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The Shelf of the Kamchatskii Cape, Eastern Kamchatka, in the Late Pliocene and Early Quaternary (Ol'khovaya Time)

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Abstract—The study of Pliocene–Quaternary sediments of the Kamchatskii Cape and the paleoecologic analysis of associated mollusks and foraminifers resulted in distinguishing the early and late Ol'khovaya transgressions. During the early Ol'khovaya transgression, approximately from 2 to 1.5 Ma, the sea-level rise reached at least 120 m. At the maximum of the early Ol'khovaya transgression, the Kamchatskii Cape represented a shelf of submeridional extension over 15 km wide. The depth ranged from 0 to more than 500 m on the continental slope. The most likely bottom water temperatures at a depth exceeding 30–40 m, were relatively stable. They ranged from –1.5 to +1.8°C on the shelf and were approaching 2°C on the continental slope. It was elucidated that the early Ol'khovaya transgression was accompanied by a slight climatic warming. The late Ol'khovaya transgression occurred from 0.73 to 0.3 Ma and was no less significant.

Key words: *stratigraphy, paleoecology, Late Cenozoic, shelf, mollusks, foraminifers, eastern Kamchatka*

INTRODUCTION

Highly detailed stratigraphic investigations in the shelf zone of the active oceanic margin raise the importance of paleoecologic analysis that reveals the relationship between changes in the composition of paleobiotic assemblages and abiotic phenomena. The elucidation of these relationships makes it possible to turn to eventual stratigraphy, that is to the calendar of geologic events.

This paper presents the results of paleoecologic research of mollusks and foraminifers from the Ol'khovaya Formation of the Kamchatskii Cape. Its major aim is to show the importance and necessity of paleoecologic investigations for deciphering the historical development of the region in the Pliocene and Quaternary.

The geologic study of the region and the paleoecologic analysis of mollusks were performed by Basilyan, and foraminifers were identified by Bylinskaya.

MATERIAL

The authors studied the most complete sections of the Ol'khovaya Formation in the central and southwestern Kamchatskii Cape along the Ol'khovaya-1, Mutnaya, and Medvezh'ya rivers and at the foot of Vysokaya Mountain (Fig. 1). Samples from fine-grained deposits for micropaleontologic research were taken by O.M. Petrov and M.E. Bylinskaya. Mollusks from the lower Ol'khovaya sediments were collected by Basilyan in 1990. Additionally, we used the collection of Petrov and materials collected by A.E. Basilyan and K.B. Barinov in 1989.

OL'KHOVAYA FORMATION AND ITS AGE

The most complete lithologic characteristic of the formation was reported previously by Gladenkov *et al.* (1994), and so we dwell only on some certain peculiarities of its structure.

According to our observations, the deposits of the lower subformation are exposed in the southwestern part of the peninsula in tectonic blocks. They overlie volcanogenic rocks and represent a monocline complicated by faulted folds and inclined westward with a dip of 30° (Fig. 2). The basal part of the lower subformation is composed of conglomerates and gravelstones, gradually replaced by sandstones and siltstones upward the section. The upper part of the subformation is represented by sandy siltstones and sandstones with gravelstone lenses. The maximum thickness of the subformation is over 400 m.

It is unconformably overlain with a hiatus by cross-bedded sandstones and conglomerates of the upper Ol'khovaya Subformation, which is represented by sandy siltstones and sandstones in the central part of the peninsula. The upper Ol'khovaya Subformation is 700 m thick.

The Ol'khovaya Formation as a whole is of a cyclic structure. We distinguish within its limits two great sedimentary cycles corresponding to subformations and separated by an erosional surface. A strong facies variability of sediments along the strike was recorded. For example, the most fine-grained part of the lower Ol'khovaya sedimentary cycle in the Mutnaya-A section is represented by sandy siltstones, in the Mutnaya-B section by clayey siltstones, and at the foot of the

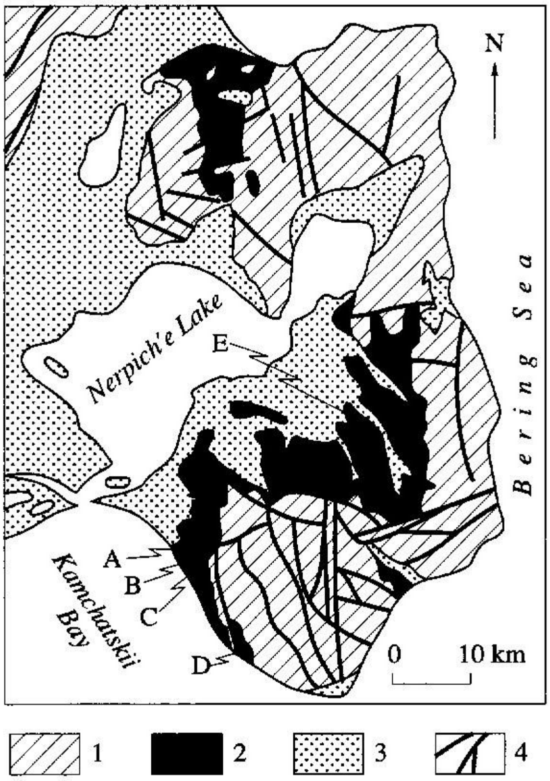

Fig. 1. Distribution of the Ol'khovaya Formation in the Kamchatskii Cape. (1) Underlying rocks; (2) Ol'khovaya Formation; (3) lower and upper Pleistocene; (4) large faults. Sections: (A) Mutnaya-A; (B) Mutnaya-B; (C) Medvezh'ya River; (D) Vysokaya Mountain; (E) Ol'khovaya-1 River.

Vysokaya Mountain by sandy siltstones with large, up to 30 × 10 m, lenses of poorly sorted conglomerates with boulders of volcanogenic and metamorphic rocks, and with sandstone and sandy siltstone blocks.

According to the diatom records, A.Yu. Gladenkov assigned the lower Ol'khovaya Subformation, excluding its lowermost part barren of diatoms, to the *Actinocyclus oculatus* Zone, and the upper subformation to the *Simonseniella curvirostris* Zone of the North Pacific (Gladenkov, 1994; Gladenkov *et al.*, 1994). Paleomagnetic research by M.A. Pevzner showed the lower subformation to correspond to the Matuyama Chron, and the upper one to the beginning of the Brunhes Chron (Petrov, 1982). The normally magnetized sequence of sandy siltstones from the basal part of the lower subformation is correlated with the Olduvai Subchron (Bylinskaya and Khoreva, 1985). The sequence is about 100 m thick. Therefore, the sedimentation rate of the lower subformation constitutes about 5 cm per 100 years, which agrees with the data on the quite similar Pliocene deposits of Karaginskii Island (Basilyan *et al.*, 1991). With regard to the sedimentation rates, the lower subformation accumulated approximately 2 to 1.2 Ma (Fig. 3). The transgressive and regressive parts of the subformation accumulated from 2 to 1.5 Ma and from 1.5 to 1.2 Ma, respectively. The age of the upper Ol'khovaya Subformation ranges between 0.73 Ma (the Brunhes Chron lower boundary) and 0.3 Ma (the upper boundary of the *S. curvirostris* zone).

MOLLUSKS

The layer-by-layer collection of mollusks, as was done in epicontinental basins (Merklin, 1950; Gekker *et al.*, 1962) in order to provide a thorough paleoecologic study, presents difficulties in the shelf zone of an active oceanic margin. In this area we deal with thick sediments heterogeneous and variable along the strike, which were accumulated under conditions of active volcanism, tectonic processes, and eustatic oscillations.

Mollusks were collected in members that are 2–10 m thick (Fig. 4) and usually composed of interlayered rocks of various granulometric composition, from conglomerates to siltstones. In each case we recorded the

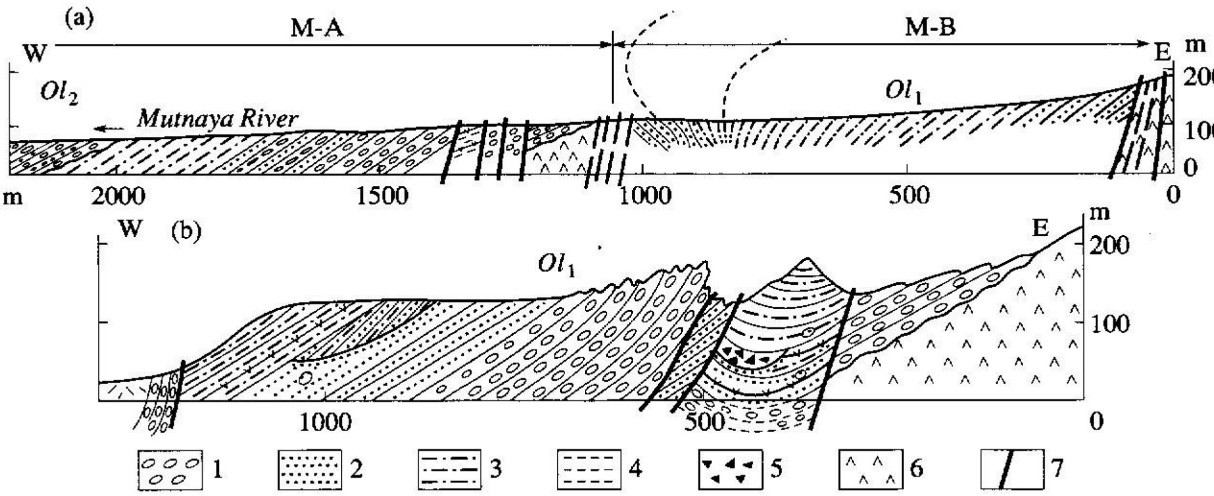

Fig. 2. Geologic profiles of the sections of the Ol'khovaya Formation across the strike: (a) along the water edge of the Mutnaya River; (b) shore section at the foot of the Vysokaya Mountain; (Ol_1) lower and (Ol_2) upper subformation; (M-A) Mutnaya-A; (M-B) Mutnaya-B; (1) conglomerate; (2) sandstone; (3) sandy siltstone; (4) siltstone; (5) conglobreccia of submarine slumps; (6) volcanites; (7) faults.

quantitative ratio between specimens of various species and their confinement to certain lithologic groups of deposits.

The mollusk community from the lower Ol'khovaya Subformation yields 95 species and subspecies of bivalves and gastropods among which modern forms constitute over 80% of the assemblage. This makes it possible to reconstruct rather closely paleoenvironments, namely, the substrate, paleotemperatures, and depth. The paleoecologic analysis was done using data on the present-day distribution of mollusks in the North Pacific (Kuznetsov, 1963; Golikov and Skarlato, 1967; Golikov and Kusakin, 1978; Skarlato, 1981; Petrov, 1982; and others).

In the first stage of the investigation, we carried out the taphonomic analysis to establish the degree of shell transportation prior to the burial. The autochthony of mollusks from a certain sample was defined by the comparison of the lithologic composition of the enclosing sediments with data on the present-day preferential substrate of corresponding species. It appeared that the deposits of both homogeneous and heterogeneous members contain species that now inhabit substrates similar to certain enclosing sediments. No mollusk shells encountered in the lower Ol'khovaya sediments, excluding those rejected due to poor preservation, i.e., broken, rounded specimens, and separate valves, were considerably transported. The mollusk spectra from interlayered deposits of various granulometric composition represent a mixture of species that now inhabit different substrates (Fig. 5).

The next step was the paleobathymetric and paleotemperature reconstructions of the mollusk paleoenvironment. In Fig. 6, for example, bottom temperatures are plotted on the abscissa and depths on the ordinate. In this diagram, each rectangle corresponds to the distribution area of a certain now-existing species, whereas their overlap (crosshatched) shows the most likely common distribution area of the whole assemblage. The most precise data on the paleodepths and bottom paleotemperatures were derived from the spectra with the greatest number of species.

The approximation of the results showed that in the Mutnaya-A section the lower sequence of nearshore sediments containing the *Mytilus* shell fragments, leaf imprints, and ripple marks was accumulated at a depth of less than 35 m. The sequence of interlayered siltstone and sandstone lying above was formed in a depth range of 35 to 40 m. The overlying sequence of fine-grained sandstones, upwardly replaced by sandy siltstones, was accumulated at a depth gradually increasing from 40 to 60 m. The sandy siltstones at the top of the lower Ol'khovaya Subformation in the Mutnaya-A section were formed as the depth decreased from 60 to 45–50 m (Fig. 7a).

Similar changes in the depth of sedimentation were recorded in the Mutnaya-B section (Fig. 7b). In this area, the deposits were accumulated at a depth increasing from 40 to 100–120 m as the transgression developed, and during a decrease of the depth back to 60 m in the course of the regression. The upper part of the section represents the sequence almost barren of mollusks and similar to that from the basal part of the Mutnaya-A section. These cross-bedded coarse-grained sandstones with lenslike conglomerate beds were accumulated in the nearshore area, most likely at a depth of less than 35 m.

The paleoecologic analysis of mollusk assemblages from the Mutnaya-A, Mutnaya-B, and Medvezh'ya River sections of the lower Ol'khovaya Subformation showed that bottom-water paleotemperatures at depths of over 35–40 m were relatively stable, ranging from –1.5 to +1.8°C.

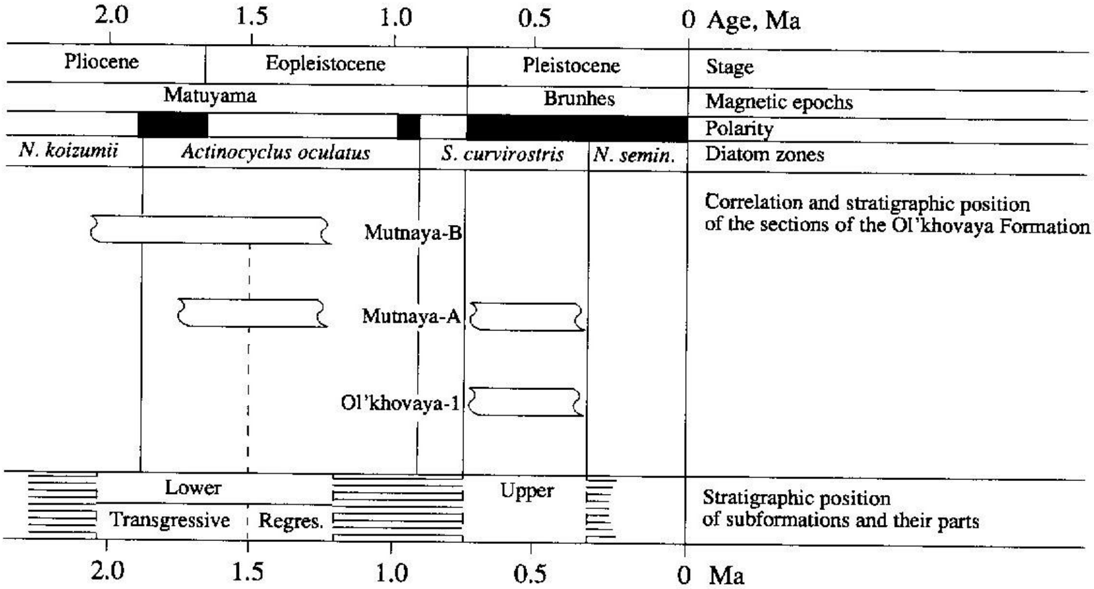

Fig. 3. Stratigraphic position of the Ol'khovaya Formation.

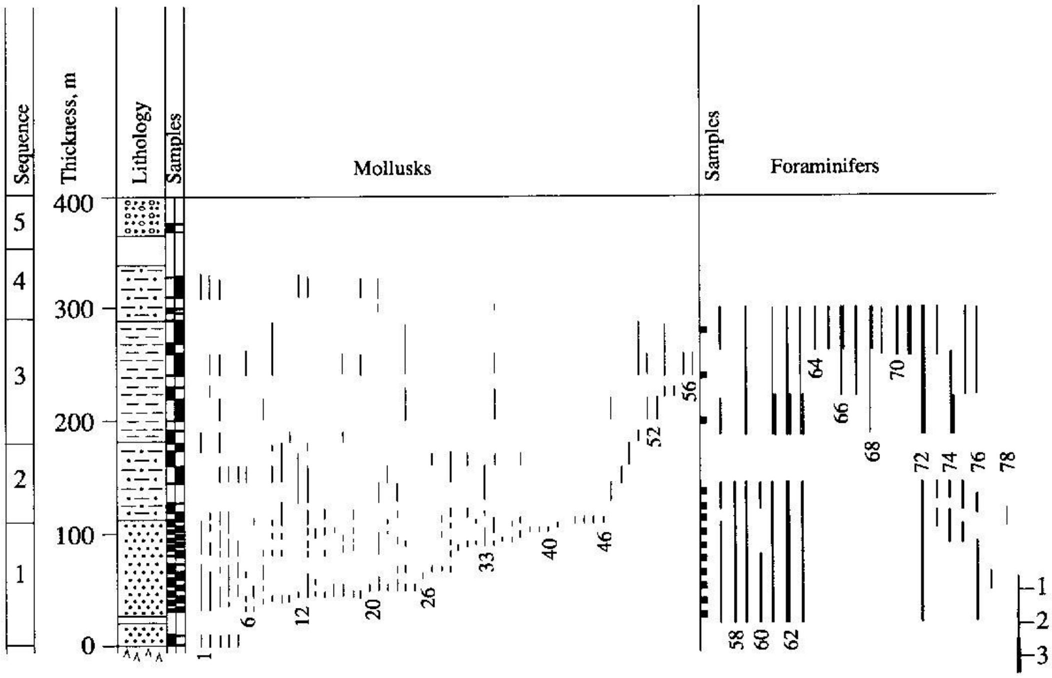

Fig. 4. Distribution of benthic fauna in the Mutnaya-B section. (1) *Ciliatocardium ciliatum* (Fabricius); (2) *Macoma calcarea* (Gmelin); (3) *Cryptonatica clausa* (Broderip et Sowerby); (4) *Hiatella actica* (Linne); (5) *Serripes groenlandicus* (Bruguiere); (6) *Mya* sp.; (7) *Astarte* (Tridonta) *borealis* (Schumacher); (8) *Buccinum* sp., (9) *Cyclocardia crebricostata* (Krause); (10) *Macoma crassula* (Deshayes); (11) *Ancistrolepis okhotensis* Dall; (12) *Periploma fragilis* (Totten); (13) *Liocyma fluctuosa* (Gould); (14) *Cyrtodaria kurriana* Dunker; (15) *Mya truncata ovata* Jensen; (16) *Boreotrophon pacificus* (Dall); (17) *Tachyrhynchus erosus* (Couthouy); (18) *Buccinum plectrum* Stimpson; (19) *Sipho* sp.; (20) *Musculus discors* (Linne); (21) *Musculus niger* (Gray); (22) *Mytilus edulis* Linne; (23) *Mya pseudoarenaria* Schlesch; (24) *Neptunea* sp.; (25) *Volutopsis planus* Petrov; (26) *Chlamys* sp.; (27) *Nuculana lamellosa lamellosa* (Leache); (28) *Margarites costalis* (Gould); (29) *Tahyrchynchus reticulatus* (Mighels et Adams); (30) *Mya truncata* Linne; (31) *Cyclocardia erimoensis* (Tiba); (32) *Oenopota metschigmensis* (Krause); (33) *Macoma moesta* (Deshayes); (34) *Yoldia* (*Chesterium*) *toporoki* Scarlato; (35) *Mysella kurilensis kurilensis* Scarlato et Ivanova; (36) *Trichotropis coronatus* Gould; (37) *Margarites helicina* (Phipps); (38) *Mya truncata olchovica* Petrov; (39) *Amauropsis islandica* (Muller); (40) *Collesella cassis* (Eschscholtz); (41) *Boreotrophon candelabrum* (A.Adams et Reeve); (42) *Pandora glacialis* Leach; (43) *Lyonsia arenosa arenosa* (Moller); (45) *Solariella varicosa* (Mighels et Adams); (46) *Buccinum polare* Gray; (47) *Sipho jordani* (Dall); (48) *Cryptonatica mammillata* Petrov; (49) *Quasisipho torquatus* Petrov; (50) *Beringius aleuticus* Dall; (51) *Aforia circinata* (Dall); (52) *Leionucula inflata inflata* (Hancock); (53) *Megayoldia* (*Portlandella*) *olchovica* Petrov; (54) *Nuculana* sp.; (55) *Megayoldia* (*Megayoldia*) *thraciaformis* (Storer); (56) *Oenopota* sp.; (57) *Buccella citronea* Leon.; (58) *B. conica* Volosh.; (59) *B. niigataensis* (Hus. et Mar.); (60) *Haynesina orbiculare* (Brady); (61) *Retroelphidium hughesi* (Cush. et Grant); (62) *C. goesi* (Stshed.); (63) *R.* ex gr. *clavatum* (Cush.); (64) *Dentalina* sp., (65) *Lagena* sp.; (66) *Epistominella pacifica* (Cush.); (67) *Globigerina bulloides* d'Orb.; (68) *Neogloboquadrina pachyderma* (Ehren.); (69) *Trifarina kokozuraensis* (Asano); (70) *Uvigerina* sp.; (71) *Islandiella norcrossi* (Cush.); (72) *Cassidulina islandica* Norv.; (73) *C. californica* Cush. et Hughes; (74) *Islandiella helenae* Feyl.-Hans. et Buzas; (75) *I. laticamerata* (Volosh.); (76) *I. sulcata* (Volosh.); (77) *Sigmomorphina lautenschlaegerae* Kuz.; (78) *Pseudopolymorphina ishikawaensis* Cush. et Ozawa. Symbols as in Fig. 2. Number of specimens per 50-g sample: (1) 1–10; (2) 10–100; (3) over 100.

In the shore outcrop near Vysokaya Mountain, the deposits of a submarine fan, formed at the foot of the continental slope, are exposed. This type of deposit is characterized by the transportation of coarse-grained material to a considerable depth along the submarine canyons down to the lower bathyal zone (Lewis, 1984).

In the section, great lenses of poorly sorted conglobreccia with volcanogenic rock boulders, sandstone blocks (up to 1 m), and sandy siltstone flyschoid blocks (up to 30 × 10 m), are included in the sequence of sandy siltstones. The blocks contain the early Ol'khovaya mollusk assemblages characteristic of depths less than 100 m. The enclosing sandy siltstones yield bathyal assemblage characterized by abundant *Calyptogena lahtakensis* Petrov, *Megayoldia* (*Portlandella*) *olchovica* Petrov, and scarce *Thyasira* sp.

Nowadays the *Calyptogena* representatives inhabit the upper bathyal to abyssal environments and are found on the combined oozy and sandy substrates of the marine fans down to the depth of 6000 m. Being specially adapted, they are symbiotically associated with colonies of chemosynthesizing methanotrophic bacteria (Fiala-Medioni and Le Pennec, 1989). This clarifies their distribution in areas of cool methane fluid venting associated with active subduction zones (Boss and Turner, 1980; Kulm *et al.*, 1986; Hashimoto *et al.*, 1989). Fossil calyptogenes occur in the Paleogene to Pleistocene deposits near great regional thrust faults (Kulm *et al.*, 1986; Campbell, 1989; Squires, 1991; Niitsuma *et al.*, 1989).

Taking into account the mollusk composition and the character of enclosing sediments, we can infer that

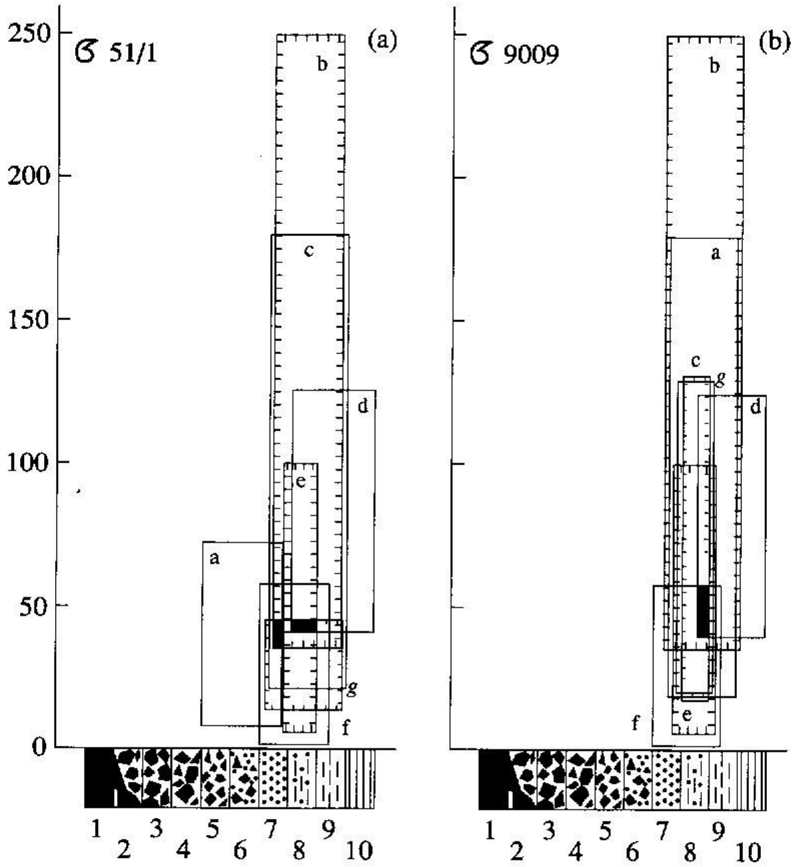

Fig. 5. Examples of the substrate and depth reconstructions (painted black in the diagram), according to the mollusk assemblage: (a) from the heterogeneous; (b) from the homogeneous members. Substrate numbers at the abscissa: (1) rocky; (2) rocky-stony; (3) stony, pebbly; (4) pebbly-gravel; (5) gravels; (6) gravelly-sandy; (7) sands; (8) oozy-sandy; (9) oozes and muds; (10) liquid muds. The vertical scale is for the habitat depth of certain mollusks (m). The distribution areas of the species inhabiting the substrates with dispersed pebble are marked with the dashed line. Sample 51/1: (a) *Spisula voyi*; (b) *Musculus niger*; (c) *Ciliatocardium ciliatum*; (d) *Periploma fragilis*; (e) *Liocyma fluctuosa*; (f) *Cyrtodaria kurriana*; (g) *Astarte montagui fabula*. Sample 9005: (a) *Ciliatocardium ciliatum*; (b) *Musculus niger*; (c) *Macoma calcarea*; (d) *Periploma fragilis*; (e) *Liocyma fluctuosa*; (f) *Cyrtodaria kurriana*; (g) *Serripes groenlandicus*.

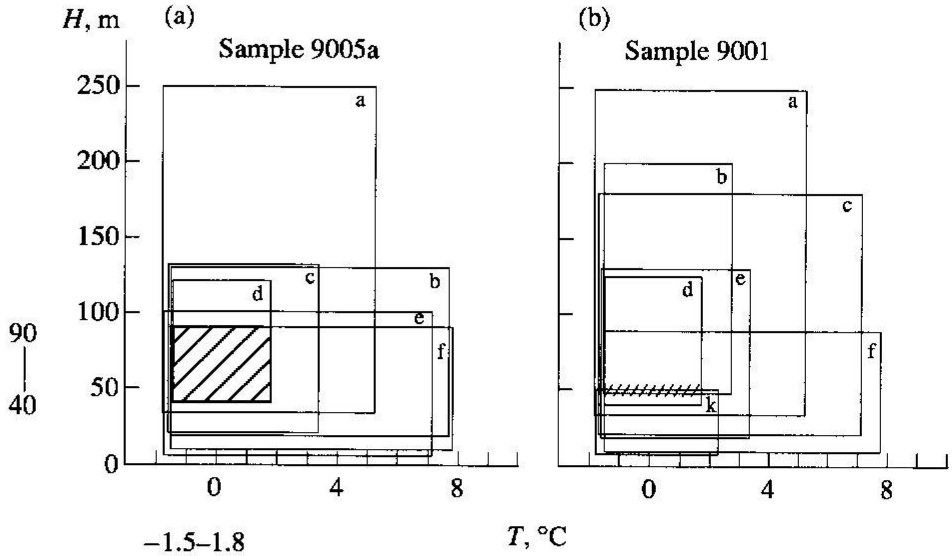

Fig. 6. The example of the depth and bottom water temperature reconstruction (crosshatched), according to the mollusk assemblage. (a) Sample 9005a (a) *Musculus niger*; (b) *Macoma calcarea*; (c) *Serripes groenlandicus*; (d) *Periploma fragilis*; (e) *Liocyma fluctuosa*; (f) *Yoldia toporoki*); (b) Sample 9001 (a) *Musculus niger*; (b) *Megayoldia thraciaeformis*; (c) *Ciliatocardium ciliatum*; (d) *Periploma fragilis*; (e) *Serripes groenlandicus*; (f) *Yoldia toporoki*; (k) *Leonucula inflata romboides*).

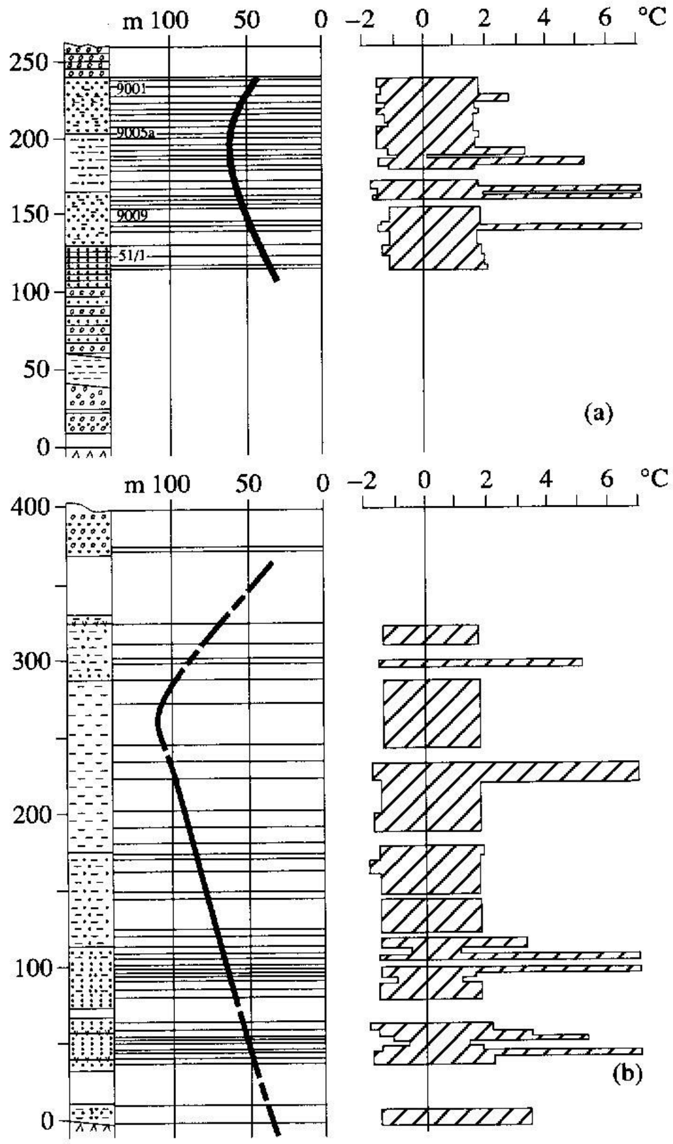

Fig. 7. Paleobathymetric and paleotemperature reconstructions from the sections: (a) Mutnaya-A and (b) Mutnaya-B. Symbols as in Fig. 2.

the deposits of the lower Ol'khovaya Subformation exposed in the Vysokaya Mountain section were formed on the continental slope at a depth of over 400–500 m. Bottom-water paleotemperatures in the fluid venting areas were positive, about 2°C.

Accordingly, the part of the lower Ol'khovaya Subformation in the southwestern Kamchatskii Cape characterized by mollusks was accumulated at a depth from 35–40 to 500 m.

Estimating the biogeographic affinity of the early Ol'khovaya mollusk assemblage, Petrov (1982) correlated it with the eastern Chukotka fauna from the highboreal Beringian Subregion, which is located considerably northwards. We should note that, in the highboreal subregion of the northwestern Pacific, the amount of boreal-arctic species increases below a depth of 5–6 m, and they become predominant beginning from a depth of 25 m. At depths from 25 to 60 m, where boreal-arctic forms are still predominant, the widely distributed boreal species increase in abundance. The predominance of these two groups is retained at greater depths as well (Skarlato, 1981).

The boreal-arctic (45%) and widespread boreal (26%) species have a dominant role in the bivalve mollusk composition of the lower Ol'khovaya assemblage. This permits the assignment of the assemblage to the highboreal Beringian Subregion only. We do not consider the direct correlation of the early Ol'khovaya assemblage with the mollusk fauna from the Eastern Chukotka Province to be justified. The upper sublittoral and littoral assemblages, whose species are decisive for the more detailed biogeographic subdivision, are completely missing in the community of the lower Ol'khovaya Subformation.

FORAMINIFERS

Foraminifers were studied according to a standard method. The 100- to 150-g samples were washed through a 100-μm sieve, and the residue was studied under the binocular microscope. The number of specimens of a certain species was converted to a 50-g dry charge of each sample. Saidova (1961) used the same method in studies of recent microfauna distribution in the Far East, which enabled the establishment of the environmental conditions of foraminifers from the Ol'khovaya Formation.

The paleoecologic analysis of the foraminifer assemblages from the lower Ol'khovaya Subformation showed their consecutive alteration in the Mutnaya-B section, indicating the change of the basin depth.

Among the foraminifers from the lower part of the subformation (Fig. 4), the relatively shallow-water elphidiids, buccells, and islandiells dominate, namely, *Buccella citronea* (Leon.), *B. conica* Volosh., *B. niigataensis* (Hus. et Mar.), *Retroelphidium hughesi* (Cush. et Grant), *Haynesina orbiculare* (Brady), and *R.* ex gr. *clavatum* (Cush.). The assemblage as a whole corresponds to a depth of no more than 100 m.

The shallow-water forms decrease in abundance upward the section, where planktonic and more deep-water benthic species appear. *Dentalina, Lagena, Trifarina,* and several *Uvigerina* species appear in the upper part of the section, suggesting the gradual deepening of the basin. Further upwards, the more deep-water *Epistominella pacifica* (Cush.) appears, reaching 50 specimens per 50-g sample in the sediments corresponding to the peak of the transgression. This corresponds to a basin depth of about 200 m (Saidova, 1961). The planktonic *Globigerina bulloides* d'Orb. and *Neogloboquadrina pachyderma* (Ehren.) also occur there in a considerable amount (up to 50 specimens per sample).

We should note that in the Mutnaya-A section, the shallower facies are exposed. For example, the foraminifer fauna from the sediments corresponding to the maximum of the transgression is similar to that from the lower beds of the Mutnaya-B section. Here the plankton is missing, *Epistominella pacifica* is few and shallow-water *Haynesina orbiculare* and *Elphidiella oregonensis* (Cush. et Grant) occur.

The foraminifer research permits some paleoclimatic conclusions. The assemblage as a whole is of the highboreal character usual for these latitudes. However, in the middle part of the Mutnaya-B section the two substantially more thermophilic species, *Sigmomorphina lautenschlaegerae* Kuz., known from the Neogene of Sakhalin, and *Pseudopolymorphina ishikawaensis* Cush. et Ozawa from the Pliocene of Japan, were found. It is interesting that among *N. pachyderma* (Ehren.) specimens from sediments accumulated at the

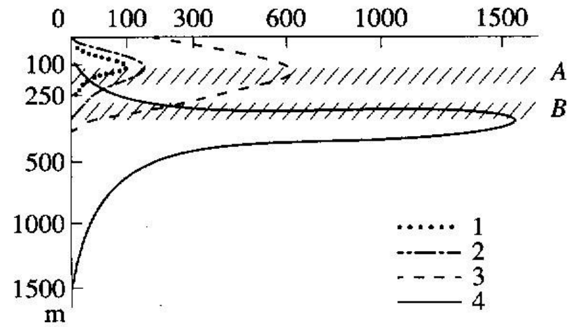

Fig. 8. Quantitative distribution of some recent benthic foraminifers by depths in the northwestern Pacific after Saidova (1961) and the paleodepth reconstructions. (*A*) At the maximum of the early Ol'khovaya transgression in the Mutnaya-B section; (*B*) during the late Ol'khovaya transgression in the Ol'khovaya-1 section. (1) *Haynesina orbiculare;* (2) *Cribroelphidium goesi;* (3) *Elphidium clavatum;* (4) *Epistominella pacifica.*

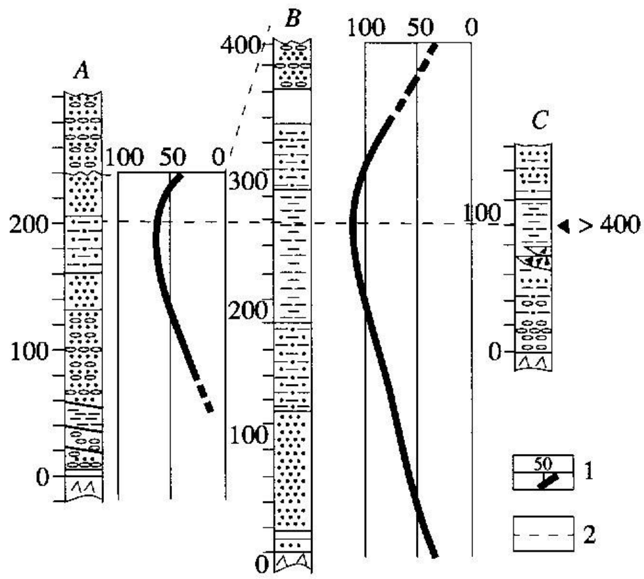

Fig. 9. Correlation of the sections of the lower Ol'khovaya Subformation. (*A*) Mutnaya-A; (*B*) Mutnaya-B; (*C*) Vysokaya Mountain. (1) The depths of sediment accumulation, m; (2) lines of correlation. Other symbols as in Fig. 2.

maximum of the transgression, the dextrally coiled forms are almost twice as many as the sinistral ones. Nowadays this is not characteristic of these latitudes and indicates warmer conditions.

Therefore, the available paleobathymetric and paleoclimatic records suggest the coincidence of the early Ol'khovaya transgression with a relative climatic warming.

The upper Ol'khovaya Subformation is exposed in the Ol'khovaya-1 section and also corresponds to a single sedimentary cycle. The subformation is almost barren of foraminifers. They were found only in its middle part, in a member of poorly sorted sandstones and conglomerates where the rich assemblage containing

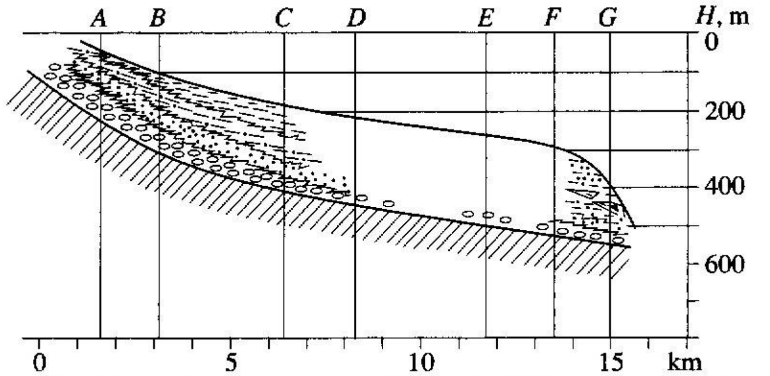

Fig. 10. Geomorphologic profile of the shelf at the maximum of the early Ol'khovaya transgression. Location of the sections: (*A*) Mutnaya-A; (*B*) Mutnaya-B; (*C*) Medvezh'ya River; (*D*) Pamyatnyi Creek; (*E*) Olen'ya River; (*F*) Obryvistyi Creek; (*G*) Vysokaya Mountain; (*H*) depth (m). Symbols as in Fig. 2.

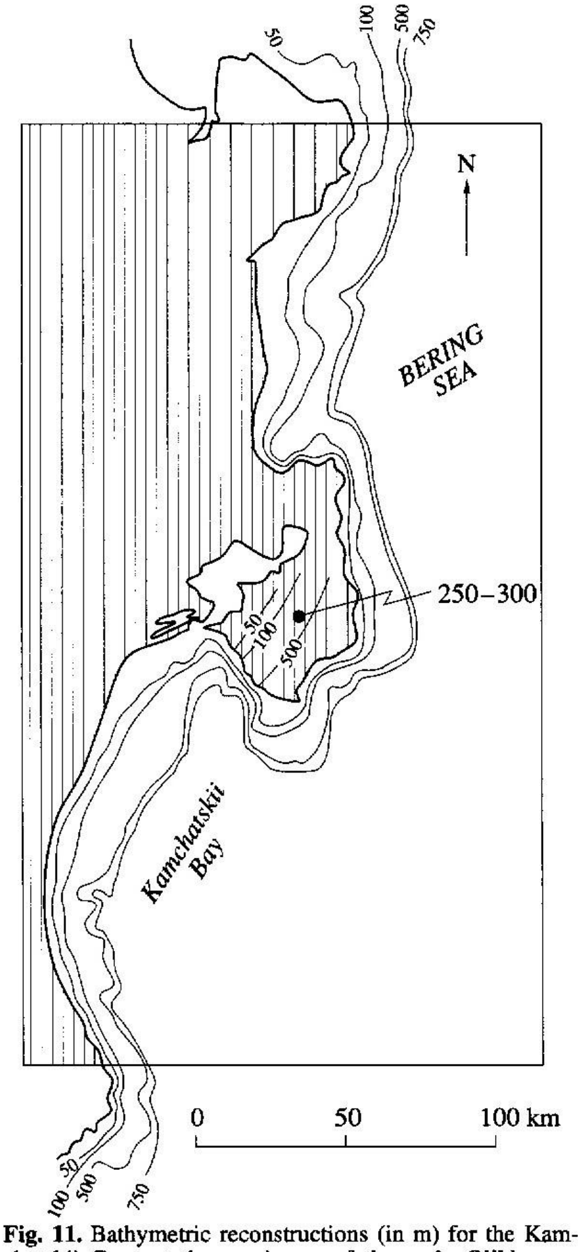

Fig. 11. Bathymetric reconstructions (in m) for the Kamchatskii Cape at the maximum of the early Ol'khovaya transgression. The point marks the basin depth at the maximum of the late Ol'khovaya transgression.

42 species occurs (Bylinskaya and Khoreva, 1985). It includes numerous planktonic forms and abundant specimens of deep-water *Epistominella pacifica* numbering 900 per 50-g sample. According to the data on recent foraminifer distribution, such an abundance of *E. pacifica* indicates a depth from 250 to 300 m (Fig. 8).

CONCLUSION

The detailed study of the deposits of the Ol'khovaya Formation and the paleoecologic analysis of the associated fauna resulted in distinguishing the early and late Ol'khovaya transgressions.

The sections of the lower Ol'khovaya Subformation were correlated in order to reconstruct the paleoshelf. The correlation was based on a single mark, the transgression maximum (Fig. 9).

According to the available data, approximately 1.5 Ma the Kamchatskii Cape represented a shelf similar in its strike and morphology to the recent shelf of Kamchatskii Bay (Figs. 10, 11). The shelf was most likely 15–20 km wide. At the maximum of the early Ol'khovaya transgression the depth changed from 0 to 60 m in the Mutnaya-A section, up to 120 m in the Mutnaya-B section, and in the Vysokaya Mountain region the continental slope was at a depth of about 500 m.

The early Ol'khovaya transgression was accompanied by relative climatic warming as evidenced by the appearance of relatively thermophilic foraminifer species at the maximum of the transgression. The bottom temperatures at the depth over 35 m were fairly stable ranging from –1.5 to +1.8°C on the shelf and approaching 2°C on the continental slope.

Most likely at the end of the Eopleistocene, tectonic activity resulted in the uplifting of the Kamchatskii Mys Range. The shelf was dissected during the late Ol'khovaya transgression in the early Pleistocene. While in the center of the present-day peninsula the position of the continental slope was retained, in its southwestern part nearshore cross-bedded sequences were accumulated. The amplitude of the uplifting is approximately 1500–2000 m by now with a mean rate of 10–13 mm/year.

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