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New Paleontological Data on Govorov, Vulkanolog, and Kocebu Guyots (Magellan Seamounts, Pacific)

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Abstract—The work aims to present new biostratigraphic data on Govorov, Vulkanolog, and Kocebu guyots of the western branch of the Magellan Seamounts (NW Pacific). The data were collected during the voyage of R/V *Gelendzhik* in 2014. Analysis of the paleontological data on planktonic foraminifers, radiolarians, and corals allows us to distinguish several stratigraphic levels, varying from Early Cretaceous to Pleistocene in age, which define the stages of geological development of the studied area. Based on the representative material on the planktonic foraminifers from layer I-2 of the ore crusts on Govorov guyot, it is established that this layer was deposited in the narrow age interval of 40.0–40.5 Ma. The data obtained clearly indicate the connection of the crust ore genesis on the seamounts with regional paleoceanic events.

Keywords: biostratigraphy, planktonic and benthic foraminifers, radiolarians, corals, Cretaceous and Cenozoic, guyots, Magellan Seamounts, the Pacific

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The Magellan Seamounts represent an arcuate chain of submarine volcanic structures, extended in the Eastern Mariana's Trench in the Pacific Ocean. Owing to the discovery of commercial contents of cobalt, manganese, and nickel in the ore crusts covering the surface of the guyots, the area of the Magellan Seamounts has attracted the attention of researchers from different countries, not only as a site of geological interest, but also as a potential area for exploitation of mineral resources.

In September–December, 2014, geological–geophysical investigations were carried out by scientists of FGUGP GNTs Yuzhmorgeologiya in the area of the guyots of the western branch of the Magellan Seamounts, which is part of the Russian Exploration Area in the Pacific, during the voyage of R/V *Gelendzhik* under the leadership of B.A. Shirokozhukhov. The research works were performed on the slopes of Govorov, Vulkanolog, and Kocebu guyots, which, together with Alba guyot, make up the area where the Russian Federation has obtained exclusive rights to explore a section of the Magellan Seamounts (Central Pacific) under the fifteen-year contract signed in March 2015.

The comprehensive geological research included the 1 : 50000 bathymetric survey with a multibeam echosounder, phototelevision profiling over the surfaces of the guyots of the Magellan Seamounts, as well as dredging sediment sampling and drilling operations using submersible drilling rigs. The current work reports only the results of biostratigraphic studies, including data indicating the age datings and formation conditions of the rocks. The stratigraphic data on the Govorov, Vulkanolog, and Kocebu guyots [1] are insufficient for compilation of medium-scale geological maps. Therefore, we need an additional rock material on the stratigraphy, paleogeography, and ore genesis within the studied guyots to extend our knowledge.

During the expedition works, the guyots were studied by means of dredging, drilling works, and dredging

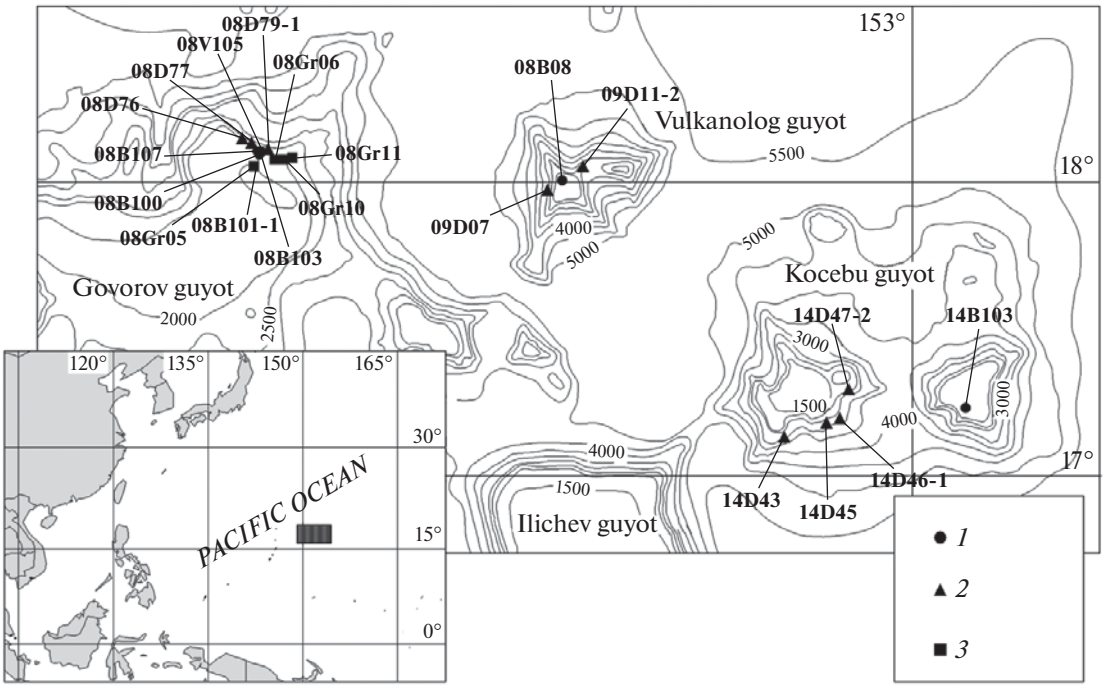

Fig. 1. Locations of drilling sites (1), dredging (2), and TV-controlled grabbing stations (3) on Govorov, Vulkanolog, and Kocebu guyots.

and TV-controlled grab system (Fig. 1). As a result, 109 samples of sedimentary rocks were collected and examined for the presence of organic remains (foraminifers, radiolarians, and corals). Foraminifers were identified in 51 rock samples, corals in 8 samples, and radiolarians in 3 samples. The age of the organic remains was determined by their correlation with the fauna of the Cretaceous and Cenozoic biozonal schemes, developed for every organic group [3, 4, 7–10, 12–14]. The percentage ratio of shallow-water macrofaunistic remains (corals and mollusks) and microfaunistic (planktonic foraminifers and radiolarians) remains allow us to estimate variations in paleodepths. Owing to the paleontological analysis of the samples from the studied guyots, the following stratigraphic levels have been distinguished: Late Aptian–Albian, Upper Cenomanian, Upper Campanian–Maastrichtian, Lower–Middle Eocene, Upper Miocene, and Pleistocene (Fig. 2).

The *Cretaceous* sedimentary rocks of the Govorov, Vulkanolog, and Kocebu guyots are represented by limestones, edaphogenic breccias, and rarely dense clays. The *Aptian–Albian* stratigraphic level was established on Kocebu guyot (station 14D46-1) based on the radiolarian assemblage extracted from massive mudstones (Sample 14D46-1-D). This complex is represented by radiolarian taxa of two different-age assemblages: *Torculum coronatum* (Squinabol), *Dactyliosphaera* sp. cf. *D. lepta* (Foreman), *Dactyliosphaera maxima* (Pessagno), large fragments of *Mallanites* sp., *Darypyle* sp. cf. *elliptika* Squinabol, *Crucella* sp., *Pessagnobrashia* sp., and *Praeconocarryoma* sp. The age of this radiolarian complex and, correspondingly, the formation time of the enclosing rocks is assigned to the Middle–Late Albian, inasmuch as the joint occurrence of the first four taxa is known from the sections of Tethyan Middle Cretaceous rocks within the UAZ 12–14 (Missilis and Anisa subzones of Spoletoensis Zone) [9]. In addition, Sample 14D46-1 contains rare *Holocryptocanium barbui* Dumitrica, *Hiscocapsa grutterinki* (Tan), *Cryptamphorella* sp. cf., *C. clivosa* (Aliev), the last occurrence of which [9, 10] is recorded in the beginning of the Late Aptian. Despite the fact that the shells of these pelagic microorganisms have traces of redeposition, their occurrence can be regarded as evidence of local pelagic sedimentation in the Magellan Seamounts as late as the Aptian.

In the micritic limestone (Sample 14D46-1E; Kocebu guyot), redeposited shells of Albian–Early Cenomanian *Planomalina buxtorfi* (Gandolfi) were identified among the Eocene planktonic foraminifers.

The Upper Cenomanian stratigraphic level on Vulkanolog guyot was established on the basis of the occurrence of foraminifer shells *Rotalipora* cf. *cushmani* (Morrow) and representatives of the genus *Dicarinella* sp. indet. in the edaphogenic breccia (Sample 09D07-A). In Sample 08B102-A (marmorized brown limestone, Govorov guyot), a single coral *Smilotrochus elongates* Duncan which inhabited this area in the Late Albian–Santonian was found.

Period	Epoch		Blow's zones no.	Planktonic foraminiferal zones (after [7])	Presence of zones	
Q	Holocene / Pleistocene		Ps 22–23	Truncorotalia truncatulinoides	■	→ 08Gr. 4–5; 08Gr. 10–11
Neogene (N)	Pliocene	L	N20–21			
		E	N19			
			N18			
	Miocene	L	N17	Groborotalia plesiotumida		
			N16	Turborotalia acostaensis	■	→ 08D76; 08B103; 08B107
		M	N15–9			
		E	N4–8			
Paleogene (₽)	Oligocene	L	P22	Globigerina ciperoensis		
			P21	Globigerina opima opima		
			P20	Globigerina ampliapertura		
		E	P19	Cassigerinella chipolensis		
			P18	Pseudohastegerina micra		
	Eocene	L	P17–16	Turborotalia cerroazulensis s.l.		
			P15	Globigerinatheka seminvoluta		
		M	P14	Truncorotaloides rohri	■	→ 08B102; 09D11-1
			P13	Orbulinoides beckmanni	■	→ 08B103; 14D46-1
			P12	Morozovella lehneri		
			P11	Globigerinatheka s. subconglobata		
			P10	Hantkenina nuttalli		
		E	P9	Acarinina pentacamerata		
			P8	Morozovella aragonensis	■	→ 08D79-1
			P7	Morozovella formosa formosa	■	→ 08B105; 14D52
			P6	Morozovella subbotinae	■	→ 14B103
				Morozovella edgari		
	Paleocene	L	P5	Morozovella velascoensis	■	→ 08B101-1
			P4	Planorotalites pseudomenardii		
		M	P3	Planorotalites pusilla pussila		
				Morozovella angulata		
			P2	Morozovella uncinata		
		E	P1	Morozovella trinidadensis		
				Morozovella pseudobulloides		
				Globigerina eugubina		
Cretaceous (K)	Late	Maastrichtian	Age		■	→ 08D77; 08D79
		Campanian			■	→ 14D43; 14D47-2
		Santonian				
		Coniacian				
		Turonian				
		Senomanian			■	→ 09D07; 09B08; 14D46-1
	Early	Albian			?	
		Aptian				

Fig.2. Geochronology of planktonic foraminiferal assemblages on Govorov, Vulkanolog, and Kocebu guyots, according to the Blow's biozonal scheme [6]. Dark sections indicate occurrence of the fauna in the given age range, white sections indicate absence.

Campanian–Maastrichtian deposits defined by data on the macro- and microfauna are common to all of the studied guyots. These deposits are represented by reef (organogenic–detrital and coral) limestones and their debris, as well as calcarenitic and rarely nanoforaminiferal limestones.

The Campanian–Maastrichtian corals occur as simple corals, as well as rare scattered coral colonies in all of the studied guyots (Fig.3).

The brown limestone from Govorov guyot (Sample 08D76) contains microfauna represented by broken and indefinable mollusk shells, corals *Mesomorpha chaetetoides* Trauth (Upper Turonian–Maastrichtian), *Aulosmilia archiaci* (Fronmentel) (Santonian–Maastrichtian), *Astraeofungia tenochi* (Felix) (Turonian–Maastrichtian), *Phyllosmilia aegiale* Felux (Turonian–Maastrichtian), as well as sponge *Pachytilodia*. The occurrence of a large amount of coral debris and scattered and broken mollusk valves may be evidence of a very strong wave (storm) action and the remoteness of the burial site from the habitat area. In the white limestones from Vulkanolog guyot (samples 09D12-A and 09B12-A), Campanian and Maastrichtian simple corals such as *Smilotrochus grandis* Siemiradzki and *Cyathoceras embaensis* Kusmicheva were found. A sample of pale brown limestone (14D43-V) from Kocebu guyot yielded a colony of corals *Heterocoenia exigua* (Michelin), which indicates the Santo-

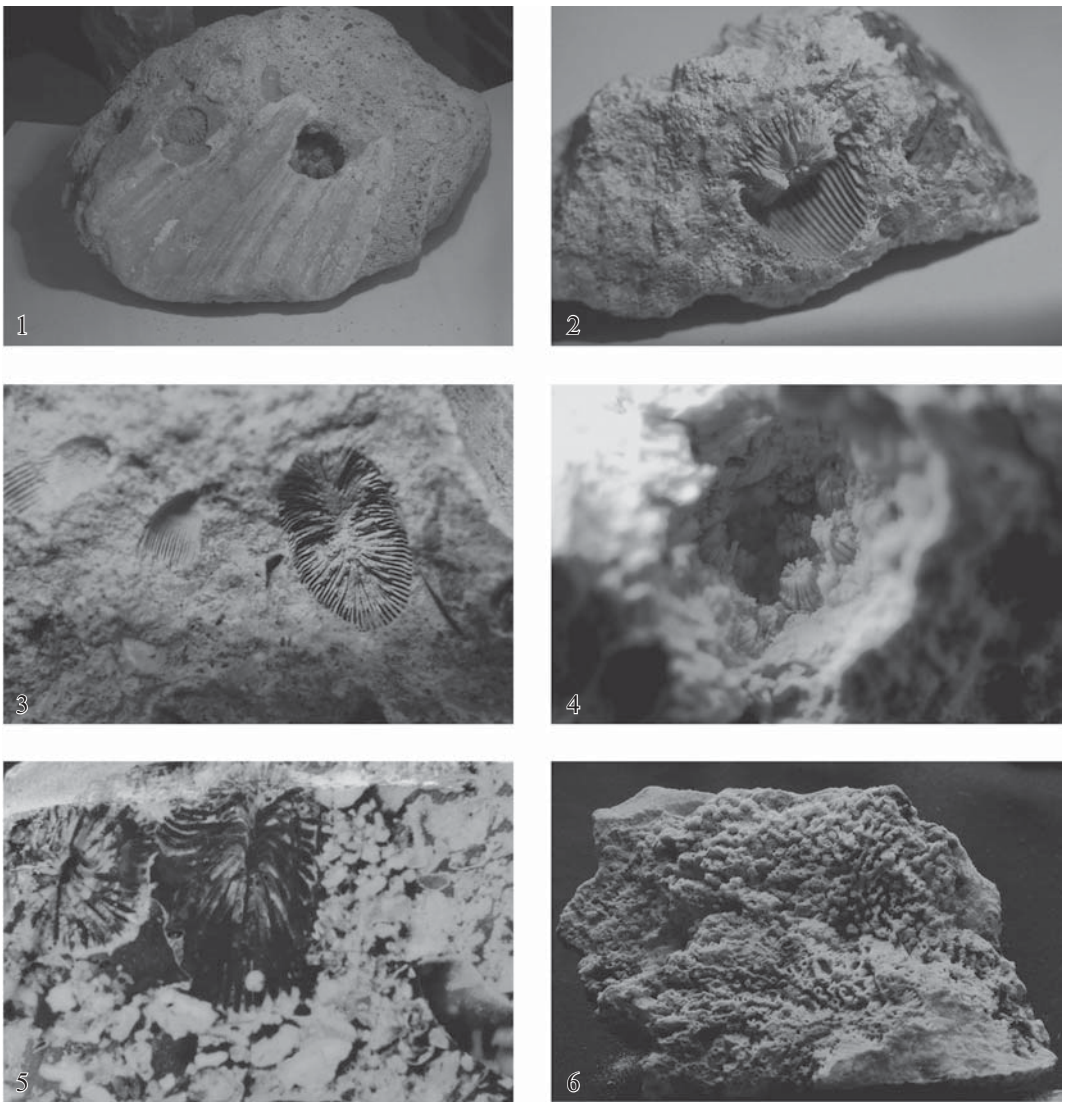

Fig. 3. Fossil corals of the Magellan Seamounts.

nian age of the enclosing rock.?Since the Campanian–Maastrichtian limestones are often recrystallized, it seems difficult to extract and identify complete foraminiferal shells. Several samples yielded foraminiferal complexes that lived in a narrower age interval: Campanian (08D79-A, 08D83-A, 08B102, 08B108-A, 08B111-A, 14D43-B) and Maastrichtian (08D77-A, 14D47-2A). If the Maastrichtian age of the deposits is easily established on the basis of the occurrence of representatives of genus *Abathomphalus*, then the Campanian age can be established only on the basis of combination of such appearing and disappearing species as *Elevatotrucana* cf. *elevata* (Brotzen), *Rugoglobigerina rugosa* (Bronnimann), *Globotruncana arca* (Cushman), etc. A more detailed description of the Campanian fauna distributed in the area of Govorov guyot, including descriptions and images of some species, was given previously in [2].

A representative assemblage of Late Campanian–Maastrichtian benthic foraminifers was identified in the rocks of Govorov guyot. The agglutinating benthos is represented by *Orbignyna inflata* (Reuss), *Orbignyna sacheri* (Reuss), *Orbignyna ovata* Hagenow, *Beisselina aequisgranenesis* (Beissel), *Gaudryina rugosa* d'Orbigny, *Gaudryina retusa* Cushman, and *Textularia baudoniana* d'Orbigny. The carbonate benthos is represented by *Gyroidina turgida* (Hagenow), *Gavelinella umbilicatula* (Mjatliuk), *Gavelinella menneri* (Keller), *Hahzawaia ekblomi* (Brotzen), *Gemmelides orcinus* (Vassilenko), *Cibicidoides voltzianus* (d'Orbigny), and *Cibidoides spiropunctatus* (Galloway et Morrey). The above-listed species can be found in both Upper Campanian and Maastrichtian deposits, while *Hanzawaia ekblomi* and *Cibidoides spiropunctatus* (Galloway et Morrey) are more common for the Maastrichtian time. Accordingly, the age of the enclosing layers can be defined as Late Campanian–Maastrichtian.

According to habitat conditions, this benthos is characteristic of the outer shelf zone, namely, the upper bathyal zone.

The *Paleogene* rocks are highly dominated by calcarenitic limestones and facially associated edaphogenic breccias. Nanoforaminiferal limestones and volcanogenic-sedimentary formations are less common. The limestones contain abundant planktonic foraminifers, which are characterized by well-preserved shells and taxonomic diversity. The data obtained make it possible to correlate these assemblages with some Paleogene biozonal complexes of the tropical scale (Fig. 2), although the limestones of this age interval are often difficult to recognize lithologically. In the studied rocks there are no typical Upper Eocene species and no Oligocene species at all, which is characteristic of the guyots of the Magellan Seamounts [3, 4, 6].

An analysis of the Paleogene complexes of planktonic foraminifers allowed us to correlate them with the zonal complexes of the Upper Paleocene (Morozovella velascoensis Zone, samples 08B101 and 08B101-B), Lower Eocene (Morozovella aragonensis Zone/Morozovella formosa Zone; samples 08B100-A, 08B105-A, 08D79-B, 08D80-B, 14D45, and 14B103-A), and the latter half of the Middle Eocene (Morozovella crassatus Zone, Orbulinoides beckmanni Zone; samples 09D11-A and 14D46-1-E). The taxonomical composition of the Paleogene complexes was previously discussed in [4].

During our fieldworks, we collected representative stone material from layer I-2 of the ore section on Govorov guyot (Magellan Seamounts) (Fig. 4). This layer has been previously attributed to the latter half of the Middle Eocene–Early Late Eocene [5]. Newly obtained data demonstrate that the studied faunistical complex from layer I-2 is taxonomically homogenous (*Acarinina bullbrooki*, *Truncorotaloides topilensis*, *Orbilinoides beckmani*, etc.) and correlated with the typical zonal complex of the Orbulinoides beckmanni Zone. As follows from [4], the index species of this biozone has a narrow age interval of distribution (40.5–40.0 Ma). It is established that the Middle Eocene thermochron was completed at 40.5 Ma ago and the cooling of the atmosphere started. As a result, in the Early Oligocene the ice volume in East Antarctica was one third higher than the current one [11]. The dense Antarctic waters settled and formed bottom currents spreading further to the north. The bottom current velocity and harsh environment relative to carbonate sediments could have resulted in hiatuses in the sedimentation. These processes were likely the reason for the long-term hiatus (Oligocene–Early Miocene) during the formation of the ore crusts and sedimentation on the Magellan Seamounts [5].

The Upper Miocene planktonic foraminiferal assemblage was identified in layer II of the ore crusts on Govorov and Vulkanolog guyots (08B103, 08D76, 08B107, 09B08) and in the substratum of iron–manganese crusts (08Gr.11). This foraminiferal assemblage includes the following set of species: *Globigerina nepenthes* Todd, *Globigerinoides obliquus* Bolli, *Neogloboquadrina acostaensis* Blow, *Sphaeroidinellopsis* s. *subdehiscens* (Blow), which is taxonomically close to the zonal complex of the Neogloboquadrina acostaensis Zone.

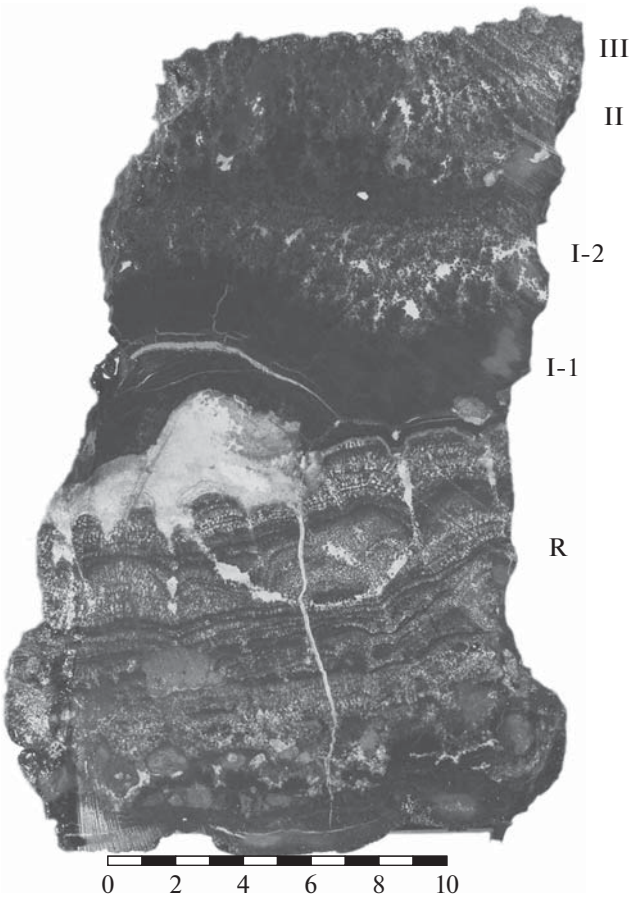

Fig. 4. Structure and age of the crust ore section across Butakov guyot [5]. III—Pleistocene; II—Miocene; I-2—the latter half of the Middle–early Late Eocene; I-1—Late Paleocene–early Early Eocene; R—Campanian–Maastrichtian.

The Pleistocene sediments, common on the summit plateau of Govorov guyot, were sampled with a TV-controlled grab system. The sediments are almost entirely composed of foraminiferal shells and admixture of organic detritus. The planktonic foraminifers represented by species of the tropical climate group correspond to the Pleistocene complex of the Truncorotalia truncatulinoides Zone (Gr. 05; Gr. 06, Gr. 10, Gr. 11). There are no ancient species-strangers in the composition of this complex. In addition, not a single specimen of species *Globorotalia fimbriata*, characteristic of the Holocene in the tropical realm of the Pacific, was found [11, 12]. This is evidence for strong erosion and rewashing of the Pleistocene sediments of the guyot summit, which are favorable for the

formation of ore crusts. The presence of numerous sandy waves (ripples), i.e., traces of submarine currents, was revealed with phototelevision profiling. According to the data recorded by the buoy-based station, the bottom-current velocities are very high (10–30 cm/sec). This velocity interval is quite sufficient for the removal of coarse-grained siltstone and fine-grained sand fractions beyond the summit plateau of Govorov guyot. As a result, these processes restrict the accumulation of bottom sediments.

The new paleontological data obtained do not allow us to develop fraction biostratigraphic schemes for subdivision of the sedimentary strata of Govorov, Kocebu, and Vulkanolog guyots. Based on the planktonic foraminifers, we confirm the validity of the Cretaceous and Mesozoic biozonal schemes, which allow determination of the age of the enclosing rocks and will contribute to solving the problems of the stratigraphy of the studied area.

CONCLUSIONS

(1) The joint occurrence of remains of shallow-water macrofauna and plankton in the Cretaceous sediments on Govorov, Vulkanolog, and Kocebu guyots testifies that there existed frequent deep-to-shallow water changes in the sedimentation conditions. The small size of the simple corals and absence of signs of fouling and overlapping indicate that they inhabited the sublithoral zone under active lithodynamic conditions. During the transgressive phases (Late Albian–Senomanian and Late Campanian–Maastrichtian), pelagic carbonate sediments were deposited at the depth of the outer shelf zone (the upper bathyal).

(2) Finds of the most ancient taxa on Kocebu guyot among such pelagic microorganisms as radiolarians are evidence that pelagic sedimentation on the Magellan Seamounts started in the Aptian rather than the Albian, as previously thought.

(3) The formation of the layer I-2 in the general ore section of Govorov guyot occurred in a narrow age interval of 40.5–40.0 Ma (Middle Eocene Orbulinoides beckmanni Zone), which was followed by a long-term hiatus during the formation of the ore crusts on the Magellan Seamounts until as late as the Middle Eocene.

(4) Analysis of the planktonic foraminifers from the surface sediments of the summit plateau of Govorov guyot demonstrates that the host sediments accumulated in the Pleistocene, but not under present-day conditions. The geochronological data together with the high bottom current velocities (10–30 cm/sec) recorded by instrumental measurements point to the prevalence of the contemporary erosion processes over the accumulation of sediments on the summit plateau of the studied guyot. These data are necessary to reveal the formation conditions of the ore crusts on Govorov guyot and can be used for studying other seamounts.

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