Eight Biodiversity Maxima of Invertebrate in the Phanerozoic of Middle Asia

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Eight maxima of invertebrate biodiversity are documented in the Phanerozoic of Middle Asia. They occurred in the Late Cambrian, Caradoc, Pragian, Visean, Kungurian, Norian, Callovian and Cenomanian. The maxima periodically alternated with the minima of biodiversity. The maxima and the minima of biodiversity periodicaly repeated every 50–70 million years.

Keywords: Middle Asia, Phanerozoic, invertebrate, biodiversity

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INTRODUCTION

Sections of all geological stages of the Paleozoic and Mesozoic systems are well exposed and contain numerous marine fossils in Middle Asia. In 1950–1990, a large-scale geological survey was conducted. Thousands of geologists and 300 paleontologists collected fossils from all geological stages of the Phanerozoic systems. Intensive paleontological investigations were carried out. The author took part in these works since 1956. In that way, during 40 years vast paleontological material was accumulated. The study of this material shows that the maxima and minima of the biodiversity in the Phanerozoic of Middle Asia periodically repeated every 50–70 million years.

The first diagram (Fig. 1) shows the maxima and minima in the Paleozoic. In the diagram, Foraminifera, Archaeocyatha, Porifera, Stromatoporoidea, Chaetetida, Anthozoa, Bryozoa, Brachiopoda, Bivalvia, Gastropoda, Cephalopoda, Tentaculita, Trilobita, Ostracoda, Cystoidea, Crinoidea, Graptolitha, Conodonta and Cambrian small shell fossils are taken into account. About 97 per cent of the known Paleozoic marine invertebrata belong to theses groups. In the second diagram (Fig. 2), the maxima and minima in the Mesozoic are shown. In Fig. 2, Foraminifera, Porifera, Stromatoporoidea, Chaetetida, Anthozoa, Brachiopoda, Bivalvia, Gastropoda, Cephalopoda, Ostracoda, Echinoidea and Conodonta are taken into account. These groups include about 95 per cent of the all known genera of the Mesozoic marine invertebrata.

MATERIALS AND METHODS

The author during more than 10 years was making a list of the fossil genera for Phanerozoic system stages of Middle Asia. For this purpose he took into account his own materials, materials obtained from I. Bardashev, N. Bardasheva, E. Boiko, V. Dronov, G. Grinenko, G. Melnikova, G. Menakova, D. Starshinin and many other geologists and paleontologists. More than 1000 paleontological and stratigraphical articles and monographs were taken into account as well. Analysis of this material revealed eight maxima of biodiversity in the Phanerozoic of Middle Asia.

THE MAXIMA AND MINIMA OF BIODIVERSITY

In the Early Cambrian, the biodiversity was not so great compared with later subdivisions of the Paleozoic (Fig. 1). In the Tommotian Stage, small shelly fossils (about 40 genera) dominated. Conodonts and traces of worms are also found. In the Atdabanian

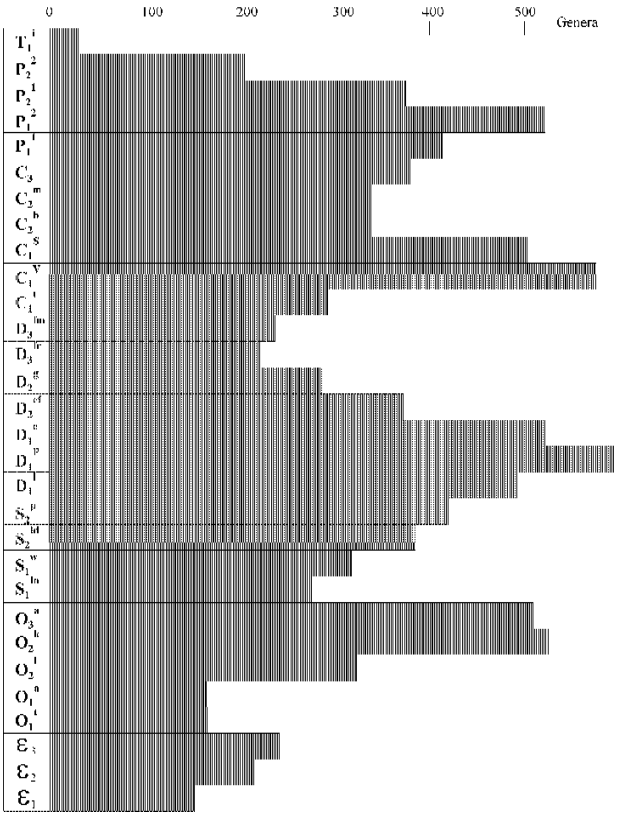

Fig. 1. The Diagram showing the number of Genera of marine Invertebrata in the Paleozoic subdivisions of Middle Asia
1 pav. Jūrinių bestuburių genčių skaičiaus Vidurinės Azijos paleozojaus padaliniuose diagrama

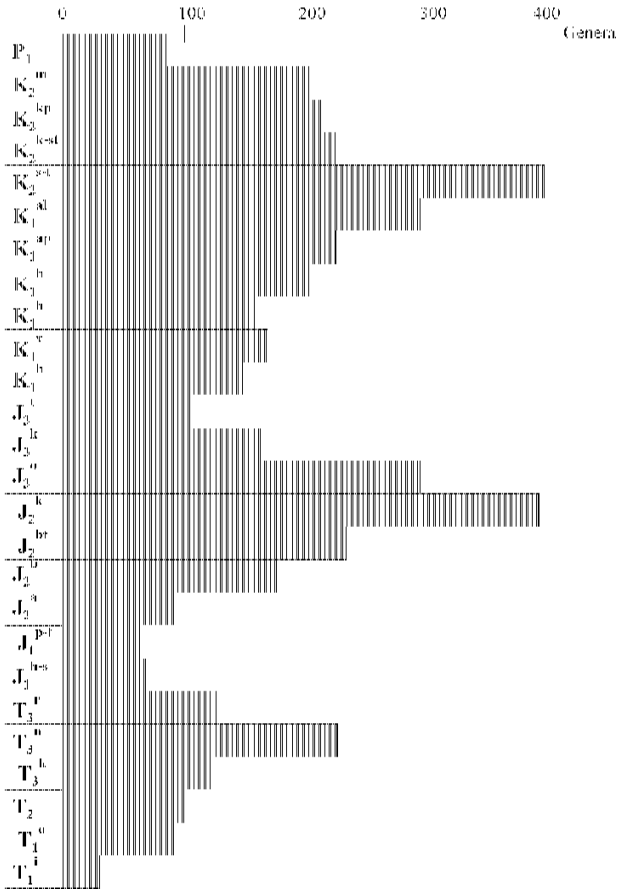

Fig. 2. The Diagram showing the number of Genera of marine Invertebrata in the Mesozoic subdivisions of Middle Asia
2 pav. Jūrinių bestuburių genčių skaičiaus Vidurinės Azijos mezozojaus padaliniuose diagrama

and especially in the Botomian Stages, Archaeocyatha (50 genera) dominated. Porifera, Inarticulata, Trilobites, Gastropods, Conodonts are recorded, too. In the beginning of the Toyonian, the diversity of Archaeocyatha reduced and in the end they disappeared. Since the Toyonian age to the end of the Cambrian, Trilobites dominated (Plate 1), and numerous Inarticulata were widely distributed.

In the Middle Cambrian, Cephalopoda appeared and the biodiversity of Trilobites and Conodonts increased. The maximum of biodiversity of the Trilobites occurred in the Late Cambrian (Plate 1). An analogous maximum is observed on the global scale as well. 540 genera of Trilobites in the Lower Cambrian, 647 in the Middle Cambrian and 794 genera in the Upper Cambrian were determined in the world literature (Чернышева, 1987). The majority of the genera and families of the Late Cambrian Trilobites disappered at the end of the Cambrian and at the beginning of the Ordovician. The mass extinction of Trilobite taxons at the end of the Cambrian and in the Tremadoc is noted on the global scale as well (Whittington, 1966).

At the beginning of the Ordovician, the number of Trilobite and Inarticulate genera abruptly decreased and the number of Articulata and Cephalopoda genera increased. The Graptolithida appeared for the first time in Middle Asia. The diversity of Brachiopods, Trilobites, Gastropods, Cephalopods increased in the Llanvirn, and Bryozoa and Crinoidea appeared in Middle Asia. In the Caradoc, the largest maximum of biodiversity occurred in the Early Paleozoic. The Brachiopoda, Trilobita, Bivalvia, Cystoidea, Crinoidea reached their top at this time, and Anthozoa appeared for the first time in Middle Asia. The diversity of Anthozoa during the Caradoc increased and reached its maximum in Ashgill.

The biodiversity of marine Invertebrate abruptly decreased at the beginning of the Silurian. The extinction of the Ordovician Invertebrata continued during the whole Ordovician, but at the end of the Caradoc it was more intensive and at the end of the Ashgill it was most intensive during the Ordovician–Silurian. At the end of the Caradoc, almost all (12 of

13) genera of Cystoidea disappeared and the generic diversity of Brachiopoda, Trilobita, Bivalvia, Crinoidea decreased. The largest extinction of the Ordovician Trilobites occurred at the end of the Middle Ashgill. In the Lower and Middle Ashgill, 90 genera of Trilobite, while in the upper Ashgill only 24 are known in Middle Asia. At the end of Ashgill there was a mass extinction of the Anthozoa, Brachiopoda, Bivalvia, Crinoidea, Graptolithida and other Invertebrata genera. An analogous extinction at the end of the Ashgill is recorded on the global scale as well. This extinction is correlated with Gondwana glaciation in the Late Ordovician and with the melting of the glacial cover at the beginning of the Silurian (Boucot, 1975).

During Silurian – Early Devonian, the number of marine Invertebrate genera increased and reached its maximum in the Pragian (Fig. 1, Plate 1). In the Emsian, Ammonoidea appeared and the number and diversity of other Cephalopoda abruptly decreased (Plate 1). At the end of the Early Devonian, the last Graptolithida disappeared (Обут, 1972) and the generic diversity of Anthozoa, Bryozoa, Brachiopoda, Trilobita, Crinoidea decreased in Middle Asia (Plate 1). A decreasing of endemism and an increase of extinction rate at the end of Early Devonian was established on the global scale as well (Boucot, 1975).

At the end of the Givetian, Heliolitoidea and many genera and families of other corals disappeared. At the end of the Frasnian, a mass extinction of the genera and species of corals happened. Many genera and families of other groups disappeared. In Plate 1 and Fig. 1 the minimum of biodiversity in the Frasnian is

Table 1. **The number of Genera of some taxonomical groups of marine Invertebrata in Palaeozoic subdivisions of Middle Asia NA Cephalopoda – Non Ammonoid Cephalopoda**
1 lentelė. **Kai kurių taksonominių grupių genčių skaičius Vidurinės Azijos paleozojaus stratigrafiniuose padaliniuose. NA Cephalopoda (neamonitiniai cefalopodai)**

	Foraminifera	Stromatoporoidea	Anthozoa	Bryazoa	Brachiopoda	Trilobita	NA Cephalopoda	Ammonoidea	Tentakulita	Crinoidea	Graptolithina	Conodonta	Other	Total
T_1	6				4			36				7	50	103
P_2^2	50		13	5	40		1	2		5		4	80	200
P_2^1	125		44	20	70	1	2	15		8		8	80	373
P_1^2	110		63	36	120	6	11	52		12		12	90	512
P_1^1	95		61	25	80		5	30		10		11	90	407
C_3	90		62	20	70	1	2	30		13		10	80	378
C_2^m	72		60	14	60		2	10		16		9	80	323
C_2^b	75		55	15	56		3	36		15		12	60	327
C_1^s	100		70	30	110	2	7	82		27		14	60	502
C_1^v	140		82	60	140	4	5	34		40		10	60	575
C_1^t	68	3(?)	43	17	60	1	4	6		30		23	40	295
D_3^{fm}	50	15	5	20	50	4	13	12	1	10		22	40	242
D_3^{fr}	42	20	31	3	55	3	2	2	3	4		20	40	225
D_2^g	32	27	75	2	60	5	6	1	4	13		14	50	289
D_2^{ef}	23	30	100	10	76	8	7	6	10	20		10	70	370
D_1^e	20	32	130	16	120	31	10	11	16	40	2	13	80	521
D_1^p	21	32	135	22	130	40	37		15	60	3	15	80	590
D_1^l	17	27	100	20	110	30	42		9	35	5	16	80	491
S_2^p	15	27	85	20	90	22	50		2	20	13	7	75	426
S_2^{ld}	14	25	87	17	66	20	46			14	20	8	70	387
S_1^w	12	16	76	25	24	7	44			16	21	16	50	317
S_1^{ln}	8	10	47	23	27	14	20			17	50	18	40	274
O_3^a	12	5	75	24	90	90	40			33	30	16	90	505
O_2^k	11		10	26	113	120	43		1	45	27	20	110	526
O_2^l				5	50	100	35			6	45	20	65	326
O_1^a					14	50	20				41	21	23	169
O_1^t					15	90	15				22	10	20	172
e_3					24	160	2					17	35	238
e_2					25	150	1					10	30	216
e_1					21	30						3	100	154

shown. The true minimum occurred at the beginning of the Famennian after mass extinction of corals and other Invertebrata. However, during the Famennian many new genera of Foraminifera, Bryozoa, Brachiopoda, Ammonoidea appeared and as a result there were more Invertebrata genera than in the Frasnian. Mass extinction of the genera and families at the end of the Frasnian was established on the global scale, too (Boucot, 1975; Oliver, Pedder, 1994). At the end of the Famennian, Tentaculita, almost all Paleozoic Stromatoporoidea and part of genera in other groups disappeared. In the Tournaisian, many new genera and families of Rugosa appered and the generic diversity of Foraminifera, Brachiopoda, Crinoidea increased.

In the Visean, the fourth Paleozoic maximum of biodiversity occurred. The flourishing of Bryozoa took place in the early Visean. Small Foraminifera, Anthozoa, Brachiopoda reached their maximum of biodiversity in the late Visean. Ammonoidea reached the maximum of biodiversity in the Serpukhovian (Namurian). At the end of the Early Carboniferous a large extinction of the genera of marine Invertebrata (Plate 1) occurred. It was dyachronous. In the middle-late Visean, the diversity of Bryozoa decreased. A certain decrease of taxonomical diversity of small Foraminifera, Anthozoa, Brachiopoda, Crinoidea began at the end of Visean and in Serpukhovian. A sharp decrease of the diversity of Ammonoidea occurred at the end of the Serpukhovian. The more intensive extinction of corals and other Invertebrate was established on the global scale at the end of Early Carboniferous as well (Василюк, 1974).

The Middle and Upper Carboniferous rocks rich in fossils are widely distributed in Middle Asia. However, the biodiversity in the Middle and Upper Carboniferous is not very great compared with the Early Carboniferous and Early Permian (Plate 1, Fig. 1).

Rocks of the Permian system are widely distributed and most fully represented in Pamir. Rocks of all stages of the Permian system here contain many fossils. During the Early Permian, biodiversity in-

Table 2. **The numer of Genera of some taxonomical groups of marine Invertebrata in Mesozoic subdivisions of Middle Asia**
2 lentelė. **Kai kurių taksonominių grupių genčių skaičius Vidurinės Azijos mezozojaus padaliniuose**

	Foraminifera	Porifera	Anthozoa	Brachiopoda	Bivalvia	Gastropoda	Ammonoidea	Ostracoda	Echinoidea	Total
P_1	30		2	6	26	5		7	14	90
K_2^m	80		7	17	35	15	16	13	20	203
K_2^{kp}	70		4	6	44	30	20	16	20	210
$K_2^{k\text{-}st}$	72		5	6	40	44	18	15	21	221
$K_2^{s\text{-}t}$	110		7	13	75	58	80	28	30	401
K_1^{al}	70	1	12	4	80	45	60	20	10	302
K_1^{ap}	40		14	6	66	50	20	21	5	222
K_1^{bar}	40		25	6	56	24	9	25	6	191
K_1^h	20		21	7	42	15	10	17	6	138
K_1^v	20		5	8	50	27	11	20	4	145
K_1^{ber}	30			10	40	10	11	21	6	128
J_3^t	20		6	7	23	7	9	10		82
J_3^k	23		25	12	56	11	10	10		147
J_3^o	40	15	34	26	100	16	25	30	7	293
J_2^k	50	25	32	45	110	10	60	50	20	402
J_2^{bt}	35		30	23	100		32	20	3	243
J_2^b	20	1	22	24	90		32	5		194
J_2^a	16		2	7	50		20			95
$J_1^{p\text{-}t}$	9			5	30		13			57
$J_1^{h\text{-}s}$	10	6	24	4	21		5			70
T_3^r	15	27	30	20	24		15			131
T_3^n	40	50	40	30	40		30	10		240
T_3^k	25	20	23	12	30	6	10			126
T_2	20	15	10	10	25	7	15			102
T_1^o	6			4	35	8	42	2		97
T_1^i	3				14		1	3		21

creased and reached its maximum at the end of this epoch. In this time the number of Foraminifera increased and the maximum of the biodiversity of the Permian Bryozoa, Brachiopoda and Ammonoidea took place (Plate 1, Fig. 1). At the beginning of the Late Permian the biodiversity of Bryozoa, Brachiopoda and especialy of Amonoidea decreased, while that of Foraminifera continued to increase. At the end of the Midian age the generic diversity of marine Invertebrata decreased very much, and at the end of the Permian there occurred the largest extinction in the Phanerozoic. It was not sudden. The extinction of Paleozoic taxa took place during the whole Paleozoic, but at the end of the Permian it was most intensive.

Marine Triassic rocks are well-known in Pamir and Mangishlak. In the Indian age the biodiversity minimum reached its lowest. Bivalvia are found frequently. Conodonta, Ostracoda are more scanty and Ammonoidea are very scanty. In the Olenekian age the biodiversity of Bivalvia and Ammonoidea was much greater (Plate 2, Fig. 2). Bivalvia and Ammonoidea dominated, Gastropoda, Ostracoda, Conodonta were rare. Mesozoic Porifera, Anthozoa, Crinoidea appeared in the Middle Triassic.

In the Norian age the Triassic Invertebrata reached the maximum of generic diversity. Porifera, Anthozoa, Brachiopoda, Bivalvia and Ammonoidea dominated. At the end of the Norian, Conodonta disappeared and extinction of other Invertebrata in Middle Asia became more intensive. During the Rhetian and Early Jurassic, more genera of marine Invertebrata became extinct than new ones appeared (Plate 2). Early Jurassic marine rocks of Middle Asia are found only in Pamir.

At the beginning of the Middle Jurassic, a large transgression of the sea began. Thus the marine Bajossian, Batonian, Callovian and Oxfordian rocks became widely distributed in Middle Asia. In the Middle Jurassic the biodiversity of all classes increased and reached its maximum in the Callovian (Plate 2, Fig. 2). The maximum of biodiversity is noted in other regions in the Callovian, too (Макридин, 1972). Oxfordian marine rocks were distributed widely in Middle Asia, but the biodiversity of marine Invertebrata was much less than in the Callovian (Fig. 2). In the Late Jurassic the regression began, and the distribution of marine Tithonian rocks was very restricted. Thus the Tithonian minimum shown in Plate 2 and Fig. 2 has only a regional character.

In the Early Cretaceous a wast transgression of the sea began in Middle Asia. The biodiversity in the Early Cretaceous increased and reached its maximum in the Cenomanian (320 genera). In Plate 2 and Fig. 2, the Cenomanian with the Turonian and the Coniacian with the Santonian are united, because their duration is 2–3 and more times less than of other ages of the Mesozoic (Афанасьев, Ясаманов, 1993). During the Turonian–Maastrichtian the biodiversity decreased. At the end of the Cretaceous, mass extinction of many taxonomical groups took place. In the Paleocene, a low minimum of biodiversity was also observed (Plate 2, Fig. 2).

CONCLUSIONS

Periodical alternations of the maxima and minima of biodiversity show that the organic world of the Earth developed by its own timing. The epochs with a more intensive formation of taxons and the epochs of their mass extinction happened during transgressions, regressions and in quiet palaeogeographic situations.

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VIDURINĖS AZIJOS FANEROZOJAUS AŠTUONI BESTUBURIŲ BIOĮVAIROVĖS MAKSIMUMAI

S a n t r a u k a

Vidurinėje Azijoje yra visi paleozojaus ir mezozojaus sistemų aukštai, sudaryti iš jūrinių uolienų su gausiomis bestuburių liekanomis. Čia galima tirti ištisą organinio pasaulio vystymosi eigą nuo kambro iki kainozojaus pradžios. Šio regiono fanerozojuje yra nustatyti aštuoni bioįvairovės maksimumai: vėlyvajame kambre, karadokyje, pragyje, vizėjyje, kunguryje, noryje, kelovėjyje, cenomanyje. Bioįvairovės maksimumai ir minimumai periodiškai kartodavosi kas 50–70 milijonų metų.

Витаутас Лелешус

ВОСЕМЬ МАКСИМУМОВ БИОРАЗНООБРАЗИЯ БЕСПОЗВОНОЧНЫХ В ФАНЕРОЗОЕ СРЕДНЕЙ АЗИИ

Р е з ю м е

В Средней Азии все геологические ярусы систем палеозоя и мезозоя представлены морскими отложениями с обильными остатками беспозвоночных. Здесь можно наблюдать непрерывное развитие органического мира от кембрия до начала кайнозоя. В этом развитии периодически повторялись максимумы и минимумы биоразнообразия. Установлено восемь максимумов биоразнообразия в фанерозое Средней Азии. Они были в позднекембрийской эпохе, карадокском, пражском, визейском, кунгурском, нориском, келловейском, сеноманском веках. Максимумы и минимумы периодически повторялись через каждые 50-70 млн. лет.