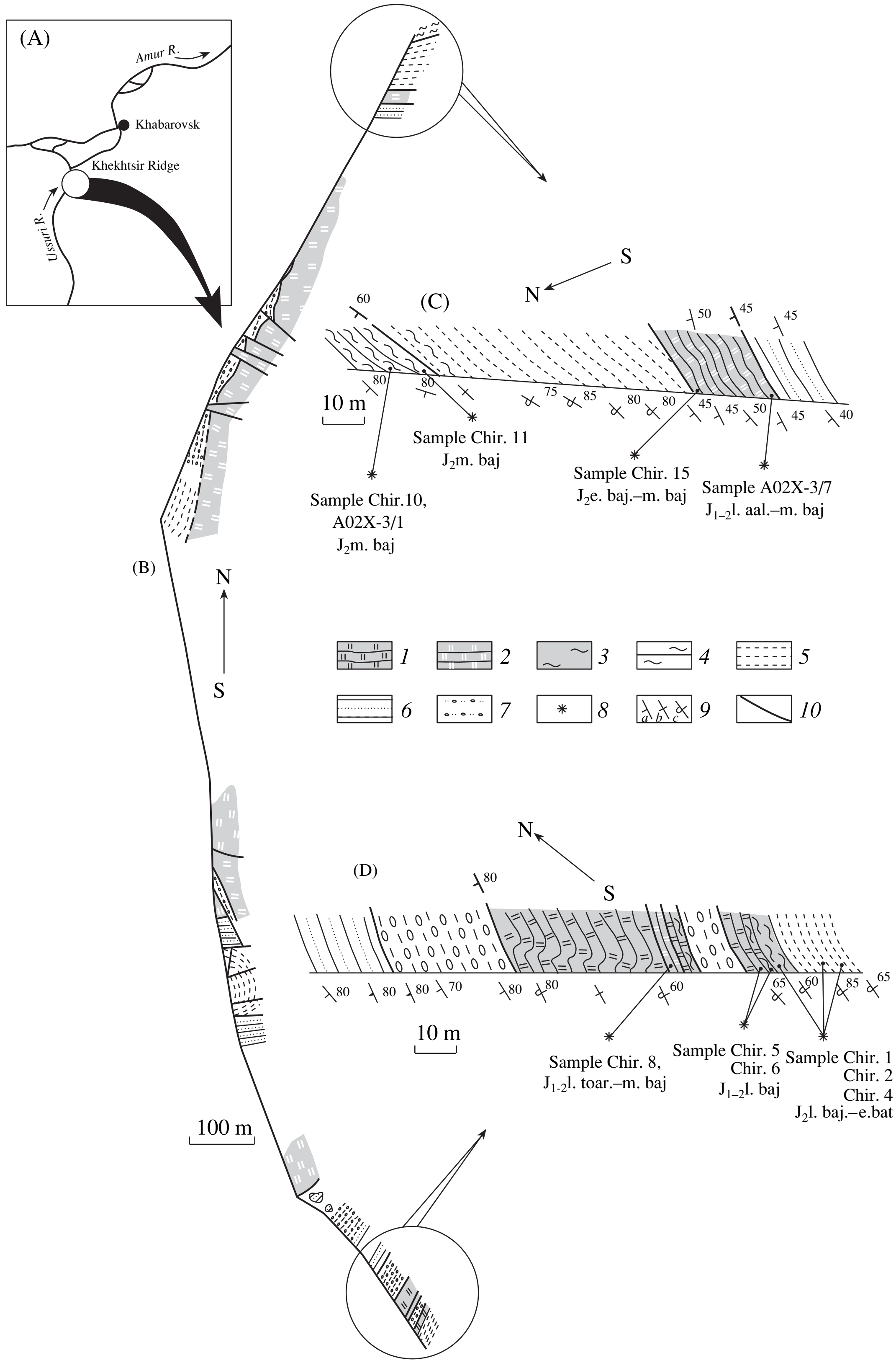

Fig. 1. Fragment of the Khabarovsk Terrane section on the left bank of the Ussuri River near its mouth. (*1*) Light greenish gray cherts; (*2*) brown-red jaspers; (*3*) greenish gray siliceous mudstones; (*4*) brow-red siliceous–tuffaceous silty mudstones; (*5*) dark greenish gray mudstones and silty mudstones; (*6*) alternating sandstones and siltstones; (*7*) foliated siltstones enclosing bodies and isometric fragments of sandstones and cherts; (*8*) radiolarian finds; (*9*) bedding attitude: (*a*) normal, (*b*) vertical, (*c*) overturned; (*10*) faults.

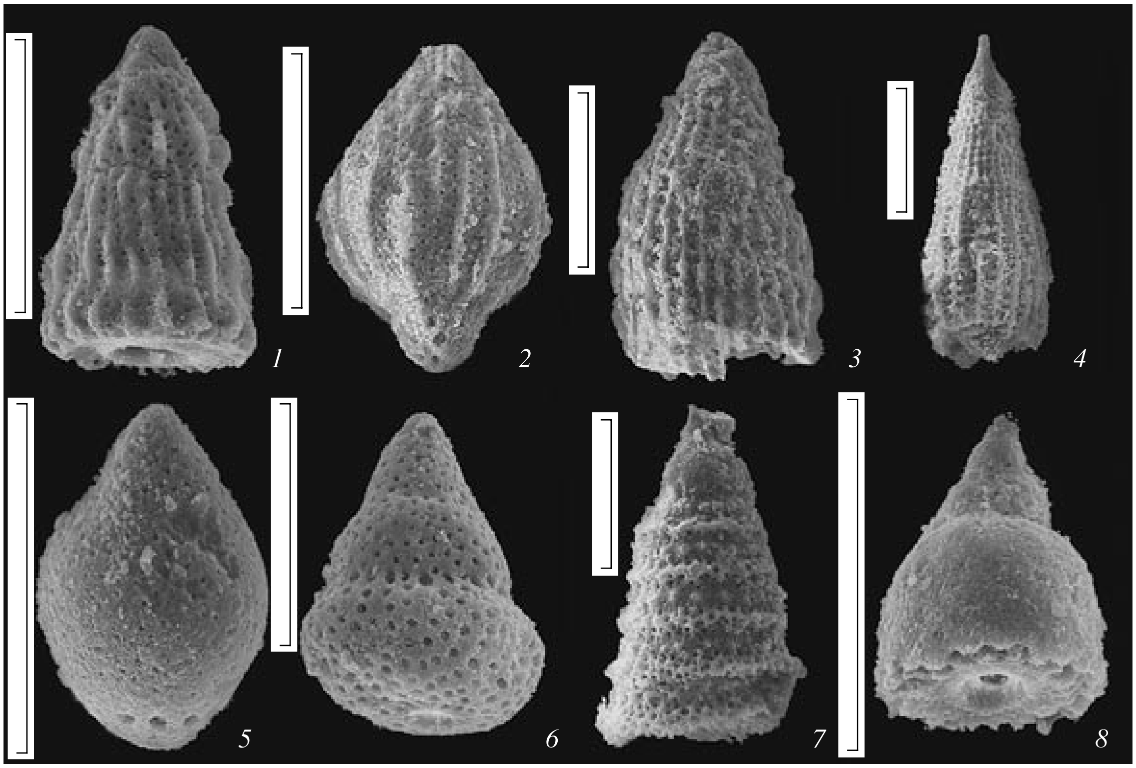

Fig. 2. Some characteristic radiolarian species from the Ussuri–Khekhtsir section. (*1*) *Hsuum* cf. *parasolense* Pessagno et Whalen (Sample Chir-11); (*2*) *Unima typicus* Ichikawa et Yao (Sample A02X-3/1); (*3*) *Parahsuum izeense* (Pessagno et Whalen); (*4*) *Hsuum matsuokai* Isozaki et Matsuda (Sample A02X-3/7); (*5*) *Tricolocapsa fusiformis* Yao (Sample Chir-6); (*6*) *Stichocapsa japonica* Yao (Sample Chir-11); (*7*) *Dictyomitrella kamoensis* Mitzutani et Kido (Sample Chir-1); (*8*) *Eucyrtidiellum unumaense* Yao (Sample Chir-1). All bars are 100 μm.

sandstones and siltstones, or massive sandstones and chaotic rocks. The latter represent intensely foliated aleuropelitic rocks with irregularly scattered fragments and blocks of the above-cited rocks. Such a structure of the terrane was assumed to be characteristic of its entire domain, including the Khekhtsir Ridge, where the packet of tectonic slices forms a large asymmetrical synform fold and the sedimentary succession is similar to that in the Khabarovsk area [11]. It turned out, however, that the terrane fragment in the Khekhtsir Ridge (Ussuri–Khekhtsir section) is substantially different. Therefore, one can refine the stratigraphy and structure of the region.

The terrane in the Khekhtsir Ridge is represented by numerous alternating slices of different lithological compositions (Fig. 1B): terrigenous, chaotic, siliceous, and siliceous-clayey rocks. According to radiolarian data, the section in question consists of two different-aged siliceous–terrigenous successions (or tectono-stratigraphic units) that accreted in different periods. The lower part of the first succession (Fig. 1C) is composed of brown-red jaspers and clayey cherts, the lower boundary of which is unclear, while the upper boundary is dated back to the Aalenian–initial middle Bajocian. Cherts are replaced upsection by brown-red siliceous–tuffaceous silty mudstones grading into greenish gray silty mudstones. The middle Bajocian age of these rocks is based on the joint occurrence of radiolarian species *Hsuum parasolense* Pessagno et Whalen, *Dictyomitrella kamoensis* Mizutani et Kido, *Stichocapsa japonica* Yao, *Unuma typicus* Ichikawa et Yao, and *Parahsuum izeense* (Pessagno et Whalen) (Fig. 2). The section is crowned by terrigenous rocks (mudstones and silty mudstones grading into alternating dark gray siltstones and light gray fine-grained sandstones with members of chaotic rocks). The second siliceous–terrigenous succession (Fig. 1D) is represented by light greenish gray cherts with an uncertain lower boundary and an upper boundary of late Bajocian age. Cherts are replaced first by an alternation of light greenish gray clayey cherts and siliceous mudstones and then by greenish gray siliceous mudstones whose latest Bajocian–early Bathonian age is suggested by the joint occurrence of *Stichocapsa japonica* Yao, *Tricolocapsa* cf. *fusiformis* Yao, and *Dictyomitrella kamoensis* Mizutani et Kido (Fig. 2). Siliceous mudstones grade into dark greenish gray mudstones, which started to accumulate in the early Bathonian.

The new data obtained indicate that the first succession is similar, in general, to the Khabarovsk–Voronezh section in terms of lithology, structure, and age of beds transitional from cherts to terrigenous rocks. The second siliceous–terrigenous succession has no analogues in terms of its age and accretion time among known sections of the Khabarovsk Terrane. Thus, the terrane includes at least two tectonostratigraphic units (Khabarovsk–Voronezh and Ussuri–Khekhtsir complexes) that characterize the successive stages in its formation. With respect to their lithology and ages, these units are confidently correlated with some structural units of the Samarka Terrane in the Jurassic prism. The latter terrane consists of five similar successive tectonostratigraphic units (Sebuchar, Amba–Matai, Saratovka, Breevka, and Katen complexes) with the ages of transitional layers corresponding to the early Pliensbachian, middle Pliensbachian–early Toarcian, Aalenian–middle Bajocian, middle–late Bajocian, and middle Bathonian–Callovian, respectively [2]. The Khabarovsk–Voronezh and and Ussuri–Khekhtsir units of the Khabarovsk Terrane can be correlated with the Saratovka and Breevka complexes, respectively.

It should be noted that northern spurs of the Bol'shoi Khekhtsir Ridge (Mt. Dvukh Brat'ev) host exposures of Triassic bedded cherts [12 and others] with interbeds of Carnian–Norian pelitomorphic limestones. A coeval siliceous–carbonate association is also mapped near the mouth of the Naolihe River at its left bank corresponding to the southern part of the Khabarovsk Terrane in China. Such a lithology of the siliceous part of the siliceous–terrigenous succession in the Jurassic prism is characteristic only of lower structural units of the Samarka (Katen Complex) and Nadanhada–Bikin (Kultukha Complex) terranes [2, 14]. These data suggest that at least one additional tectonostratigraphic unit can be defined in the Khabarovsk Terrane. Thus, like other terranes of the Jurassic prism, the Khabarovsk Terrane consists of different-aged tectonostratigraphic complexes that reflect the successive accretion of fragments of paleoceanic plate cover located at different distances from the spreading center.

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