JURIJ ALEXANDROVICH ORLOV MEMORIAL NUMBER
JOURNAL OF THE PALAEONTOLOGICAL SOCIETY OF INDIA
VOL. 20, 1977 pp. 62—68 (*For* 1975).

METAZOIC CYCLE IN THE ORGANIC WORLD DEVELOPMENT

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ABSTRACT

Based on the analysis of various cycles in the organic world development and of specific features of past biospheres, the authors substantiate the division of the Palaeozoic era, suggested by them in 1962, in two independent eras: Paleozoic, consisting of Cambrian-Silurian —era of marine life, and Metazoic comprising Devonian-Permian—era of land invasion by terrestrial plants and animals. Paleozoic and Metazoic biospheres qualitatively differ from each other.

The problem involved in dis nguishing certain cycles of development in the history of the Earth and its organic world always attracted researchers' attention since it is of great interest for solving both a number of theoretical problems and purely practical ones, specifically for establishing boundaries between stratigraphical units of different ranks.

As known, the history of the Earth is now divided into five large cycles or eras : Archeozoic, Proterozoic, Paleozoic, Mesozoic and Cenozoic. Of these, the first two are generally united into Cryptozoic eon, and the last three, into Phanerozoic eon. Of these three Phanerozoic eras Paleozoic was the most durable one and, perhaps, the most complex by events. Just in this time interval all phyla and nearly all classes of the organic world emerged, and a considerable number of groups of organisms of a rather obscure systematic affinity appeared and then disappeared completely.

As known, the Paleozoic era was established by J. Phillips (1840). In the 19th century, in England it was devided in two suberas : Proterozoic and Deuterozoic but later this division was discarded since first in North America and then all over the world Proterozoic got a different, now usual for us, sense. We need not to dwell on the history of division of the Paleozoic era since the question is well covered in Leonov's monograph (G. P. Leonov, 1973). Of the works of relatively recent past it should be mentioned the article of A. N. Mazarovich (1947) in which the Paleozoic era is divided into independent Eopaleozoic and Neopaleozoic. The former includes not only Cambrian and Silurian periods (division of Silurian into Ordovician and Silurian had not yet gained then universal acknowledgement) but also Sinian period, i.e. Later Proterozoic in a generally accepted sense.

Several authors consider the Paleozoic as a single era but divide it into suberas. Thus, R. Moor (1933), D. D. Donovan (1966), G. I. Nemkov, M. V. Muratov et al. (1974) consider it as consisting of two suberas : Early Paleozoic (Cambrian, Ordovician, Silurian) and Late Paleozoic (Devonian, Carboniferous, Permain), whereas N. B. Vassoevich (1954) conventionally divides Paleozoic into Lower (Sinian, Cambrian, Ordovician), Middle (Silurian, Devonian, Lower Carboniferous), and Upper (Middle Carboniferous-Permian). It is worth noting that a part of Precambrian is referred to Paleozoic and that the boundaries of suberas do not always coincide with the boundaries of periods.

In 1962, the present authors, taking into account specific features of the Early and Late Paleozoic cycles in the organic world evolution, suggested the division of Paleozoic era in two independent eras : Paleozoic proper consisting of Cambrian, Ordovician and Silurian, and Metazoic era comprising Devonian, Carboniferous and Permian (Drushchits, Shimansky, 1962a, b). Later, however, the first of the authors suggested to regard them as suberas (Drushchits, Obrucheva, 1971; Drushchits, 1974). It is interesting to note that in some works of general character the authors' suggestion about the expediency of dividing Paleozoic in two independent eras was admitted, while in others it was subjected to rather sharp criticism. The usefulness of the division of Paleozoic into Paleozoic (encompassing Cambrian, Ordovician and Silurian) and Metazoic (Devonian, Carboniferous, Permian) was acknowledged in Sadykov's book "Ideas of a Rational Stratigraphy" (L. M. Sadykov, 1974). True, the author pointed out that the term "Metazoic" is not very apt though admissable. The opposite view is shared by G. P. Leonov in his monograph "Osnovy Stratigraphii" (1973, Vol. I). Among other problems, this researcher pays great attention to the cyclic nature of the organic world development and the possibility of its use for verifying the International Geological Time Scale. Proceeding from the analysis of taxons of various ranks of invertebrates, vertebrates and plants, G. P. Leonov doubts the possibility of an objective singling out of various cycles in the organic world development, which would coincide with the boundaries of the subdivisions accepted in the International Geological Time Scale. The impossibility of the said division can be explained by several methodological difficulties and intricacy of certain principal questions involved. In Leonov's opinion, two cycles can be rather objectively distinguished in Phanerozoic era on the basis of the diagram of the total number of classes. These cycles are Paleozoic and Mesocenozoic. The cycles are set apart with greater difficulties in case of a more detailed analysis of groups. G. P. Leonov is right in maintaining that there are significant discrepancies in the development history of a majority of invertebrates, Agnatha and fishes, on the one hand, and a majority of vertebrates, plants and a greater part of arthropods, on the other. In the development of the former Paleozoic and Mesocenozoic cycles are manifested rather clearly and are separated by an expressed drop in the number of orders and families in the Triassic. The development pattern of the latter has a more involved characer; more or less distinctly it can be singled out Late Paleozoic-Early Mesozoic and Late Mesozoic-Cenozoic cycles. Borders in the development of animals and plants do not coincide either. Having analysed a great number of graphs showing the development of various taxons of most groups of organic world, G. P. Leonov comes to the conclusion that the "notion of the "natural cycle" of developmet will get its real sense also only in relation to the course of development characteristic of each of the given groups of organisms separately. As far as the course of development of the organic world of the Earth as a whole is concerned, this notion acquires only convetional meaning since it actually reflects peculiarities of the development of the organic world not as a whole but only of a part of it" (p. 501).

It is but natural that the isolation of independent Paleozoic and Metazoic cycles in the organic world development meets no sympathy of the author, too. Thus, quite reasonably he points out that the groups that Drushchits and Shimansky indicated as typical of Paleozoic, i.e. Cambrian, Ordovician and Silurian, appeared at different time and that some of these groups were typically only of a particular period and not of all the three. So much the interesting that the author accepts, nevertheless, the Paleozoic cycle (in the usual sense of the term) to be divided into Early Paleozoic (Cambrian-Silurian) and Late Paleozoic (Devonian-Permian) subcycle (p. 498). Even more clearly the idea is expressed further in the paper in question : "When Drushchits and Shymansky single out "Paleozoic" and 'Metazoic", they mean to set apart the cycles of major importance, the very existence of which in principle is beyond doubt and is universally recognized" (p. 506).

In this connection it is necessary, first of all, to consider in brief certain problems concerning the use of data on the development of various groups of organic world by ascertaining its cycles of development, and to elucidate the concept of the cycle in the organic world development as an objective phenomenon. The authors of the present article believe that the problem of the cycle should not be solved by a mere calculation of the number of taxons or the numbr of new taxons of particular groups or even all the groups known for the given time span. We have come to this conclusion on the basis of the following reasoning. Up to now it is not quite clear to what extent a taxon rank should be taken into consideration in ascertaining geochronological subdivisions of this or that extent. In a number of cases this is not taken into account, and in clearing up one and the same boundary some researchers operate both with species and genera complexes. From our point of view this leads to endless discussions only. On the other hand, it is hardly possible with absolute precision to establish that the genus group taxons correspond, for example, to stage boundaries and family group taxons coincide with the boundaries of periods. Firstly, in a number of cases a stage boundry is at the time a period boundary; secondly, the tempo of development of various groups may considerably vary and in this sense taxons of the same rank but of different groups may be of unequal value. Nevertheless, even with account to these limitations, it is quite obvious that the larger the subdivision of the International Geological Times Scale the higher is the rank of the organic world taxons by which this subdivision is characterised. This proposition is rather obvious; it is even mentioned in the "Stratigraphical Classification.", and says that "the nature and extent of changes in flora and fauna serve as the major reason for ascertaining a taxon rank of stratigrphical units, their "hierarchical" subordination" (1965, p. 19).

The absence of a uniform, generally accepted classification of animals and plants even at the order-class level has seriously impaired the possibility of using the higher taxons statistics for resolving problems associated with the cyclic nature in the organic worlddevelopment. Presently, there is even no universally shared opinion as to the number of types and classes of organic world. Invertebrates include not less than 80-90 groups that may to this or that extent pretend to the class rank. Of these, about 40 groups represent completely extinct animals; the rank of a great number of these groups is not ascertained so far. Even for better studied taxons there is no common interpretation of their rank. To illustrate this, we may take the classes Pantopoda and Protopantopoda (Dubinin, 1962) which more frequently are placed into one class *Pycnogonides* (Drushchits, 1974). Some competent researchers consider the class of *Myriopoda* as consisting of several independent classes *Diplopoda*, *Symphyla* and *Chiliopoda* (Sharov, 1962). The number of such examples at the order level is even greater. Sometimes even with the coincidence of names and coverage of the ascertained higher-rank taxons the rank itself does not coincide. This was the case with nautiloidea and close to them groups which in different manuals and monographs are treated either as superorders or as independent subclasses (Zhuravleva, 1972). The abovesaid makes us to question the possibility and efficiency of efforts aimed at purely statistical solution of the problem on the isolation of major cycles in the organic world development and, respectively, of the higher rank geochrones even on the basis of taxons of an order-class group. This proposition is also well reflected in the above-cited instruction of stratigraphic classification: "large natural cycles in the Earth history conform to major cycles in the development of flora and fauna, though this relationship manifests itself in very intricate forms" (1965, p. 18).

From all said above arises an involuntary impression about particular subjectivity in understanding the cycles in the organic world development and of inevitably clear-cut difference in the opinion of various researchers on this question.

It appears doubtful that the term "cycle of organic world development" is aptly used, though the validity of the term 'cycles of development of individual groups of plants and animals" cannot be questioned. What does the term "cycle" in the organic world development stand for ? The authors believe that cycles must differ in the level of organisation of groups forming the biosphere and in appearance of new groups most typical of the future biosphere. The new always originates from the old but from a certain moment the new becomes the leading factor playing a significant part in the development of biosphere, the old biosphere turns thus to a qualitatively new biosphere, and one cycle of the organic world development, replaced by another The present authors think that the higher-rank geochronological units (eons, eras, periods), that are ascertained by cycles of the organic world development, qualitatively differ from stages, and most of all from zones. Stages and zones are readily distinguished by the development patterns of specific groups of organisms, whereas eras and periods are characterized by a general level of the biosphere development. As an analogy one may point to the differences between taxons of specific and generic groups, on the one hand, and taxons of a type and class rank, on the other. For the former precise diagnosis with indication of characteristic features in the organisms structure is of great value and, for the latter, the general structural pattern.

One should not, also, mix the question concerned with cycles of development with the question about borders, and most of all about boundaries of individual subdivisions of the International Geological Time Scale. A majority of large taxons appears and extincts not at the borders. Of 90 classes (and groups of an order-class rank of not quite clear systematic affinity) of invertebrates and vertebrates, a most part appears and diminishes not at the borders of periods. A boundary between subdivisions should be, in any case, determined proceeding from a detailed development of the groups mostly important in the stratigraphy, irrespective of the boundary of which subdivision rank it fits. In all probability, this strange contradiction between the nature of the geochrone as such and its boundary can be explained by the fact that any geochrone even of the top-rank, begins from the subordinate geochrone of the lower rank—the boundary of the lower geochrone at the same time will be that of the higher one. The boundary is always conventional in relation to the development of the organic world as a whole, but it should be rather distinct by the presence of one of the leading and rapidly evolving groups. Unfortunately, it is not always attainable. D. L. Stepanov writes in this connection the following : "This is why a step-by-step modification should be considered as the normal and, in all likelihood, the most common type of change of flora and fauna in the Earth's history. That is why the boundaries of not only systems but also of erathems (groups) all over the world are indistinct and their ascertaining causes till now endless discussions" (Stepanov, 1974, p. 21). It was reported on the existence of transitional layers that practically exclude the establishment of an exact boundary between stratigraphical subdivisions (Khalfin, 1973, 1974).

The present authors think that the problem of geochronological subdivisions of the International Scale, which are established by the cycles of organic world development, call a considerably greater theoretical interest than the problem of boundaries (it is always concrete and concerns a certain boundary) since it is connected with regularities revealed in the development of the past biosphere. The authors have analysed the distribution pattern of more than 110 major taxons of the organic world that include classes, groups of the order-class rank of a not quite distinct systematic affinity (algae and worms were treated on the type of level) as well as subclasses of vertebrates. A tentative calculation has shown that in Cambrian more than 40 groups appeared and 13 groups extincted, in Ordovician 20 groups appeared and 5 extincted, in Silurian—15 and 1 respectively, in Devonian—22 and 12, in Carboniferous period—17 and 7, in Permian 3 taxons appeared and 7 taxons extincted. In Mesozoic appeared only some groups : mammals appeared in Triassic, birds—at the end of Jurassic, angiosperma—at the beginning of Cretaceous. Besides, in Jurassic and Cretaceous periods appeared certain algae and invertebrates whose rests are not reported from more earlier deposits. Even the only listing of these groups (Figs. 1-3) could demonstrate that

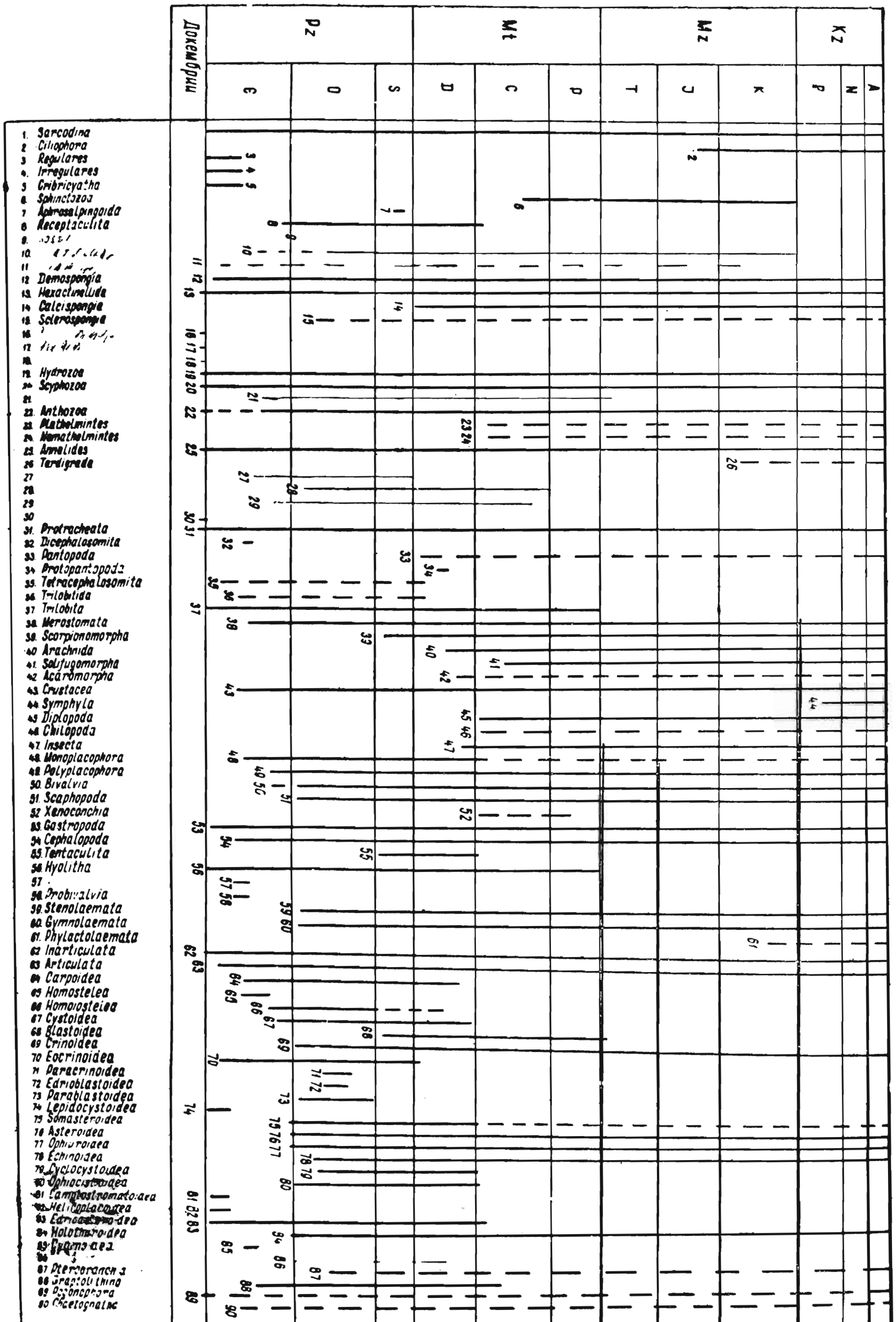

Fig. 1. Scheme of geochronological distribution of major groups of fossil invertebrates:
1. Sarcodina; 2. Ciliophora; 3. Regulares; 4. Irregulares; 5. Cribricyatha; 6. Sphinctozoa; 7. Aphrosalpingoida; 8. Receptaculita; 9. Soanitidae; 10. Stromatoporata; 11. Hydroconozoa; 12. Demospongia; 13. Hexactinellida; 14. Calcispongia; 15. Sclerospongia; 16. Rangeomorpha; 17. Pteridinomorpha; 18. Erniettomorpha; 19. Hydrozoa; 20. Scyphozoa; 21. Conulata; 22. Anthozoa; 23. Plathelmintes; 24. Nemathelmintes; 25. Annelides; 26. Tardigrada; 27. Hyolithelmintes; 28. Cornulitida; 29. Coleolida; 30. Angustiocherida; 31. Protracheata; 32. Dicephalosomita; 33. Pantopoda; 34. Protopantopoda; 35. Tetracephalosomita; 36. Trilobitida; 37. Trilobita; 38. Merostomata; 39. Scorpionomorpha; 40. Arachnida; 41. Solifugomorpha; 42. Acaromorpha; 43. Crustacea; 44. Symphila; 45. Diplopoda; 46. Chilopoda; 47. Insecta; 48. Monoplacophora; 49. Polyplacophora; 50. Bivalvia; 51. Scaphopoda; 52. Xenoconchia; 53. Gastropoda; 54. Cephalopoda; 55. Tentaculita; 56. Hyolitha; 57. Mitrosagophora; 58. Probivalvia; 59. Stenolaemata; 60. Gymnolaemata; 61. Phylactolaemata; 62. Inarticulata; 63. Articulata; 64. Carpoidea; 65. Homostelea; 66. Homoiostelea; 67. Cystoidea; 68. Blastoidea; 69. Crinoidea; 70. Eocrinoidea; 71. Paracrinoidea; 72. Edrioblastoidea; 73. Parablastoidea; 74. Lepidocystoidea; 75. Somasteroidea; 76. Asteroidea; 77. Ophiuroidea; 78. Echinoidea; 79. Cyclocystoidea; 80. O,hiocystoidea; 81. Camptostromateidea; 82. Helicoplacoidea; 83. Edrioasteroidea; 84. Holothuroidea; 85. Gyamoidea; 86. Machaeridia; 87. Pterobranchia; 88. Graptolithina; 89. Pogonophora; 90. Chaetognatha.
For groups 6, 7, 8, 9, 10, 11, 16, 17, 18, 21, 27, 28, 29, 30, 56, 57, 58, 85, 86 we failed to establish the rank of the invertebrates or their position in the scheme or both.

the Early and Later Paleozoic substantially differ from each other and that this distinction is associated with a drastic structural change in the biosphere.

Three periods : Cambrian, Ordovician and Silurian, constituting, in authors' opinion, the Paleozoic era proper were the time of the absolute domination of marine invertebrates (Fig. 1) or Thalassazoic, i.e. the era of marine life. True, in the Middle Ordovician first vertebrates (*Agnatha*) appeared, and at the end of Silurian emerged representatives of the first unit of Gnathostomata (class of *Acanthodii*). Revolutin of jawlss fishes (*Agnatha*) into jawed vertebrtes was accompanied according to A. N. Severtsev (1967), by important modifications in the following three systems of organs : outer skeleton, the oral apparatus, and in the

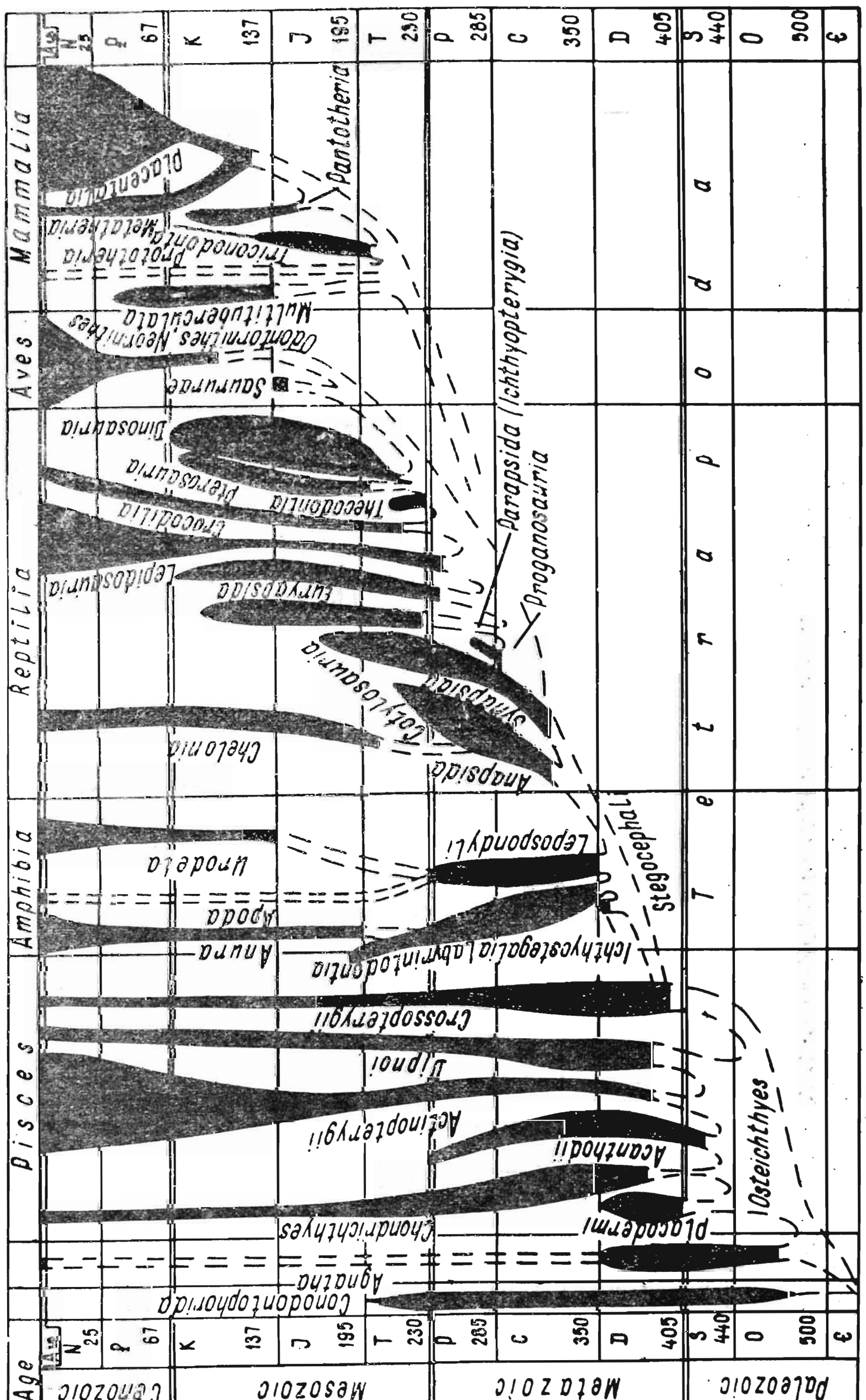

Fig. 2. Scheme of historical development of vertebrates.

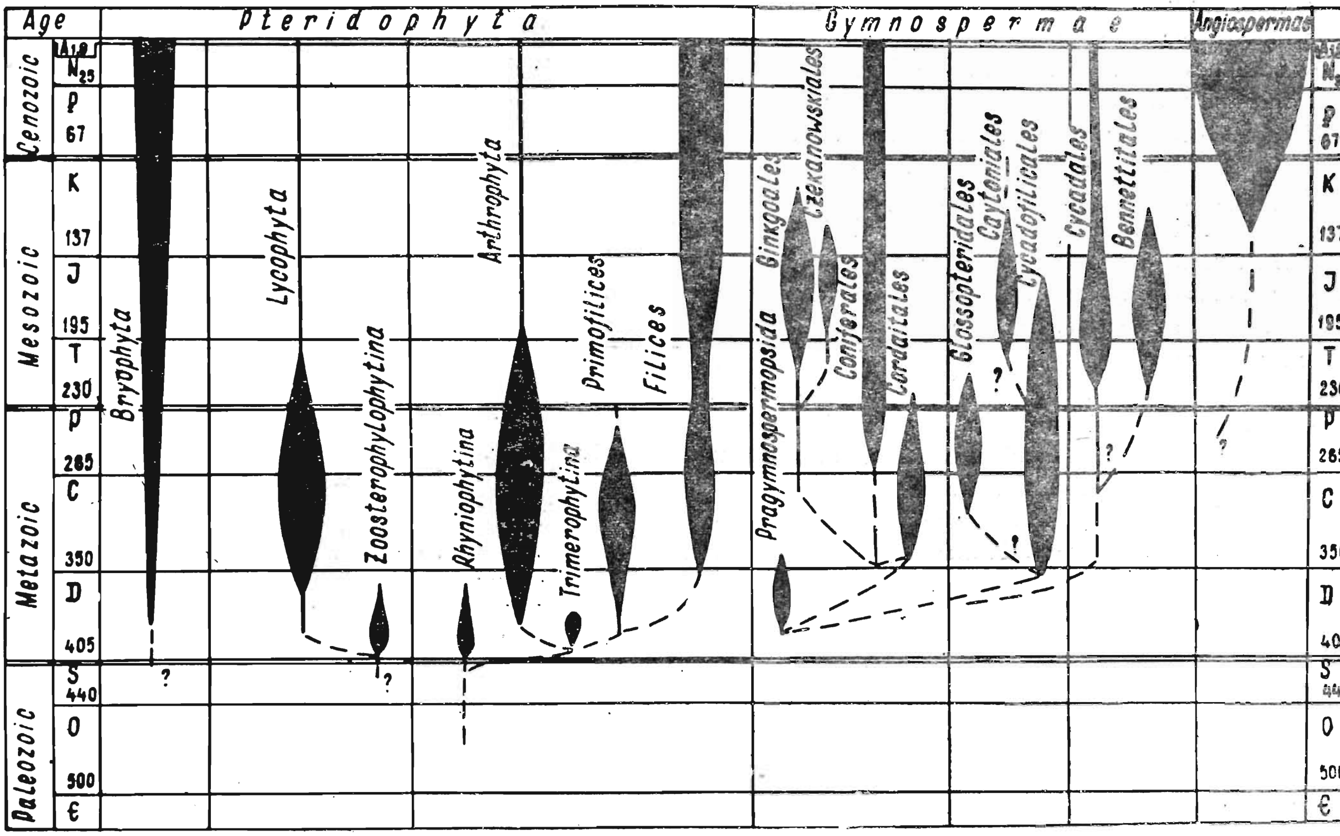

Fig 3. Scheme of historical development of plants.

locomotor organ; all this resulted in aromorphosis or morphophysiological progress of this group of vertebrates. The development of the oral apparatus of a shapping type markedly increased the function of feeding and the function of attacking and defending. The change in the mode of food gaining caused appropriate modifications in the locomotor system, and the appearance of paired fins, as well as the improvement of the organs of sense; development of nervous system and of all other systems còrrelative to the nervous system.

At the end of Silurian first land vascular plants appeared, *Rhyniophytina* (*Cooksonia*) being one of them. The origin of first land plants, their first coming out from marine environment to land was connected with a number of aromorphous conversions such as appearance of new and, above all, of conducting tissue, transferring the water and organic substance to all parts of the plant, a covering tissue protecting it from unfavourable environment conditions, and a mechanical tissue strengthening the plant. In their appearance land plants differed from algae. They evolved such vegetative organs as the stalk, leaves and roots.

Nevertheless, Predevonian groups of vertebrates and higher plants played only insignificant role in the Paleozoic biosphere.

The three subsequent periods, Devonian, Carboniferous and Permian, which the authors unite into Metazoic era or simply Metazoic, are characterized by the invasion of the land by plants and animals, plants being the first and then animals, both invertebrates and vertebrates followed them. A qualitative rebuilding of the biosphere took place in Devonian although it lasted the whole period. During Devonian a large number of primitive groups of invertebrates (tentaculites, several lower classes of echinoderms), and a major part of *Agnatha* (previously known as *Ostracodermi*) extincted.

Beginning of Devonian is associated with the divergent development of land vascular plants whose classification has not been worked out thoroughly enough. Psilophytileans were divided into a number of new groups, among which *Rhyniophytina* (*Rhynia*), *Zoosterophylophytina* (*Zoosterophyllum*,) and *Trimerophytina* (*Psilophyton*) were typical of Early Devonian. Large branches of plants, common in Metazoic, appeared somewhat later, they include *Lycophyta*, *Arthrophyta*, primofilices, among which researchers distinguish *Cladoxylopsida* and *Coenopteridopsida*. And finally, in the Middle Devonian *Progymnospermopsida* appeared, from which in the Early Carboniferous period true *Gymnospermae* (*Cordaitales*, *Pteridospermidae*) originated. These groups of plants featured new structural traits which underwent only some minor changes during the phylogenesis (Mejen, 1971).

In the Early Devonian shelled fishes (*Placodermi*), appeared among gnathostomous vertebrates and acanthodes continued their development; in the Middle Devonian two new branches of fishes developed; cartilaginous (*Chondrichthyes*) and bony fishes (*Osteichthyes*); the latter immediately diverged into three branches : lobe-finned fishes (*Crossopterygii*), lung fishes (*Dipnoi*), and ray-finned fishes (*Actinopterygii*). At the end of Devonian, first land quadrapodes—amphibious animals (*Amphibia*) derived from lobe-finned fishes. Devonian, therefore, is characterized by well pronounced changes in the organic world development. True, some researcher may arrive at the idea that the border between Paleozoic and Metazoic should be drawn between Devonian and Carboniferous periods and not between Silurian and Devonian. The Carboniferous period is characterized by luxuriant development of plant life; amphibians and reptiles envade the land, winged insects (*Pterygota*) appear; the outer appearance of biosphere becomes quite different. Naturally, these changes were of great importance. One should remember that in reality, as far as the quantitative aspect of the subject is concerned, insects played if not the leading then almost the leading role in the animal life development. The comparison of the number of taxons of insects with those of other groups of animals has shown that insects surpass by far the remaining groups of animals, and, hence, they must play a greater role in the development of biosphere as a whole. Nevertheless, one should bear in mind that all or near all changes which took place in the organic world during the Carboniferous period were more than a mere continuation of the events that had happened in Devonian. The latter is characterized, as we have already noted, by the aromorphorous development of many groups of animals and plants, and therefore it can be considered as the beginning of the new era—Metazoic, the new cycle in the development of not only particular large branches of organic world, which played extremely important role in its subsequent evolution but also as a new cycle in the development of the biosphere as a whole, too. We believe that the importance of the border between the Early Paleozoic and Late Paleozoick i.e. Paleozoic and Metazoic as we understand them, is not less essential than the borders between Metazoic and Mesozoic and between Mesozoic and Cenozoic.

Proceeding from the foregoing, it follows that one of the tasks of the present-day paleontology is the study of the past biospheres, their formation, interrelations, development and replacement by new biospheres. Such an approach makes it possible to elucidate regularities of the organic world development in our planet. It is but natural that the study of paleobiospheres can be possible only on the basis of a comprehensive investigation of individual phyla of animals and plants and the elucidation of regularities of their development, but for all this the biosphere should not be considered as a mere sum total of such phyla. One should study interrelations between all groups of animals and plants and their environments. Cycles and regularities in the development of the biosphere as a whole will inevitably differ from cycles and regularities found in the development of individual groups of the organic world.

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