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GEOLOGY

The First Joint Find of Coniacian–Santonian Radiolarians and Planktonic Foraminifers in Western Kamchatka

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Radiolarians and inoceramids in Santonian–early Campanian neritic facies of northwestern Kamchatka were known long ago [1–3]. The radiolarian assemblage, which includes 25 species, originates from carbonate concretions in the siliciclastic rocks (siltstones and sandstones) of the lower subformation of the Bystraya Formation (Talovka Group) developed in the lower reaches of the eponymous river. This assemblage is represented by species known only from the Russian Platform and California in a 2 : 1 proportion. At the same time, planktonic foraminifers widely used in zonal stratigraphy have never been found in this region. L.G. Bragina has studied radiolarians in samples collected by M.A. Pergament at the eastern coast of the Penzhina Bay. In addition, the Penzhina radiolarian assemblage consists largely of Spumellaria, long-living *Amphipyndax stocki* (Campbell et Clark), *Xitus asymbatos* (Foreman), or relict (*Crolanium triquetrum* Pessagno) Nasselaria forms with insufficient stratigraphic resolutions, i.e., of low significance for the stratigraphic subdivision of volcanogenic–siliceous sequences in adjacent Kamchatka and Koryak Highland areas.

In this connection, special searches of microfossils were carried out in siliceous rocks. Thorough paleontological studies of volcanogenic–siliceous sections conducted in western Kamchatka in 2002–2005 showed that locally abundant siliceous radiolarian skeletons were accompanied by both inoceramid remains and numerous identifiable carbonate foraminiferal tests. In the northern Kamchatka radiolarian–foraminiferal assemblage, we were able to detect some new radiolarian genera and species, which are characteristic of both high-latitude (*Heliodiscus borealis* Vish., *Spongasteriscus rozanovi* Vish., and *Prunopyle stanislavi* Vish.) and tropical (*Multiastrum flos* Vish. and *M. regalis* Vish.) regions, as well as benthic foraminifers [2]. In some samples, radiolarians were found together with numerous benthic foraminifers, such as *Stensioina* cf. *exculpta* (Reuss), which is distributed in the Turonian–Maestrichtian but more frequently in the Coniacian–Santonian interval; *Osangularia* aff. *florealis* (White) characteristic of the Coniacian–Eocene; and *Hyperammina* cf. *nodosariaformis* (Subbotina) typical of the Upper Cretaceous.

The Coniacian–Santonian foraminiferal–radiolarian assemblage with numerous planktonic foraminifers was found in three areas of western Kamchatka: Ust'-Palana (samples 171/01, 202/01, 302/01, and 303/01), Cape Pyatibratskii (sample 96/01), and Mt. Kinkil (samples 219/01 and 234/01).

In the northernmost outcrop of the Palana area (Fig. 1), the foraminiferal–radiolarian assemblage was extracted using hydrofluoric acid from the low-calcareous chert horizon of the 9-m-thick siliceous sequence (samples 170/99–175/99, 169/01, 171/01, and 177/01). Figures 2 and 3 illustrate identified foraminiferal and radiolarian species, respectively.

The Coniacian–Santonian foraminiferal assemblage, which consists of *Archaeoglobigerina bosquensis* Pessagno (Coniacian–Santonian), *Hedbergella delrioensis* (Carsey) (Aptian–early Senonian), *H. holmdelensis* Olsson (Coniacian–Maestrichtian, *Heterohelix globulosa* (Ehrenberg) (Turonian–Campanian), *H. reussi* (Cushman), and *Globigerinelloides ultramicra* (Subbotina) (Albian–Campanian), was found in the middle part of the low-calcareous chert horizon (Ust'-Palana, samples 173/99 and 202/01). A similar foraminiferal assemblage represented largely by planktonic forms was found in a low-calcareous chert lens (sample 159/99) exposed 200 m away in the southern areas. It includes *Globigerinelloides ultramicra, Archaeoglobigerina bosquensis, Hedbergella delrioensis*, and *H. holmdelensis*.

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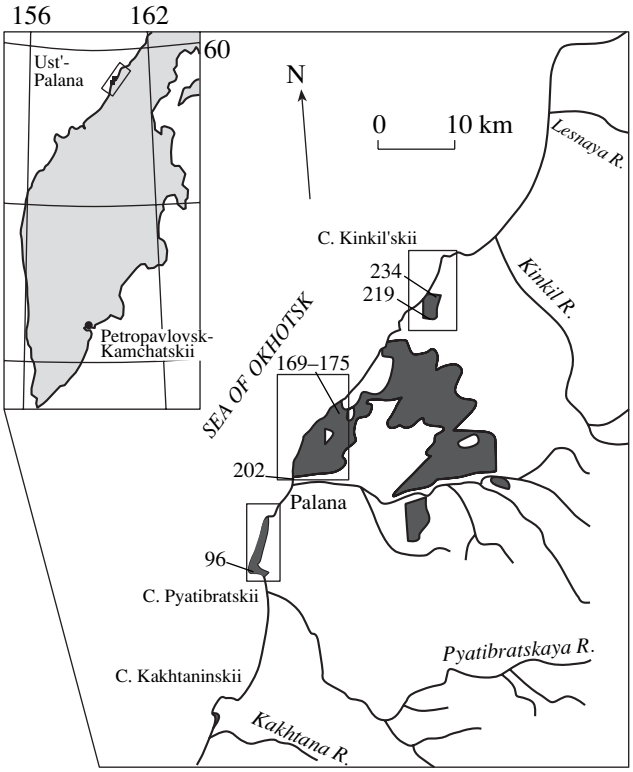

Fig. 1. Localities of joint finds of radiolarians and planktonic foraminifers in western Kamchatka. Locality 169–175: collection of D.V. Kurilov, D.V. Kovalenko, and E.E. Chernov; other localities: collection of D.V. Kovalenko and E.E. Chernov.

The Coniacian–early Santonian radiolarian assemblage is established in 0.5-m-thick green cherts (sample 170/99) and 5-m-thick gray tuffaceous cherts (sample 171/99) immediately underlying variegated cherry-green cherts (0.2 m), which yielded the Coniacian–Santonian radiolarian–foraminiferal assemblage (sample 173/99).

The Coniacian–early Santonian radiolarian assemblage is composed of the following species: *Archaeospongoprunum bipartitum* Pessagno, *Crucella plana* Pessagno, *Pseudoaulophacus praefloresensis* Pessagno, *Lipmanium? sacramentoensis* Pessagno, *Dictyomitra urakawaensis* Taketani, *D. densicostata* Pessagno, *Amphipyndax ellipticus* Nakaseko et Nishimura, *A. stocki* (Campbell et Clark), and *Cornutella californica* (Campbell et Clark) at the base of the section (sample 170/99); *Pseudoaulophacus* aff. *floresensis* Pessagno, *P.* ex gr. *praefloresensis* Pessagno, *Dictyomitra densicostata* Pessagno, *D.* cf. *multicostata* Zittel, *Archaeodictyomitra* cf. *squinaboli* Pessagno, *Stichomitra* ex gr. *manifesta* Foreman, *S.* aff. *communis* Squinabol, *Amphipyndax stocki* (Campbell et Clark) var. A Vishnevskaya, *A. stocki* (Campbell et Clark) var. B Vishnevskaya in the horizon located 3 m higher in the section (sample 171/99).

The horizon located 3.2 m upsection includes the following Coniacian–early Santonian radiolarian assemblage (samples 175/99 and 177/01): *Theocapsomma* aff. *amphora* (Campbell et Clark), *Dictyomitra densicostata* Pessagno, *D.* cf. *multicostata* Zittel, *Archaeodictyomitra* cf. *squinaboli* Pessagno, *Stichomitra* ex gr. *manifesta* Foreman, *Amphipyndax stocki* (Campbell et Clark) var. A Vishnevskaya, and *A. stocki* (Campbell et Clark) var. B Vishnevskaya.

The coeval and taxonomically similar foraminiferal–radiolarian assemblage was established during repeated sampling at several localities in the Pyatibratskii and Kinkil areas. Previously, siliceous interbeds (samples 84/99, 85/99, 86/99) in volcanogenic sequences yielded the Coniacian–early Campanian radiolarian assemblage: *Phaseliforma carinata* Pessagno, *Porodiscus vulgaris* Lipman, *Orbiculiforma* cf *vacaensis* Pessagno, *O. quadrata* Pessagno, and *Amphipyndax stocki* (Campell et Clark) [4].

The micropaleontological study of highly metamorphosed cherts of the Irunei Formation (upper Campanian) carried out in its stratotype area (Mt. Irunei) only yielded the Coniacian–early Campanian radiolarian assemblage: *Alievium* cf. *superbum* (Squinabol), *Archaeospongoprunum bipartitum* Pessagno, *Cromyosphaera tschurini* Lipman, *Pseudoaulophacus* aff. *floresensis* Pessagno, *Orbiculiforma(?) sempiterna* Pessagno, *O.* ex gr. *persenex* Pessagno, *Dorypyle* cf. *ovoidea* (Squinabol), *Dictyomitra densicoststa* Pessagno, *Archaeodictyomitra squinaboli* Pessagno, *Stichomitra* cf. *livermorensis* (Campbell et Clark), *S. manifesta* (Campbell et Clark), and *Amphipyndax stocki* (Campbell et Clark) var. A Vishnevskaya. The age of the assemblage is established based on the first appearance of Coniacian species *Orbiculiforma persenex* Pessagno and *Archaeodictyomitra squinaboli* Pessagno and the Coniacian–early Santonian index species *Archaeospongoprunum bipartitum* Pessagno. The upper (early Campanian) age limit is determined by the last appearance of *Alievium superbum* (Squinabol) and *Orbiculiforma persenex* Pessagno, as well as the presence of the late Santonian–early Campanian species *Pseudoaulophacus floresensis* Pessagno.

The coeval well-preserved radiolarian assemblage was also discovered in a section of light green, bedded, locally highly silicified siliceous rocks occurring among basalts exposed in the Tikhaya River basin of western Kamchatka (sample 64/00 DH). It contains the following species: *Cromyosphaera tschurini* Lipman, *Orbiculiforma persenex* Pessagno, *O.* sp. A, *Multastrum flos* Vishnevskaya, *Spongotripus morrenoensis* Campbell et Clark, *Pseudoaulophacus* aff. *floresensis* Pessagno, *Diacanthocapsa euganea* (Squinabol), *Stichomitra manifesta* Foreman, *S. livermorensis* (Campbell et Clark), *Dictyomitra densicostata* Pessagno, and others. Such a species assemblage suggests that the siliceous rocks of the volcanogenic sequence have the Coniacian–early Campanian age. These radiolarian species are accompanied by benthic foraminifers *Planularia* sp. and Rotaliidae gen. et sp. indet.

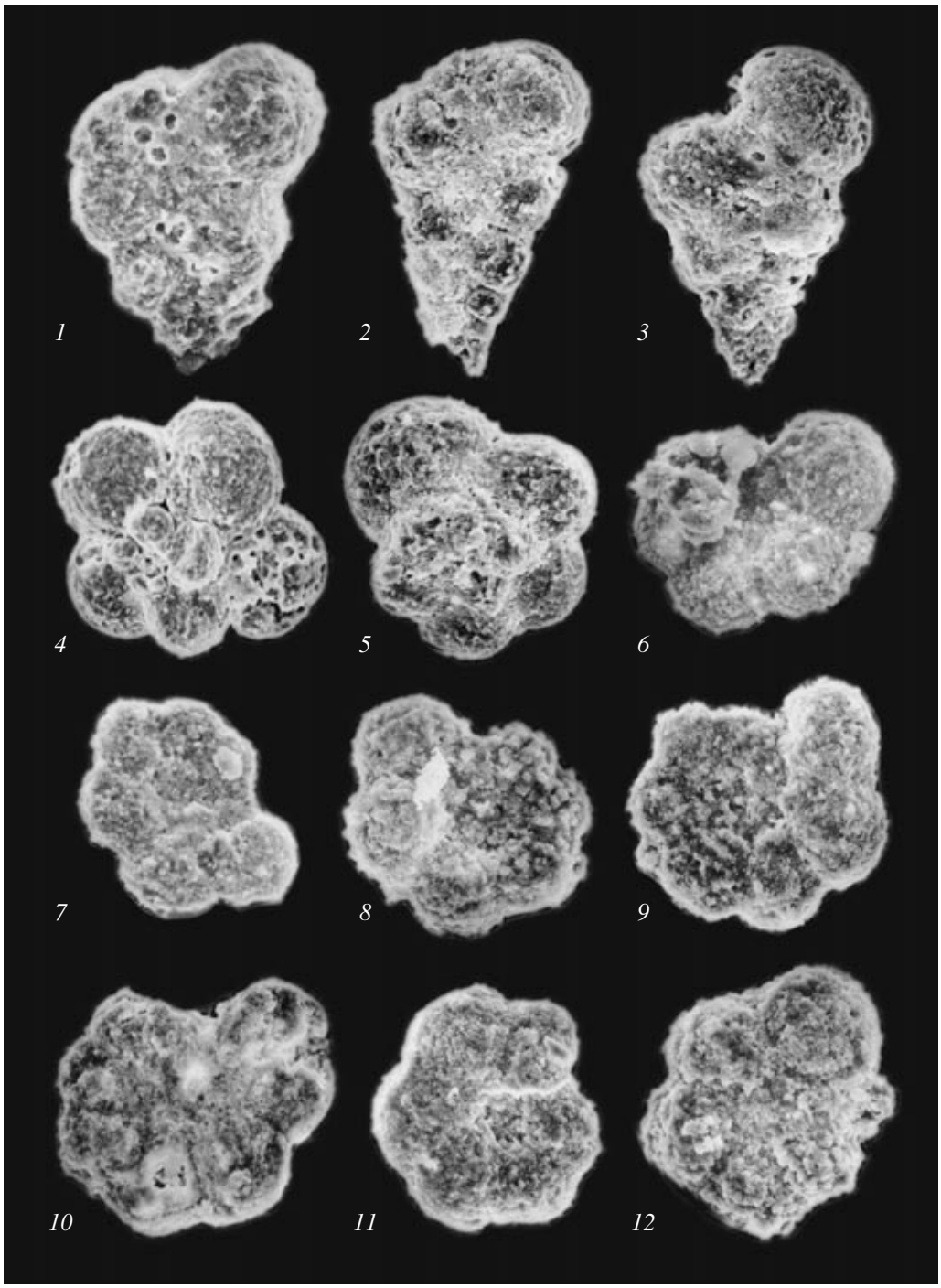

Fig. 2. The Coniacian–Santonian foraminiferal assemblage from the Ust'-Palana River basin. (*1*) *Heterohelix reussi* (Cushman), ×210, sample 173/99; (*2, 3*) *Heterohelix globulosa* (Ehrenberg), ×160, ×150, sample 173/99; (*4*) *Archaeoglobigerina bosquensis* Pessagno (Coniacian–Santonian), ×130, sample 173/99; (*5*) *Hedbergella holmdelensis* Olsson, ×200, sample 173/99; (*6*) *Hedbergella delrioensis* (Carsey), ×220, sample 159/99; (*7, 8*) *Hedbergella* aff. *holmdelensis* Olsson, ×200, ×210, sample 159/99; (*9, 10*) *Globigerinelloides ultramicra* (Subbotina), ×200, ×190, sample 159/99; (*11, 12*) *Archaeoglobigerina* aff. *bosquensis* Pessagno (Coniacian–Santonian), ×210, sample 159/99.

The radiolarian assemblage of close age is found in the 20-m-thick fragmentary section of siliceous rocks exposed along the right tributary of the Rossoshina River. The basal part of the section is composed of bright red clayey cherts replaced upsection by light green tuffaceous cherts with abundant inoceramid prismatic layers. The section is crowned by alternating red clayey cherts and light green compact cherts without

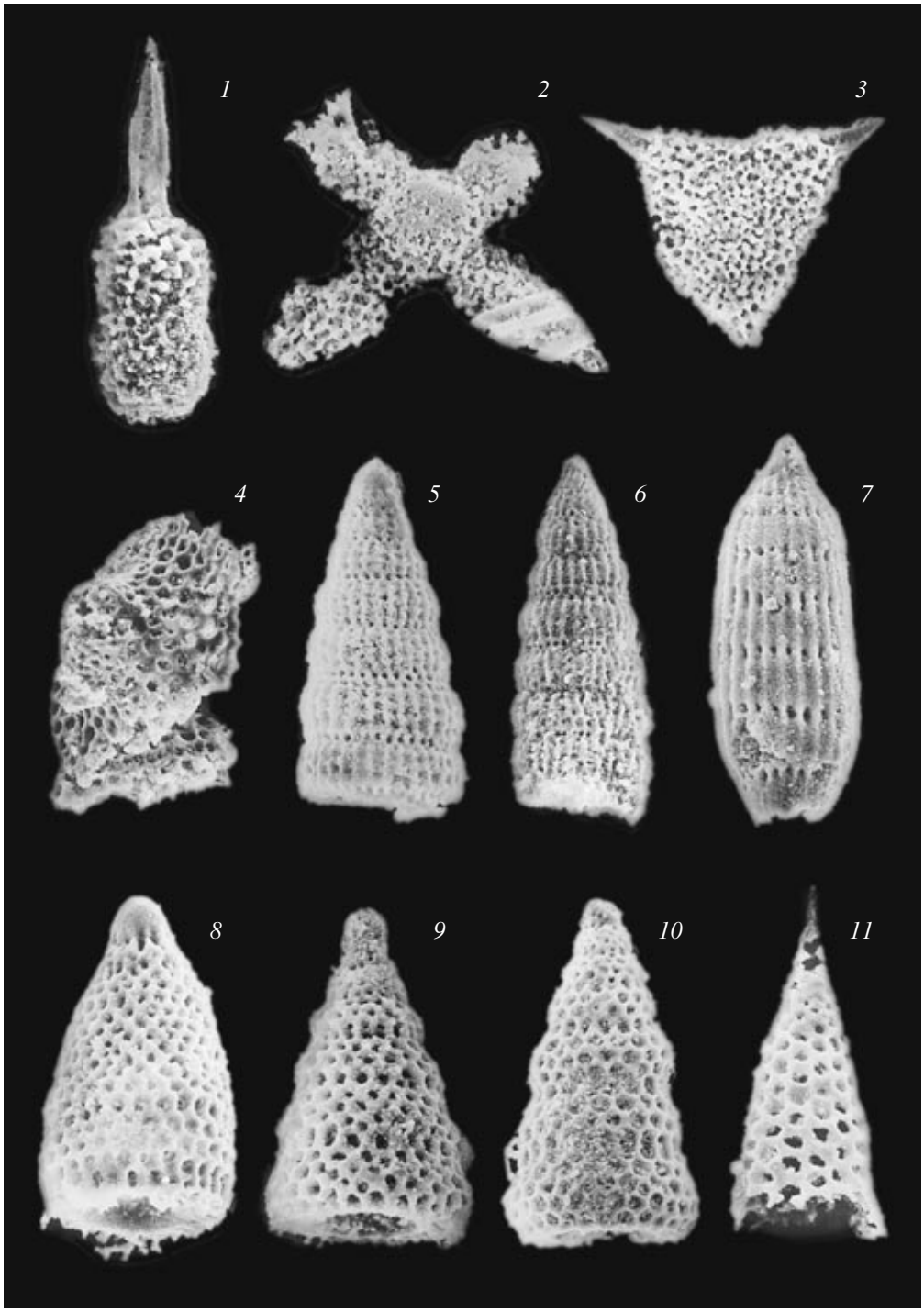

Fig. 3. The Coniacian–Santonian radiolarian assemblage from the Ust'-Palana River basin (sample 170/99 K). (*1*) *Archaeospongoprunum bipartitum* Pessagno, ×100; (*2*) *Crucella plana* Pessagno, ×180; (*3*) *Pseudoaulophacus praefloresensis* Pessagno, ×200; (*4*) *Lipmanium? sacramentoensis* Pessagno, ×200; (*5, 6*) *Dictyomitra urakawaensis* Taketani: (*5*) ×200, (*6*) ×200; (*7*) *Dictyomitra densicostata* Pessagno, (*8*) *Amphipyndax ellipticus* Nakaseko et Nishimura, ×180; (*9, 10*) *Amphipyndax stocki* (Campbell et Clark): (*9*) ×200, (*10*) ×200; (*11*) *Cornutella californica* (Campbell et Clark), ×210.

inoceramid prismatic layers. One of the samples yielded the Santonian–early Campanian radiolarian assemblage. The radiolarian finds are mainly confined to interbeds of red clayey cherts in the upper part of the section. The extracted assemblage is represented by the following species: *Cromyosphaera tschurini* Lipman, *Stichomitra* cf. *manifesta* Foreman, *S. livermorensis* (Campbell et Clark), *Dictyomitra* sp. A., *Amphipyndax*

awaensis Nakaseko et Nishimura, and *A. stocki* (Campbell et Clark).

In addition, radiolarians were obtained from siliceous boudins at the top of the basaltic flow. They are composed of dark red cherts with inoceramid prismatic layers and compact jaspers. The red cherts yielded *Pseudoaulophacus* aff. *floresensis* Pessagno, *Cromyosphaera vivenkensis* Lipman, *Phaseliforma* cf. *carinata* Pessagno, and *Amphipyndax stocki* (Campell et Clark). The jaspers also yielded well-preserved radiolarians: *Crucella aster* (Lipman), *Cromyosphaera vivenkensis* Lipman, *Stichomitra livermorensis* (Campbell et Clark), and *Xitus asymbatos* (Foreman) (RD 4/00).

The first joint finds of carbonate and siliceous microfauna in northern Kamchatka are of particular significance because of the following reasons. First, they reliably substantiate the Coniacian–Santonian age of volcanogenic–siliceous rocks, the presence of which in this area was previously doubted [5]. Second, they imply the deposition of siliceous sediments at lower paleolatitudes. In addition, they stimulate further purposeful searches for similar assemblages in Cretaceous sequences of northeastern Russia.

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