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The Midian Stage of the Permian and Its Boundaries

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Abstract—The Midian Stage is suggested to correspond to the *Yabeina*–*Lepidolina* Genozone, i.e., to the entire existence time of the index genera. The first occurrence level of *Yabeina* forms is in the *Neoschwagerina margaritae* Zone in its stratotype section, and this zone should be considered as a constituent unit of the stage. This is also evident from a significant renewal of fusulinid and smaller foraminifer assemblages at the base of indicated zone, which was caused by a widespread transgression. The *Lepidolina kumaensis* Zone should be included into the Midian Stage as well. At present, none of the fauna groups seem to be suitable to precisely determine the stage boundaries. This problem remains to be solved in the future.

Key words: stratigraphy, fusulinids, the Permian System, stage, Tethys, correlation.

INVESTIGATION HISTORY OF THE MIDIAN STAGE

In 1958, Miklukho-Maclay (1958) distinguished the Murgabian Stage as a unit comprising the *Neoschwagerina*, *Sumatrina*, and “*Polydiexodina*” beds (Table 1). The Djamantal, Deire, and Karasu beds were later included in this stage according to data on the stratotype section of the Murgab River basin (Mt. Djamantal), and the southeastern Pamirs (Leven, 1967). The upper Kutal Beds along with the overlying Takhtabulak Formation were referred here to the Pamirian Stage.

Miklukho-Maclay reported on fusulinids from the Djamantal and Karasu beds. Neoschwagerinids were most characteristic among them, however, he did not attest to the presence of *Yabeina* and *Lepidolina*, which are the most evolved genera of this group. Nevertheless, Miklukho-Maclay decided to include into Murgabian Stage not only the *Neoschwagerina*, but also the *Yabeina* Beds, as it is evident from his correlation

schemes (Miklukho-Maclay, 1963). In the overlying Pamirian Stage, fusulinids are represented only by smaller, often aberrant forms, and all their larger representatives were assumed to become extinct at the Murgabian–Pamirian boundary.

The evident discordance between the factual data on the stratotype and Miklukho-Maclay’s idea to include the *Yabeina* Beds into the Murgabian Stage caused a serious, still on going discussion concerning the upper boundary of this stage. The later discovery of *Yabeina archaica* from the Karasu Beds (Dutkevich, 1967; Leven, 1967), which somehow supported the concept of including the *Yabeina* Beds in the stage, did not improve the general situation. The primitive character of this *Yabeina* species leaves room for considering it as the first indication of a younger fusulinid assemblage of the *Yabeina*–*Lepidolina* Genozone. Moreover, the Karasu Beds are composed of clastic limestones, mostly conglobreccias presumably of turbidity origin.

Table 1. Evolution of ideas on stratigraphic ranges of Murgabian and Midian stages

Miklukho-Maclay (1958, 1963)	Leven (1963)	Leven (1975)	Leven (1980)
Pamirian Stage <i>Reichelina</i> and smaller foraminifers	Pamirian Stage <i>Lepidolina</i> , <i>Yabeina</i>	Changhsinghian Stage	Dorashamian Stage
		Dzhulfian Stage	Dzhulfian Stage
Murgabian Stage <i>Neoschwagerina</i> , <i>Sumatrina</i> , “ <i>Polydiexodina</i> ”	Murgabian Stage <i>Neoschwagerina</i> , <i>Sumatrina</i> , “ <i>Polydiexodina</i> ”	Capitanian Stage <i>Yabeina</i> , <i>Lepidolina</i>	Midian Stage <i>Yabeina</i> , <i>Lepidolina</i>
		Murgabian Stage <i>Neoschwagerina</i>	Murgabian Stage <i>Neoschwagerina</i>
Darvazian Stage <i>Cancellina</i> , <i>Misellina</i>	Kubergandian Stage <i>Cancellina</i> , <i>Armenina</i> , <i>Misellina</i>	Kubergandian Stage <i>Cancellina</i>	Kubergandian Stage <i>Cancellina</i> , <i>Armenina</i> , <i>Misellina ovalis</i>

They bear mainly redeposited fusulinids, and this occurrence mode may be assigned to *Yabeina archaica* as well.

Compiling data on the Tethys in 1963, I noted that many smaller and aberrant fusulinids typical of the Pamirian Stage alone, as suggested by Miklukho-Maclay, show their first occurrence in the *Yabeina-Lepidolina* Genozone. This was my argument for including the latter into the Pamirian Stage (Leven, 1963). This idea did not contradict the available data on the stratotype of the Murgabian Stage, although its range in this case differed from that suggested by Miklukho-Maclay.

The new scale of more detailed stage subdivisions for the Tethyan region was published in 1975 (Leven, 1975a). In this scale, the *Yabeina-Lepidolina* Genozone was identified as an individual stage corresponding to the Capitanian Stage of the North American scale, and the latter name was accepted. However, discussing the new scale at the plenary session in 1980, the Interdepartmental Stratigraphic Committee (ISC) of the former USSR doubted the identity of the newly distinguished and Capitanian stages. When editing afterward the explanatory note to the Tethyan scale, I changed the unit name for the Midian Stage (Leven, 1980). The Arpa and Khachik formations of the Permian in Transcaucasia were suggested to be the unit stratotype, and, with the last name, the stage was authorized by the ISC (*Postanovleniya ...*, 1981).

According to the initial definition, the Midian Stage includes the sequence part between the Murgabian and Dzhulfian stages, which corresponds to the *Yabeina-Lepidolina* Genozone. The lower stage boundary is placed at the first occurrence level of extremely evolved higher fusulinids of *Yabeina* and *Lepidolina* genera, which also mark the mass abundance of aberrant forms. Such taxa as *Kahlerina*, *Dunbarula*, *Paradunbarula*, *Lantschichites*, *Chusenella*, *Sumatrana*, *Metadoliolina* along with extremely evolved *Neoschwagerina* and some other forms were listed as most characteristic of the stage (Leven, 1980).

The upper stage boundary was identified as corresponding to the base levels of the *Araxoceras latum* Zone of the ammonite zonation (including the *Araxilevis* Beds of the Dzhulfian Stage stratotype) and *Clarkina leveni* Zone of the conodont scale. It was suggested that this boundary should mark the total extinction of schwagerinids and neoschwagerinids, although there were other opinions concerning its significance.

FURTHER STUDIES ON THE MIDIAN STAGE AND RELATED PROBLEMS

After publication of the Tethyan scale with the newly introduced Midian Stage (Leven, 1980), numerous later stratigraphic and paleontologic works provided grounds to considerably specify its characteristics and to distinguish it in different regions from the

Mediterranean to the Far East and Japan. At the same time, new data yielded certain problems, first of all concerning the inadequate interpretation of the stage boundaries and its stratigraphic range.

First, I would like to mention the investigations of the scientific group under Kotlyar's leadership, whose monograph (Kotlyar *et al.*, 1989) presents comprehensive paleontologic substantiation of the Midian Stage based on type sections in the Transcaucasia, Pamirs, and the Far East. These researchers correlated the Midian deposits throughout the Tethys and confirmed the original characteristics of the stage. The sole difference is the statement on a somewhat lower position of its upper boundary, and I discuss this point below in more detail.

Japanese scientists, led by K. Nakazawa, also performed a large study of the Upper Permian. The group (Nakazawa *et al.*, 1975; *Iranian-Japanese ...*, 1981; *Pakistan-Japanese ...*, 1985) published detailed descriptions of sedimentary sequences in Iran, Kashmir, and the Salt Range, and demonstrated that they really include deposits of the Midian Stage. Publications of Chinese and French researchers (Zhang Zugi, 1984; Xiao *et al.*, 1986; Sheng and Jin Yugan, 1994; Lys, 1988a; Vachard and Ferrière, 1991; Vachard and Razgallah, 1993) explored further the paleontologic characteristics of the stage in different Tethyan regions. Because the Midian Stage is identified as an equivalent of the *Yabeina-Lepidolina* Genozone, the works of Ozawa (1975), Kobayashi (1986), and Rui Lin (1983) are of special interest for the description of the phylogeny and stratigraphic distribution of zonal index species. In addition, I should mention several works dealing with problems of the Midian Stage boundaries in their relation to one or another geological and biotic event (Kotlyar *et al.*, 1989; Leven, 1992, 1993a, 1993b; Jin Yugan *et al.*, 1994b; Mei Shilong *et al.*, 1994; Kozur, 1994; Vachard and Ferrière, 1991).

All these studies confirmed the individual and peculiar character of the Midian Stage in the geological history of the Tethys. This stage marked a wide transgression, which resulted in a substantial renewal of marine biota, extended its distribution areas, and gave rise to a higher taxonomic diversity of principal faunal groups. Sedimentary sequences, which were studied in various parts of the Tethys, showed that the Midian Stage can be recognized throughout this region. Its paleontologic characteristics were carefully refined and substantiated, and new results allowed the correlation of data on fusulinids, smaller foraminifers, brachiopods, ammonoids, and conodonts.

At the same time, it should be noted that current ideas on the stratigraphic range of the Midian Stage and criteria to distinguish its boundaries are controversial for several reasons. Boundaries of the *Yabeina-Lepidolina* Genozone, which corresponds to the Midian Stage by definition, are not determined very precisely. General principles of tracing the stage boundaries in

Table 2. Stratigraphic schemes of the Akasaka section after different authors

Deprat, 1914	Ozawa, 1927	Morikawa, 1958	Hongo, 1959
<i>Y. inoyei</i> <i>Y. globosa</i>	<i>Y. globosa</i>	<i>N. minoensis</i> <i>Y. inoyei</i> "Y." <i>katoi</i> <i>Y. globosa</i>	<i>Y. globosa</i>
" <i>N. globosa</i> " (= <i>G. gifuensis</i>) " <i>N. margaritae</i> " (= <i>Y. ozawai</i>)	" <i>N. margaritae</i> " (= <i>Y. ozawai</i>)	<i>Y. (=L.) igoi</i> <i>N. (=G.) larga</i> " <i>N. margaritae</i> "	<i>G. douvillei</i> <i>G. gifuensis</i> <i>Y. ozawai</i>
" <i>N. craticulifera</i> "	" <i>N. craticulifera</i> "	" <i>N. craticulifera</i> "	" <i>N. craticulifera</i> "

concrete sections lacking index species of the zone are unclear. The upper boundary of the Midian and the lower boundary of the Dzhulfian stages are identified on the basis of fusulinids and ammonoids, respectively, and it is difficult to coordinate these different criteria. Finally, stratotypes of the Midian and Murgabian stages are poorly chosen, and this allows for personal interpretations. We shall consider these points in more detail below.

YABEINA-LEPIDOLINA GENOZONE: DISTINGUISHING CRITERIA AND CHARACTERISTIC FUSULINIDS

The *Yabeina-Lepidolina* Genozone corresponds to the Midian Stage by definition, and it is important to specify its actual meaning.

Originally, the stratigraphic range of the genozone was identified by a theoretical approach. It was thought to comprise the total evolutionary interval of index genera, whose appearance and extinction were presumably coeval with large reorganization stages in fusulinid biota. It was and remains precisely this principle, which affords an opportunity to speculate on the distinctive Midian Stage in the Tethys evolution.

As usual, reality turned out to be more complex than the hypothesis. It does not disprove the latter in general, but complicates many particular problems, among which the precise determination of appearance and extinction levels of *Yabeina* and *Lepidolina* forms is the most important. Yabeins and lepidolins in particular were most abundant in the eastern Tethys (southern China, Indochina, Japan, and the Far East). They occur as components of different fusulinid assemblages, whose relations in space and time are debatable. Understanding these relations, we may solve general problems concerning the Midian Stage. Using typical representatives of *Yabeina* and *Lepidolina* genera, it is possible to subdivide the studied assemblages into the four following types: (1) *Y. ozawai-L. igoi*, (2) *Y. globosa*, (3) *L. multiseptata*, and (4) *L. kumaensis*.

The first assemblage was distinguished in the classical Akasaka section of Japan, precisely in beds corre-

sponding to the *Neoschwagerina margaritae* Zone after Ozawa (1927). Honjo (1959) discovered yabeins at the base of the beds, and identified them as representing the new species *Y. ozawai*. He also noted that forms, distinguished by Ozawa as *N. margaritae* Deprat, are not identical to the holotype of Deprat (1913), and represent a synonym of the new *Yabeina* species. Accordingly, this scientist renamed the *N. margaritae* Zone as the *Y. ozawai* Zone.

Honjo discovered yabeins only from the basal part of the zone. Its upper part (Table 2) was better studied by Morikawa and Suzuki (Morikawa, 1958; Morikawa and Suzuki, 1961). In the corresponding part of the section, Morikawa distinguished *Neoschwagerina margaritae* Deprat, "*N.*" (= *Gifuella*) *larga* Morikawa et Suzuki, and "*Yabeina*" (= *Lepidolina*) *igoi* Morikawa et Suzuki beds, or zones in his terms. The first of these units correlates well with the *Y. ozawai* Beds of Honjo's scheme, because they yielded the same *Gifuella* forms: *G. amacula* Honjo (= "*N.*" *muratai* Morikawa et Suzuki). In overlying beds, this taxon shows a higher organization. The "*N.*" (= *G.*) *larga* Beds contain remains of *Yabeina?* sp.; "*Y.*" (= *L.*) *igoi* occurring higher in the section is the descendant of *G. larga*, and differs from the latter only by its secondary spiral septula. This level also bears first "*Y.*" (= *L.*) *multiseptata* (Deprat). Thus, the entire interval of the *N. margaritae* Zone after Ozawa contains yabeins and lepidolins. In addition to them and the *Gifuella* forms already mentioned, this interval also yielded *Gifuella gifuensis* Honjo, *G. douvillei* Ozawa, *Neoschwagerina margaritae* Deprat, *N. colaniae* Ozawa, *N. minoensis* Deprat, *N. sakaguchii* Yamagiwa, *Pseudodoliolina* spp., *Verbeekina* spp., *Parafusulina* spp., *Pseudofusulina* spp., and *Codonofusiella* spp. It should be noted that some forms, pictured in cited publications and identified as *N. margaritae*, were mistaken for this taxon, because they have more primitive aspects as compared to the holotype (Leven, 1993b).

The next *Y. globosa* fusulinid assemblage was reported from the higher level of the same section. In addition to *Y. globosa* (Yabe), it includes *Yabeina inouyei* Deprat, *Neoschwagerina katoi* Ozawa, *N. mar-*

garitae Deprat, *N. minoensis* Deprat, "N." (= *Gifuella*) *okuboi* Morikawa et Suzuki, "N." (= *G.*) *hanaokensis* Morikawa et Suzuki, *Sumatrina annae* Volz, *Parafusulina* spp., *Pseudofusulina* spp., and *Kahlerina* spp. (Deprat, 1914; Ozawa, 1927; Morikawa, 1958; Honjo, 1959; Hanzawa and Murata, 1963). Fusulinids, which were discovered by Kobayashi (1986) from the Gozeniyama Formation of the southern Kwanto Mountains, may also represent the same assemblage. Reported from here are the following forms: *Yabeina globosa* (Yabe), *Neoschwagerina minoensis* Deprat, "Colania" (= *Gifuella*) *larga* (Morikawa et Suzuki), *Verbeekina verbeeki* Geinitz, *Chusenella* spp., *Pseudofusulina* spp., *Dunbarula* spp., *Paradoxiella* spp., *Rausarella* spp., *Sichotenella* spp., *Reichelina* spp., *Nankinella* spp., and *Kahlerina* spp. Using a large data base, Kobayashi elaborated the considerable morphologic diversity of *Y. globosa* species. In his opinion, *Y. inouyei* and *N. katoi* from the Akasaka section are synonyms and represent morphologic varieties of this species. In addition, the assemblage under consideration includes many smaller and aberrant fusulinids typical of the Midian Stage.

The *L. multiseptata* fusulinid assemblage is the most widespread in southeastern Asia. Its general characteristics were reported by Ozawa (1975). Dominant representatives of this assemblage belong to the *Gifuella*-*Lepidolina* phylogenetic lineage in contrast to the previous assemblage with prevailing *Neoschwagerina* and *Yabeina* forms, whose phylogenetic evolution was coeval. The compiled list of genera and species occurring together with fusulinids of *L. multiseptata* group in many localities of Japan (Toriyama, 1954, 1958; Ozawa, 1975), China (Sheng, 1963; Xiao *et al.*, 1986), and Indochina (Ishii, 1966; Ishii *et al.*, 1969; Ozawa, 1975; Toriyama *et al.*, 1975; Tien, 1979; Ingvat *et al.*, 1980; Toriyama, 1984; and others) is as follows: *Gifuella douvillei* (Ozawa), *Neoschwagerina cheni* Sheng, *N. margaritae* Deprat, *N. kueichowensis* Sheng, *N. haydeni* Dutkevich et Khabakov, *Sumatrina annae* Volz, *S. longissima* Deprat, *S. fusiformis* Sheng, *Pseudodoliolina pseudolepida* (Deprat), *Metadoliolina multivoluta* (Sheng), *M. gravitesta* (Kanmera), *Verbeekina verbeeki* (Geinitz), *Eopolydioxodina* spp., *Parafusulina* spp., *Pseudofusulina* spp., *Chusenella* spp., *Schubertella* spp., *Dunbarula* spp., *Codonofusiella* spp., *Lantschichites* spp., *Sichotenella* spp., *Reichelina* spp., *Nankinella* spp., and *Staffella* spp.

The *L. kumaensis* assemblage is known only in some sections (Kuma, Shikoku, southeastern Kwanto, and Iwaizaki) of Japan (Ozawa, 1975) and the Far East (Kotlyar *et al.*, 1989). The most representative assemblage was reported from Primor'e, where *L. kumaensis* Kanmera occurs in the *Parafusulina stricta* and *Metadoliolina lepida*-*Lepidolina kumaensis* zones of the Chandalaz Horizon (Kotlyar *et al.*, 1989). The cited authors believed that this form is also present in the underlying *Monodioxodina sutschania*-*Metadoliolina dutkevitchi* Zone, however this assumption turned out

to be invalid (G.V. Kotlyar, personal communication). It was proved that the first occurrence level of *L. kumaensis* is in the *P. stricta* Zone. Above it, this form becomes abundant and attains its highest state of evolution giving rise to the new *Neosumatrina* genera (data of N.O. Chediya cited from Kotlyar *et al.*, 1989).

The composition of associated forms changes upward in the section. Representatives of the Schwagerinida order prevail near the base and lose their significance higher. *Metadoliolina* and *Lepidolina* forms are dominant among higher fusulinids especially in the upper zone. The latter comprise several varieties of *L. kumaensis* Kanmera and *L. multiseptata* Deprat typical of the aforementioned assemblage. The upper zone also yielded rare *Neoschwagerina* and several *Yabeina* species.

The assemblage of smaller fusulinids (including their aberrant forms) is very diverse and abundant. It includes different species of such genera as *Sichotenella*, *Reichelina*, *Parareichelina*, *Rausarella*, *Codonofusiella*, *Dunbarula*, *Minojapanella* (Wutuella), *Lantschichites*, *Kahlerina*, and *Pseudokahlerina*. It is significant that *Codonofusiella*, *Reichelina*, and *Sichotenella* forms show their appearance already in the *M. sutschanica*-*M. dutkevitchi* Zone, while those of *Lantschichites* and *Kahlerina* genera occur in the *P. stricta* Zone.

As it was already mentioned, relations between the described fusulinid assemblages in space and time are not very clear. Representative sections are rare, their outcrops with different fusulinid assemblages are spatially dismembered and confined to contrasted sedimentary facies. In addition, there is no commonly accepted view on fusulinid taxonomy and phylogenetic evolution. The latter does not fit the simple model of divergent evolution, but is more readily consistent with the idea suggesting a parallel development, in which forms, similar in their features and assigned on this basis to the same taxon (for instance, to yabeins), actually originated in parallel phylums and perhaps at different times because of distinct evolutionary rates.

The most detailed model of relations between distinct fusulinid assemblages was elaborated by Ozawa (1970, Fig. 2). For the stratigraphic range in question, he distinguished four assemblages: (1) *Neoschwagerina craticulifera*, (2) *Yabeina globosa*, (3) *Lepidolina multiseptata shiraiwensis*-*Colania* (= *Gifuella*) *douvillei*, and (4) *Lepidolina multiseptata multiseptata*-*L. kumaensis*. According to Ozawa, the first of them is characteristic of the second half of the Middle Permian, i.e., of the *N. craticulifera* and *N. margaritae* zones. The second and third are coeval, and correspond to the *Y. globosa* Zone of the Upper Permian. The *L. multiseptata multiseptata*-*L. kumaensis* assemblage is already of the Dzhulfian age.

I agree with Ozawa's conclusion that the *N. craticulifera* assemblage is the oldest among them, and would add only that its part, occurring in the *N. margaritae*

(= *Y. ozawai*) Zone, includes yabeins and lepidolins even here, as follows from data on the Akasaka section. There is no question that *Y. globosa* and *L. multiseptata shiraiwensis*-C. (=G.) *douvillei* assemblages are approximately coeval. Actually, first forms of the *L. multiseptata* group appear below the *Y. globosa* beds. Therefore, these beds are, at least partially, the appropriate level for the abundance of respective *Lepidolina* species.

The most complex problem is to identify the stratigraphic position of the *L. multiseptata multiseptata*-*L. kumaensis* beds. When placing them above the *Y. globosa* beds into the Dzhulfian Stage, Ozawa (1979, p. 39, Fig. 10) had in mind the higher evolutionary level of *L. kumaensis* as compared to any *Yabeina* forms. However, it is not inconceivable that progressive evolution toward thinner, but denser test walls and greater number of axial and secondary spiral septula was faster in the *Gifuella*-*Lepidolina* phylogenetic lineage as compared to that of *Neoschwagerina*-*Yabeina* taxa. In this case, *L. kumaensis* could be older in origin than was assumed by Ozawa, and this is supported by data on the Chandalez Horizon in Primor'e. Nevertheless, it is not to be supposed that the uppermost beds bearing *L. kumaensis* (*M. lepida*-*L. kumaensis* Zone in Primor'e) are younger than the *Y. globosa* beds. Precisely, this interval of the sequence, but not the entire biozone of *L. kumaensis* species is usually termed as the *L. kumaensis* Zone in publications.

Rui Lin (1983), who discovered *L. kumaensis* in association with *L. multiseptata* from the middle part of the Maokou Formation in southern China, also was in favor of the earlier appearance of the former form. However, his arguments are not very correct, because fusulinids, which were identified in this case as *L. kumaensis*, are at a lower level of evolution relative to the authentic representatives of this species, and in this respect, they are more similar to *L. igoi* from the Akasaka section.

In summarizing the discussed data, I would like to state the following:

(1) *Yabeina* and *Lepidolina*—the index genera of the Midian Stage—are approximately coeval with respect to their appearance and extinction time.

(2) The *Yabeina*-*Lepidolina* Genozone comprises the stratigraphic interval from the *N. margaritae* Zone, first distinguished by Y. Ozawa, up to and including the *L. kumaensis* beds.

(3) Accordingly, by its original definition, the Midian Stage corresponds to this stratigraphic interval of the sequence.

(4) In such an understanding, the Midian Stage can be subdivided into three units: *Y. ozawai*-*L. igoi*, *Y. globosa*-*L. multiseptata*, and *L. kumaensis* (s.s.) zones. However, one should bear in mind that this subdivision is somewhat arbitrary, because boundaries between these zones have so far not been identified very pre-

cisely, and two upper zones may partially overlap each other.

(5) The fusulinid assemblage of the first zone is distinct because of the first appearance of primitive *Yabeina* and *Lepidolina* forms. It also includes abundant *Gifuella* species and such forms as *N. margaritae* Deprat (s.l.), *N. colaniae* Ozawa, *N. haydeni* Dutkevich et Khabakov, *N. craticulifera* (Schwager) (s.s). Associated taxa are *Pseudodoliolina*, *Verbeekina*, *Sumatrana annae* Volz, *S. fusiformis* Sheng, and the first representatives of *Metadoliolina*. It is likely that *Afghanella sumatranaeformis* (Gubler) also occurs at this stratigraphic level. Schwagerinids are represented here by *Chusenella*, *Parafusulina*, *Pseudofusulina*, *Eopolydiexodina*, and possibly *Rugososchwagerina* and *Monodiexodina* genera. *Codonofusiella*, *Dunbarula*, *Rauserella*, *Reichelina*, and *Parareichelina* forms were recognized among smaller fusulinids.

The *Y. globosa*-*L. multiseptata* Zone is marked by an abundance of *Yabeina* and *Lepidolina* species. *L. kumaensis* seems to appear here. Representatives of the *Neoschwagerina* genus include highly evolved *N. margaritae* Deprat (s.s), *N. katoi* Ozawa, and *N. minoensis* Deprat. Such taxa as *Sumatrana longissima*, *Metadoliolina*, and *Verbeekina* occur frequently and associate with numerous *Chusenella*, *Pseudofusulina*, and *Parafusulina* forms. *Codonofusiella*, *Dunbarula*, *Lantschichites*, *Minojapanella* (*Wituella*), *Reichelina*, *Rauserella*, *Sichotenella*, and *Kahlerina* genera are abundant among smaller and aberrant fusulinids.

Lepidolina and *Metadoliolina* species are dominant in the *L. kumaensis* Zone. They associate with less abundant *Yabeina*, *Neoschwagerina*, *Parafusulina*, *Pseudofusulina*, and *Chusenella* forms. Like the previous zone, this one encloses approximately the same assemblage of smaller and aberrant fusulinids.

BOUNDARIES OF THE MIDIAN STAGE

At present, there is no doubt that the Midian Stage is a distinct stratigraphic unit, which can be traced nearly everywhere. However, problems concerning its boundaries are still unresolved.

For the lower boundary, I would reduce the problem to two main questions: (1) should we include the beds, which used to be referred to the *N. margaritae* Zone, into the Midian Stage; and, subsequently, (2) what criteria provide the means to recognize and trace this boundary. The situation with the upper boundary is more complex because of diverse approaches to its identification.

Lower boundary of the Midian Stage. As follows from data discussed above, all the Murgabian generic taxa, with a possible exception of *Praesumatrina*, are passing into the Midian Stage. Therefore, identifying the lower boundary of the latter by using fusulinids, we should take into account only the appearance of new genera. The Akasaka section, for instance, demon-

strates that the first occurrence of *Yabeina* and *Lepidolina* genera is confined to the *N. margaritae* Zone. Is this sufficient evidence for placing the boundary at the base of this zone? From the formal viewpoint, the answer is yes, because by definition the Midian Stage corresponds to the *Yabeina*-*Lepidolina* Genozone. However, such an answer would be more convincing, if a greater number of taxa in the fusulinid community showed their renewal.

To evaluate the situation from this standpoint, I shall try to analyze all changes in fusulinid biota from the basal beds of the *N. margaritae* Zone.

In addition to *Yabeina* and *Lepidolina*, the most characteristic Midian genera are *Dunbarula*, *Codonofusiella*, *Lantschichites*, *Reichelina*, *Sichotenella*, *Rauserella*, *Kahlerina*, *Metadoliolina*, *Sumatrana*, and *Chusenella*. Some of them, such as *Dunbarula*, *Codonofusiella*, *Sumatrana*, and *Chusenella*, appear in the Murgabian Stage, they are, however, not very characteristic of the latter. Other genera have never been reported from beds known to be Murgabian in age.

Unfortunately, fusulinid assemblages from the *N. margaritae* Zone of the Akasaka section are not very diverse, and as far as the aforementioned genera are concerned, the zone yielded here only *Codonofusiella* forms. Therefore, we shall consider fusulinids from other localities, which include beds traditionally correlated with the stratotype of the *N. margaritae* Zone.

In southern China, the *Yabeina* beds directly overlie the *Neoschwagerina* (after Sheng, 1963), or *Afghanella schencki* Zone (after Xiao *et al.*, 1986). The upper part of the latter yielded fusulinids typical of the *N. margaritae* Zone, which are represented by such characteristic species as *Neoschwagerina haydeni* Dutkevich et Khabakov, *Gifuella gifuensis* Honjo, *G. douvillei* (Ozawa), *Afghanella sumatranaeformis* (Gubler), *Sumatrana longissima* Deprat, *S. fusiformis* Sheng, *S. annae* Volz, *Metadoliolina pulchra* (Sheng), and many others. *Kahlerina* sp., which was noted among them, does not occur in lower strata.

In the Salt Range, the *N. margaritae* Zone is thought to correspond to the lower beds 1 and 2 of the Wargal Formation, because the last bed yielded its index species (*Pakistan-Japanese ...*, 1985). Here and in bed 1, this species occurs together with *Codonofusiella* and *Reichelina* forms, typical fossils of the Midian Stage. The Midian age of these beds is also substantiated by the discovery of conodonts of the *Hindeodus excavatus*-*Merrilina divergens* Zone, and these fossils suggest that the beds are correlative with the upper part of the Maokou Formation in southern China. Conodonts from overlying beds 4 and 5 belong to the *Hindeodus julfensis*-*Clarckina leveni* Zone of the Dzhulfian Stage¹ (Wardlaw and Pogue, 1995). The Murgabian Stage seems to be entirely missing in this section.

¹ H. Kozur (personal communication), who revised conodonts from the Wargal Formation, concluded that bed 4 still is of the Midian Stage, and indicative Dzhulfian taxa appear only in bed 5.

In the southeastern Pamirs, the Karasu Beds of the Gan Formation used to be considered as an equivalent of the *N. margaritae* Zone (Leven, 1967; Kotlyar *et al.*, 1983), although Miklukho-Maclay (1958) included them into the Murgabian Stage. The beds bear *Yabeina archaica* Dutkevich et Khabakov and highly evolved *Neoschwagerina* forms, such as *N. ex gr. margaritae* Deprat, *N. minoensis* Deprat, and *N. haydeni* Dutkevich et Khabakov. They are in association with *Dunbarula* spp. and *Codonofusiella* spp., both unknown from underlying deposits.

In the Khwaja-Ghar and Bulola localities of northern Afghanistan, the *N. margaritae* Zone is correlative with beds E and F of the carbonate group transgressively overlying limestones with fusulinids of the lower Murgabian Substage (Leven, 1982; Leven, in press). These beds enclose abundant fusulinids: *Dunbarula kitakamiensis* Choi, *Codonofusiella* sp., *Yangchienia haydeni* Thompson, *Kahlerina pachythea* Kochansky-Devidé, *Pseudokahlerina compressa* Sosnina, *Colania* n. sp., *Neoschwagerina margaritae* Deprat, *N. haydeni* Dutkevich et Khabakov, *N. occidentalis* Kochansky-Devidé, *N. kojensis* Toumanskaya, *Afghanella tumida* Skinner et Wilde, *A. schencki* Thompson, *A. robbinsae* Skinner et Wilde, *A. sumatranaeformis* (Gubler), *Sumatrana annae* Volz, *Verbeekina verbeeki* (Geinitz), *Pseudodoliolina ozawai* Yabe et Hanzawa, *Armenia crassispira* (Chen), *Chusenella minuta* Skinner, *C. sinensis* (Sheng), *Rugosochusenella* n. sp., *Rugosofusulina furoni* (Thompson), *Pseudofusulina paralpina* (Chen), *P. gigantea* (Deprat), *Eopolydiexodina afghanensis* (Thompson), and *E. bithynica* (Erk). Lys and Lapparent (1971) reported from these beds also *Reichelina minuta* Erk, *R. pulchra* K.M.-Maclay, and *R. cribroseptata* Erk (Lys and Lapparent, 1971). Such genera as *Reichelina*, *Kahlerina*, *Codonofusiella*, and *Dunbarula* indicate the Midian age of the beds. However, the rest of the assemblage is usually typical of the *N. margaritae* Zone of the Murgabian Stage. Nevertheless, the beds should be referred to the Midian Stage, because their *Neoschwagerina* forms are similar, or even identical, to respective species from localities in Turkey, Croatia, and Tunisia, where they occur in association with *Yabeina* species (Skinner, 1969; Kochansky-Devidé, 1965; Lys, 1988a; Vachard and Razgallah, 1993). In addition to *Yabeina* and *Neoschwagerina* genera, the described beds also yielded most of the taxa listed above.

A similar fusulinid assemblage, though lacking yabeins and therefore considered as Murgabian (Siehl, 1967; Vachard, 1980), is known from limestones exposed at the Altimur Pass southward of Kabul. From these rocks, I identified *Dunbarula nana* Kochansky-Devidé, *Lantschichites minimus* (Chen), *Yangchienia thompsoni* Skinner et Wilde, *Kahlerina pachythea pusilla* Kochansky-Devidé, *K. globiformis* Sosnina, *K. africana* Skinner et Wilde, *Nankinella* sp., *Sphaerulina croatica* Kochansky-Devidé, *Reichelina* cf. *changhsingensis* Sheng et Chang, *Colania* sp.,

Neoschwagerina margaritae Deprat, *N. haydeni* Dutkevich et Khabakov, *Verbeekina* (*Verbeekina*) *verbeeki* (Geinitz), *V. (Paraverbeekina) pontica* A.M.-Maclay, *V. (Quasiverbeekina)* n. sp., *Pseudofusulina hupehensis* (Chen), *P. solita* (Skinner), and *Rugososchwagerina* n. sp.

Lantschichites, *Kahlerina*, and *Reichelina* forms from this assemblage definitely indicate its Midian age. This conclusion is confirmed, because limestones immediately overlying this level contain the typical Dzhulfian fusulinids, among which *Lantschichites*, *Codonofusiella*, *Reichelina*, *Colaniella*, *Robuloides*, and some other taxa were identified by A. Ziehl and D. Vachard.

Localities of the Velebit and Lika ranges in Croatia, which were described by Kochansky-Devidé (1965), are also very significant for the analysis in question. Here, the beds ("second and third limestone zones") bearing *Yabeina syrtalis* (Douville) are doubtlessly of the Midian age. Light dolomites below them yielded *Neoschwagerina rotunda* Deprat, *N. craticulifera* (Schwager), *N. occidentalis* Kochansky-Devidé, and *N. margaritae* Deprat, which are very similar to the species from Afghanistan. Moreover, in both regions these taxa associate with *Dunbarula*, *Kahlerina*, *Verbeekina*, *Sphaerulina*, and *Nankinella* forms. All these taxa, including genus *Neoschwagerina*, proceed into the *Yabeina* Beds.

A similar situation was observed in Tunisia, where distinct beds with *Yabeina syrtalis* (Douville) and *Y. punica* (Douville) also yielded highly evolved species of *Neoschwagerina*, *Kahlerina*, *Reichelina*, *Rausserella*, *Codonofusiella*, *Dunbarula*, and *Chusenella* genera (Skinner and Wilde, 1967; Vachard and Razgallah, 1993). This fusulinid assemblage is definitely Midian in general composition, and I cannot agree with Vachard and Razgallah, who referred it, though with reservations, to the Murgabian Stage based on the presence of *Neoschwagerina* forms. As was shown, this genus is transient throughout the Midian interval up to the *M. lepida*-*L. kumaensis* Beds.

Well-founded data by Lys (1988b), which are based on drilling results, allowed him to show that deposits transgressively overlying the Lower Permian strata contain fusulinids of the *N. margaritae* Zone and beds transitional between this and *N. craticulifera* Zone. From the upper part of this interval, he identified *Rausserella staffi* Skinner et Wilde, *Reichelina cribroseptata* Erk, *Codonofusiella nana* Erk, *C. paradoxa* Dunbar et Skinner (= *Lantschichites*?), *Dunbarula mathieui* Ciry, *D. nana* Kochansky-Devidé, *Yangchienia thompsoni* Skinner et Wilde, *Chusenella rabatei* Skinner et Wilde, *Pseudofusulina navillei* (Erk), *Eopolydiexodina afghanensis* (Thompson), *E. bithynica* (Erk), *E. megasphaerica* (Leven), *Neoschwagerina fusiformis* Skinner et Wilde, *N. tebagensis* Skinner et Wilde, and *Sumatrina annae* Volz. Somewhat lower, this scientist recorded *Codonofusiella nana*

Erk, *Dunbarula nana* Kochansky-Devidé, *Leella bel-lula* Skinner et Wilde, *Rugososchwagerina sera* (Erk), *Afghanella africana* Skinner et Wilde, *A. robbinsae* Skinner et Wilde, *A. tumida* Skinner et Wilde, *Sumatrina longissima* Deprat, *Verbeekina (Paraverbeekina) pontica* A.M.-Maclay, and *V. (Verbeekina) verbeeki* (Geinitz).

In total, this fusulinid assemblage is identical to that from Afghanistan and similarly includes typical smaller and aberrant fusulinids of the Midian Stage.

Fusulinids, which were discovered from exotic blocks in Sicily (Skinner and Wilde, 1966), can be attributed to the same assemblage. Present among them are highly evolved representatives of *Neoschwagerina*, *Verbeekina*, *Chusenella*, *Rugososchwagerina*, *Yangchienia*, and some other taxa, as well as *Kahlerina*, *Dunbarula*, and *Rausserella* species. These fusulinids associate with ammonoids of the so-called "Sicilian Assemblage" (Gemmellaro, 1887). It is also interesting that similar ammonoids were recorded in the Cache Creek Group of British Columbia, where they occur together with primitive *Yabeina* forms (Ross, 1971). These data provide additional grounds to correlate strata bearing this fauna with the *N. margaritae* Zone in its stratotype.

This information shows that in the central and western Tethys fusulinid assemblages experienced renewal with the appearance of many Midian genera before the emergence of *Yabeina* forms in the beds, which used to be correlated with *N. margaritae* Zone. The changes are notable not only among fusulinids, but also in assemblages of smaller foraminifers, which incorporated at that time such genera as *Dagmarita*, *Baisalina*, *Hemigordiopsis*, *Froncina*, *Abadehella*, *Neoendothyra*, *Rectostipulina*, and some others typical of the Midian Stage (Lys, 1988b; Altiner, 1984). The evident reason of this renewal was the marine transgression over the Tethyan region, most noticeable in its peri-Gondwana areas (Lys, 1988a, 1988b; Baud *et al.*, 1993; Leven, 1993a, 1993b). As is clear from many sections (Tunisia, Oman, Croatia, Turkey, and Iran), the beginning of the transgression was confined to the time of the *N. margaritae* Zone.

To summarize the discussion, it is possible to conclude the following:

(1) In the eastern Tethys, the first occurrence level of *Yabeina* and *Lepidolina* genera is confined to the *N. margaritae* Zone in its stratotype section.

(2) In more western areas, *Yabeina* forms appear later, however the beds correlative with the *N. margaritae* Zone of Japan enclose here other genera typical of the Midian Stage. Some of them are transient and occur even higher in the sequence, in the Dzhulfian and Dorashamian stages. A similar situation is also characteristic of smaller foraminifers.

(3) The renewal of foraminiferal assemblages was related to a wide transgression.

(4) Both the abiotic and biotic events were more significant at the beginning than at the end of the *N. margaritae* interval. Therefore, the base of this zone seems to represent the preferable level for the lower boundary of the Midian Stage.

(5) This model of the boundary position does not suggest a revision of the original concept identifying the Midian Stage as a unit corresponding to the *Yabeina-Lepidolina* Genozone, because these genera first appear at the base of the *N. margaritae* Zone in its stratotype locality. The zone base is also marked by first occurrences of many other index genera of the Midian Stage listed in its initial definition.

(6) The model is in good agreement with data on the stage stratotype corresponding to the Permian stratigraphic range of the Arpa and Khachik formations in Transcaucasia. Actually, remains of *Yangchienia thompsoni*, *Sumatrina annae*, *Verbeekina*, *Chusenella*, *Pseudofusulina*, and first species of *Kahlerina*, *Minojapanella* (*Wutuella*), *Codonofusiella*, *Dunbarula*, and *Reichelina* genera are confined to the base of the Arpa Formation. The same level yielded here typical taxa of smaller foraminifers of the Midian Stage, such as *Abadehella*, *Neoendothyra*, *Dagmarita*, *Pseudolangella*, and *Partisania* (Leven, 1975b; Kotlyar *et al.*, 1989). All of these genera and species are also characteristic of beds referred to the *N. margaritae* Zone.

(7) Fusulinids do not provide a unique criterion to place and trace the Murgabian-Midian boundary, regardless of its definition. One may speculate only on a series of interchangeable indicators, among which are the following: the first occurrence (in general, but not in a particular section) of *Yabeina* and *Lepidolina* taxa; the appearance of *Afghanella* species corresponding to the evolutionary level of *Afghanella robbinsae* and *A. tumida*; the emergence of *Sumatrina* forms of *S. annae* and *S. fusiformis* type; the origin of evolved *Neoschwagerina* species such as *N. haydeni* (s.s.), *N. craticulifera* (s.s.), and *N. occidentalis*; and finally, the first occurring representatives of *Kahlerina*, *Reichelina*, *Sichotenella*, and *Lantschichites* genera.

All these features mark the lower boundary of the Midian Stage, if it corresponds to the base of the *N. margaritae* Zone. At present, it is difficult to suggest the limitotype for this version of the boundary position. Sections of southern China are most promising in this respect. In the case of a higher position, the boundary becomes less expressive and is marked by changes at species level only.

It should be stressed that the Midian Stage was distinguished as a part of the former Murgabian Stage. It is the part that was inadequately studied by Miklukho-Maclay. Therefore, in the current stratigraphic scale, the Murgabian Stage is smaller in range than the original, insufficiently substantiated unit. According to formal principles of stratigraphic nomenclature, it seems to be more correct to identify the rest of the former Murgabian Stage (below the Midian interval) under the new

stage name. However, at the proper time, this principle was left unsatisfied, and now it would be unreasonable to change anything, because the name of Murgabian Stage is widely used as applied to *Neoschwagerina* Beds underlying strata with *Yabeina* and *Lepidolina* species.

Upper boundary of the Midian Stage. Upon first examination of the Midian Stage in the type sections of Transcaucasia, this boundary was placed at the base of the *Araxoceras latum* Zone including the beds bearing brachiopods of *Araxilevis* genus (Leven, 1980). This boundary position corresponded to the originally defined lower boundary of the Dzhulfian Stage, which was fixed at the base of ammonite ("Prototoceras") beds in the Dzhulfa locality (Schenck *et al.*, 1941). In the later publication (*Evolyutsiya ...*, 1965), this boundary was interpreted somewhat differently. It was lowered down to the base of the so-called *Codonofusiella* (Chanahchi) Beds, because all *Schwagerina* and *Neoschwagerina* forms disappear at this level. Recently, this viewpoint was supported by Kotlyar *et al.* (1989), and their arguments remain the same. In addition, it was noted that the Chanahchi Beds are distinct because of first appearing *Araxilevis* species and first ammonoids from the Araxoceratidae family. The cited authors also argued that this position of the boundary corresponds to the boundary level between the Maokou and Wuchiaping formations in southern China, which again marks the disappearance level of schwagerinids and neoschwagerinids, and the first occurrence of araxoceratids.

In recent years, there have been attempts to solve this problem by using conodonts. According to Kozur *et al.* (1978), the Midian-Dzhulfian boundary is, in its original definition, almost identical to the base of the *Clarkina leveni* Zone, which is well traceable in many Tethyan sections. In southern China, this level is in the middle of the Wuchiaping Formation, and Chinese scientists are in favor of distinguishing the Wuchiapingian Stage, which is of greater stratigraphic range, instead of the Dzhulfian Stage, and they place its lower boundary at the base of the *Clarkina postbitteri* Zone (Jin Yugan *et al.*, 1994a, 1994b). However, the conodont taxonomy and zonation for the Permian interval in question are thus far insufficiently elaborated, as is evident from a series of publications (Jin Yugan *et al.*, 1994a, 1994b; Kozur, 1994; Mei Shilong *et al.*, 1994). Therefore, using data on conodonts alone, it is preferable to rely on the base of the *C. leveni* Zone, which is well traceable and adequately understood.

Problems concerning the boundary between the Midian and Dzhulfian stages arise due to fact that it was originally defined either by data on fusulinids, as in the first instance, or by the ammonoid succession, as in the second. Because of their different facial control, these faunal groups are inappropriate for obtaining a definite answer to the question: what event in the evolution of ammonoids (brachiopods and conodonts as well) corre-

Table 3. Position of the *L. kumaensis* Zone in different correlation schemes

Ammonoids	Conodonts	Kotlyar <i>et al.</i> (1989)	Kotlyar <i>et al.</i> (1983)	Toriyama (1973)
<i>Araxoceras</i>	<i>C. leveni</i>			<i>L. k.</i>
<i>Eoaraxoceras</i> <i>Roadoceras</i>	<i>C. assimetrica</i> <i>C. dukouensis</i> <i>C. postbitteri</i>		<i>L. k.</i>	
<i>Timorites</i>	<i>M. granti</i> <i>M. xuanhanensis</i> <i>M. praexuanhan</i> <i>M. altudaensis</i>	<i>L. k.</i>		

sponded to the mass extinction of schwagerinids and neoschwagerinids, which marks the upper boundary of the Midian Stage? In other words, what is the interval in the ammonite and conodont zonations equivalent to the *L. kumaensis* Zone, the uppermost in the stage? There are several opinions concerning this problem (Table 3).

Most of the arguments in favor of one or another solution are indirect, controversial, and not very convincing. Only three schemes considering relations between the *L. kumaensis*, conodont and ammonoid zones are sufficiently concrete.

One of them has already been mentioned in the description of the *L. kumaensis* Zone. It is based on the sequence in the Sichuan Province of China studied by Rui Lin (1983). His find of *L. kumaensis* species in the middle part of the Maokou Formation allowed him to conclude that the pertinent zone corresponds to the entire upper portion of the formation. This was the reason to suggest a higher position of the *C. postbitteri*, *C. dukouensis*, and *C. assimetrica* conodont zones, which were recognized in basal strata of the Wuchiaping Formation and correlated with the *Codonofusiella* (Chanahchi) Beds in Transcaucasia.

Kotlyar (1994) used these data to substantiate the range of the *L. kumaensis* Zone in the Tethyan scale. As was mentioned, however, paleontologic determinations by Rui Lin are incorrect. The forms that he described are more primitive than *L. kumaensis*, and their host rocks are hardly younger than the lower Midian strata. This conclusion does not contradict the data on fusulinids discovered from the upper 100 m of the sequence and dated as merely Midian in age. As for the *L. kumaensis* Zone proper, it is equally possible that it corresponds to either the uppermost strata of the Maokou Formation, or to basal beds of the Wuchiaping Formation, and may even be missing in the section, because the latter formation overlies the former with a distinct unconformity.

The next fact, which was used by Kotlyar to substantiate the pre-Wuchiapingian age of the *L. kumaensis* Zone, is the occurrence of conodonts *Mesogon-*

dolella postserrata, *Clarkina bitteri*, *C. rosenkrantzi*, *C. denticulata*, and *C. wilcoxi* in association with the index fusulinid assemblage in the upper part of the Chandalaz Horizon in Primor'e. However, only the first of the listed conodont species is definitely pre-Wuchiapingian in age. *C. bitteri* shows a wide stratigraphic range up to the *C. leveni* Zone. According to Kozur (1994), the upper part of the last zone also yielded *C. rosenkrantzi*, although this form appears to be older in origin. Wardlaw and Mei Shilong (1994) reported that the first occurrence level of *C. wilcoxi* is at the base of the *Merrilina divergens* Zone distinguished near the top of the Word Formation in Texas, although in Kozur's opinion this zone corresponds to the lower part of the *C. leveni* Zone. This controversial dating of conodont assemblages does not provide grounds for conclusive inferences, and only additional data can clarify the problem.

Relations between the *L. kumaensis* and ammonite zones can be discussed using available data on the Kitakami localities in Japan. The *L. kumaensis* Beds were distinguished here in the upper part of the Iwaizaki Limestone (Ishii *et al.*, 1975). The overlying Toyoma Formation yielded ammonoids including the *Araxoceras* forms, which are typical of the lower half of the Dzhulfian (s.s.) Stage. Other recovered genera (*Protoceras*, *Stacheoceras*, and *Cyclolobus*) may occur in the Dzhulfian and somewhat older strata. These data allow us to speak definitively only about pre-Dzhulfian age of the *L. kumaensis* Beds, if this stage begins with the *Araxoceras* Zone. Furthermore, these beds may correspond to either the ammonite zones distinguished in lower strata of the Wuchiaping Formation in China, or to somewhat older units. It is also necessary to bear in mind that geological relations between beds bearing fusulinids and ammonoids are not very clear in this locality, and it is not inconceivable that they are of tectonic origin.

The unbiased consideration of the above data shows that the pre-Wuchiapingian age of the *L. kumaensis* Zone can be accepted without reservation. They also allow it to be correlated with the lower part of the Wuchiaping Formation in China and *Codonofusiella* Beds in Transcaucasia. In this regard we should note the recent information (Jin Yugan *et al.*, 1994a; Wardlaw and Pogue, 1995) on typically Dzhulfian conodonts from the Kalabagh Beds of the Wargal Formation, which are usually considered on the basis of brachiopods and smaller foraminifers to be an equivalent of the *L. kumaensis* Zone. If these data are validated, then the range of this zone may be regarded in accordance with Toriyama's idea (Toriyama, 1973) as comprising not only the lower, but also the middle part of the Wuchiaping Formation, which is the stratigraphic analogue of the *Araxoceras latum* Zone of the Dzhulfian Stage in Transcaucasia.

Evaluating all the data concerning the upper boundary of the Midian Stage, I came to the following conclusions:

(1) The fusulinid succession does not permit the *L. kumaensis* Zone to be disassociated from underlying deposits, and this zone should be considered as a constituent of the Midian Stage.

(2) Accordingly, the upper stage boundary must be placed at the top of the zone. It may correspond to the base of the *Codonofusiella* Beds in Transcaucasia, and to lower boundaries of the Wuchiaping Formation and ammonoid *Araxoceras*, or conodont *C. leveni* zones in China depending on the expected data on the position of *L. kumaensis* Zone in the accepted ammonoid and conodont zonations. Prior to this, the boundary should be left at the level accredited by the ISC, i.e., at the base of the *Araxoceras* Zone. The earlier disappearance of schwagerinids and neoschwagerinids in some sequences, for instance in type sections of Transcaucasia, may be related to relevant facial conditions.

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