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Evolution of the Jurassic Tethyan Foraminifera

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Abstract – The evolution of foraminiferal assemblages that inhabited the East Mediterranean basins during the Jurassic is discussed using the analysis of the material obtained during my work in Syria from 1986 to 1991 and of the Jurassic foraminifera collections from the adjacent countries, the Crimea, Caucasus, and southwestern Europe. Analysis of the taxonomic composition of the assemblages and their changes through time and space revealed stages of the foraminifera development related to sea basin dynamics in the Jurassic. Faunal assemblages differing in composition and structure are confined to different facies-ecological environments and structural zones. The time range of some stages is nearly equal to the stratigraphic unit of age (stage). According to the biological peculiarities of the fauna, i.e., the dominant morphotypes, rates of evolution, tolerance, intensity of speciation, distribution areas, degree of endemism, two large stages (megaphases) of the Tethyan foraminiferal evolution are recognized: the early-middle Jurassic and late Jurassic–early Cretaceous.

The evolution of foraminifera, like any other group of organisms, is a multicomponent process, rates and trends of which depend on a number of factors: biological peculiarities of a group under discussion, its dependence on a complex of abiotic factors, species migrations, and others.

Most of these factors are unstable during even the smallest stage in foraminiferal evolution, a zone, in this case. The wider the studied distribution area of the group and the longer the analyzed period of its evolution, the more complex and reliable its evolutionary patterns.

The vast areas of the Mesozoic Tethys ocean inhabited by the diverse and abundant Jurassic biota including foraminifera are of exceptional interest for such studies.

Using my own abundant materials, mostly from Syria, partly from Israel, Crimea, Caucasus, and Western Europe, as well as publications on the other Tethyan regions, such as the French-Spanish Pyrenees, Algeria, Morocco, Sinai, Saudi Arabia, Iran, and Iraq, I attempted to consider the Jurassic foraminiferal evolution in the Tethys.

Analysis of the foraminiferal assemblages included studies on their taxonomic composition, facies and ecological dependence, distribution area sizes of both the assemblages and principal components (mainly at the generic level), and morphological peculiarities of dominant groups.

According to the dominant groups, the Jurassic Tethyan foraminifera belong to the cyclamminid-pfenderinid type of Protozoa, (Gordon, 1970; Basov *et al.*, 1972; Basov, 1974; Kuznetsova and Gorbachik, 1985), which inhabited the tropical and subtropical basins.

Ecologically, these are benthic forms, i.e., facies-controlled organisms. Planktonic foraminifera, which appear in the Jurassic, are rare, but they occur in the deposits of three of the seven studied stages.

In a biogeographic sense, these assemblages contain tropical Tethyan endemics, widespread subtropical forms, and cosmopolites occurring outside of the Tethys in the Boreal realm (boreal-cosmopolitan elements) (Fig. 1).

Bearing in mind the foresaid, I have distinguished the main stages of the Jurassic foraminiferal evolution in Syria and the adjacent Mediterranean regions.

The first stage corresponding to the lower Jurassic, which cannot be divided into stages in Syria, is distinguishable in fauna from Morocco and southwestern France. The stage is characterized by the occurrence of representatives of the Orbitopsellidae family restricted in distribution by the tropical Tethyan area. Associated *Pseudocyclammina*, *Lituosepta*, *Haurania*, and *Pfenderina*, which are also endemics, have a wider stratigraphic distribution and are recorded in the middle and partly upper Jurassic of the East Mediterranean.

In Syria, the lower Jurassic sediments were deposited in shallow, sometimes brackish-water basins, as indicated by an impoverished composition of foraminiferal assemblages and by the presence of fresh-water ostracodes. In the Crimea, this time was characterized by a deposition of Tavriya Series lacking foraminifers.

The second stage spans the stratigraphic interval of the Aalenian–lower Bajocian and is characterized in Syria by a predominance of boreal-cosmopolitan elements (*Epistomina*, *Lenticulina*, and *Citharina*) and less abundant Tethyan endemics (*Timidonella*). In southwestern Syria, these assemblages were formed under conditions of the mid-littoral zone. In southwestern Europe, identical assemblages existed in similar settings (Pellissie *et al.*, 1984).

The third stage corresponds in time to the Bajocian. Secreting benthic foraminifera retain their predomi-

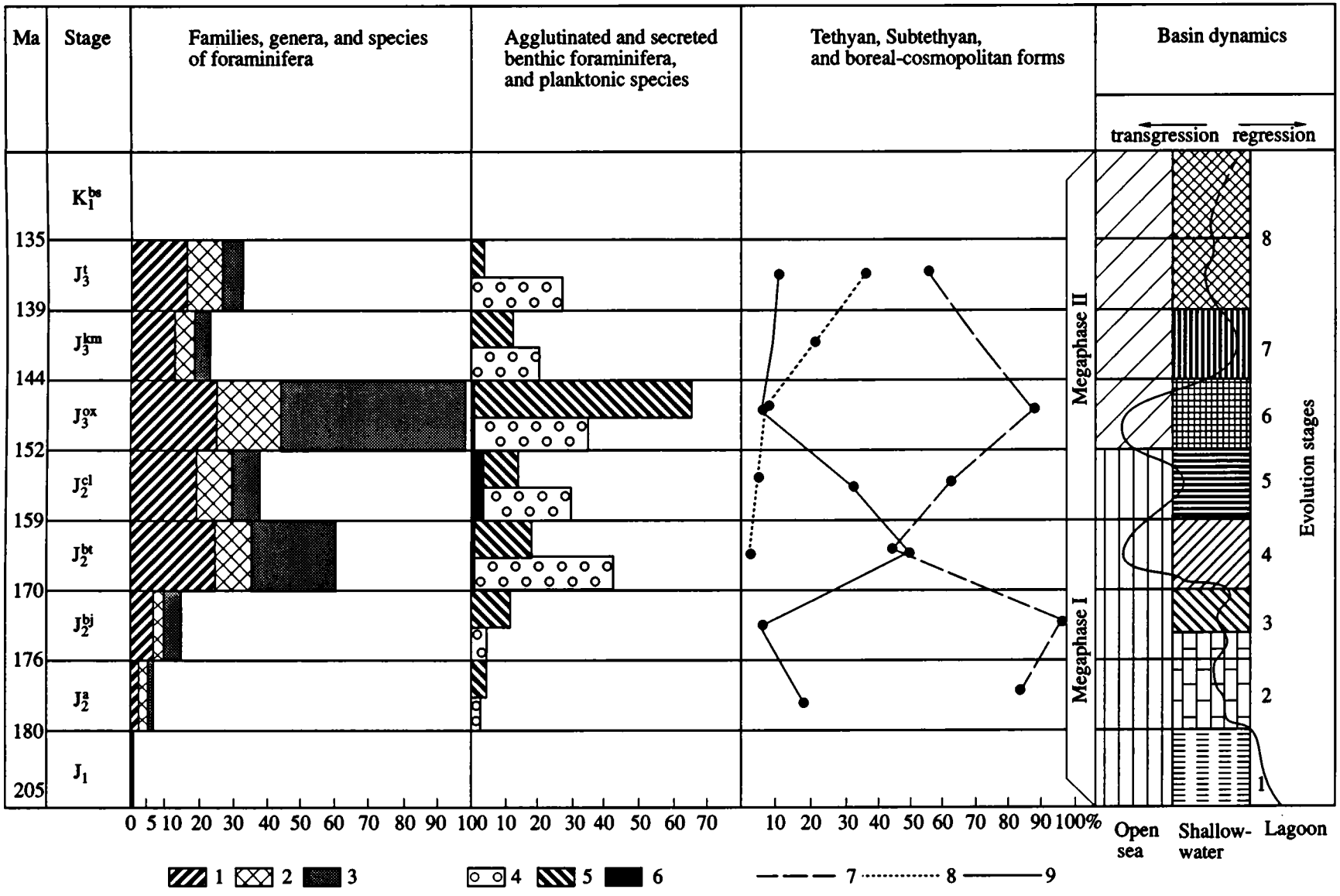

Fig. 1. Relations between different taxonomic, ecological, and paleobiogeographic components in the Jurassic foraminiferal thanatocoenoses of Syria and the basin dynamics.

1 – families; 2 – genera; 3 – species; 4 – agglutinated benthic foraminifera; 5 – secretory benthic foraminifera; 6 – planktonic foraminifera; 7 – boreal-cosmopolitan forms; 8 – Subtethyan forms; 9 – Tethyan forms.

nance in the assemblages, and the Tethyan elements are still of secondary importance. The wide distribution of these assemblages over the Mediterranean enables the correlation of the Bajocian deposits in Algeria, Morocco, Sinai, and southwestern Syria, revealing a common stage in fauna evolution.

The fourth (Bathonian) stage corresponds to a wide transgression. In the Mediterranean, it is marked by the occurrence of various foraminiferal assemblages, which evolved in different parts of the rapidly expanding basin. The boreal-cosmopolitan elements continue to predominate in southern and southwestern Syria, Sinai, and northern Africa, but in central and northwestern Syria, southwestern France, and Algeria they were of minor importance. Here the Tethyan endemics increase sharply in abundance and taxonomic diversity. The planktonic foraminifera (*Conoglobigerina* and *Globuligerina*) appear for the first time. The Syrian foraminiferal assemblages were renewed at the genus level. Eighteen genera originated at either the beginning, or in the middle of the Bathonian stage (Fig. 2).

The fifth stage of the foraminiferal development spans the Callovian, when there was some contraction of the marine transgression and an increased differentiation of facies-ecological environments in the East Mediterranean. Two types of assemblages, inheriting in general their composition from the Bathonian faunas, are typical of this stage. Southwestern Syria and the Sinai Peninsula were areas of terrigenous–carbonate sedimentation, which preserved assemblages dominated by the boreal-cosmopolitan elements. Here less abundant Tethyan forms inhabited the shallow-water mediolittoral zones and the carbonate platform areas. Northwestern Syria, the French-Spanish Pyrenes, and Morocco were occupied by the shallow-water Tethyan endemics. Transitional type assemblages with abundant boreal-cosmopolitan elements appeared in the Crimea and Caucasus. The planktonic foraminifera advanced in species diversity.

The sixth stage, marked by significant changes in the Mediterranean foraminiferal assemblages, is related to the expansion of the marine transgression in the Oxfordian. The taxonomic diversity of this group reaches its maximum; the secreting benthic forms increase sharply in importance; and the planktonic foraminifera continue to develop. The boreal-cosmopolitan to Tethyan elements ratio is 9 : 1, varying slightly in different parts of the basin. In the remote regions, the assemblages are characterized by a uniform composition. The environmental uniformity seems to be characteristic during the wide transgression that reaches the central part of Syria (the Palmyrides). New taxa (*Everticyclammina*, *Choffatella*, *Mesoendothyra*, and *Alveosepta*) appear and spread over the Crimea, Caucasus, Syria, and Israel. These taxa existed till the end

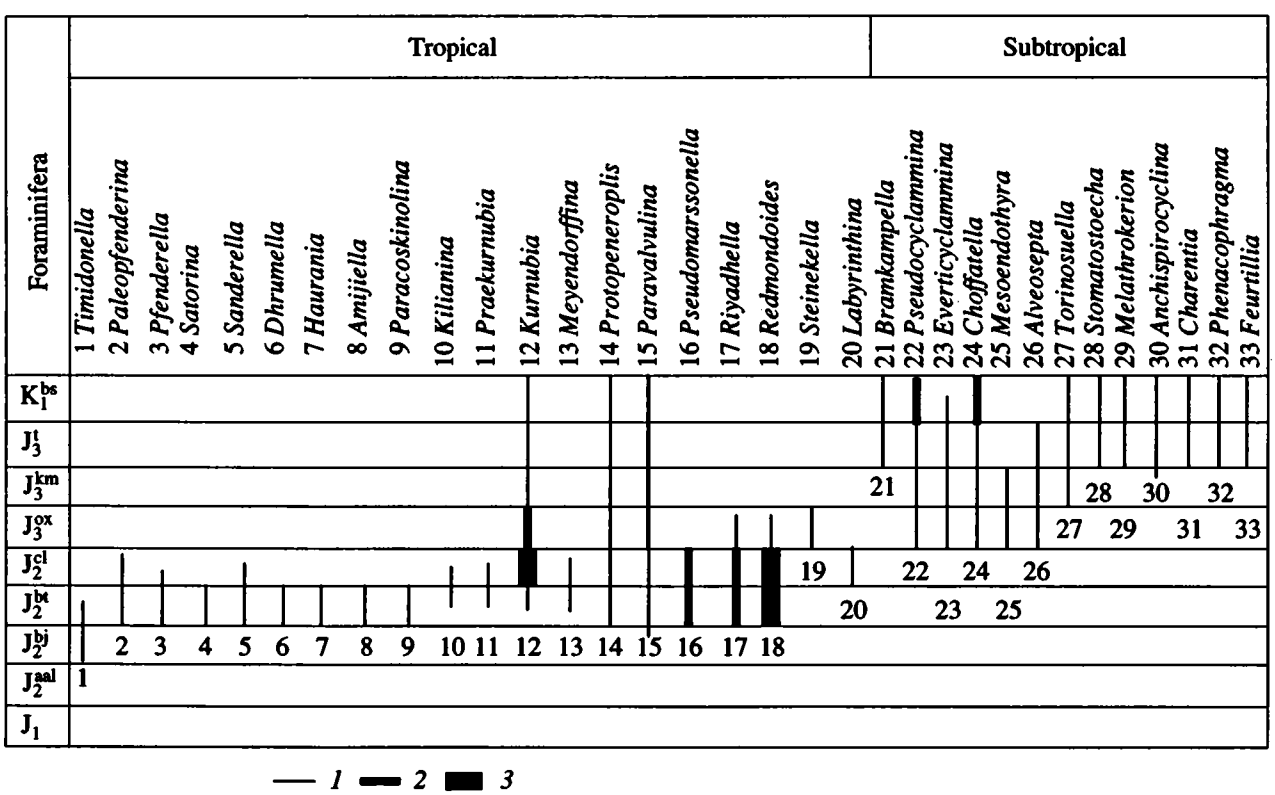

Fig. 2. Stratigraphic range of some foraminiferal genera (the tropical and subtropical types of the Tethyan fauna).

1 – one or two species; *2* – three - five species; *3* – more than five species.

of the Jurassic, and some of them occurred in the Cretaceous.

The beginning of *the seventh (Kimmeridgian) stage* is related to a regressive phase in the development of the East Mediterranean basins accompanied by a general structural reorganization of the region. This resulted in an improverished fauna composition and a mosaic pattern of the Kimmeridgian deposits in Syrian territory. The deposits occur mostly in its southwestern part and are very similar to the coeval deposits of Israel in composition and depositional environments. In the foraminiferal assemblages, the boreal-cosmopolitan elements predominate distinctly over the Tethyan forms. In northwestern Syria, the randomly preserved Kimmeridgian deposits yielded foraminiferal assemblages, which included Subtethyan elements (*Torinosuella*). The agglutinated benthic species dominated over the secreted forms. No planktonic foraminifera have been recovered in the coastal shallow-water sediments.

The eighth and final stage of the foraminiferal development spans the end of the Jurassic and the beginning of the Cretaceous, indicating that the Tithonian and Berriasian assemblages share a common evolutionary stage. The deposits of this age have a limited and mosaic distribution in the Near East. The assemblages show high taxonomic diversity and retain the previous relationships between the Tethyan, Subtethyan and boreal-cosmopolitan groups, amid which the Subtethyan and cosmopolitan elements dominate, while the Tethyan endemics are less abundant. At the beginning of the stage, the generic composition of the Tethyan fauna was renewed: six new genera appeared and were then distributed widely in the Cretaceous. These genera belong to the subtropical fauna widespread in the Near East, Crimea, Caucasus, southwestern Europe, and northern Africa. It is characteristic that the modifications in the foraminiferal composition occurring near the Jurassic–Cretaceous boundary are as adynamic in the Tethys area as they are in the Boreal province. The fauna was renewed only at the species level. New Cretaceous elements appeared at the beginning and in the middle of the late Tithonian.

When analyzing changes in the foraminiferal assemblages in the context of their close relations to the development of the Jurassic Tethyan basins, I refrained from discussing such important factors as biological peculiarities, rates of evolution, and the spatial distribution of this group.

Since a rate of evolution of a taxon (a genus in our case, because we deal with the generic categories as far as evolution is concerned) varies inversely in relation to the duration of its existence, I attempted to define the moments of the rate changes, the relationships between the Tethyan foraminifera during the Jurassic, and some morphological trends in their evolution.

The Jurassic evolution of the Tethyan foraminifers in the Mediterranean can be divided into two large stages, or megaphases, differing in the morphotypes of their dominants, rates of evolution, area of distribution, and intensity of speciations.

The first megaphase spans the long interval from the early Jurassic (Pliensbachian–Toarcian) to the end of the middle Jurassic (Callovian). Foraminiferal assemblages of this megaphase are characterized by: (1) the occurrence of highly specialized forms with complex exo- and endoskeletal structures, a particular morphotype, (2) a high degree of fauna endemism at the family level, (3) a reduced tolerance as a result of the high specialization of the fauna, (4) limited distribution areas of genera and families, (5) high rates of genus evolution; genus life-intervals are 5.5 - 11 Ma, those for species are, accordingly, 1 - 3 Ma, which corresponds to one or two ammonite zones, and (6) highly intensive speciation.

The second megaphase of the Tethyan foraminiferal evolution occurs from the late Jurassic to the beginning of the early Cretaceous, having such characteristics as: (1) the occurrence of highly specialized forms along with more adapted, competitive groups, mainly of the family Lituolidae, which became dominants, (2) a different morphotype of dominants, (3) a lesser degree of endemism of the assemblages (at the genus level), (4) moderate tolerance, (5) broader distribution areas covering the tropical and subtropical Tethyan regions (the East Mediterranean, Crimea, Caucasus, North Africa, Central Europe), and (6) moderate rates of evolution. Generic taxa existed for 17 - 21 Ma. Worth noting, the rates of species evolution did not decrease in comparison to the previous stage, and the species life-periods are 1 - 3 Ma.

So, these are the peculiarities of evolution of the foraminifera, which inhabited the Mediterranean in the Jurassic.

The evolutionary trends discussed were revealed by thorough studies of the foraminiferal assemblages from Syria.

Analysis of the composition, structure, and stratigraphic range of the Syrian assemblages suggests the following conclusions.

The most abundant and diverse assemblages are confined to the deposits of the Bathonian, Callovian, Oxfordian, and Tithonian stages. The Liassic, Aalenian(?), Bajocian, and Kimmeridgian strata, which have limited distribution in Syria, are characterized by less abundant, although locally rather diverse and copious assemblages. The quantitative relationship between the benthic forms with secreted and agglutinated tests is variable. Most of the stages show a predominance of arenaceous over calcareous forms, and only in the Bajocian and Oxfordian did the calcareous foraminifera become dominant in the benthic thanatocoenoses. This is related to the occasional invasions of the boreal-cosmopolitan forms, mainly of the Lenticulinidae and Vaginulinidae families, dominant in the assemblages from the Boreal provinces, Madagascar, western Indostan, and the Atlantic shelf of Canada. As was previously noted, the planktonic foraminifers are scarce

and represented by single specimens of *Globuligerina bathoniana* (Pazdro), *G. calloviensis* K. Kuzn., *G. meganomica* K. Kuzn., and *G. oxfordiana* (Grigelis). But these species are of great stratigraphic and correlative importance, being zonal index species for the foraminiferal zones of the Bathonian, Callovian, and Oxfordian. They subglobally distributed and can be used to correlate sections from different paleobiochores: provinces, areas, and belts.

ASSEMBLAGE ANALYSIS

The earliest Jurassic strata in Syria are of Liassic age and contain ostracodes and rare foraminifera. They are exposed in two sections, in the Anti-Lebanon, near the village of Arneh and in the Coastal Mountains, near the village of Jdaida. The first section yielded rare specimens of *Trochammina nana* Brady known from the Liassic of western Europe and an ostracode assemblage including *Procytheridea magnicoutensis* Apostolescu, *P. sermoisensis* Apostolescu, *P. triebel* Klingler, *P. vermiculata* Apostolescu, *Procytheridea* sp., *Progonocythere strilla* Sylvester-Bradley, *Aphelocythere kuhni* Triebelel et Klinger, *Isobythocypris ovalis* Bate and Coleman, *Cytherelloidea* sp., *Limnocythere* sp. nov. A, and *Limnocythere* sp. nov. B. The Jdaida section yielded tests of *Involutina liassica* (Jones), typical of the Liassic strata in Europe and North America.

The middle Jurassic strata are represented by deposits of all four stages and contain abundant and diverse foraminiferal thanatocoenoses.

The oldest assemblages include *Timidonella sarda* Bassoulet, Chabrier et Fourcade, *Ammobaculites cobbani* Loeblish et Tappan, *Lenticulina protracta* (Bornemann), *Citharina chlatrata* (Terquem), *C. pauperata* (Terquem), and *Praelamarckina humilis* Kaptarenko, which are characteristic of the Aalenian and Aalenian–Bajocian. The species list shows the presence of both typical Tethyan forms (*Timidonella sarda*) and boreal-cosmopolitan elements represented by the genera *Lenticulina*, *Astacolus*, and *Citharina*, which occur in abundance in western Europe, Madagascar, the Sinai Peninsula, and Morocco. This assemblage was found for the first time, present only in the sections of the Jurassic strata in southwestern Anti-Lebanon, Syria (the village of Arneh, the Hermon Mountains, and the foothills of the Jebel Sheikh Range). The assemblage is characterized by a high diversity of abundant species. For example, forms of *Timidonella sarda* Bassoulet, Chabrier et Fourcade are represented in some beds by dozens of tests of micro- and megalospherical generation. The same is true for the Lituolidae family, especially for abundant tests of some species of *Ammobaculites*. *Praelamarckina humilis* Kapt., known from the Aalenian in the platform part of the Ukraine and northwestern margins of the Donets basis, is represented by sporadically occurring small-sized specimens.

The Bajocian assemblages inherit particular features from their predecessors. They also include abundant boreal-cosmopolitan forms of Lenticulinidae and Vaginulidae, but no Tethyan endemics. The assemblages show more diverse taxonomic composition and include up to 30 species of 11 genera and 7 families. Noteworthy, the appearance of some Ceratobuliminidae (*Praelamarckina*, *Lamarckella*, and *Reincholdella*) and Epistominidae (*Epistomina*) in the Bajocian. These forms have a broad geographical distribution. However, being benthic organisms, they are indicative of facies-ecological environments and are related, generally, to shallow shelf sediments. Quite a different assemblage was recovered from the Bajocian deposits of the Coastal Mountains. It is less diverse than that from the Anti-Lebanon and consists mainly of rare lenticulins (*Lenticulina polymorpha* (Terq.), *L. veta* Hoffman), marginulins (*Marginulina solida* Terq.), and nodosariids.

No fossiliferous Bajocian strata have been found in the region of Kurd-Dag and Palmyrides.

The Bathonian is marked by a wide marine transgression in the East Mediterranean and many other regions of the world. Deposits of this age are recorded in all the Jurassic sequences of Syria, and contain abundant and diverse foraminiferal assemblages. Their composition differs considerably from that of the Bajocian assemblage, being more diverse: these assemblages include up to 65 species of 42 genera and 24 families.

The assemblages became dominated by forms with agglutinated tests, their secretory species are of secondary importance. There are new and scarce planktonic foraminifera of a single species *Globuligerina bathoniana* (Pazdro). According to their composition, the Bathonian assemblages, which inhabited the Syrian territory, can be classified into two main types. The first type found in the Anti-Lebanon includes abundant forms of Lituolidae, Lenticulinidae, Polymorphinidae, Ophtalmidiidae, Trocholinidae, Ceratobuliminidae, and planktonic Globuligerinidae. The assemblage is similar in composition to the Bathonian foraminiferal assemblage from the Sinai Peninsula, the Jebel Maghara Range (Said and Barakat, 1958). The most typical forms are *Reophax horridus* (Schwager), *Recurvoides bartouxi* Said et Barakat, *Ammobaculites fontinensis* Terquem, *A. suprajurassicus* (Schwager), *A. hermonensis* sp. n., *Lenticulina polymorpha* (Terquem), *Citharina proxima* (Terquem), *Lamarckella antiqua* Kapt., and *Globuligerina bathoniana* (Pazdro). The Bathonian strata of the Coastal Mountains, Kurd-Dag and Palmyrides contain another assemblage, which is dominated by the Tethyan endemics of the families Cyclamminidae (*Amijiella*, *Dhrumella*), Spirocyclinidae (*Haurania*), Dorothiidae (*Eomarssonella*), Protolixoplectidae (*Pseudomarssonella*, *Riyadhella*), and Dictioconidae (*Kilianina*, *Meyendorffina*, *Paracoscinolina*). The family Pfenderinidae is represented by numerous species of the genera *Paleopfenderina*, *Pfenderella*, *Praekurnubia*, and *Kurnubia*, which is of the utmost importance in this case.

The succession of foraminiferal assemblages enables us to subdivide the Bathonian strata of the

Coastal Mountains, with the most abundant and diverse fauna into lower and upper substages consisting of several zones or fauna beds. A distinct sequence of the assemblages and steady taxonomic composition is characteristic of the whole distribution area of this fauna type. The typical early Bathonian species include: *Haurania deserta* Henson, *Amijiella amii* (Henson), *Redmondoides lugeoni* (Septfontaine), *Pseudomarssonella primitiva* Redmond, *Riyadhella arabica* Redmond, *Protopeneroplis striata* Weynschenk, *Paleopfenderina trochoidea* (Smout et Sugden), *Dhrumella evoluta* Redmond, and *Globuligerina bathoniana* (Pazdro). Noteworthy is the almost complete absence of boreal-cosmopolitan elements typical of the southern Hermon assemblage.

Thus, the beginning of the Bathonian is marked by significant modifications in the foraminiferal assemblages, the appearance of new generic taxa of the Tethyan endemics (Fig. 1), and the decreasing importance of boreal-cosmopolitan elements.

The late Bathonian shows the same trends, four new genera appear near the early-late Bathonian boundary, in addition to the still existing genera known from the early Bathonian (*Paleopfenderina*, *Pfenderella*, *Satorina*, *Sanderella*, *Dhrumella*, *Haurania*, *Amijiella*, *Protopeneroplis*, *Pseudomarssonella*, *Riyadhella*, and *Redmondoides*). The boundary between the substages is defined by the renewal of species composition, a less important role of the genera *Haurania* and *Amijiella*, and the appearance of species of the above listed new Tethyan genera. The most typical late Bathonian species include: *Kilianina blancheti* Pfen., *Meyendorffina bathonica* Auroze and Bizon (zonal index species), *Paracoscinolina occitanica* Peyb., *Praekurnubia crusei* Redm., *Kurnubia bramkampi* Redm., *Berthelinella paradoxa* (Berth.), *Limognella dufaurei* Pell. and Peyb., *Paleopfenderina salernitana* Sart. and Cresc., *Mesoendothyra croathica* Gusič, *Pseudomarssonella bipatriata* Redm., and *Globuligerina bathoniana* (Pazdro) (Pellisse *et al.*, 1984).

The beginning of the Callovian is characterized by a contracting transgression and impoverished foraminiferal assemblages with still evolving Bathonian species and genera. The Callovian assemblages are clearly inherited from the Bathonian foraminifers. Most of the late Bathonian species continued to exist in the Callovian, when no new genera originated. The Tethyan endemics are still of prime importance in the assemblages, but there are also some forms of wide geographical distribution: Polymorphinidae (*Eoguttulina*, *Globulina*) Ammodiscidae (*Ammodiscoides*), Verneuilinidae (*Paleogaudryina*), and Haplophragmoidiidae (Haplophragmoides). During the evolution of the planktonic foraminifera, *Globuligerina bathoniana* (Pazdro) is replaced by the Gallovian species *Globuligerina meganomica* K. Kuznetsova and *G. calloviensis* K. Kuznetsova. They are still rare, but occur both in purely carbonate and in terrigenous-carbonate deposits. Callovian foraminiferal assemblages dominated by agglutinated forms are less diverse than those of the Bathonian, and contain representatives of 16 families, 29 genera, and nearly 60 species.

Like the Bathonian, the Callovian is also characterized by two types of assemblages: in Anti-Lebanon, the forms of wide geographic distribution are still dominant, whereas the Coastal Mountains were inhabited mainly by the Tethyan endemics. The composition of the Callovian assemblages is insufficient to define two units of this stage in Syria (as in the Crimea). In sections of different structural zones the stage varies, but in complete and continuous sections the main species assemblage can be traced as essentially consistent from the uppermost Bathonian to the base of the Oxfordian. In Anti-Lebanon, the most characteristic species are *Lituotuba nodus* Kos., *Kurnubia palastiniensis* Henson, *Paleogaudryina varsoviensis* Biel. et Poz., *Nautiloculina colithica* Mohler, and *Ammobaculites fontinensis* (Terquem).

The assemblage from the Coastal Mountains includes: *Ammodiscoides magharaensis* Said et Barakat, *Sanderella laynei* Redm., *Steinekella crusei* Redm., *Kurnubia palastiniensis* Henson, *Paleopfenderina salernitana* (Sart. et Cresc.), *Astacolus pellucida* Said et Barakat, *Frondicularia spissa* (Terq.), and *Reincholdella dreheri* Bart.

The Oxfordian was the expansion period of the marine transgression, which resulted in wide distribution of deposits of this age in the East Mediterranean, including Syria. These deposits contain extremely rich faunal communities, the most important components of which are foraminifera. Their assemblages are characterized by high taxonomic diversity, a uniform composition over vast areas (as a result of extensive fauna migrations), high density of most species populations reflecting the environmental stability of the paleobasins, the occurrence of planktonic forms, a higher abundance of secreted benthic forms as compared to agglutinated species and the dominance of widespread boreal-cosmopolitan components over the Tethyan endemics. These peculiarities are typical of foraminiferal assemblages from all areas of the Oxfordian deposits in Syria. Their taxonomic diversity (28 families, 46 genera, and more than 100 species) is high enough to reveal successive assemblages, to subdivide the Oxfordian into lower and upper substages, and to distinguish their foraminiferal zones. The early Oxfordian foraminiferal assemblages from the Anti-Lebanon sections (Hadar, Rowda, and Wadi Al-Karn) contain the following species: *Alveosepta jaccardi* (Schrodt), *Ammobaculites coprolithiformis* (Schwag.), *Pseudocyclammina maynci* Hott., *Mesoendothyra* sp., *Lenticulina brueckmanni* (Mjatl.), *L. quenstedti* (Guemb.), *L. russiensis* Mjatl., *Astacolus vacellantes* Esp. et Sigal, *Planularia beierana* (Guemb.), *Citharina entypomatus* Esp. et Sigal, *C. paralella* Biel. et Poz., *Marginulinopsis suprajurassicus* (Schwager), *Conorboides paravalendisensis* Reiss, *Spirillina kuebleri* Mjatl., *Epistomina nemunensis* Grig., *E. porcellanea* Brueckm., and *Globuligerina oxfordiana* (Grig.).

The assemblage consists mainly of widespread secreted benthic forms known from the Boreal province, Madagascar, the Sinai Peninsula, western Europe, Canada, and the Crimea. This permits us to correlate deposits of the lower Oxfordian *Lenticulina brueckmanni–Globuligerina oxfordiana* zone in european Russia, the Crimea, and Caucasus (*Stratigrafiya i Korrelyatsiya* ..., 1985).

The lower Oxfordian strata grade into the middle-upper Oxfordian beds. Their foraminiferal assemblages were clearly inherited from the earlier fauna. The species composition is renewed by the following late Oxfordian forms: *Reophax metensis* Franke, *Haplophragmium lutzei* Hanzl., *Ammobaculites brunsteini* Cushm., *Trocholina transversarii* Paalz., *Lenticulina quenstedti* (Guemb.), *L. audax* Loebl. et Tapp., and *Steinekella steineki* Redm. The last-mentioned species belongs to the Paleopfenderinidae family, peculiar to the Tethys. The Tethyan and Subtethyan endemics are only represented by the genera *Steinekella*, *Pseudocyclammina*, and *Everticyclammina*. The genera are poorly diversified at the species level, but in some beds their forms are very abundant.

The taxonomic stability of the late Oxfordian foraminiferal assemblages is reflected in the widespread zones distinguished in Syria, which can be considered as units of a common stratigraphic scale. Similar, though less diverse foraminiferal assemblages were recovered from the Oxfordian strata of the Palmyrides, despite the fact that previously they were thought to be missing here (Jarmakani *et al.*, 1989).

In Syria, the Kimmeridgian is marked by the beginning of a structural reorganization, extensive uplifts, and sea basin contraction, which influenced the composition, structure, and spatial distribution of foraminiferal assemblages.

Occurrences of Kimmeridgian strata are restricted mainly to Anti-Lebanon (the Wadi Al-Karn and Wadi Favuar sections). The shallow-water sediments here are predominantly clastic, oolitic, and stromatoporitic limestones, and contain impoverished foraminiferal assemblages: *Reophax hounstoutensis* Lloyd., *Triplasia jurassica* Mjatl., *Marssonella doneziana* Dain., *M. hehti* Dieni et Massari, *Citharina lepida* (Schwag.), and *Alveosepta personata* (Tobler). The last form is an index species from a zone of the same name, which occurs widely in the Mediterranean carbonate facies. This form is the only "Tethyan" species in the assemblage, whereas the rest are represented by widespread euryfacies forms. A similar assemblage with more Tethyan elements occurs in the deposits of the Coastal Mountains (the Nicola quarry), here defined as Kimmeridgian. The assemblage contains *Ammobaculites pellucida* Said et Barakat, *Pseudocyclammina* sp., *Alveosepta personata* (Tobler), *Nautiloculina oolithica* Mohler, and *Lenticulina subtilis* (Wins). It includes in general 14 families, 20 genera, and 25 species, most of which are agglutinated forms; planktonic species are lacking.

In the rest of the Syrian territory, there was either no Kimmeridgian sedimentation (Kurd-Dag), or sediments of this age were eroded as a result of the pre-Cretaceous uplifts, as evidenced by ostracode and foraminiferal faunas redeposited in the Cretaceous strata of some localities (the Wadi Jahannam section, Coastal Mountains).

The Tithonian deposits are preserved in only a few sections of Syria because the pre-Cretaceous uplifts involved a major part of the territory. They were studied in the Anti-Lebanon (the Wadi Al-Karn, Sad Al-Karn, and Wadi Favuar sections) and the Coastal Mountains (the Qadmous section), The deposits yielded abundant assemblages of high species diversity. They contain the widespread zonal species *Anchispirocyclina lusitanica* (Egger) and *Melathrokerion eospiralis* Gorb. The corresponding zone is recognizable in Syria, the Crimea, Caucasus, and probably in Morocco. The incompleteness of the Tithonian strata prevents a detailed subdivision. The Tithonian foraminiferal assemblages from Anti-Lebanon are characterized by a mixed composition including both the Tethyan and Subtethyan endemics and cosmopolitan forms, namely: *Gaudryina vadazi* Cushm. et Glaz., *Stomatostoecha compressa* Gorb., *Melathrokerion eospirialis* Gorb., *Alveosepta powersi* Redm., *Verneuilina angularis* Gorb., *Marssonella hehti* Dieni et Mass., *Anchispirocyclina lusitanica* (Egger), *Pseudocyclammina* sp. 1, and *Kurnubia jurassica* Redmond. The Tithonian strata of the Coastal Mountains (the Qadmous section) produced an assemblage differing in species composition and dominated by the Tethyan endemics *Bramkampella arabica* Redm. and the Subtethyan species: *Choffatella decipiens* Schlum., *Anchispirocyclina lusitanica* (Egger), *Pseudocyclammina parvula* Hott., *Feurthillia frequens* Maync, *Torinosuella* sp., and others. All these species are very abundant. In addition, the assemblage includes the Tithonian forms, which appeared in the Tithonian and then evolved in the Cretaceous. This section is likely to exhibit the latest Jurassic strata (the late Tithonian) and the beds transitional to the Berriasian.

Thus, the analysis of the development of the Jurassic foraminiferal assemblages allows the following conclusions.

(1) Study of the foraminifera evolution in relation to the dynamics of the Mediterranean sea basins revealed a number of stages different in the composition, structure, and distribution of their assemblages. Many of these stages correspond in duration to such stratigraphic units as a stage. Biological peculiarities of the studied foraminifera enable the recognition of two large evolutionary stages (megaphases); early-middle Jurassic and late Jurassic–early Cretaceous. These stages are different in their morphotypes of dominants, degree of endemism, tolerance, rates of evolution, intensity of speciation, and area distribution sizes of the foraminifers. The results show that the biological transformations of the fauna were slower than the changes in the abiotic factors that influenced the basins that were their habitat.

(2) The most distinct steps in the fauna renewal are recorded at the beginning of the Bathonian, in the late Bathonian, at the beginning of the Oxfordian, and at the beginning of the Tithonian. All these boundaries are marked by appearance of new taxa of a generic rank.

(3) All genera appearing in the middle Jurassic (Aalenian–Callovian) are tropical endemics. Beginning from the late Jurassic (Oxfordian–Tithonian) till the early Cretaceous (Berriasian–Barremian), new elements of the assemblages are represented exclusively by Subtethyan genera, which had wider distribution areas outside of the Tethys.

(4) In the Mediterranean, the changes in the foraminiferal assemblages near the Jurassic–Cretaceous boundary were of the same nature as in the Boreal province. The fauna was renewed at the specific level only, the Cretaceous and Jurassic assemblages are very similar, new elements (genera) appeared mainly in the Tithonian, and then evolved in the early Cretaceous.

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