ISSN 1819-7140, Russian Journal of Pacific Geology, 2008, Vol. 2, No. 5, pp. 412–421. © Pleiades Publishing, Ltd., 2008.
Original Russian Text © A.N. Filippov, I.V. Kemkin, 2008, published in Tikhookeanskaya Geologiya, 2008, Vol. 2, No. 5, pp. 42–52.

First Finds of Late Tithonian and Middle–Late Albian Radiolarian Assemblages in Volcanogenic–Siliceous Rocks of the Amur River Right Lower Reaches and Their Tectonic Significance

A. N. Filippov and I. V. Kemkin

Far East Geological Institute, Far East Branch, Russian Academy of Sciences, Vladivostok, Russia

Received August 13, 2007

Abstract—The lithological–stratigraphic study of volcanogenic–siliceous rocks developed on the left side of the Machtovaya River, a right tributary of the Amur River, yielded the first radiolarian assemblages of the late Late Tithonian, the late Late Tithonian–early Valanginian, and the middle–late Albian age. It is established that the stratigraphic succession of volcanogenic–siliceous rocks in this area is composed of upper Tithonian–Valanginian dark red to red-brown cherts with basalts in the lower part of the section and Albian dark gray clayey cherts, olive-gray siliceous–tuffaceous argillites, and tufaceous siltstones in its upper part. The replacement of cherts by their clayey varieties likely occurred in the Aptian. The composition, structure, and age of these strata and the rocks constituting the Kiselevka–Manoma accretionary complex are different, which indicates their different tectonic origin.

Key words: *radiolarians, Late Jurassic–Early Cretaceous, volcanogenic–siliceous rocks, Lower Amur River region.*

DOI: 10.1134/S1819714008050047

INTRODUCTION

Volcanogenic–siliceous rocks in the Lower Amur River region prevail in the Kiselevka–Manoma accretionary complex [3, 4, 11]. The latter is located on the left and right sides of the Amur River, where it is traceable in the form of a narrow (5–15 km) NE-trending band along the eastern margin of the Albian–Cenomanian terrigenous sediments (Fig. 1). Two segments of the latter are known in this region: the northeastern segment in the Kiselevka Settlement and Lake Udyl on the left side of the Amur River and the southwestern segment in the lower reaches of the Manoma River on its right side. The northeastern segment is displaced relative to the southwestern one along the Central Sikhote Alin Fault for 150 km. This accretionary complex is made up of Jurassic and Lower Cretaceous cherts, siliceous–clayey rocks, and basic volcanics. It is presumed that it was formed in the terminal Early Cretaceous owing to subduction of the Izanagi oceanic plate [4, 11].

In other areas of the Lower Amur River region, volcanogenic–siliceous rocks were usually included into Cretaceous terrigenous stratigraphic units characterized by the macrofauna. Their age and tectonic nature in many areas remained debatable.

We present the first information on the age and structure of siliceous and siliceous–clayey rocks studied in one of such areas on the left side of the Machtovaya River (right tributary of the Amur River), which allowed us to specify the tectonic structure of the region.

REGIONAL TECTONIC POSITION AND PREVIOUS STUDIES

Different viewpoints on the tectonic structure exist for the study region (Fig. 1b), which indicates our insufficient knowledge of it and the different interpretations of the available factual material. In this region, Natal'in [1, 10, 11, 21] distinguished the Amur Complex, which consists of the Lower Cretaceous–Cenomanian terrigenous rocks interpreted as representing turbiditic facies of the sedimentary infill of the deep-sea trench, and the Kiselevka–Manoma accretionary complex made up of Jurassic and Lower Cretaceous cherts. According to Khanchuk [14–16, 19], Berriasian–Valanginian terrigenous rocks are ascribed to the Zhuravlevka–Amur turbidite terrane, while Jurassic–Lower Cretaceous cherts associated with basalts and limestones, as well as Albian–Cenomanian terrigenous rocks, belong to the Nizhnii Amur Terrane of the Middle Cretaceous accretionary prism. Kaidalov [5] proposed an alternative approach to the structural–tectonic subdivision. He defined the Amur lithotectonic zone as being composed of the following units (from the top

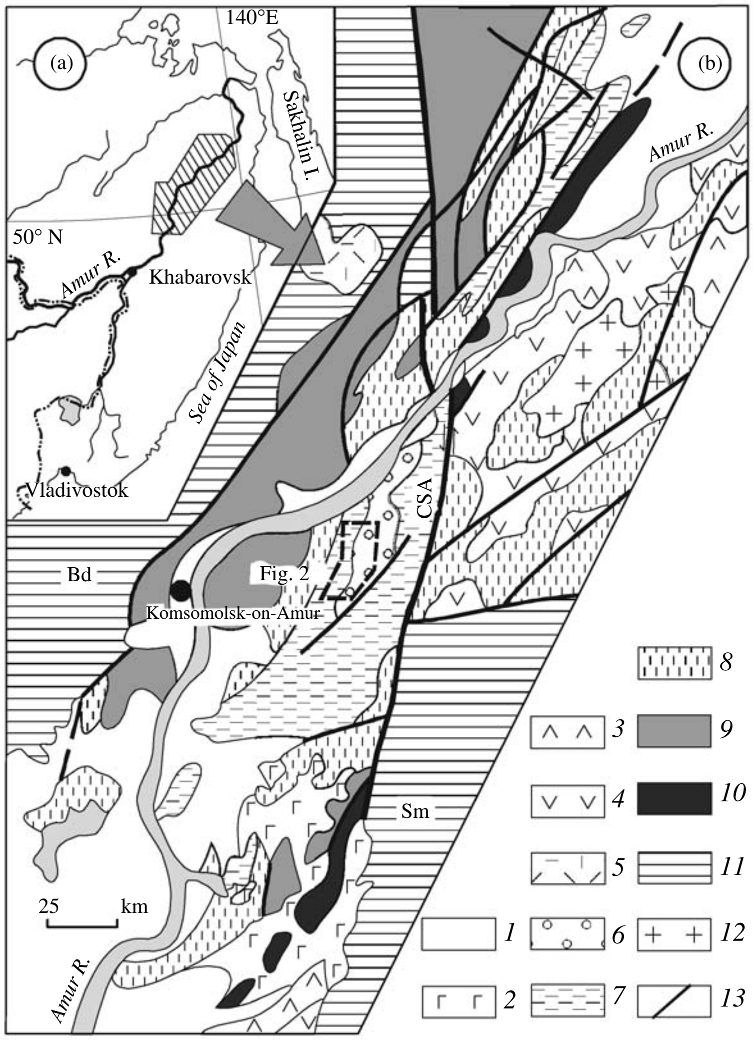

Fig. 1. Schematic location of the study area (a) and its geological map (after [2]) with the study area (b).
(*1*) Quaternary sediments; (*2*) Neogene basalts; (*3*) Paleogene andesites; (*4*) Late Cretaceous andesites; (*5*) Late Cretaceous acid volcanics; (*6–9*) terrigenous sediments: (*6*) Cenomanian, (*7*) Albian–Cenomanian, (*8*) Barremian–Albian, and (*9*) Berriasian–Valanginian.; (*10*) Kiselevka–Manoma accretionary complex; (*11*) terranes of the Jurassic accretionary prism: Samarka (Sm) and Badzhal (Bd); (*12*) granites; (*13*) faults; (CSA) Central Sikhote Alin Fault.

upward): Triassic–Middle Jurassic cherts, Middle–Upper Jurassic terrigenous and siliceous–clayey rocks with basic volcanics, and Berriasian–Valanginian terrigenous sediments. The Jurassic–Lower Cretaceous cherts of the Kiselevka Formation, siliceous–clayey rocks with Valanginian–Aptian volcanics, and Albian–Cenomanian terrigenous sediments were ascribed by him to the Chayatyn subzone. The study area (the left side of the Machtovaya River) is located in the Amur accretionary complex (according to Natal'in), the Nizhnii Amur Terrane (according to Khanchuk), and the Chayatyn subzone (according to Kaidalov) (Fig. 1b).

The volcanogenic–siliceous rocks on the left side of the Machtovaya River were described for the first time by I.P. Boiko during the large-scale geological mapping in 1962. They were mapped as extended members up to 20 m thick inside the Cenomanian Largasin terrigenous formation. Based on the results of reconnaissance studies, V.I. Anoikin distinguished these rocks in 2002 as an autonomous siliceous–volcanogenic sequence of presumably Early Cretaceous age.

COMPOSITION AND AGE OF THE VOLCANOGENIC–SILICEOUS ROCKS

The volcanogenic–siliceous rocks were studied in the Mount Innokent'evka area and on the left side of the Pongdan River (Fig. 2). They are largely represented by massive and brecciated dark red to red-brown radiolarian cherts. The cherts are composed of fine-grained quartz–chalcedony aggregates saturated with powdery particles of hematite. Radiolarian skeletons are well preserved and constitute 40–60% of the rock volume (Fig. 3a). The cherts are associated closely with mas-

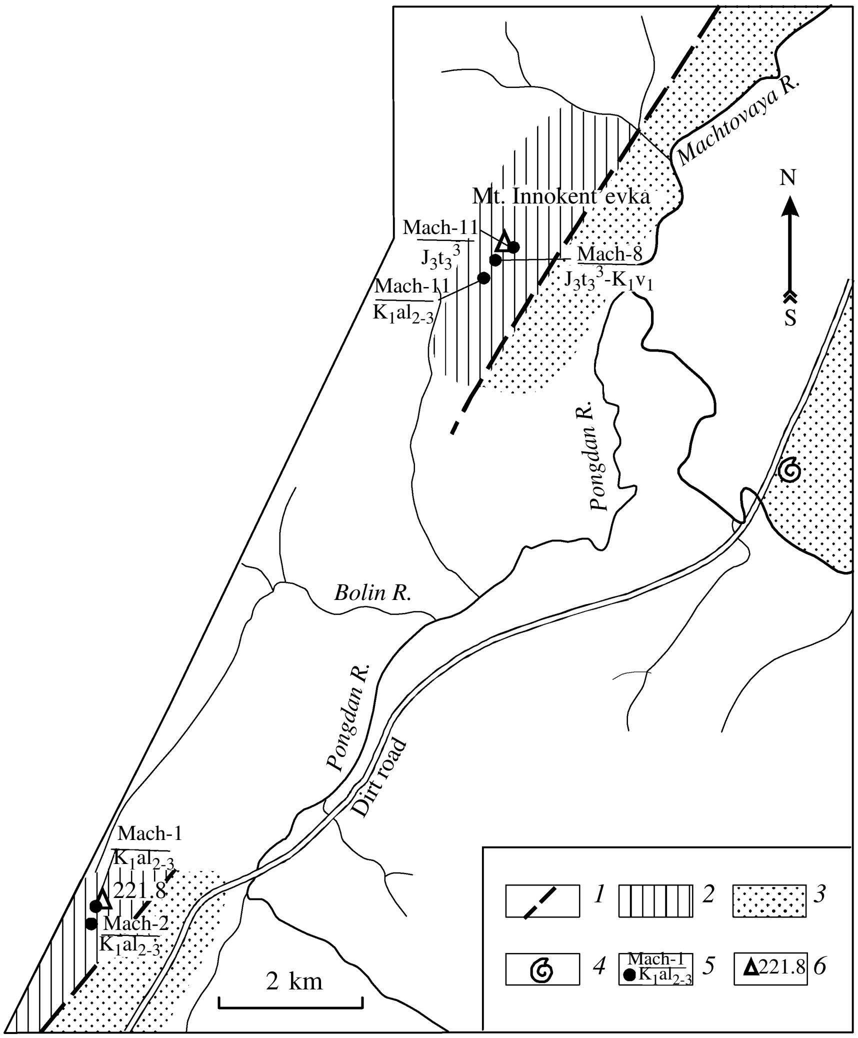

Fig. 2. Schematic geological structure of the lower reaches of the Machtovaya River and sampling sites for the radiolarian analysis (compiled based on materials by V.I. Anoikin).

(*1*) inferred faults; (*2*) siliceous–volcanogenic rocks; (*3*) terrigenous rocks; (*4*) macrofauna locality; (*5*) localities with radiolarians and their age; (*6*) prevalent height.

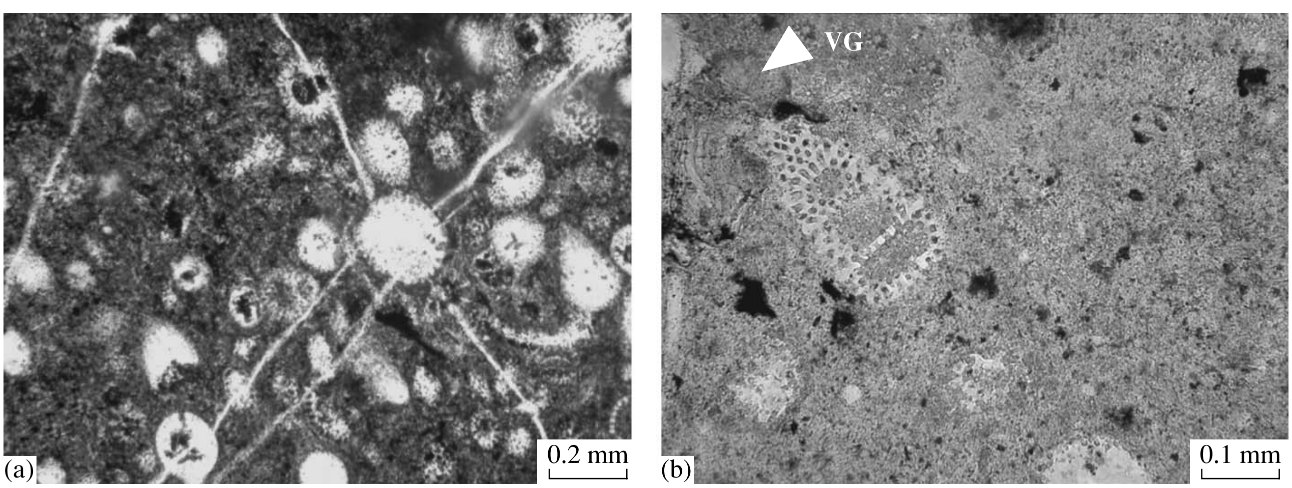

Fig. 3. Photomicrographs of thin sections of siliceous rocks from the Machtovaya area: (a) red-brown radiolarian chert (thin section Mach-4, parallel nicols); (b) dark-gray clayey chert with well-preserved radiolarians and fragments (VG) of volcanic glass (thin section Mach-2, parallel nicols).

sive and amygdaloidal basalts frequently enclosing cherty xenoliths. There are also rocks representing a mixture of siliceous sediment and fragments of basaltic lava. Dark gray radiolarian clayey cherts with a banded–bedded structure are less common. They are made up of clayey and quartz–chalcedony aggregates with abundant coalified particles and Fe hydroxides. Radiolarian skeletons are perfectly preserved and constitute 20–60% of the rock volume (Fig. 3b). The clayey cherts contain up to 10–15% of the silt-sized plagioclase fragments and mica flakes. Their banded–bedded structure is determined by the enrichment of some layers 2–5 mm thick in clayey particles and carbonaceous matter. Olive–gray siliceous–tuffaceous mudstones are rare in this area. Siliceous–tuffaceous mudstones are more enriched in clayey material as compared with clayey cherts. Detrital components in tuffaceous siltstones are represented by angular quartz and plagioclase grains. The rock contains abundant fork-shaped quartz fragments with a ferruginous film, which likely represent pyroclastic material. It also includes fragments of altered volcanic glass. Radiolarian skeletons are rare. The cement is quartz–clayey material with Fe hydroxides.

These volcanogenic–siliceous rocks are supposedly in fault contact with the terrigenous sequence consisting of members of alternating sandstones and siltstones, beds of massive sandstones, dark gray siltstones, and siliceous–tuffaceous mudstones.

The age of the siliceous–clayey rocks is established based on radiolarians, which were extracted by a weak solution of hydrofluoric acid, picked from the residue, and photographed under a scanning electron microscope. Dark red cherts taken in the Mount Innokentíevka area (sample mach-11) yielded a diverse radiolarian assemblage (Table 1, Fig. 4). Based on the co-occurrence of *Wrangellium puga, W. depressum*, and *Pseudodictyomitra carpatica* (all of which first appeared in the late Late Tithonian) and *Eucyrtidiellum pyramis, Archaeodictyomitra minoensis*, and *Zhamoidellum ovum* (the last occurrence of which is also recorded in the late Late Tithonian [17, 18]), its age is determined as the late Late Tithonian. It should be noted that the genus *Wrangellium* is renamed as *Svinitzium* [18]. In this connection, radiolarians of similar morphology are identified in some works as *Svinitzium depressum* and *Svinitzium puga* with former stratigraphic ranges. A similar situation is also characteristic of representatives of the genus *Parvicingula*, which received the new name *Tethysetta* [18]; the genus *Sethocapsa* renamed *Hiscocapsa* [22]; and the species *Pseudodictyomitra nuda* Shaaf, which is now called *Loopus doliolum* [18]. In this work, we use the former (more traditional) generic and species names of the mentioned radiolarian taxa, while taking into consideration that their stratigraphic ranges remain the same.

A red-brown chert sampled 300 m southwest of the previous one (sample mach-8) contains a similar radiolarian assemblage (Table 1). The co-occurrence of *Xitus* cf. *gifuensis*, whose upper age limit is restricted by the early Valanginian, and *Wrangellium depressum*, whose first appearance is registered in the late Late Tithonian, allows the assemblage to be dated back to the late Late Tithonian–early Valanginian [17, 18].

Dark gray clayey cherts taken southwest of Mount Innokent'evka (sample mach-4) and at a height of 221.8 m (samples mach-1 and mach-2) provided a different radiolarian assemblage with taxa characterized by a wider stratigraphic range (Table 1, Fig. 4). Nevertheless, the co-occurrence of species such as *Stichomitra* ex gr. *mediocris*, which became extinct in the terminal late Abian, and *Orbiculiforma* cf. *cachensis* with its evolutionary appearance in the mid-Albian allows correlation of this assemblage with the middle–late Albian [17, 18, 22, 23]. It should be noted that this assemblage consists of dominant (80–85%) multicyrtoid radiolarians representing new species of the genera *Stichomitra, Xitus*, and *Parvicingula*, whose description is the task of future studies (Fig. 4).

DISCUSSION

According to available data, the stratigraphic range of volcanogenic–siliceous rocks in the Machtovaya River area, which are traceable, according to geological mapping, in the northeastern direction up to the lower reaches of the Shelekhova River, spans the uppermost Tithonian–upper Albian. Dark red and red-brown cherts with basic volcanics were probably deposited in the period lasting from the late Late Tithonian to the early Valanginian. Clayey cherts associated with siliceous–tuffaceous mudstones and tuffaceous siltstones correspond to the middle–late Albian. The interval of the Valanginian–lower Albian is barren of microfauna. Nevertheless, the spatial relations between the red-brown and dark gray clay suggest that they belong to a single succession. The transition from cherts to their clayey varieties likely occurred in the Apian. The relationships between the volcanogenic–siliceous and terrigenous rocks, which are mapped as the Cenomanian strata [2], have remained unclear.

The obtained data indicate that the composition, stratigraphic succession, and age of the volcanogenic–siliceous rocks in the Machtovaya area and Kiselevka–Manoma accretionary complex are different (Fig. 5). In the Kiselevka–Manoma Terrane, they are Early Jurassic (Hettangian)–early Albian in age and less than 500 m thick [8, 13]. Their lower part (Lower Jurassic–Lower Cretaceous) is composed of pelagic cherts with volcanic bodies and beds of volcanogenic–siliceous and detrital cherty rocks. In the Kiselevka Settlement area, the Valanginian–Hauterivian interval is composed of pelagic cherts with basalts [3]. According to [6], this level is represented by volcaniclastic sediments of debris flows with large cherty and limestone bodies. Hemipelagic siliceous–clayey sediments are confined to the Barremian–Aptian to lower Albian interval, Radiolarians in siliceous and siliceous–clayey rocks of the Machtovaya area

Radiolarians	Samples				
	mach 1	mach 2	mach 4	mach 8	mach 11
Acaeniotyle sp.	+	+			
Alievium sp.	+				
Archaeodictyomitra sliteri Pessagno					
Archaeodictyomitra excellens (Tan)				cf.	
Archaeodictyomitra minoensis (Mizutani)					+
Archaeodictyomitra ex gr. *vulgaris* Pessagno				+	+
Cinguloturris cylindra Kemkin et Rudenko				+	
Crolanium sp.	+				
Crucella (?) *inflexa* (Rust)	+	+			
Dactylidiscus longispinus (Squinabo)		cf.			
Dactyliosphaera maxima (Pessagno)		+			
Eucyrtidiellum pyramis Aita					+
Orbiculiforma sp.	+				
Orbiculiforma cachensis Pessagno	+	cf.			
Orbiculiforma cf. *maxima* Pessagno		+			
Pantanellium lanceola (Parona)				+	
Parvicingula sp.	+	+	+		
Phaseliforma sp.	+				
Pseudoaulophacus sp.		+			
Pseudodictyomitra sp.				+	+
Pseudodictyomitra carpatica (Lozyniak)					+
Pseudodictyomitra ex gr. *nuda* Shaaf				+	
Sethocapsa sp.				+	+
Sethocapsa subcrassitestata Aita				cf.	
Sethocapsa uterculus (Parona)				cf.	cf.
Sethocapsa kaminogoensis Aita				+	cf.
Stichocapsa sp.	+	+			
Stichomitra? sp.	+	+	+		
Stichomitra ex gr. *mediocris* (Tan)	+	+	+		
Thanarla sp.				+	
Thanarla ex gr. *brouweri* (Tan),				+	
Wrangellium sp.				+	+
Wrangellium depressum (Baumgartner)				+	+
Wrangellium puga (Schaaf)					+
Zhamoidellum ovum Dumitrica					+
Xitus sp.	+	+	+	+	+
Xitus gifuensis Misutani					cf.
Xitus spineus Pessagno			cf.		
Xitus spicularius (Aliev)				cf.	cf.
Age	K_1al_{2-3}	K_1al_{2-3}	K_1al	$J_3t_3^3$-K_1v_1	$J_3t_3^3$

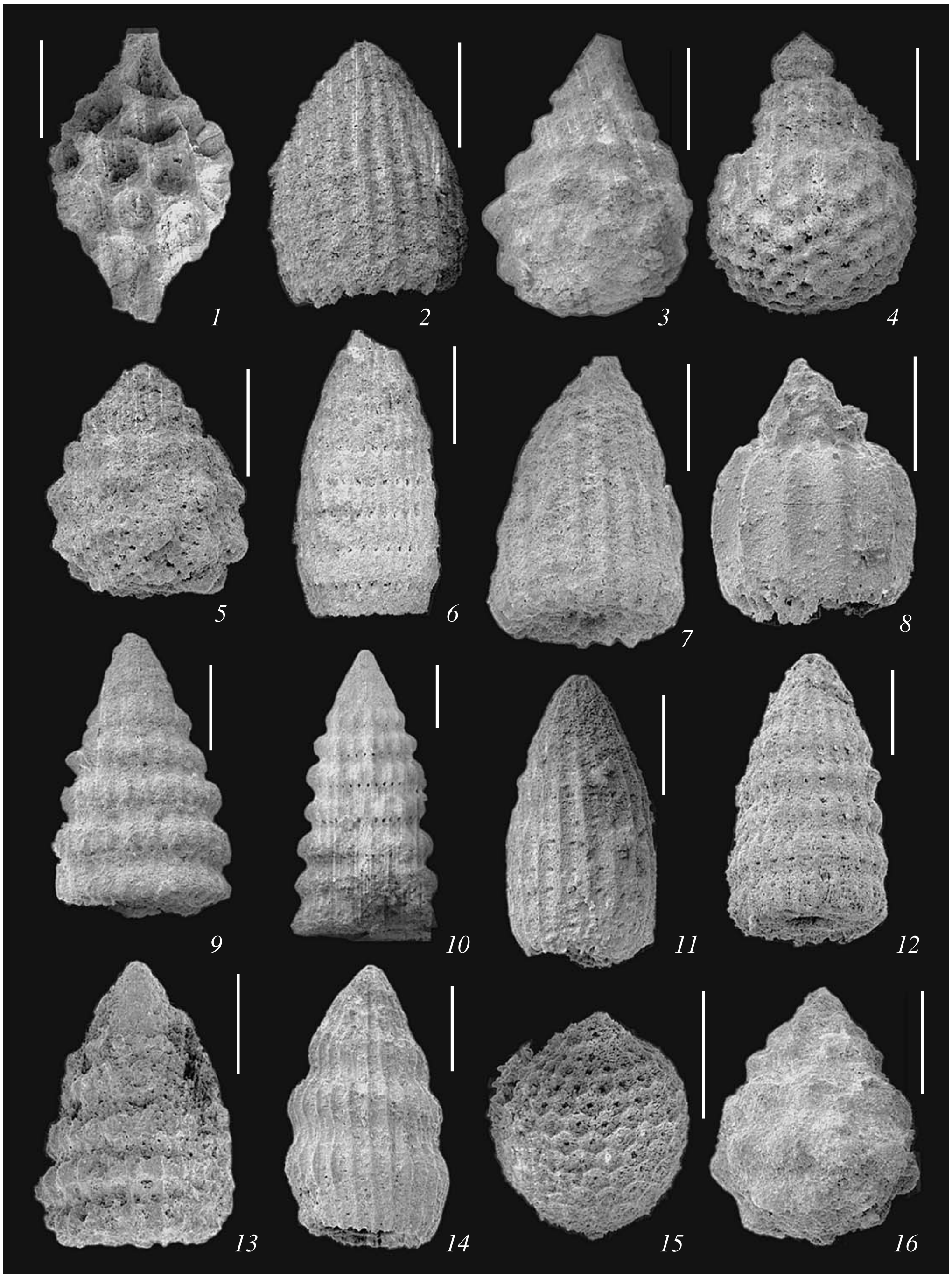

Fig. 4-1. Late Jurassic–Early Cretaceous radiolarians from cherty rocks developed in the middle reaches of the Machtovaya River. All the bars are 10 μm.

(*1*) *Pantanellium lanceola* (Parona), Sample Mach-8 (62262); (*2*) *Thanarla* ex gr. *brouweri* (Tan), Sample Mach-8 (62277); (*3*) *Sethocapsa kaminogoensis* Aita, Sample Mach-8 (62288); (*4*) *Sethocapsa* cf. *uterculus* (Parona), Sample Mach-8 (62291); (*5*) *Xitus* cf. *gifuensis* Misutani, Sample Mach-8 (62293); (*6*) *Pseudodictyomitra* ex gr. *nuda* Shaaf, Sample Mach-8 (62294); (*7*) *Archaeodictyomitra* ex gr. *vulgaris* Pessagno, Sample Mach-8 (62296); (*8*) *Eucyrtidiellum pyramis* Aita, Sample Mach-11 (62302); (*9*) *Wrangellium depressum* (Baumgartner), Sample Mach-11 (62304); (*10*) *Pseudodictyomitra carpatica* (Lozyniak), Sample Mach-11 (62306); (*11*) *Archaeodictyomitra* ex gr. *vulgaris* Pessagno, Sample Mach-11 (62307); (*12*) *Wrangellium puga* (Schaaf), Sample Mach-11 (62309); (*13*) *Wrangellium depressum* (Baumgartner), Sample Mach-11 (62310); (*14*) *Archaeodictyomitra minoensis* (Mizutani), Sample Mach-11 (62311); (*15*) *Zhamoidellum ovum* Dumitrica, Sample Mach-11 (62319); (*16*) *Sethocapsa* cf. *kaminogoensis* Aita, Sample Mach-11 (62320).

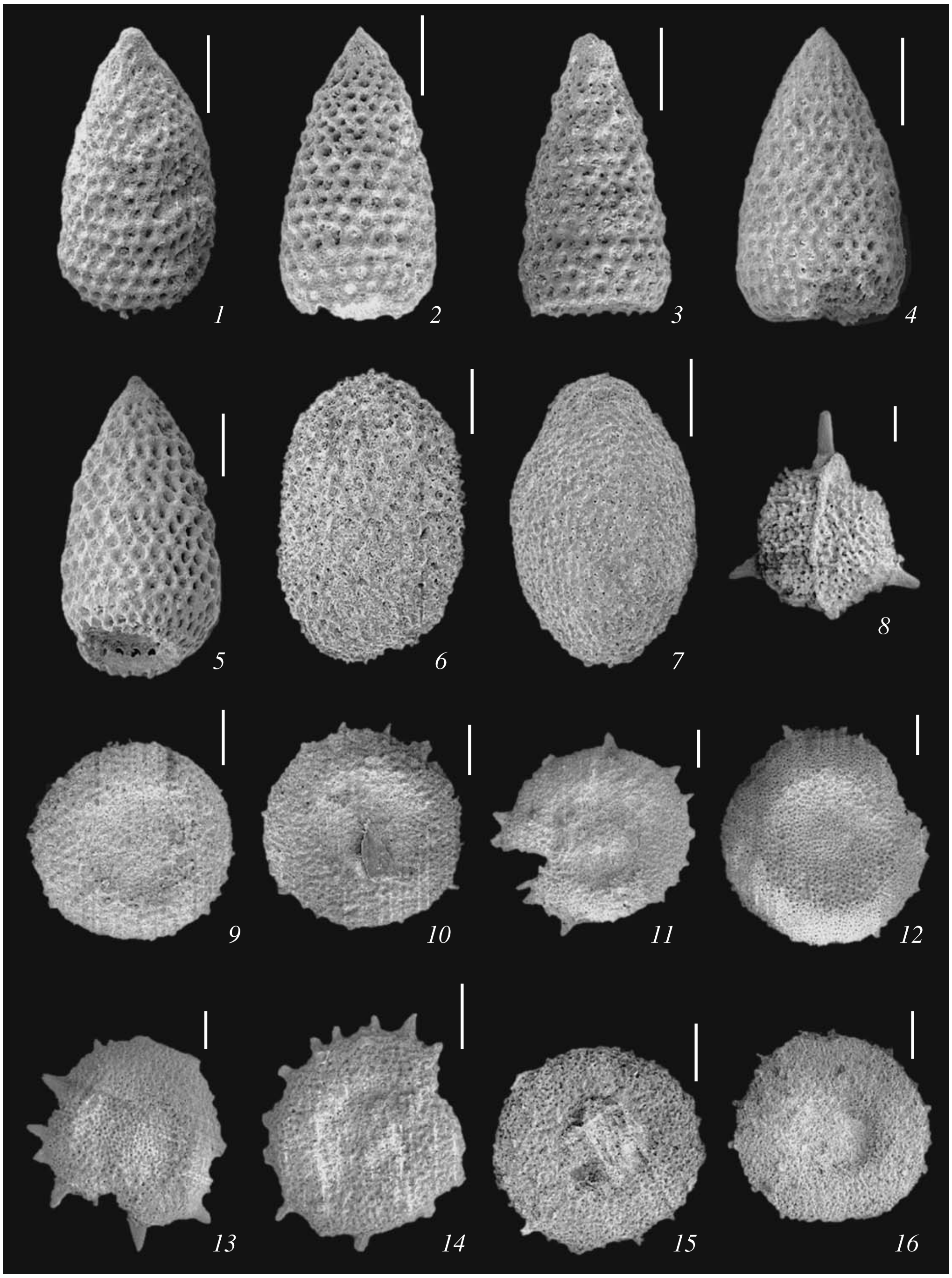

Fig. 4-2. Early Cretaceous radiolarians from siliceous–clayey rocks developed in the middle reaches of the Machtovaya River. All the bars are 50 μm.

(*1–5*) *Stichomitra* ex gr. *mediocris* (Tan): (*1*) Sample Mach-1 (62016), (*2*) Sample Mach-1 (62027), (*3*) Sample Mach-2 (62096), (*4*) Sample Mach-2 (62108), (*5*) Sample Mach-4 (62201); (*6, 7*) *Phaseliforma* sp.: (*6*) Sample Mach-1 (62012), (*7*) Sample Mach-1 (62008); (*8*) *Acaeniotyle* sp., Sample Mach-2 (62142); (*9*) *Orbiculiforma* sp., Sample Mach-1 (62036); (*10–13*) *Orbiculiforma* cf. *cachensis* Pessagno: (*10*) Sample Mach-1 (62057), (*11*) Sample Mach-1 (62070), (*12*) Sample Mach-1 (62075), (*13*) Sample Mach-1 (62077); (*14*) *Orbiculiforma* cf. *maxima* Pessagno, Sample Mach-2 (62107); (*15*) *Orbiculiforma belliatula* Wu, Sample Mach-2 (62151); (*16*) *Orbiculiforma* cf. *cachensis* Pessagno, Sample Mach-2 (62196).

while terrigenous sediments of the near-continental (or near-island arc) sedimentation zone constituting the upper part of the stratigraphic succession are represented by Albian olistostromes or missing [7, 9].

Volcanogenic–siliceous rocks in the Machtovaya area are developed northwest of the band-shaped distribution area of siliceous and volcanogenic rocks of the Kiselevka–Manoma accretionary complex (Fig. 1) and

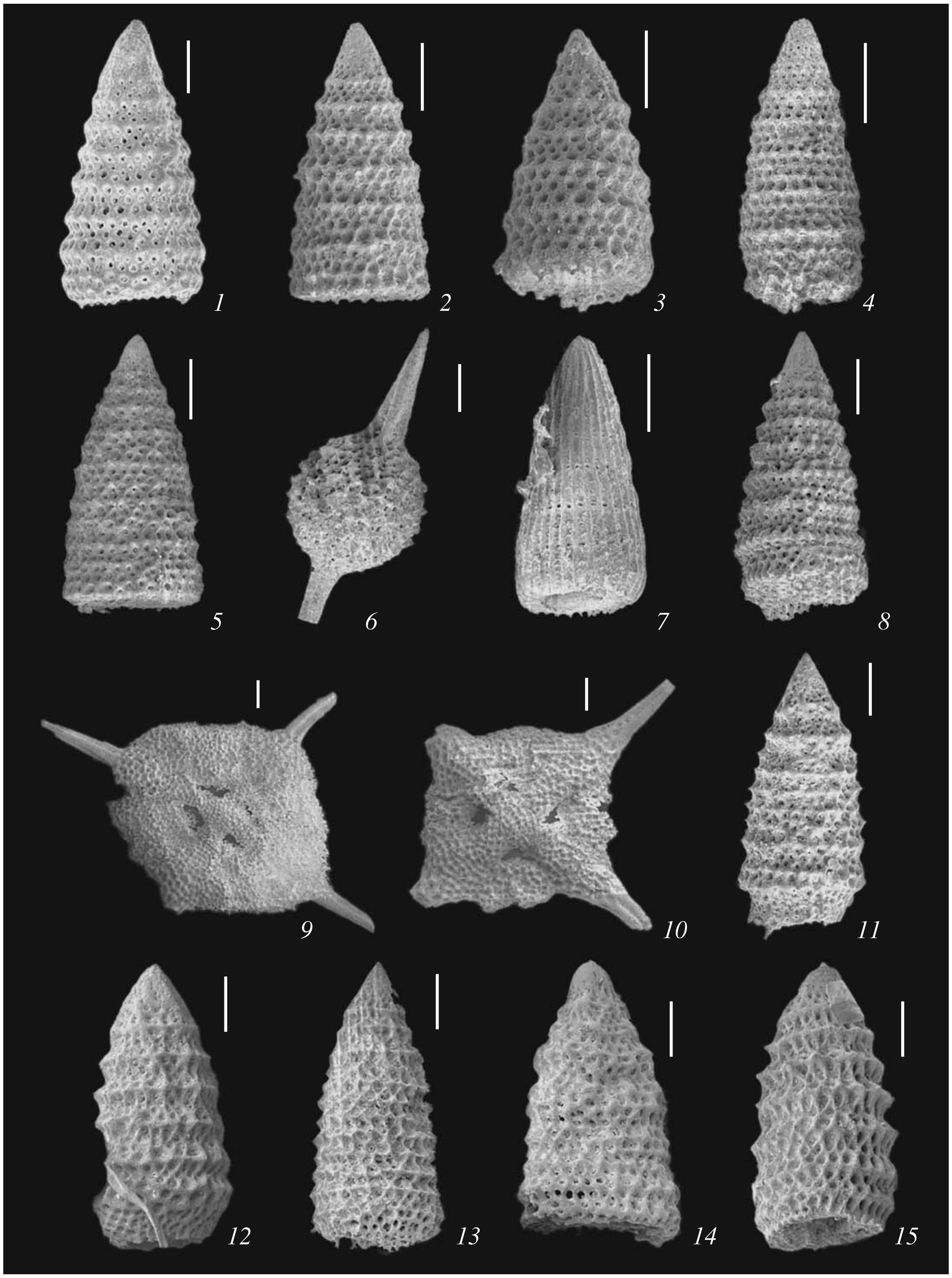

Fig. 4-3. Early Cretaceous radiolarians from siliceous–clayey rocks developed in the middle reaches of the Machtovaya River. All the bars are 50 μm.

(*1–5*) *Parvicingula* sp.: (*1*) Sample Mach-1 (62004), (*2*) Sample Mach-1 (62018), (*3*) Sample Mach-1 (62026), (*4*) Sample Mach-1 (62041), (*5*) Sample Mach-1 (62073); (*6*) *Acaeniotyle* sp., Sample Mach-1 (62049); (*7*) *Archaeodictyomitra* cf. *sliteri* Pessagno, Sample Mach-1 (62055); (*8*) *Crolanium* sp., Sample Mach-1 (62066); (*9, 10*) *Crucella* (?) *inflexa* (Rust): (*9*) Sample Mach-1 (62074); (*10*) Sample Mach-2 (62113); (11–15) *Xitus* sp.: (*11*) Sample Mach-1 (62013), (*12*) Sample Mach-2 (62130), (*13*) Sample Mach-2 (62165), (*14*) Sample Mach-2 (62178), (*15*) Sample Mach-4 (62207).

southeast of coeval terrigenous sequences attributed to the Zhuravlevka–Amur Terrane [14–16]. They are largely composed of upper Tithonian–Valanginian turbidites approximately 2000 m thick, which are unconformbly overlain by Albian–Cenomanian shallow-marine sediments [12, 20]. Such spatial position and differences in the vertical succession of age-similar sediments (Fig. 5) indicate that, in its geological history

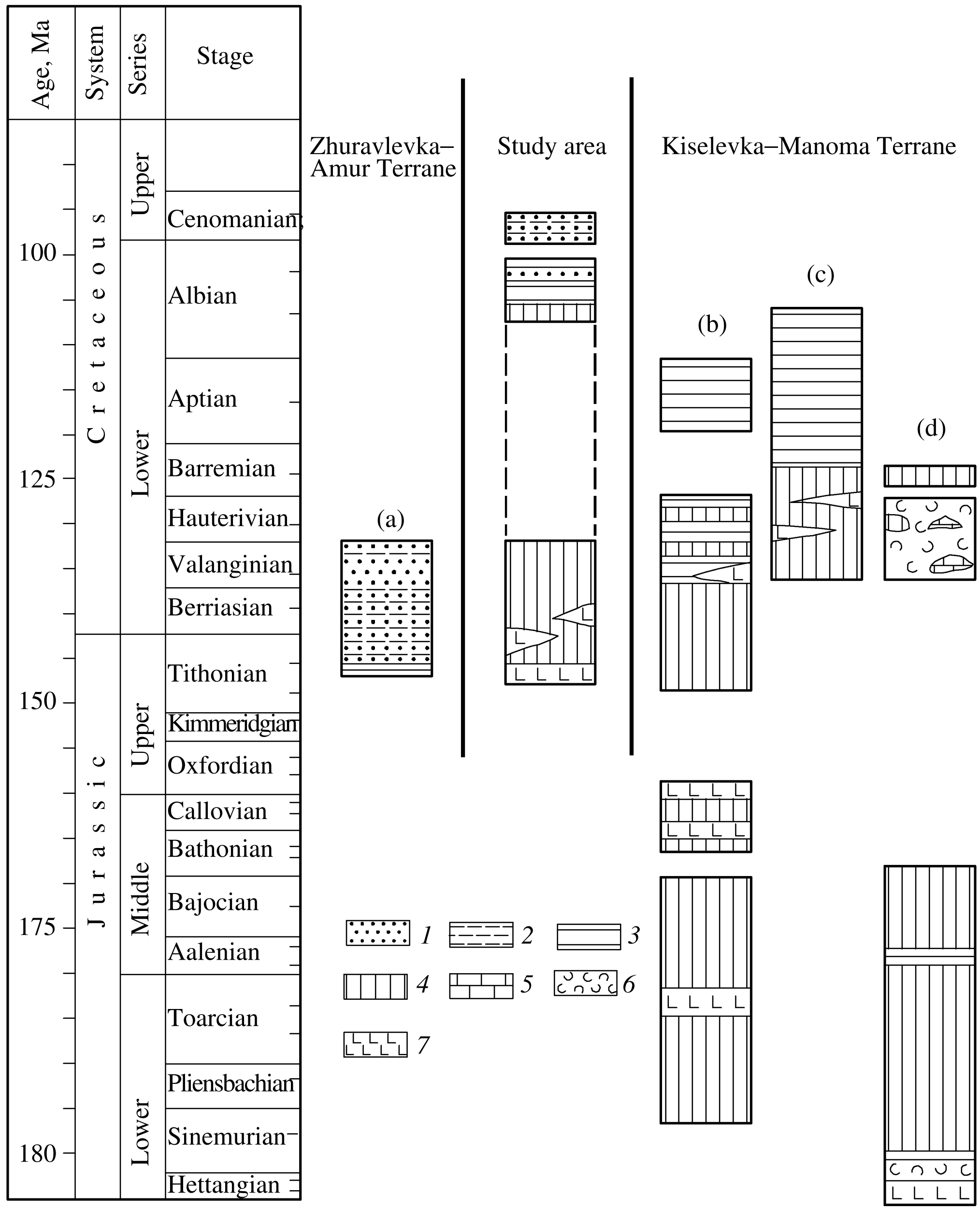

Fig. 5. Lithologic–stratigraphic columns of volcanogenic–sedimentary rocks in the lower reaches of the Amur River. (a) On the right side of the Amur River opposite Komsomolsk-on-Amur [20]; (b) Manoma River [13]; (c–d) Kiselevka Settlement area: (c) after [13], (d) after [6].

(1) sandstone, (2) silfstone, (3) mudstone, (4) chert, (5) limestone, (6) volcanoclastic rock, (7) basalts.

and tectonic nature, the study area is different from the adjacent regions. The origin of the upper Tithonian–Albian cherts and volcanics of the Machtovaya area, which evidently represent a fragment of the autonomous tectonic structure, can be clarified by further studies. It is conceivable that they represent the base of the marginal basin. The existence of this basin and its relative isolation are indirectly confirmed by the specific middle–late Albian radiolarian assemblage with a significant amount of species that are unknown in Cretaceous marine sediments of the Tethys and Pacific farming areas.

CONCLUSIONS

The volcanogenic–siliceous rocks developed on the left side of the Machtovaya River (right tributary of the Amur River) contain radiolarian assemblages of the late Late Tithonian–Early Valanginian and middle–late Albian. These finds make it possible to reconstruct the primary succession of sediments, where the lower (upper Tithonian–Valanginian) part is composed of dark red and red-brown cherts with basalts and the upper part is represented by dark gray clayey cherts associated with olive-gray siliceous–tuffaceous mudstones and tuffaceous siltstones. The composition, the stratigraphic succession, and the age of the volcanogenic–siliceous rocks developed in the Machtovaya area and neighboring Kiselevka–Manoma accretionary complex and Zhuravlevka–Amur Terrane are substantially different, which indicates their different tectonic nature.

ACKNOWLEDGMENTS

This work was supported by the Far East Branch of the Russian Academy of Sciences (grant no. 06-III-A-08-316).

REFERENCES

1. Ch. B. Borukaev and B. A. Natal'in, "Accretion Tectonics of Southern Russian Far East," Geol. Geofiz. **35** (7–8), 89–93 (1994).
2. *Geological Map of the Amur Region and Adjacent Territories on a Scale 1 : 2 500 000. Explanatory Note*, Ed. by L. I. Krasnyi, et al., (St. Petersburg–Blagoveshchensk–Kharbin, 1996) [in Russian].
3. S. V. Zyabrev, "Early Cretaceous Cherts of the Kiselev–Manoma Terrane—the Youngest Oceanic Deposits in the Southern Continental Part of the Russian Far East," Tikhookean. Geol., No. 6, 74–82 (1994).
4. S. V. Zyabrev, M. V. Martynyuk, and E. K. Shevelev, "Southeastern Fragment of the Kiselev–Manoma Complex, Sikhote Alin: Stratigraphy, Subduction Accretion, and Postaccretionary Displasements," Tikhookean. Geol. **24** (1), 45–58 (2005).
5. V. A. Kaidalov, "Global Structural Features of Mesozoic Sequences in the Lower Amur Region and the Northern Sikhote Alin," in *Proceedings of 4th Yu. A. Kosygin Readings on Tectonics, Deep Structure, and Geodynamics of Eastern Asia, Khabarovsk, Russia, 2003* Ed. by N. P. Romanovskii (Inst. Tikhooken. Geol. Im. Yu. A. Kosygina Dal'nevost. Otd. Ross. Akad. Nauk, Khabarovsk, 2003), pp. 17–30.
6. G. L. Kirillova, T. Sakai, K. Isida, et al., "Structure and Genesis of Late Jurassic–Early Cretaceous Accretion Complexes in the Amur Region," in *Proceedings of 36th Tectonic Conference on Tectonics and Geodynamics of Continental Lithosphere* (GEOS, Moscow, 2003), Vol. 1, pp. 253–255.
7. P. V. Markevich, A. N. Fillipov, A. I. Malinovskii, et al., "Cretaceous Island-Arc Sedimentation Region in the Lower Amur Region of the Russian Far East," Dokl. Akad. Nauk **356** (1), 73–77 (1997) [Dokl. Earth Sci. **356** (7), 955–959 (1997)].
8. P. V Markevich, V. P. Kopnovalov, A. I. Malinovskii, et al., *Lower Cretaceous Deposits of the Sikhote Alin* (Dal'nauka, Vladivostok, 2000) [in Russian].
9. P. V. Markevich, A. N. Fillipov, A. I. Malinovskii, et al., *Cretaceous Volcanosedimentary Rocks of the Lower Amur Region: Structure, Composition, and Depositional Environments,* (Dal'nauka, Vladivostok, 1997) [in Russian].
10. B. A. Natal'in and S. V. Zyabrev, "Structure of Mesozoic Sequences in Valley Amur River," in *Guidebook for Geological Excursions* (Khabarovsk, 1989) [in Russian].
11. B. A. Natal'in, "Mesozoic Accretionary and Collision Tectonics in South Far East of the USSR", Tikhookean. Geol., No. 5, 3–23 (1991).
12. *The Decisions of 4th Interdepartmental Regional Stratigraphic Conference on Precambrian and Phanerozoic of the Far East and Eastern Baikal Region* (KHTGP, Khabarovsk, 1994) [in Russian].
13. A. N. Fillipov, "Jurassic–Early Cretaceous Volcanic Cherty Complex of the Manoma River, Northern Sikhote Alin: Fragment of the Sedimentary Cover of a Paleoceanic Plate," Tikhookean. Geol. **20** (1), 25–38 (2001).
14. A. I. Khanchuk, V. V. Golozubov, I. V. Kemkin, et al., "Pre-Upper Cretaceous Structural–Lithologic Complexes of the Sikhote-Alin Fold System", in *Proceedings of Workshop on Tectonics and Mineralogy of the Northeastern USSR, Magadan, Russia, 1990* (Dal'nevost. Otd. Akad. Nauk SSSR, Magadan, 1990), pp. 232–234 [in Russian].
15. A. I. Khanchuk, *Extended Abstracts of Doctoral Dissertation in Geology and Mineralogy* (Moscow, 1993).
16. A. I. Khanchuk, "Paleogeodynamic Analysis of Formation of Ore Deposits in the Russian Far East," in *Ore Deposits of Continental Margins* (Dalínauka, Vladivostok, 2000), pp. 5–34 [in Russian].
17. P. O. Baumgarther, L. OíDogherty, S. Gorican, et al., "Radiolarian Catalogue and Systematics of Middle Jurassic and Early Cretaceous Tethyan Genera and Species," in *Middle Jurassic to Lower Cretaceous Radiolarians of Tethys: Occurrences, Systematics, Biochronology*, Ed. by P. O. Baumgartner, et al. (Memories de Geology, Lausanne, 1995), No. 23, 37–685 (1995).
18. P. Dumitrica, A. Immenhauser, and R. Dumitrica-Jud, "Mesozoic Radiolarian Biostratigraphy from Masirah Ophiolite, Sultanate of Oman. Part 1: Middle Triassic, Uppermost Jurassic, and Lower Cretaceous Spumellarians and Multisegmented Nasselarians," in *Bulletin of National Museum of Natural Sciences* (Paris, 1997), No. 9, pp. 1–106.
19. A. I. Khanchuk, "Pre-Neogene Tectonics of the Sea of Japan Region: A View from the Russian Side," Earth Sci. **55** (3), 275–291 (2001).
20. G. L. Kirillova, "Upper Jurassic–Lower Cretaceous of the Fore-Arc Deposits of the Komsomolsk Series along the Right Bank of the Amur River Opposite Komsomolsk-on-Amur," in *Upper Jurassic–Cretaceous Deposits of East Asia Continental Margin along the Amur River. Field Excursion Guidebook* (FEB Ross. Akad. Nauk, Khabarovsk, 2002), pp. 37–49.
21. V. A. Natal'in, "History and Modes of Mesozoic Accretion in Southern Russia," Island Arc **2** (1), 15–34 (1993).
22. L. O'Dogherty, "Biochronology and Paleontology of Mid-Cretaceous Radiolarians from Northern Appenines (Italy) and Betic Cordillera (Spain)," Mem. Geol. (Lausanne), No. 21, 1994.
23. A. Schaaf, "Late Early Cretaceous Radiolarians from the Deep Sea Drilling Project. Leg 62," in *Initial Reports of the Deep Sea Drilling Project* (US Gov. Print. Off., Washington, 1981), Vol. 62, pp. 419–470.

Recommended for publishing by G.L. Kirillova