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PERMIAN FUSULINID ASSEMBLAGES AND STRATIGRAPHY OF THE TRANSCAUCASIA

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Riassunto. Viene descritta la successione permiana della Transcaucasia, comprendente le formazioni Davaly, Asni, Gnishik, Arpa, Khachik e Akhura. Viene anche fornita una datazione precisa delle formazioni fondata sulla analisi delle associazioni a fusulinidi. La Formazione Davaly corrisponde al piano Boloriano del Permiano inferiore (Cisuraliano), la formazione Asni è riferibile al piano Kubergandiano e alla parte inferiore del piano Murgabiano del Permiano medio (Guadalupiano); la formazione Gnishik corrisponde all'incirca alla parte superiore del Murgabiano; e le formazioni Arpa e Khachik rappresentano l'intero Midiano, sempre del Permiano medio. Solo l'Orizzonte Chanakhchy della parte sommitale della formazione Khachik sono correlati con la Serie superiore del Permiano (Lopingiano) così come definita dalle recenti proposte della Sottocommissione Internazionale di Stratigrafia del Permiano, concernente i limiti delle Serie. La Formazione Akhura infine comprende i piani Dzhulfiano e Dorashamiano del Permiano superiore.

Successivamente sono presentate in modo dettagliato le correlazioni tra il Permiano della Transcaucasia e le successioni più significative della regione tetidiana (Iran centrale, Pamir sudorientale, Cina meridionale e Giappone). Anche in queste aree come in Transcaucasia, il Permiano presenta rapporti trasgressivi sulle unità sottostanti. Sebbene la trasgressione sia iniziata nel Boloriano, essa raggiunse il suo massimo nel Kubergandiano e di conseguenza in molte sezioni la successione trasgressiva inizia nel Kubergandiano. I depositi del Permiano medio e superiore della Trascaucasia appartenevano alla stessa piattaforma carbonatica dell'Iran e della Turchia meridionale. Estesi dominii carbonatici di acque basse sono documentati nelle parti meridionali dell'Afghanistan e della Cina. Un cambiamento nel regime sedimentario è registrato in tutte queste aree al limite tra le epoche Guadalupiana e Lopingiana. Il Guadalupiano fu caratterizzato da un intenso accumulo di calcari organogeni e bioclastici, prodotti da organismi bentonici, soprattutto alghe e foraminiferi, mentre nel Lopingiano prevalsero calcilutiti e marne, con l'aumento del significato degli organismi nectonici e necto-planctonici, come cefalopodi e conodonti. Il cambio di regime sedimentario fu rapido e probabilmente causato dalla regressione, di breve durata, post-Midiana. Tale cambio provocò una significativa crisi biologica che portò all'estinzione dei grandi fusulinidi, di goniatiti e agoniatiti, dei tabulati, della maggior parte dei Rugosa e di altri organismi ancora. Questi eventi segnarono l'inizio della "Grande Estinzione" del Permiano terminale, che si concluse al limite Permiano/Triassico.

Le associazioni a fusulinidi sono illustrate in nove tavole e pure nove sono le specie nuove descritte: *Codonofusiella* (?) *vediensis*, *Chalaroschwagerina davalensis*, *Pseudofusulina arpaensis*, *P. araxensis*, *P. pjatakovae*, *Rugosochusenella davalensis*, *Misellina (Misellina) caucasica*, *Cancellina armenica*, e *Sumatrina vediensis*.

Abstract. The Permian sequence of the Transcaucasia, which comprises the Davaly, Asni, Gnishik, Arpa, Khachik, and Akhura Formations, is described. A precise dating of the formations based on the analysis of fusulinid assemblages is also provided. The Davaly Formation corresponds to the Bolorian Stage of the Lower Permian (Cisuralian); the Asni Formation corresponds to the Kubergandian Stage, and to the lower half of the Murgabian Stage of the Middle Permian (Guadalupian); the Gnishik Formation corresponds approximately to the upper half of the Murgabian Stage; and the Arpa and Khachik Formations represent the entire Midian Stage of the Middle Permian. Only the uppermost Chanakhchy Beds of the Khachik Formation are referred to the upper series of the Permian (Lopingian), based on the latest proposal of the International Subcommission on Permian Stratigraphy concerning series boundaries. The Akhura Formation encompasses the Dzhulfian and Dorashamian Stages of the Upper Permian.

Refined correlations between the Permian sequence of the Transcaucasia and the most complete Permian sequences of the Tethyan region (Central Iran, southestern Pamirs, South China, Japan) are presented. The transgressive overlapping of the Permian deposits is recorded in these areas, similar to the Transcaucasia. Although the transgression began during the Bolorian, it reached the widest extent in the Kubergandian and therefore, in most sections the transgressive series begins with deposits of Kubergandian age. The Middle and Upper Permian deposits of the Transcaucasia, Iran, and southern Turkey belonged to a single carbonate platform. Similar extensive carbonate platforms are recorded in the southern parts of Afghanistan and China. A change in the sedimentary regime was recorded in all these platforms at the boundary between the Guadalupian and Lopingian epochs. The Guadalupian time was marked by the intensive accumulation of biolitithic and detrital limestones produced by benthic organisms, mainly algae and foraminifers, whereas in the Lopingian time, carbonate and clayey micritic deposition dominated, and the role of nectonic-planctonic and nectonic organisms, such as cephalopods and conodonts, increased. The sedimentation change was abrupt and caused probably by the short-term post-Midian regression. The change resulted in a significant biotic crisis when larger fusulinids, goniatitids and agoniatitids, tabulate corals, most rugose corals and other organisms became extinct. These events marked the onset of the Late Permian "Great Extinction", which ended at the Permian/Triassic boundary. Nine paleontological plates show the main fusulinid assemblages. Nine new species are described: *Codonofusiella (?) vediensis*, *Chalaroschwagerina davalensis*, *Pseudofusulina arpaensis*, *P. araxensis*, *P. pjatakovae*, *Rugosochusenella davalensis*, *Misellina (Misellina) caucasica*, *Cancellina armenica*, and *Sumatrina vediensis*.

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Introduction.

The Permian sections of the Transcaucasia are well known. Notably, three of nine stages of the Tethyan scale (Midian, Dzhulfian, and Dorashamian) were established there (Leven, 1980, 1981a,b; Schenck et al., 1941; Rostovtsev & Azarian, 1974). The Permian stratigraphy of this region was developed mainly by Abich (1878), Stoyanov (1910), Bonnet (1912a,b), Bonnet & Bonnet (1947), Yakovlev (1941), Sadykov (1954), A. D. Miklukho-Maclay (1955), Azizbekov (1961). A decisive role in the recent subdivision of the Transcaucasian Permian deposits belongs to Arakelyan, who distinguished Carboniferous and Permian deposits and subdivided the latter, referring six units to the Lower Permian and three to the Upper Permian (Geology of the Armenian SSR, 1964). Subsequently, the scale of Arakelyan was refined and the chronologic assignment of the formations to epochs was changed by Leven (1975), who showed that most Permian sections in the region begin with Upper Permian deposits and the sections in the northwest include only Lower Permian deposits of small thickness. These data were later confirmed (Kotlyar et al., 1983, 1989) and are now completely accepted. However, fusulinids, which were used to determine the chronology of the formations, have not yet received adequate study. This is especially true for the higher fusulinids (Order Neoschwagerinida), which provide the most accurate chronologic resolution. In some publications (Ruzhentsev & Sarycheva, 1965; Rauser-Chernousova et al., 1974), fusulinids were inadequately calibrated in the sequence and ages of their assemblages (Sakmarian, Artinskian, and Kungurian) were erroneously defined. This paper provide a revised biostratigraphy as well as the correlation of the Permian sequence of the Transcaucasia to the most complete and best studied sections of the Tethyan area using all the most recent data. The article is based on the Author's personal observations and fusulinid collection. The collection is stored in the Geological Institute (GIN) of the Russian Academy of Sciences, collection number GIN 4768.

General characteristics of the Permian sequence of the Transcaucasia.

The most significant outcrops of the Permian deposits of the Transcaucasia are located in the area between the left tributaries (the Vedy and Dzhagry rivers) of the Arax River in Armenia and in the Nakhichevan district of Azerbajdzhan. The Dorasham 1 and Dorasham 2 sections are located separately, along the left bank of the Arax River to the west of the town of Dzhulfa (Fig. 1). The good exposure and simple geologic structure of the sections facilitate their study and allow the stratigraphic subdivisions to be followed for a long distance. Due to the lateral persistence of these subdivisions, a single Permian scale can be applied to the entire region (Fig. 2). Lithologically, six formations can be recognized in the section: the Davaly, Asni, Gnishik, Arpa, Khachik, and Akhura formations, whose characteristics are summarized below, bottom to top:

The Davaly Formation. The formation was established by Arakelyan (Geology of the Armenian SSR, 1964), who included in this unit the entire limestone series of Permian age exposed on the southern slope of the Sarypap Hill near the Davaly Settlement (at the town of Ararat, 30 km to the south of Erevan) (Fig. 2). The formation is exposed also at the neighboring Khorvirab Hill. The limestone series of the Sarypap Hill is divided into two parts by an unconformity surface and a horizon of red conglomerates. Fusulinids of the Kubergandian Stage found above this surface allow the correlation of this part of the sequence to the lower part of the Asni Formation. Therefore, only the lower half of the sequence

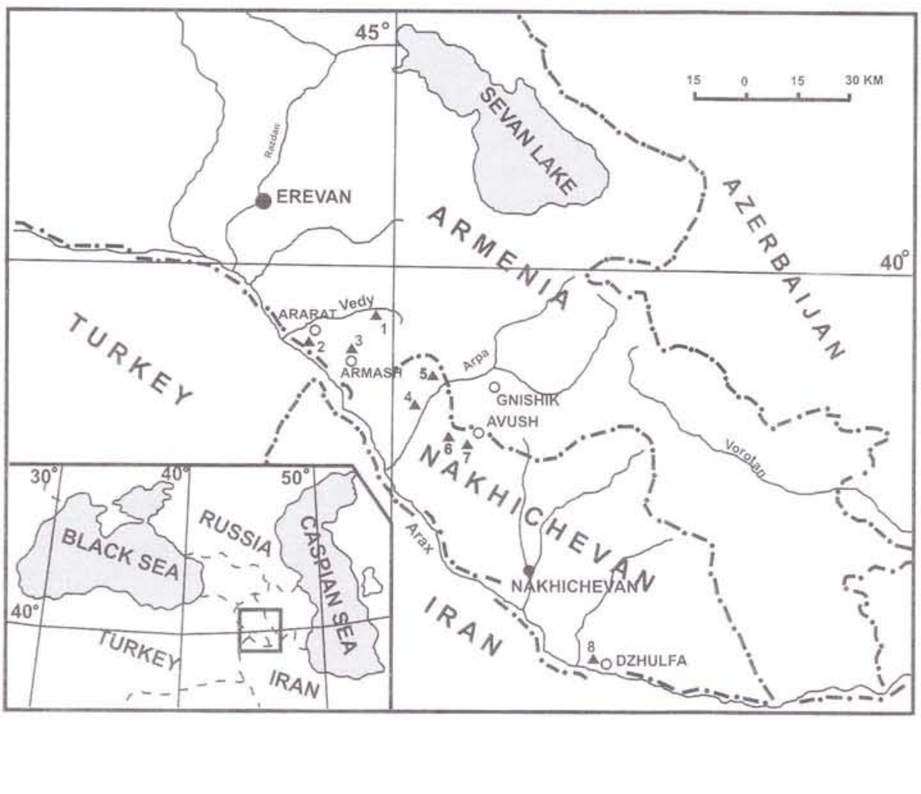


Fig. 1 - Index map of the studied area with the localities of the sections (see Fig. 2).

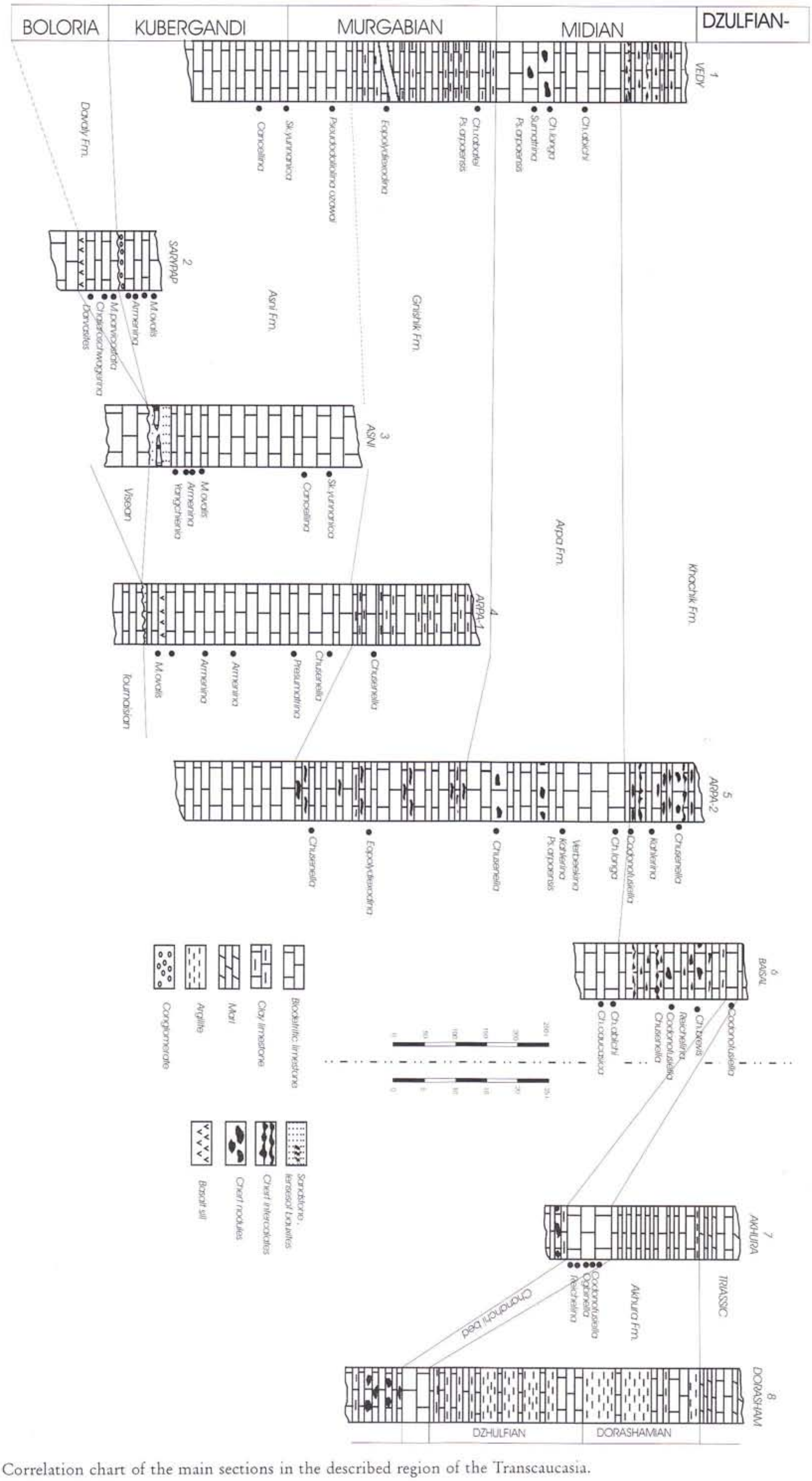


Fig. 2 - Correlation chart of the main sections in the described region of the Transcaucasia.

can be referred to the Davaly Formation. The formation is underlain by light-colored, coarsely bedded and massive limestones with brachiopods and corals of Visean age. There is no direct contact between Carboniferous and Permian limestones, because they are separated by an interstratal diabase body 1-1.5 m thick. Above the diabases, the section is represented by dark-gray to black, medium bedded, bituminous algal-fusulinids limestones with a clayey lower part and a detrital upper part. Together with fusulinids and algae, the formation includes fragments and, rarely, entire shells of brachiopods, columnals of crinoids, echinoid spines, and smaller foraminifers. Pjatakova (1984) identified the conodonts *Sweetocristatus arcticus* Szaniawski, *Sweetognathus* aff. *whitei* (Rhodes) from the basal part of the formation and *Neostreptognathodus prayi* Behnken in the upper part of the section. The total thickness of the formation is 45-50 m.

The Asni Formation. The formation was established by Arakelyan (Geology of Armenian SSR, 1964) in its type section in the Asni Gorge near the Armash Village (Fig. 1, 2). It rests on the underlying deposits without visible angular unconformities, but there is commonly a significant hiatus. In the Sarypap Hill only, the Asni Formation is underlain by the Lower Permian limestones of the Davaly Formation. The formations are separated by a thin (up to 3 m) bed of red conglomerates containing poorly rounded calcareous and, to lesser extent, sandy and quartz pebbles. In all the other sections, the Asni Formation lies on the eroded surface of Upper Devonian or Lower Carboniferous deposits. Red conglomerates, including well rounded pebbles as well as ferruginous sandstones with interbeds and lenses of pisolitic bauxites up to 2-3 m thick are frequent at its base. The variable thickness of the basal member reaches 20 m. However, this member is frequently missing and the section begins directly with the limestones, which are difficult to distinguish, without faunal evidence, from similar underlying Lower Carboniferous limestones. The formation is composed of compact dark-gray limestones, which are thin-bedded in the lower 20-30 m of the section and medium- and coarse-bedded above. They are commonly bituminous and frequently dolomitized. The limestones are mainly represented by detrital algal-foraminiferal varieties. There are fragments of skeletons of bryozoans, brachiopods, crinoids, and gastropods.

The fossil content of the formation is dominated by fusulinids, which occur throughout the section. Abundant algae are mostly rock-producers. Some coral horizons are recorded. The lower horizons are composed predominantly by branching colonies of *Waagenophyllum indicum* (Waagen and Wentzel), *Chihsiaphyllum chihsiaense* (Yoh), and *Ipsiphyllum* sp. The upper part of the formation shows prevalence of *Wentzelophyllum volzi* (Yabe and Hayasaka). The rare brachiopods have not yet been studied. The total thickness of the formation is 250-300 m.

The Gnishik Formation. It was established by Arakelyan (Geology of Armenian SSR, 1964) in the Gnishik River basin (Fig. 1). I studied the section in the Arpa River basin where the formation shows a sharp contact with the underlying and overlying beds. The formation is mostly represented by thin-bedded, occasionally shaly, dark-gray and black bituminous foraminiferal-algal biodetrital limestones. The occasional admixture of clayey and terrigenous material colors the limestones light-gray and yellowish. The thin-bedded layers alternate with coarser-bedded compact varieties. The base of the formation is drawn at the first occurrence of thin-bedded limestones. The total thickness of the formation reaches 300 m.

The formation is distinguished by abundant brachiopods confined mainly to the thin-bedded limestone members. They were described in a monograph by Sarycheva & Grunt (in Ruzhentsev & Sarycheva, 1965). Colonies of rugose corals, which include *Wentzelophyllum kueichowense* (Huang) and *Ipsiphyllum armenicum* Dobroljubova, are present throughout the unit.

The Arpa Formation. It was established by Leven (1975) based on the outcrops along the right bank of the Arpa River (Fig. 1, 2). Several sections were described in detail by Kotlyar et al. (1989). This formation is represented mainly by light gray, compact, coarse-bedded and massive limestones, which are predominantly biogenic (algal and algal-foraminiferal) or detrital. Occasionally, the lower part of the formation shows a relatively thin interval of bedded clayey limestones similar to those of the Gnishik Formation. The boundary between these formations is indistinct and is defined by the predominance of bedded or massive limestone varieties in the Arpa Fm. Therefore, Arakelyan (Geology of Armenian SSR, 1964) did not distinguish the Arpa Formation but included these limestones in either the Gnishik Formation or the overlying Khachik Formation. The characteristic feature of the Arpa Formation is the occurrence of siliceous concretions of different size and shape. The total thickness of the formation is about 250-300 m.

The paleontologic content of the formation was described by Kotlyar et al. (1989). It should be noted that the formation contains abundant fusulinids, small foraminifers, and algae. Corals, gastropods, bryozoans, and brachiopods occur as well. The distinguishing feature of this formation is the occurrence of *Sphinctozoa* represented by the species *Amblysiphonella sarychevae* Zhuravlieva and *Colospongia arakeljani* Zhuravlieva.

The Khachik Formation. It was established by Arakelyan (Geology of Armenian SSR, 1964) in the Avush Gorge, to the south of the Khachik Village. The unit shows a transitional boundary with the underlying Arpa Formation, from which it may be distinguished by its darker color. It is mainly composed of thin-bedded clayey, bituminous limestones passing into calcareous mudstones and alternating with more compact, thick-bedded algal-foraminiferal and biodetrital limestones commonly dark gray and black in color. Chert interbeds and lenticular inclusions are characteristic. The lighter-colored compact limestones called "Chanahchy Beds" may be observed at the very top of the unit (Kotlyar et al., 1989). The total thickness of the formation is about 150-200 m.

The paleontologic content of the Khachik Formation is described thoroughly by Ruzhentsev and Sarycheva (1965) and Kotlyar et al. (1989). As in the underlying formations, fusulinids, small foraminifers and algae are the main components. Miliolids are especially abundant among small foraminifers. They form white disseminations in the dark deposits, which can be noticed by naked eye. Rare corals, brachiopods, and bryozoans, as well as ostracods, more abundant than those of the older deposits, are recorded.

The Akhura Formation. It was established by Leven (1975) in its type section at the Dorasham 2 railway station, near the town of Dzhulfa (Fig. 1, 2). Another good section crops out near the Akhura Village. The formation differs sharply in every aspect from other formations. It consists commonly of limestones, which alternate with mudstones in the type section. The limestones, opposite to the underlying ones, are represented mainly by well-bedded, thin, detrital micritic varieties with frequent clayey content. The bituminous content of the underlying limestones is not recorded. Detritus includes fragmentary shells of brachiopods, cephalopods, gastropods, and ostracods. Interbeds composed entirely of crinoid columnals or brachiopod and cephalopod shells are present. Some interbeds are crowded with conodonts. The limestones and mudstones of the lower part of the formation are commonly white, yellowish and greenish colored while those of the upper part are predominantly pink and brick red. The sharp contact between the Akhura and Khachik Formations suggests a short gap in sedimentation. Until recently, the sharp boundary between the Akhura Formation and the Triassic deposits provided evidence for three missing cephalopod zones (Zhao et al., 1978, 1981). However, the records of Zakharov (1988), as well as data on conodonts (Kozur et al., 1978) indicate the continuity of the section. Unlike the other Permian units, the formation under consideration is very thin. The maximal (51 m) and the minimal (3 m) values are recorded in the Dorasham 2 section and in the Ardych section, respectively. Although heavily condensed, the section is continuous, as demonstrated by the occurrence of all the conodont zones recognized in thicker sections. Because the paleontologic description of the formation was presented extensively in a number of papers and monographs (Ruzhentsev & Sarycheva, 1965; Kotlyar et al., 1983; Kozur et al., 1978; Grigorjan, 1990), no further discussion is necessary. It should only be emphasized that the composition of the biotic associations underwent sharp and considerable changes between the Khachik and Akhura ages. All fusulinids and almost all smaller foraminifers and algae, which were sediment-producers, became extinct. Tabulate corals and waagenophyllids rugose corals disappeared as well. The brachiopod assemblage was completely renewed. Conodonts and cephalopods acquired a leading role. This, in combination with different lithofacies, suggests significant changes in sedimentation, environments and habitats, whose characteristics are still unknown.

Analysis of the fusulinid assemblages and dating of the formations.

Fusulinids are distributed throughout the Permian sequence, except for the Akhura Formation, and provide a basis for its biostratigraphic division. The occurrence of fusulinids was first reported by Abich (1878). Some species were described by Dutkevich (1937), A. D. Miklukho-Maclay (1955), Toumanskaya (1952), Baulina (1963), and Scherbovich (1964). Integrated studies and the monograph describing the fusulinids from the upper part of the sequence were carried out by Rauser-Chernousova, Rozovskaya, and Chedija (Ruzhentsev & Sarycheva, 1965; Kotlyar et al., 1983, 1989). Fusulinids from the lower part of the sequence were described by Rauser-Chernousova, Rozovskaya, and Scherbovich (Rauser-Chernousova et al., 1974). Despite many publications, the taxonomy and biostratigraphy of the fusulinid assemblages are adequately studied only from the upper part of the sequence (the Arpa and Khachik Formations). As to the assemblages of the other parts of the sequence, their composition and biostratigraphy need to be revised considerably. The characteristics of the fusulinid assemblages of the formations described above are addressed in the following paragraphs.

The Davaly Formation. Fusulinids are recorded throughout the formation. The main components of the assemblage are *"Eostaffella" serotina* Leven, *Schubertella rara* Sheng, *Sch. exilis* Suleimanov, *Sch. giraudi* (Deprat), *Sch.* cf. *kingi* Dunbar and Skinner, *Sch. plana* Lange, *Toriyamaia* sp., *Darvasites ordinatus ordinatus* (Chen), *D.*

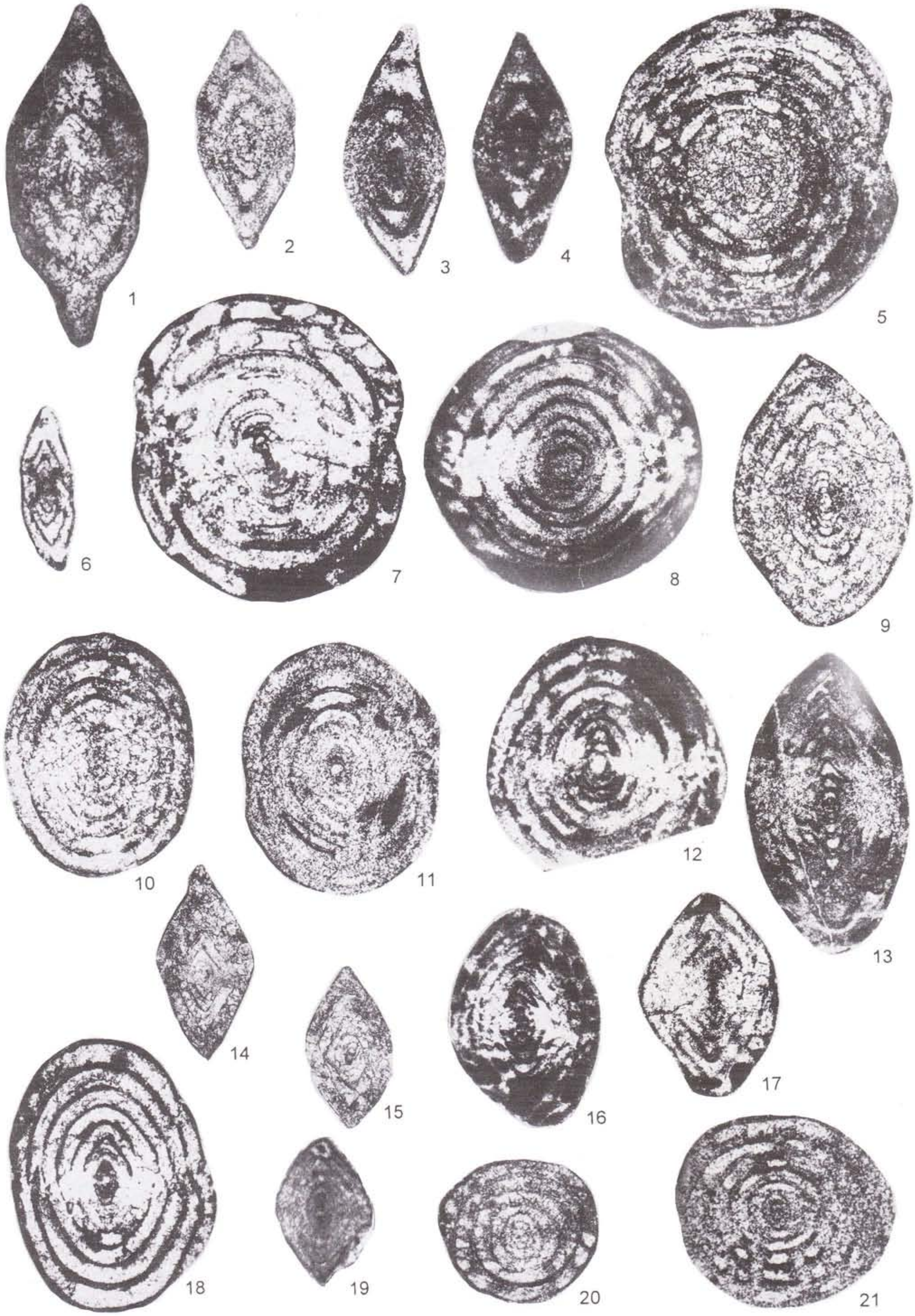
ordinatus longus Leven, *D.* aff. *contractus* (Schellwien and Dyhrenfurth), *Chalaroschwagerina vulgaris* (Schellwien and Dyhrenfurth), *Ch. darvasica* Leven, *Ch. globosa* (Schellwien and Dyhrenfurth), *Ch. kushlini* (Leven), *Ch. davalensis* n. sp., *Pseudofusulina* sp., *Chusenella minuta* Skinner, *Rugosochusenella davalensis* n. sp., *Praeskinnerella* cf. *guembeli guembeli* (Dunbar and Skinner), *P.* cf. *guembeli pseudoregularis* (Dunbar and Skinner), and *P. kueichowensis* (Sheng).

Beginning from the middle part of the formation, the species listed are associated with *Misellina (Brevaxina) olgae* Leven, *M. (Misellina) parvicostata* (Deprat), *M. (M.) shengi* Zhang and Dong, and *M. (M.) ibukiensis* Kobayashi. The species described earlier by Scherbovich (Rauser-Chernousova et al., 1974): *Darvasites daroni* A. Miklukho-Maclay, *Chalaroschwagerina vulgaris* (Schellwien and Dyhrenfurth), *Ch. armenica* (Scherbovich) should undoubtedly be included in the assemblage of this formation. The assemblage, with the exclusion of some new species, is typical of the Bolorian Stage of the Lower Permian and has broad distribution in the Tethyan province. The most characteristic feature is the association of primitive *Misellina* with *Chalaroschwagerina*, *Darvasites* and *Praeskinnerella*. *Misellina* is represented mainly by the subgenus *Misellina*, thus indicating the *Misellina (Misellina) parvicostata* Zone, i. e. the upper half of the Bolorian Stage. The lower half of this stage (the *Misellina (Brevaxina) dyhrenfurthi* Zone), likely corresponds to the lower part of the formation. It cannot be excluded that the basal part of the formation belongs to the Yakhtashian Stage. This hypothesis is supported by the conodont records at the base of the formation. For example, *Sweetognathus whitei* is typical of the Artinskian Stage which correlates approximately to the Yakhtashian Stage. *Neostreptognathodus prayi* is a characteristic species of the Kathedral Formation of Texas, which is correlated to the Bolorian Stage. As for *Sweetocristatus arcticus*, Kozur (1995) considers it to be indicative of the uppermost beds of the Artinskian Stage and of the basal part of the Kungurian (Cathedralian according to Kozur) Stage.

The Asni Formation. Fusulinids are distributed throughout the formation. They show the highest diversity in its lower part. The higher portion of the section is characterized almost entirely by eurybiontic *Staffellida* (*Staffella*, *Nankinella*, *Sphaerulina*, etc.). Representatives of other orders (Schwagerinida, Neoschwagerinida, Schubertellida) commonly occur sporadically but they form extensive accumulations in some interbeds. The formation is very thick and corresponds to a considerable time interval. Therefore it contains several fusulinid assemblages indicative of different ages. The oldest assemblage was found in the basal part of the formation (the Sarypap section) and includes *Pseudoendothyra* sp., *Staffella* sp., *Eoschubertella obscura* (Lee and Chen), *Schubertella rara* Sheng, *Sch.* cf. *giraudi* (Deprat), *Sch.* aff. *exilis* Suleimanov, *Yangchienia hainanica* Sheng, *Pseudofusulina postkraffti* (Leven), *P. isomie* Igo, *P. aghilensis* (Reichel), *P.* cf. *emaciata* (Beede), *Praeskinnerella pavlovi* (Leven), *P.* aff. *afghanensis* Leven, *P.* cf. *guembeli pseudoregularis* (Dunbar and Skinner), *P. parviflucta* (Zhou), *P. fragilis* Leven, *Skinnerella* aff. *yunnanica* (Sheng), *S. elliptica* (Sheng), *Rugosochusenella davalensis* n. sp., *Misellina (Brevaxina) olgae* Leven, *M. (Misellina) minor* (Deprat), *M. (M.) shengi* Zhang and Dong, *M. (M.) ibukiensis* Kobayashi, *M. (M.) ovalis* (Deprat), *M. (Paramisellina)* sp., and *Armenina* cf. *salgirica* A. M.-Maclay. Among the fusulinids listed, there are no *Darvasites* and *Chalaroschwagerina* characteristic of the Yakhtashian and Bolorian stages of the Lower Permian. However, typical Middle Permian Yangchienia, true *Skinnerella*, and first *Armenina* are recorded. *M. (M.) ovalis*, typical of the lower zone of the Kubergandian Stage together with primitive *Misellina*, also appears. In general, the assemblage is similar to that of the basal beds of the lower

PLATE 1

Fig. 1-4 - *"Pseudoendothyra"* aff. *constricta* Igo, Ueno et Sashida. x 50. Lower part of Asni Formation; axial sections, GIN 4768/1, 4768/2, 4768/3 and 4768/4.
Fig. 5 - *Staffella sphaerica* (Abich). x 20. Axial section, GIN 4768/5; upper part of Asni Formation.
Fig. 6 - *Nankinella* (?) sp. x 20. Axial section, GIN 4768/6; upper part of Asni Formation.
Fig. 7 - *Staffella quinglongensis* Zhang et Dong. x 20. Axial section, GIN 4768/ 7; upper part of Asni Formation.
Fig. 8, 12 - *Sphaerulina weiningensis* Liu, Xiao et Dong. x 20. Middle and upper part of Asni Formation; 8 - subaxial section GIN 4768/8; 12 - axial section GIN 4768/9.
Fig. 9 - *Nankinella hunanensis* Chen. x 20. Axial section, GIN 4768/10; lower part of Asni Formation.
Fig. 10, 11 - *Staffella transiens* Kochansky-Devidé. x 20. Axial sections, GIN 4768/11 and 4768/12; lower part of Asni Formation.
Fig. 13 - *Nankinella longgensis* Nie et Song. x 20. Axial section,GIN 4768/13; middle part of Asni Formation.
Fig. 14, 15 - *Nankinella rarivoluta* Wang, Sheng et Zhang. x 20. Axial sections, GIN 4768/14; Khachik Formation.
Fig. 16, 17 - *Nankinella kotakiensis* (Fujimoto et Kawada). x 20. Axial sections, GIN 4768/15 and 4768/16; lower et middle part of Asni Formation.
Fig. 18 - *Nankinella orientalis* K. Miklukho-Maclay. x 20. Axial section, GIN 4768/17; lower part of Asni Formation.
Fig. 19 - *Nankinella nagatoensis* Toriyama. x 20. Axial section, GIN 4768/19; lower part of Asni Formation.
Fig. 20, 21 - *Sphaerulina croatica* Kochansky-Devidé. x 20. Axial sections, GIN 4768/19 and 4768/20; middle part of Asni Formation.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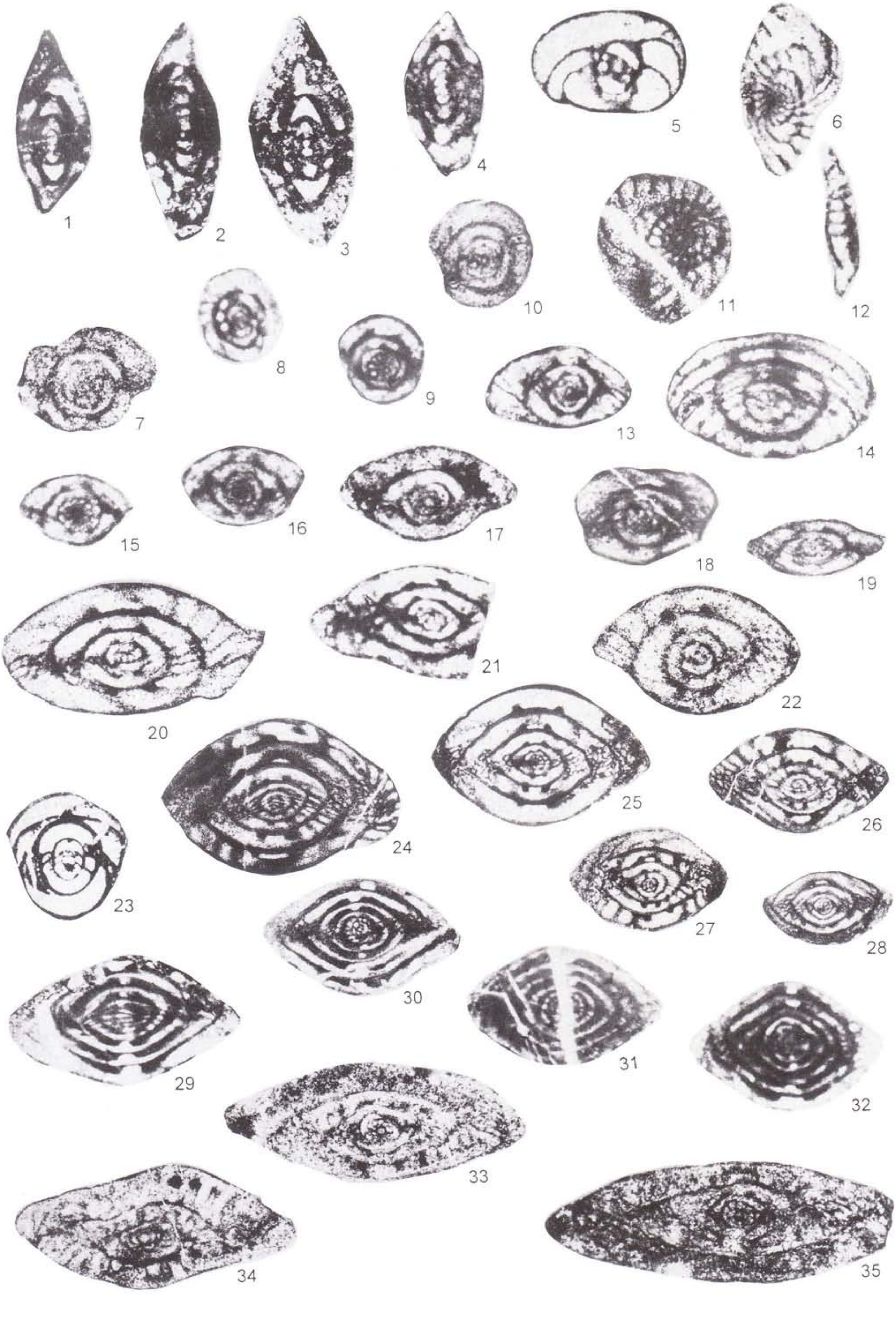
zone (the *Armenia- Misellina ovalis* Zone) of the Kubergandian Stage in its type sections in the southeastern Pamirs (Leven, 1981b; Chedija et al., 1986). Fusulinids are associated with ammonoids characteristic of the Roadian Stage of the Guadalupian Series of North America. The lower zone of the Kubergandian Stage is also characterized by a fusulinid assemblage recorded in the lower parts of the Asni Formation in all the other localities studied. This persistent assemblage is represented by *Sichotenella* (?) sp., *Pseudoendothyra* aff. *constricta* Igo, Ueno and Sashida, *Staffella transiens* Kochansky-Devidé, *S. sphaerica* (Abich), *Nankinella hunanensis* (Chen), *N. longgensis* Nie and Song, *N. orientalis* K. M.-Maclay, *N. kotakiensis* (Fujimoto and Kawada), *N. nagatoensis* Toriyama, *Pisolina excessa* Lee, *Eoschubertella* sp., *Schubertella rara* Sheng, *S.* cf. *melonica* Dunbar and Skinner, *Neofusulinella lantenoisi* Deprat, *Yangchienia* sp., *Chusenella schwageriniformis* Sheng, *Ch. douvillei* (Colani), *Misellina (Misellina) ovalis* (Deprat), *M. (M.) claudiae* (Deprat), *M. (M.) parvicostata* (Deprat), *M. (M.) caucasica* n. sp., *Armenina salgirica* A. M.-Maclay, *A. karinae* A. M.-Maclay, *A. ventricosa* (Ueno), *A. asiatica* Leven, and *A. urtzensis* Leven.

Although this assemblage was assigned to the same *Armenia -Misellina ovalis* Zone, it appears to be slightly younger than the assemblage from the lower part of the Asni Formation of the Sarypap section. The abundance of highly developed *Armenina* and *Misellina*, the absence of primitive species of the latter, and the appearance of *Chusenella* and abundant *Neofusulinella* suggest that this assemblage can be assigned to the upper half of the *Armenina- Misellina ovalis* Zone. Thus, in all localities the Asni Formation section begins with stratigraphically higher horizons than in the Sarypap Hill outcrop.

The upper half of the Asni Formation is poorly characterized by fusulinids, which are mainly represented by abundant Staffellida. Beginning from the middle of the section, *Cancellina* appears: i.e. *Cancellina (Cancellina) primigena* Hayden, *C. (C.) praeneoschwagerinoides* Leven, *C. (C.) armenica* n. sp. together with *Pseudoendothyra* sp., *Staffella sphaerica* (Abich), *S. transiens* Kochansky-Devidé, *Nankinella hunanensis* (Chen), *N. kotakiensis* (Fujimoto and Kawada), *Nankinella* (?) sp., *Pisolina excessa* Lee, *Sphaerulina croatica* Kochansky-Devidé, *Eoschubertella znensis* (Rauser), *Schubertella rara* (Sheng), *Neofusulinella lantenoisi* Deprat, *N. saraburiensis* Toriyama, Kanmera and Ingavat, *N.* cf. *tumida* Leven, *Codonofusiella* (?) *vediensis* n. sp., *Skinnerella gruperaensis* (Thompson and Miller), *S.* cf. *yunnanica* (Sheng), *Chusenella conicocylindrica* Chen, *Ch. schwageriniformis* Sheng, *Armenina* cf. *salgirica* A. M.-Maclay, and *A. karinae* A. M.-Maclay. The presence of *Cancellina* allows an assignment of this assemblage to the upper zone of the Kubergandian Stage - the *Cancellina cutalensis* Zone. Slightly above the beds with *Cancellina*, there is an easily traceable bed overfilled with *Skinnerella*, such as *Skinnerella yunnanica* (Sheng), *S.* aff. *subrectangularis* (Kling), *S.* cf. *dronovi* (Leven), *S. vinogradovi* (Leven), *S. gundarensis* Leven, and *S. gruperaensis* (Thompson and Miller). They are accompanied by *Nankinella longgensis* Nie and Song, *Staffella* cf. *sphaerica* (Abich), *Sphaerulina weiningensis* Zhang and Dong, *Schubertella* sp., *Neofusulinella lantenoisi* Deprat, *Chusenella schwageriniformis* Sheng, and *Ch. conicocylindrica* Chen. This assemblage is characteristic of both the upper part of the Kubergan-

PLATE 2

Fig. 1-4 - *Sichotenella* (?) sp. x 50. Axial sections: 1, 2 and 4 - GIN 4768/21, 3 - GIN 4768/22; lower part of Asni Formation.
Fig. 5 - *Toriyamaia* sp. x 50. Axial section, GIN 4768/23; Davaly Formation.
Fig. 6, 11, 12 -*Reichelina* sp. 6 - oblique section, GIN 4768/24; 11 - subsagittal section, GIN 4768/25; 12 - tangential section, GIN 4768/25; Arpa Formation.
Fig. 7 - *Schubertella* aff. *lata* Lee et Chen. x 50. Axial section, GIN 4768/26; Arpa Formation.
Fig. 8 - *Eoschubertella obscura* (Lee et Chen). x 50. Axial section, GIN 4768/11; lower part of Asni Formation.
Fig. 9 - *Eoschubertella znensis* (Rauser). x 50. Axial section, GIN 4768/27; middle part of Asni Formation.
Fig. 10 - *Eoschubertella* sp. x 50. Axial section, GIN 4768/28; lower part of Asni Formation.
Fig. 13, 15 -18 -*Schubertella rara* Sheng. x 50. Axial sections: 13 - GIN 4768/ 29; lower part of Asni Formation; 15 - GIN 4768/30, lower part of Asni Formation; 16 - GIN 4768/31, Davaly Formation; 17 - GIN 4768/32, middle part of Asni Formation; 18-GIN 4768/164, lower part of Asni Formation.
Fig. 14 - *Schubertella* cf. *melonica* Dunbar et Skinner. x 50. Subaxial section, GIN 4768/33; lower part of Asni Formation.
Fig. 19 - *Schubertella plana* Lange. x 50. Subaxial section, GIN 4768/34; Davaly Formation.
Fig. 20, 21 - *Schubertella exilis* Suleimanov. x 50. Axial sections, GIN 4768/35 and 4768/36; Davaly Formation.
Fig. 22 - *Schubertella giraudi* (Deprat). x 50. Subaxial section, GIN 4768/38; Davaly Formation.
Fig. 23 - *Kahlerina tenuitheca* Wang, Zhang et Zheng. x 20. Axial section, GIN 4768/39; Arpa Formation.
Fig. 24-27 - *Neofusulinella lantenoisi* Deprat. x 20. 24 - subaxial and axial sections, GIN 4768/40, 4768/41, 4768/42 and 4768/43; middle part of Asni Formation.
Fig. 28 - *Neofusulinella saraburiensis* Toriyama, Kanmera et Ingavat. x 20. Axial section, GIN 4768/42; middle part of Asni Formation.
Fig. 29-32 - *Yangchienia hainanica* Sheng. x 30. Axial and subaxial sections, GIN 4768/44, 4768/45, 4768/46 and 4768/47; lower part of Asni Formation.
Fig. 33, 35 - *Ogbinella ogbinensis* (Chedija). x 50. Axial sections, GIN 4768/48; Khachik Formation, Chanahchi bed.
Fig. 34 - *Ogbinella avushensis* (Chedija). x 50. Axial section, GIN 4768/49; Khachik Formation, Chanahchi bed.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dian Stage and the lower part of the Murgabian Stage. The typical early Murgabian *Presumatrina neoschwagerinoides* (Deprat), *Pseudodoliolina ozawai* Yabe and Hanzawa, and *Verbeekina sp.* were found above the beds with *Cancellina* and abundant *Skinnerella*. *Staffella sphaerica* (Abich), *S. quinglongensis* Zhang and Dong, *Nankinella* cf. *hunanensis* Chen, *Schubertella sp.*, *Boultonia sp.*, *Codonofusiella* (?) sp., *Rauserella* (?) sp., *Pseudofusulina* sp., *Skinnerella* aff. *sapperi* (Staff), *Laosella* aff. *gigantea* (Deprat), *Chusenella schwageriniformis* Sheng, *Ch. chihsiaensis* (Lee), *Ch. conicocylindrica* Chen, *Ch. sinensis* Sheng, *Armenina* cf. *salgirica* A. M.-Maclay, and *A. karinae* A. M.-Maclay were found in association with the mentioned species and slightly above them. Thus, the data presented suggest that the Asni Formation corresponds to the entire Kubergandian Stage and the lower half of the Murgabian Stage.

The Gnishik Formation. Compared to the previous formation, it has poorer fossil content. It is characterized by fusulinids, which are confined to the interbeds of coarse-bedded limestones and mainly represented by abundant Staffellida: *Staffella transiens* Kochansky-Devidé, *S. sphaerica* (Abich), *Nankinella kotakiensis* (Fujimoto and Kawada), *S. quinglongensis* Zhang and Dong, *Sphaerulina croatica* Kochansky-Devidé, *S. ogbinensis* Rozovskaya, etc. In many sections, there is a bed overfilled with *Eopolydiexodina persica* (Kahler) approximately in the middle part of the formation. The uppermost beds of the formation contain *Pseudofusulina arpaensis* n. sp. and *Chusenella brevis* Rozovskaya, as well as *Neoschwagerina ex* gr. *cheni* Sheng, *Sumatrina* sp., and *Verbeekina furnishi* Skinner and Wilde, according to Kotlyar et al. (1989). In general, the fusulinids listed indicate the upper Murgabian.

The Arpa Formation. The Arpa Formation is characterized by fusulinids throughout. The high diversity of fusulinids are confined to the lowermost beds of the formation. Among them, I identified *Kahlerina tenuitheca* Wang, Sheng and Zhang, *Dunbarula* sp., *Yangchienia thompsoni* Skinner and Wilde, *Pseudofusulina arpaensis* n. sp., *P. pjatakovae* n. sp., *P. araxensis* n. sp., *Chusenella rabatei* Skinner and Wilde, *Ch. longa* Rozovskaya, *Sumatrina vediensis* n. sp., and *Verbeekina* cf. *verbeeki* (Geinitz). Chedija in Kotlyar et al. (1989) reported *Reichelina* sp., *Rauserella* sp., *Minojapanella* (*Wutuella*) sp. and some species of *Pseudofusulina* and *Chusenella* from the same part of the section. In the upper part of the section *Chusenella*, including very characteristic *Chusenella abichi* (A. M.-Maclay) as well as *Ch. longa* Rozovskaya, *Ch. caucasica* Chedija, and *Ch. brevis* Rozovskaya are predominant. Representatives of the genera *Schubertella*, *Codonofusiella*, *Dunbarula*, *Pseudofusulina*, and *Rugosofusulina* occur sporadically.

The formation is dated as Midian (lower Midian). Although the fusulinids listed do not include *Yabeina* and *Lepidolina* that are characteristic of this stage, the age assignment was inferred from the presence of typical Midian genera, such as *Reichelina*, *Codonofusiella*, and *Kahlerina*. In the Abadeh section of Central Iran (Iranian-Japanese Research Group, 1981), the characteristic *Chusenella* of the group of *Chusenella abichi* were found in association with the species *Neoschwagerina margaritae*. The latter appears in the Akasaka section of Japan with primitive *Yabeina* and extends into the *Yabeina globosa* Zone (Leven, 1993).

The Khachik Formation. The Khachik Formation is not rich in fusulinids. I identified *Pseudoendothyra sp.*, *Staffella sp.*, *Nankinella rarivoluta* Wang, Sheng and Zhang, *Kahlerina* sp., *Reichelina* sp., *Codonofusiella* sp., *Pseudofusulina solita* Skinner, *P. pjatakovae* n. sp., *P. arpaensis* n. sp., *P. araxensis* n. sp., *Chusenella brevis* Rozovskaya and *Verbeekina* cf. *verbeeki* (Geinitz). Chedija

PLATE 3

Fig. 1-3 - *Pseudodunbarula dzhagadzurensis* Chedija. x 50. 1, 2 - subaxial sections, GIN 4768/50 and 4768/51; 3 - sagittal section, GIN 4768/52; Khachik Formation, Chanahchi bed.

Fig. 4, 7, 8 - *Pseudodunbarula arpaensis* Chedija. x 50. Axial and subaxial sections, GIN 4768/50, 4768/53 and 4768/51; Khachik Formation, Chanahchi bed.

Fig. 5, 6 - *Ogbinella ardaglensis* (Chedija). x 50. Axial sections, GIN 4768/54 and 4768/55; Khachik Formation, Chanahchi bed.

Fig. 9- 13 - *Codonofusiella* (?) *vediensis* n. sp. x 50. 9 - Subsagittal section, GIN 4768/16; 10 (holotype) - 13 - subaxial sections, GIN 4768/56, 4768/16 and 4768/8; middle part of Asni Formation.

Fig. 14, 15, 17-20 -*Codonofusiella kwangsiana* Sheng. x 50. Axial and subaxial sections (except fig. 20), GIN 4768/57, 4768/54, 4768/58 and 5768/59; fig. 20 - subsagittal section, GIN 4768/49; Khachik Formation, Chanahchi bed.

Fig.16 - *Codonofusiella* (?) *asiatica* K. Miklukho-Maclay. x 50. Tangential section, GIN 4768/55; Khachik Formation, Chanahchi bed.

Fig. 21, 30 - *Codonofusiella tenuissima* Sheng. x 50. 21 - sagittal section, GIN 4768/60; 30 - axial section, GIN 4768/61; Khachik Formation, Chanahchi bed.

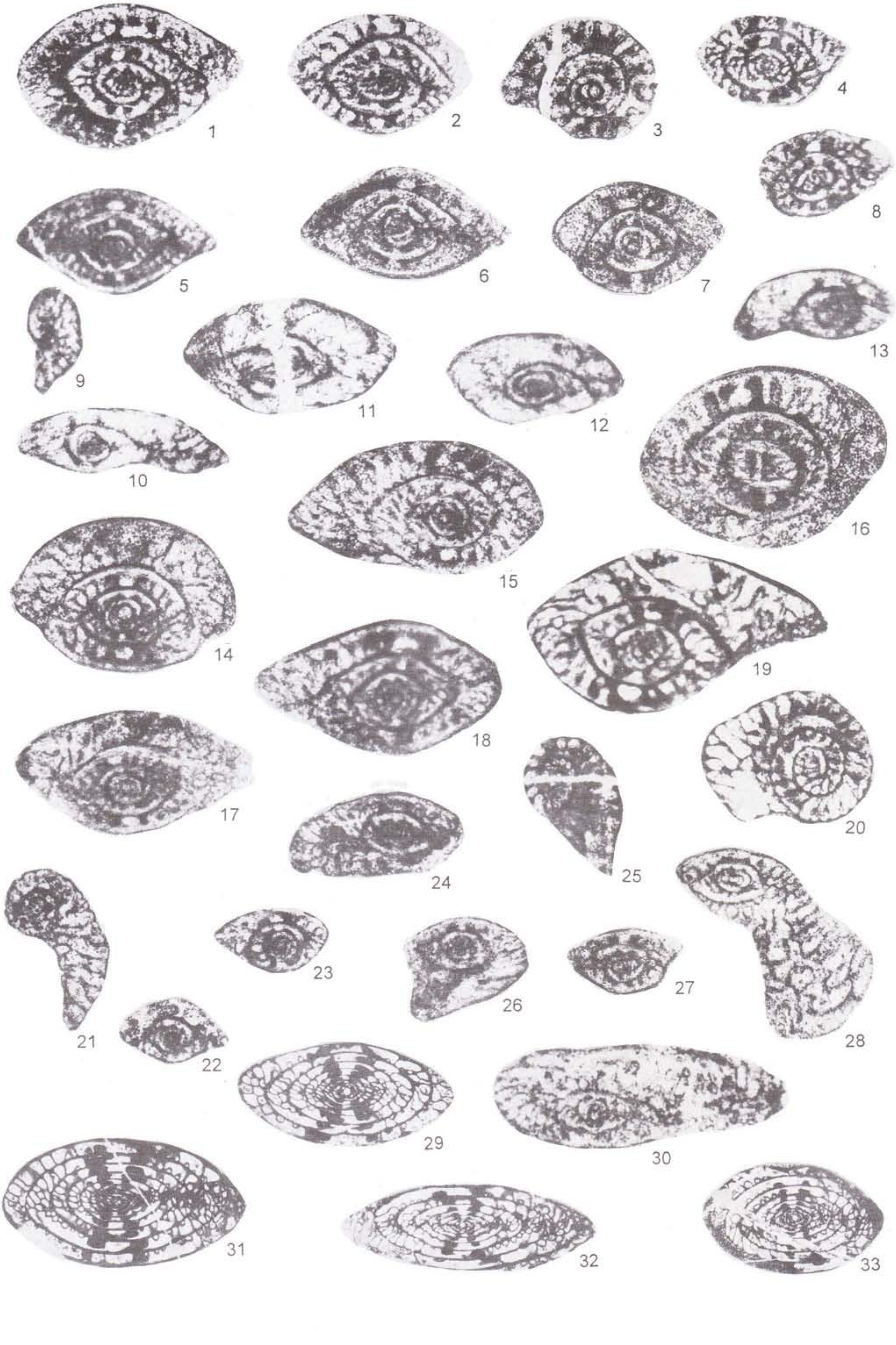
Fig. 22-27 - *Codonofusiella erki* Rauser. x 50. Axial and subaxial sections (except fig. 25), GIN 4768/62, 4768/50, 4768/63, 4768/64,and 4768/52; fig. 25 - sagittal section, GIN 4768/63; Khachik Formation, Chanahchi bed.

Fig. 28 - *Codonofusiella* sp. x 50. Subaxial section, GIN 4768/65; Khachik Formation, Chanahchi bed.

Fig. 29, 31 - *Darvasites ordinatus ordinatus* (Chen). x 10. Axial sections, GIN 4768/66 and 4768/67; Davaly Formation.

Fig. 32 - *Darvasites ordinatus* longus Leven. x 10. Axial section, GIN 4768/68; Davaly Formation.

Fig. 33 - *Darvasites* aff. *contractus* (Schellwien et Dyhrenfurth). x 10. Axial section, GIN 4768/69; Davaly Formation.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in Kotlyar et al. (1989) also reported *Rauserella* sp., *Chusenella dorashamensis* Rozovskaya, *Ch. referta* Skinner and Wilde, *Ch. schwagerinaeformis* Sheng, *Ch. minuta* Skinner, *Ch. tingi* Chen, *Kahlerina ovalis* Chedija, *K. constricta* Chedija, *Pseudokahlerina porrecta* Chedija, and *Neoschwagerina pinguis* Skinner. In general, this assemblage is similar to the assemblage of the Arpa Formation and also is of Midian age. The co-occurrence of *P. solita* and *N. pinguis* with highly developed *Yabeina*, such as *Yabeina opima* Skinner, in sections in Turkey (Skinner, 1969) is of some interest because it supports the Midian age of this part of the section.

The fusulinid assemblage of the uppermost (so called Chanahchy) beds of the Khachik Formation is different from the assemblage described above as it does not contain larger fusulinids of the order Schwagerinida, which dominate the lower portion of the section. Small forms of the order Schubertellida become prevalent. Among them, *Pseudodunbarula arpaensis* Chedija, *P. minima* (Sheng and Chang), *P. dzhagadzurensis* Chedija, *Codonofusiella kwangsiana* Sheng, *C. kueichowensis* Chen, *C. golubinensis* Sosnina, *C. dzhulfensis* Rauser, *C. tenuissima* Sheng, *C. erki* Rauser, *C. schubertelloides* Sheng, *C. dzhagrensis* Chedija, *C.* (?) *asiatica* K. M.-Maclay, *Ogbinella ardaglensis* Chedija, *O. ogbinensis* Chedija, *O. avushensis* Chedija and *Dunbarula* sp. were identified by Chedija in Kotlyar et al.(1989), Rauser-Chernousova in Ruzhentsev & Sarycheva (1965), and later by myself. In addition, rare representatives of other orders (Ozawainellida, Staffellida), such as *Reichelina changhsingensis* Sheng and Chang. *R. cribroseptata* Erk, *R. minuta* Erk, *R. tenuissima* K. M.-Maclay, *R. mirabilis* (Dutkevich), and *Pseudoendothyra* sp. were found.

This assemblage shows a strong similarity to the fauna present in the lower half of the Wuchiaping Formation of South China (Sheng, 1963), which dates the Chanahchy Beds to the lower part of the Wuchiaping Stage proposed in the global Permian scale (Jin, 1996). Some researchers equate this stage with the Dzhulfian Stage of the Tethyan scale (Kotlyar et al., 1989), in which case the Chanahchy Beds would be dated as lower Dzhulfian. However, by definition, the lower Dzhulfian boundary is drawn at the top of the Chanahchy Beds (Leven, 1980). Therefore, Kotlyar in Kotlyar et al. (1983), and later myself, included these beds into the Midian Stage and correlated them with the *Lepidolina kumaensis* Zone, characterized by the association of many of the listed smaller fusulinids and most advanced representatives of the orders Schwagerinida and Neoschwagerinida. If this correlation is correct, which is still unclear, the Chanahchy Beds must be of Midian age. A proposal by Kozur (1996) to recognize this part of the section as an independent stage (Laibinian Stage), positioned between the Midian and Dzhulfian stages, is probably worth attention.

The *Akhura Formation* contains only rare *Reichelina media* K. M.-Maclay, *R. tenuissima* K. M.-Maclay and *Codonofusiella* (?) *sp.*

Correlation.

The relationships between the well known Permian sequence of the Transcaucasia and other Permian sequences of the Tethyan area have been clearly established and are referred to in many correlation maps (Leven, 1980; Nakazawa, 1990, Kotlyar, 1997; and others). This concerns especially the upper part of the sequence, which was studied thoroughly in the context of the Permian-Triassic boundary problem. Therefore, this article focuses on the lower part of the sequence.

The Transcaucasian Permian sequence is correlated herein to the best known sequences which served as the bases for building the Tethyan stage scale and the regional Chinese and Japanese scales. The correlation of this sequence with the sequences of the adjacent territory of Iran will be discussed as well.

Iran.

The Permian deposits are widespread throughout this country. Their sequence is generally similar to that of the Transcaucasia. The sequence is represented

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PLATE 4

All x 10

Fig. 1 - *Chalaroschwagerina darvasica* Leven. Subaxial section, GIN 4768/23; Davaly Formation.
Fig. 2, 4 - *Chalaroschwagerina vulgaris* (Schellwien et Dyhrenfurth). Axial sections, GIN 4768/70 and 4768/71; Davaly Formation.
Fig. 3 - *Chalaroschwagerina kushlini* (Leven). Axial section, GIN 4768/72; Davaly Formation.
Fig. 5, 6 - *Chalaroschwagerina davalensis* n. sp. Axial sections, GIN 4768/73 and 4768/74 (holotype); Davaly Formation.
Fig. 7, 9 - *Pseudofusulina* aff. *emaciata* (Beede). Axial sections, GIN 4768/75; lower part of Asni Formation.
Fig. 8 - *Chalaroschwagerina globosa* (Schellwien et Dyhrenfurth). Axial section, GIN 4768/76; Davaly Formation.
Fig. 10 - *Pseudofusulina* sp. Subaxial section, GIN 4768/77; Davaly Formation.
Fig. 11 - *Pseudofusulina aghilensis* (Reichel). Axial section, GIN 4768/78; lower part of Asni Formation.
Fig. 12, 16 - *Pseudofusulina pjatakovae* n. sp. 12 - axial sections, GIN 4768/79 (holotype); Arpa Formation; 16 - axial section GIN 4768/80; lower part of Khachik Formation.
Fig. 13, 15 - *Pseudofusulina postkraffti* (Leven). Axial sections, GIN 4768/81 and 4768/82; lower part of Asni Formation.
Fig. 14 - *Pseudofusulina isomie* Igo. Axial section, GIN 4768/83; lower part of Asni Formation.


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mostly by a thick series of predominantly carbonate deposits lying transgressively on the underlying units. These are the Ruteh and Nesen Formations in the Alborz (Assereto, 1963; Fantini-Sestini & Glaus, 1966; Jenny-Deshusses, 1983), the Jamal Formation in the Tabas Mountains, eastern Iran (Ruttner et al., 1968), the Surmaq, Abadeh and Hambast Formations in the Abadeh area, Central Iran (Iranian-Japanese Research Group, 1981), and the Dalan Formation in the Zagros Mountains (Douglas, 1936, 1950; Szabo & Kheradpir, 1978). This transgressive succession is of Guadalupian-Lopingian age. Similar to the Davaly Formation of the Transcaucasia, its basal part bears locally (Tabas, Abadeh) *Darvasites*, *Chalaroschwagerina*, and *Misellina* of Bolorian age (Iranian-Japanese Research Group, 1981; Ruttner et al., 1968; Kahler, 1974). The carbonate deposits are underlain with a hiatus by predominantly terrigenous Asselian-Sakmarian or older sediments. The similarity between the Guadalupian sequences of the Transcaucasia and Iran is emphasized by their thickness and poor fusulinid content.

All this suggests that in the Guadalupian and Lopingian epochs, the Trancaucasia was a part of the extensive carbonate platform system that covered the entire territory of Iran. In this respect, the comparison of the Transcaucasian sequence with the section to the southeast of the town of Abadeh, Central Iran, is most representative. This section became known after Taraz (1971, 1973, and 1974) established there the new Abadehian Stage. Later the section was studied carefully by the joint Iranian-Japanese Research Group (1981) and lately by Baghbani, who obtained the most complete collection of fusulinids. I do not know any published description of this collection. However, I had a possibility to acquaint with it when attending the Congress "The Permian of the Globe" held in Perm, 1994. The correlation of the Abadeh and Transcaucasian sections is based on my identifications, which are in general analogous to the identifications of Baghbani, but he infers a later age of the fusulinid assemblage from the basal part of Bed 1 of the Surmaq Formation.

The Abadeh section of the Permian deposits begins with the terrigenous Vazhnan Formation bearing Sakmarian *Robustoschwagerina* and *Pseudoschwagerina*. The deposits of this age are missing in the Transcaucasia. The Vazhnan Formation is overlain with a hiatus by the carbonate Surmaq Formation (Fig. 3). Locally at its base, there are *Darvasites* cf. *ordinatus* (Chen) of Bolorian age (Iranian-Japanese Research Group, 1981), which also occurs in the Davaly Formation. However, as in the Transcaucasia, the Surmaq Formation section commonly begins with the Kubergandian beds. The basal part of Unit 1 yielded *Yangchienia* sp., *Minojapanella* sp., and *Skinnerella* spp. Upsection *Armenina* sp., *Cancellina dutkevichi* (Leven), *C. praeneoschwagerinoides* Leven, and *Neofusulinella* sp. and above them *Presumatrina neoschwagerinoides* (Deprat) and *Neoschwagerina simplex* (Ozawa) were found. The listed fusulinids suggest that the upper and, probably, lower zones of the Kubergandian Stage and the lower zone of the Murgabian Stage correspond to the lower part of Unit 1 of the Surmaq Formation. This allows a correlation of this part of the section to the entire Asni Formation.

The Gnishik Formation corresponds approximately to the upper half of Unit 1, from which *Eopolydiexodina* spp., *Neoschwagerina* aff. *margaritae* Deprat, *Afghanella* spp., and *Sumatrina annae* Deprat are described (Iranian-Japanese Research Group, 1981).

The Arpa Formation can be correlated to Units 2 and 3 of the Surmaq Formation due to the occurrence of *Chusenella abichi* (A.M.-Maclay) characteristic of the Arpa Formation in Unit 3 and in the upper part of Unit 2.

The Khachik Formation is well correlated to the Abadeh Formation. This concerns especially the Chanahchy Beds correlated reliably with Unit 5 of the Abadeh Formation. These subdivisions contain similar fusulinid assemblages dominated by species of *Codonofusiella*, such as *C. lui* Sheng, and *C. kwangsiana* Sheng. The correspondence of the larger, lower part of the Khachik Formation to Unit 4 of the Abadeh Formation is inferred from the similarity of their position between the beds with *Ch. abichi* and those with *Codonofusiella*. Fusulinid records (*Yabeina* sp., *Metadoliolina* sp., *Chusenella* sp., *Codonofusiella* sp.) of Unit 4 do not contradict this inference. Moreover, they indicate that Unit 4 belongs to the Midian Stage, which does not allow the Abadeh Stage to be established as a transitional stage between

PLATE 5

All x 10

Fig. 1, 8 - *Pseudofusulina solita* Skinner. Axial sections, GIN 4768/84 and 4768/85; Khachik Formation.

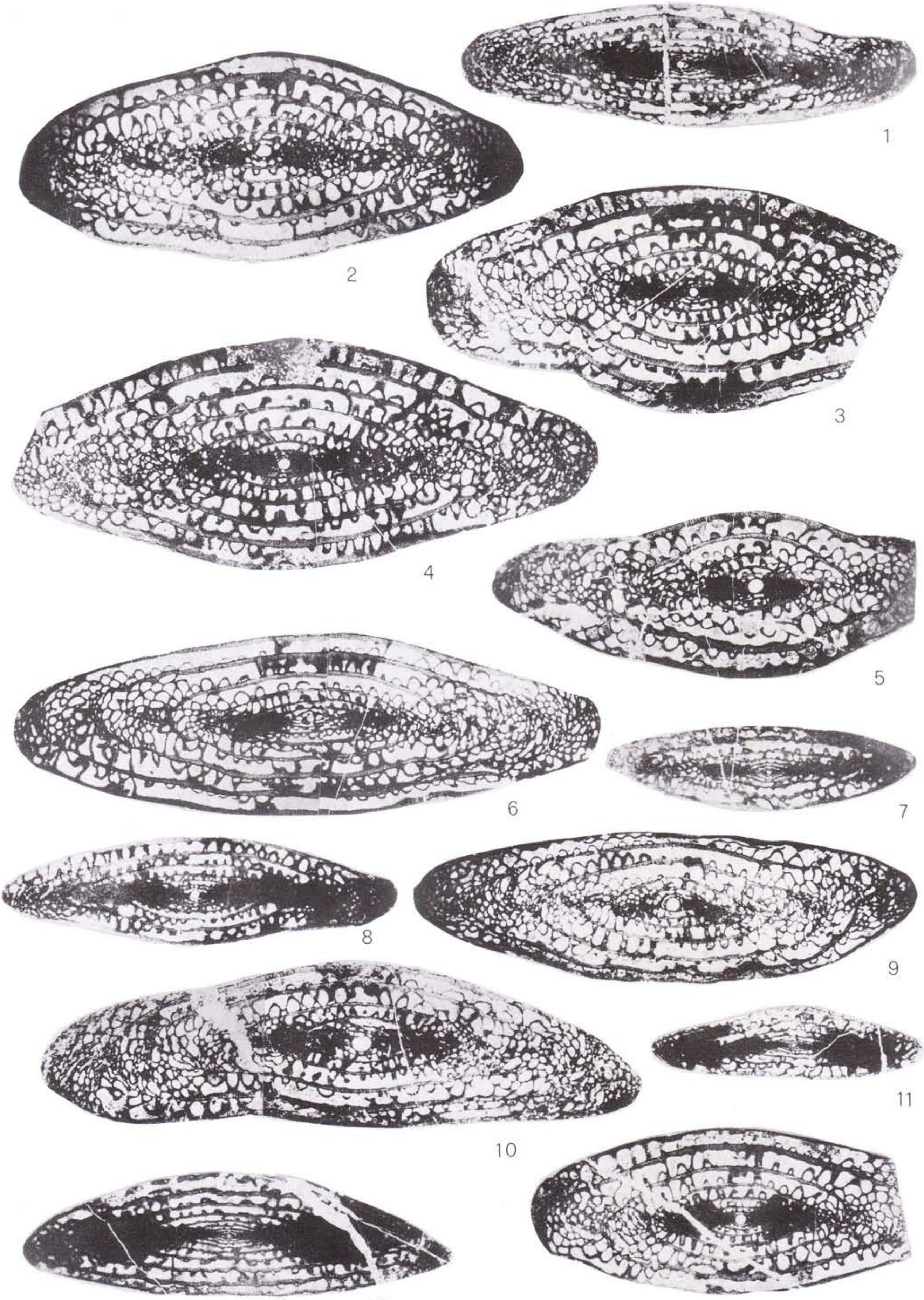
Fig. 2-4 - *Pseudofusulina arpaensis* n. sp. Axial sections, GIN 4768/86, 4768/87 and 4768/88 (holotype); lower part of Khachik Formation.

Fig. 5 - *Pseudofusulina* aff. *pjatakovae* n. sp. Axial section, GIN 4768/89; lower part of Khachik Formation.

Fig. 6, 9, 10- *Pseudofusulina araxensis* n. sp. Axial sections, GIN 4768/90 (holotype), 4768/39 and 4768/91; Arpa Formation and lower part of Khachik Formation.

Fig. 7,11, 12- *Rugosochusenella davalensis* n. sp. Axial sections, GIN 4768/92, 4768/93 and 4768/47 (holotype); Davaly Formation and the base of Asni Formation.

Fig. 13 - *Pseudofusulina* sp. *Axial section*, GIN 4768/94; Arpa Formation.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the Guadalupian and Lopingian series of the Permian System. The Akhura Formation corresponds to the entire Hambast Formation, which also contains *Araxoceras* and *Clarkina leveni* (Kozur, Mostler and Pjatakova) in the lower part and *Paratirolites* and *Clarkina subcarinata* (Clark) in the upper part. It is noteworthy that, like the Akhura Formation, the Hambast Formation has an inconsiderable thickness in comparison with the remaining portion of the Permian sequence. The upper parts of the strata under comparison are red in color. Lithologically, these deposits are also very similar, being dominated by micritic varieties of limestones passing into clayey limestones and mudstones. The underlying strata mainly contain remains of benthic organisms, among which algae and fusulinids are dominant. In the Akhura and Hambast formations, they virtually disappear and are replaced by nektonic-benthic cephalopods and nektonic conodonts. The Transcaucasian and Abadeh sequences are remarkably similar, although separated by a distance of 1000 km. Baghbani (1997) even believes it is possible to identify the same beds and formations described in the Abadeh section also in the Dzhulfian section of the Transcaucasia and the neighboring Kuh-e-Ali Bashi section on the opposite bank of the Arax River.

As shown above, beginning from the Kubergandian and locally from the Bolorian stages, the Transcaucasian and Abadeh sections are represented by a continuous succession of predominantly carbonate marine sediments. The same composition characterizes a section in the Shotori Mountains near the town of Tabas. In this section the basal part of the Jamal Formation yielded *Misellina*, *Chalaroschwagerina globosaeformis* (Leven), *Pseudofusulina kraffti* (Schellwien and Dyhrenfurth) and other forms of Bolorian age (Ruttner et al., 1968; Kahler, 1974), which allow its correlation to the Davaly section of the Transcaucasia. The higher parts of the Jamal Formation contain *Cancellina pamirica* (Leven) and *Armenina* sp. of Kubergandian age, characteristic of the lower half of the Asni Formation (Kahler & Kahler, 1979; Jenny-Deshusses, 1983). Further up in the section, Murgabian and Midian *Partisania*, *Paradagmarita*, *Neoschwagerina* and other forms (Jenny-Deshusses, 1983) recorded from the Arpa and Khachik formations of the Transcaucasia occur, as well as Wuchiapingian and Changhsingian *Reichelina*, *Codonofusiella*, *Palaeofusulina* (Baghbani, 1997), which make this portion of the sequence correlatable to the Akhura Formation.

These data cast doubt on Baghbani's (1997) suggestion that the Jamal Formation section begins with the Murgabian Stage and that the Midian Stage is missing.

Data on Alborz are very controversial. We can only say with confidence that this section, as well as the Transcaucasian section, includes Middle-Upper Permian transgressive carbonates (the Ruteh and Nesen formations), which yielded faunas of Murgabian, Midian, Wuchiapingian, and, according to the latest data (Baghbani, 1997), Changhsingian ages (Stepanov et al., 1969; Stöcklin, 1971; Jenny-Deshusses, 1983; and others).

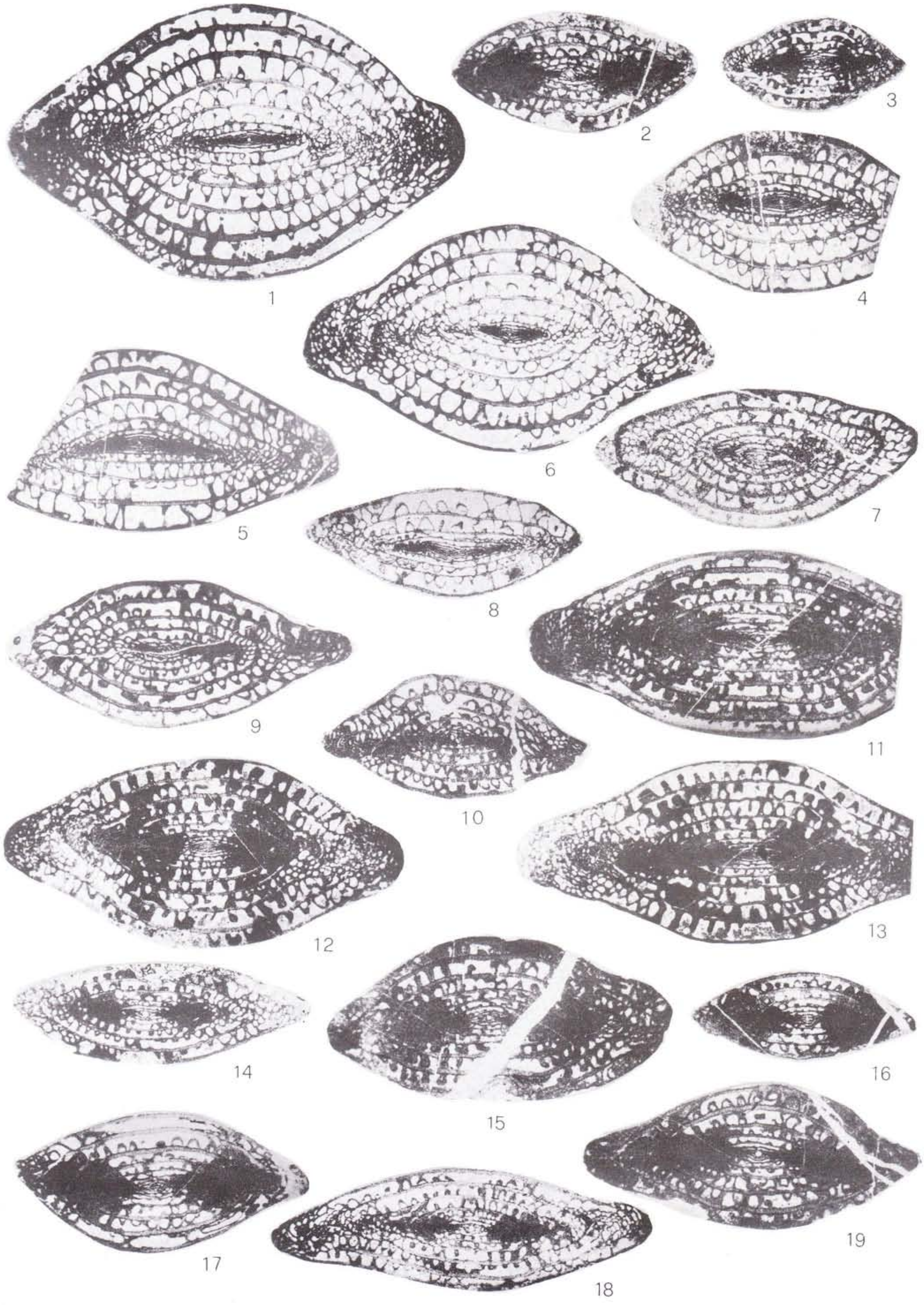
This serves as a basis to correlate the Ruteh and Nesen formations with the Gnishik, Khachik, and Akhura formations of the Transcaucasia. The likely occurrence of units analogous to the Asni Formation has not been yet proved.

The hiatus in sedimentation between the Ruteh and Nesen formations cannot be excluded but it is unlikely, as suggested by Baghbani (1997). Information on the Permian deposits of Zagros is scattered. As everywhere in Iran, the Guadalupian-Lopingian deposits recognized as the Dalan Formation are represented by carbonates transgressively overlying sandstones with terrestrial flora. According to recent data (Baghbani, 1997), similar to the Transcaucasian section, this formation is exposed most completely in the Oshfaran Kuh Mountain ranges from the Kubergandian Stage to Changhsingian Stage inclusive. In the Kuh-e Surmeh and Kuh-e Dena sections, the Dalan Formation can be divided into three parts, i.e. the lower and upper carbonate portions separated by clastic or salt-bearing deposits of continental and lagoonal origin. The latter are assigned to the upper Murgabian - lower Midian. The transgressive upper carbonate unit begins with beds containing *Shanita*, a genus of small foraminifers typical of the Midian Stage

PLATE 6

All x 10

Fig. 1, 6 - *Chusenella abichi* (A. Miklukho-Maclay). Axial sections, GIN 4768/95 and 4768/96; Arpa Formation.
Fig. 2, 16, 17 -*Chusenella schwageriniformis* Sheng. Axial sections, GIN 4768/97, 4768/98 and 4768/99; middle part of Asni Formation.
Fig. 3 - *Chusenella minuta* Skinner. Axial section, GIN 4768/38; Davaly Formation.
Fig. 4 - *Chusenella brevis* Rozovskaya. Axial section, GIN 4768/100; Arpa Formation.
Fig. 5, 8 - *Chusenella longa* Rozovskaya. Axial sections, GIN 4768/101 and 4768/102; Arpa Formation
Fig. 7, 9 - *Chusenella sinensis* Sheng. Subaxial sections, GIN 4768/103 and 4768/104, upper part of Asni Formation.
Fig. 10 - *Chusenella douvillei* (Colani). Axial section, GIN 4768/105; lower part of Asni Formation.
Fig. 11,15,19 -*Chusenella conicocylindrica* Chen. Axial sections, GIN 4768/106, 4768/107 and 4768/108; middle and upper part of Asni Formation.
Fig. 12, 13 - *Chusenella caucasica* Chedija. Axial sections,GIN 4768/109 and 4768/110; Arpa Formation.
Fig. 14, 18 - *Chusenella rabatei* Skinner et Wilde. Axial sections, GIN 4768/111 and 4768/112; Arpa Formation.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(more likely, its upper part), and ends with *Palaeofusulina* beds of Changhsingian age. The lower carbonate layer yielded Murgabian fusulinids. Its basal part was assigned by Bakhbani (1997) to the Kubergandian Stage.

Turkey.

The Permian sections of Turkey correlatable with those of the Transcaucasia and Iran are preserved in the Taurus nappes (the Kemer, Bademli, Hadym, Pinarbashi, and Tufanbeili sections) (Lys & Marcoux, 1978; Monod, 1977; Altiner, 1981; Zaninetti et al., 1981) and in allochthonous position in the southeast (the Hazro and Hakkari sections) (Fontaine, 1981; Köylüoglu & Altiner, 1989). As in the Transcaucasia and Iran, all of these sections are represented by predominantly carbonate marine deposits transgressively overlying Lower Permian or older sediments. These deposits are commonly considered to begin with the Murgabian Stage (Lys, 1986; Altiner, 1981; Baud et al., 1993). I think they are not older than Midian in age, because typical Midian foraminifers, such as *Shanita amosi* Bronnimann, Whittaker and Zaninetti, *Baisalina pulchra* Reitlinger, *Paraglobivalvulina mira* Reitlinger, *Rectostipulina*, *Codonofusiella*, *Reichelina*, were found at the very base of the Pinarbashi and Tufanbeili sections (Altiner, 1981; Zaninetti et al., 1981). The lower part of the carbonate Pamuchak Formation section of the Antalya region, which contains *Codonofusiella* spp. and *Hemigordiopsis renzi* (Reichel) (Lys & Marcoux, 1978; Lys, 1986), is likely of Midian age. Specimens of the genera *Eopolydiexodina* and *Rugososchwagerina*, commonly considered as Murgabian forms, were found in the upper part of the section. However, the first genus shows a wide stratigraphic range extending from the Kubergandian Stage to the Midian Stage inclusive. Moreover the scarcely known *Rugososchwagerina* are usually confined to the uppermost beds of the Murgabian Stage, but in Afghanistan they are associated with typical Midian *Reichelina*, *Kahlerina* and *Lantschichites* (Leven, 1997). The basal part of the limestones of the Bademli (Alanya) section, which contains *Baisalina pulchra* Reitlinger and *Codonofusiella paradoxica* Dunbar and Skinner (Monod, 1977), and the lower part of the Gomaniibrik Formation of the Hazro section in southeastern Turkey (Lys, 1986) are likely Midian in age. Most likely the Murgabian and probably the Kubergandian deposits constitute only the basal part of the thick Guadalupian-Lopingian succession in the Hadym nappe (Altiner, 1984), as shown by the presence of *Neofusulinella*, *Presumatrina* and primitive *Neoschwagerina* among the specimens from this part of the section, which I identified after Dr. Çatal from the Geological Survey of Turkey and Prof. Güvenç from Hojatepe University, Ankara kindly brought them to me for examination. All this evidence indicates that the Guadalupian transgression spread over most parts of southern Turkey later than in Iran and the Transcaucasia. These regions were not reached by the onset of this transgression in the late Bolorian - early Kubergandian time, but they were covered by sea waters later, during the more extensive transgression of Midian (late Murgabian?-Midian) time.

The southeastern Pamirs.

The Permian sequence of this region is described according to the data of Leven (1967), Grunt and Dmitriev (1973), Leonova & Dmitriev (1989), and Kotlyar et al. (1983, 1989).

The Davaly Formation of the Transcaucasia corresponds to the upper part of the Kochusu Formation (or, more likely, to the entire unit), the Shindy Formation, and the lowermost part of the Kuberganda Formation of the southeastern Pamirs (Fig. 3). The deposits above and below the volcanogenic Shindy Formation contain the typical Bolorian fusulinid assemblage, which includes the species *Misellina* (*Misellina*) *parvicostata* (Deprat), *Chalaroschwagerina globosa* (Schellwien and Dyhrenfurth), and *Darvasites ordinatus* (Chen). All of these species were also found in the Davaly Formation. The fusulinids are associated with a rich so called "Buzterin" assemblage of ammonoids. Bogoslovskaya and Leonova in

PLATE 7

All x 10, except fig. 17

Fig. 1 - *Praeskinnerella kueichowensis* (Sheng). Axial section, GIN 4768/113; Davaly Formation.

Fig. 2 - *Praeskinnerella parviflucta* (Zhou). Axial section, GIN 4768/114; lower part of Asni Formation.

Fig. 3, 4, 7, 12 -*Praeskinnerella guembeli pseudoregularis* (Dunbar et Skinner). Axial sections, GIN 4768/115, 4768/116, 4768/117 and 4768/118; Davaly Formation and lower part of Asni Formation.

Fig. 5 - *Praeskinnerella pavlovi* (Leven). Axial section, GIN 4768/119; lower part of Asni Formation.

Fig. 6, 10, 11, 13 -*Skinnerella elliptica* (Sheng). Axial sections, GIN 4768/120, 4768/121, 4768/122 and 4768/123; lower part of Asni Formation.

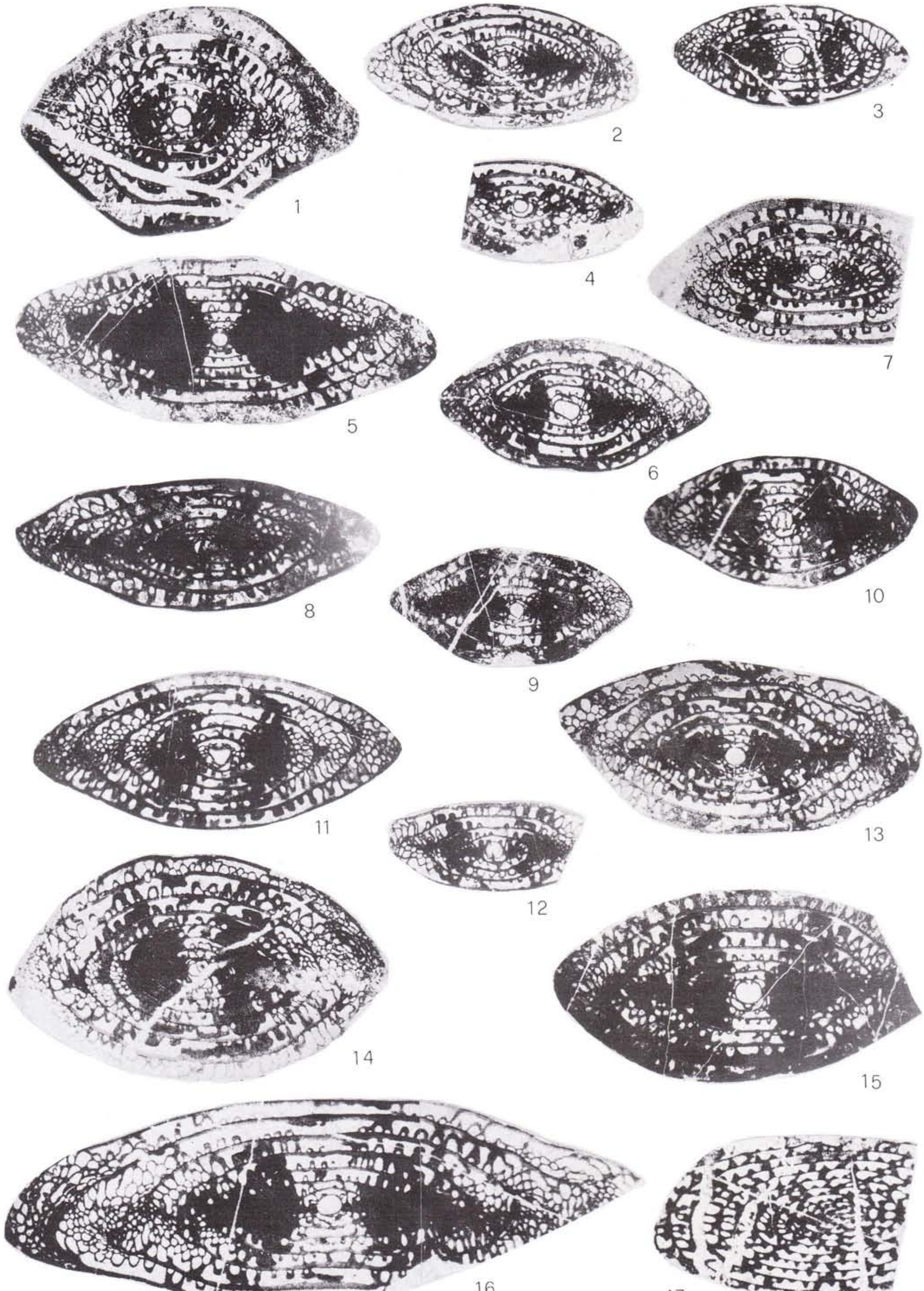
Fig. 8 - *Praeskinnerella* aff. *afghanensis* Leven. Axial section, GIN 4768/124; lower part of Asni Formation.

Fig. 9 - *Praeskinnerella fragilis* Leven. Axial section, 4768/125; lower part of Asni Formation.

Fig. 14, 15 - *Skinnerella gundarensis* Leven. Aaxial sections, GIN 4768/126 and 4768/127; middle part of Asni Formation.

Fig. 16 - *Skinnerella yunnanica* (Sheng). Axial section, GIN 4768/128; middle part of Asni Formation.

Fig. 17 - *Pseudodoliolina ozawai* Yabe et Hanzawa. x15. Subaxial section, GIN 4768/165, upper part of Asni Formation.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Leonova & Dmitriev (1989) consider this assemblage to be transitional between the Artinskian and Roadian assemblages, which allows correlation of the enclosing beds of SE Pamirs and, consequently, of the Davaly Formation to the Kungurian Stage of the Uralian scale and to the Kathedralian Stage of the North American scale (Ross & Ross, 1987).

This correlation is supported by conodonts associated with the ammonoids (Kozur et al., 1994; Kozur, 1995). However, unlike the ammonoid specialists, Kozur admits the correspondence of the lower part of the Kochusu Formation to the Yakhtashian Stage of the Tethyan scale or the Artinskian Stage of the Urals. As already mentioned, this may be true also for the Davaly Formation. The sequences of the regions under consideration bear another similarity: the upper Yakhtashian (?)-Bolorian sediments transgressively overlap eroded deposits, such as the Upper Devonian-Lower Carboniferous in the Transcaucasia and the Tashkozyk Formation of the Sakmarian Stage in the Pamirs.

In the southeastern Pamirs, the type sections of the Kubergandian Stage (Leven, 1981b; Chedija et al., 1986) contain beds corresponding to the *Armenina*, *Misellina ovalis* Zone (the lower zone of this stage) immediately above the beds with the Late Bolorian fusulinids. The fusulinid assemblage shows close similarity to that of the basal Asni Formation, due to the presence of abundant *Armenina* and highly developed *Misellina*, the appearence of *Skinnerella*, *Neofusulinella*, and the first *Yangchienia* and the disappearance of *Darvasites* and *Chalaroschwagerina*, characteristic of the Bolorian Stage.

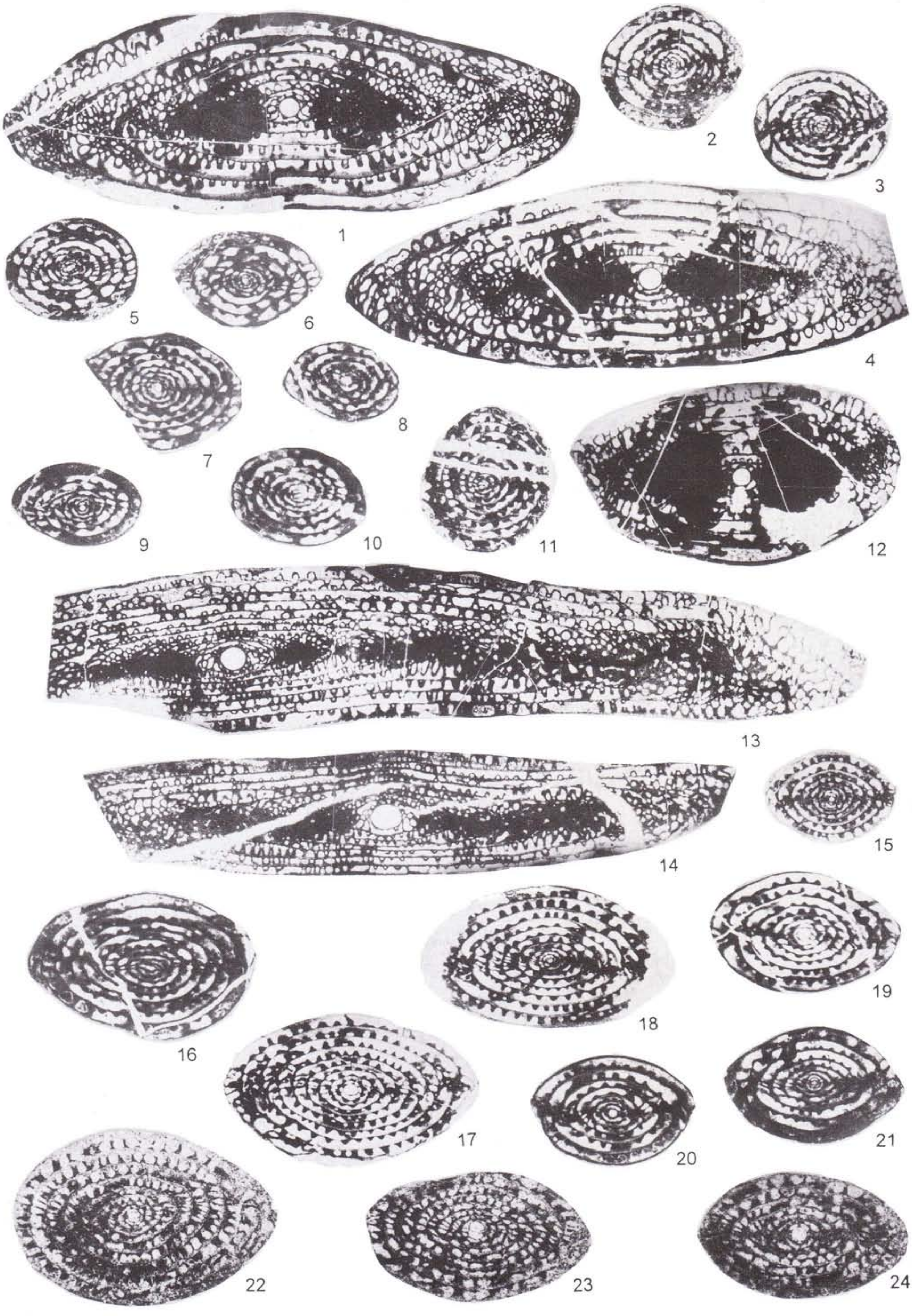
The occurrence of ammonoids including *Paraceltites*, *Stacheoceras*, *Bamianiceras*, and *Popanoceras* correlates this part of the sequence of the southeastern Pamirs to the Roadian Stage (mainly to its lower part) of the North American scale (Chedija et al., 1986).

The middle part of the Asni Formation, corresponding to the upper zone of the Kubergandian Stage, is correlative to the *Cancellina cutalensis* Zone of this stage of the southeastern Pamirs, as demonstrated by common *Cancellina* and abundant *Skinnerella*. The presence of *Presumatrina neoschwagerinoides* (Deprat) and *Pseudodoliolina ozawai* Yabe and Hanzawa provides the basis for the correlation of the upper part of the Asni Formation to the lower half of the Murgabian Stage (the lower part of Dzhamantal Beds of the Gan Formation) exposed in the type section at the Dzhamantal Mountain. The Gnishik Formation can be arbitrarily correlated to the upper half of the Murgabian Stage or to the upper part of Dzhamantal Beds and to the Deire Beds of the Gan Formation. Regretfully, there is no available direct data supporting this correlation.

In the southeastern Pamirs, there are no precise analogues of the Transcaucasian Arpa and Khachik sequence which is a type section of the Midian Stage (Leven, 1980). Both formations can be correlated approximately to the Karasu Beds of the Gan Formation, due to the common occurrence of highly developed *Neoschwagerina* and *Chusenella* of the group of *Chusenella abichi* (A. M.-Maclay), *Kahlerina* and other forms. These beds of the southeastern Pamirs contain *Yabeina* and *Lepidolina*, which confirms the inferred equivalence of the Arpa and Khachik formations to the *Yabeina-Lepidolina* Genozone, correspondent in scope, by definition, to the Midian Stage. It is hard to tell which deposits of the Pamirian sequence are analogous to the "Chanahchy Beds" of the Khachik Formation and the part of the Akhura Formation, which belongs to the Dzhulfian Stage. Probably, they are the Kutal Beds of the Gan Formation with *Dunbarula*, *Codonofusiella*, and *Reichelina*. This inference is in disagreement with the brachiopod records from the overlying Takhtabulak Formation, which indicate the correspondence of this formation to the Dzhulfian Stage of the Transcaucasia (Grunt & Dmitriev, 1973). However, according to the data on conodonts, such as *Clarkina subcarinata* (Sweet) (Kozur et al., 1994), the Takhtabulak Formation is correlative to the upper Dorashamian part of the Akhura Formation. The indirect evidence of this correspondence is the occurrence of advanced *Colaniella*, such as *Colaniella parva* (Colani) and *C. cylindrica* K .M.-Maclay, as well as *Palaeofusulina* aff. *fusiformis* Sheng at the base of the

PLATE 8

Fig. 1, 4 - *Skinnerella yunnanica* (Sheng). x 10. Axial sections, GIN 4768/129 and 4768/130; middle part of Asni Formation.
Fig. 2, 3 - *Misellina (Misellina) parvicostata* (Deprat). x 15. Subaxial sections, GIN 4768/131 and 4768/132; Davaly Formation.
Fig. 5-10 - *Misellina (Misellina) shengi* Zhang et Dong. x 15. Axial sections, GIN 4768/36, 4768/133, 4768/134 and 4768/135; Davaly Formation and base of the Asni Formation.
Fig. 11 - *Misellina (Brevaxina) olgae* Leven. x 15. Subaxial section, GIN 4768/137; lower part of Asni Formation.
Fig. 12 - *Skinnerella vinogradovi* (Leven). x 10. Axial section, GIN 4768/138; middle part of Asni Formation.
Fig. 13, 14 - *Eopolydiexodina persica* (Kahler). x 10. Axial sections, GIN 4768/139 and 4768/140; Gnishik Formation.
Fig. 15 - *Misellina (Misellina) claudiae* (Deprat). x 15. Axial section, GIN 4768/141; lower part of Asni Formation.
Fig. 16-19 - *Misellina (Misellina) ovalis* (Deprat). x 15. Subaxial and axial sections, GIN 4768/136, 4768/142, 4768/141 and 4768/143; lower part of Asni Formation.
Fig. 20, 21 - *Misellia (Misellina) caucasica* n. sp. x 15. Axial sectons, GIN 4768/144 (holotype) and 4768/145; lower part of Asni Formation.
Fig. 22-24 - *Cancellina praeneoschwagerinoides* Leven. x 15. Subaxial and axial sections GIN 4768/146 and 4768/147; middle part of Asni Formation.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Takhtabulak Formation. These forms characterize the Changhsingian Stage of South China, which is correlated with the Dorashamian Stage (Sheng, 1963). The stratigraphic ranges of *Colaniella* and *Palaeofusulina* have not yet been established precisely. Their first appearance in the Dzhulfian Stage (Jenny-Deshusses & Baud, 1989; Zhu, 1996) cannot be excluded.

South China.

According to the latest refined chronostratigraphic scale for the Permian of China (Sheng & Jin, 1994; Zhang, 1994; Zhu & Zhang, 1994), the Transcaucasian sequence corresponds fully to the Yanghsingian and Lopingian series (Fig. 3). The Davaly Formation is well correlated to the *Brevaxina dyhrenfurthi* Zone - the lower zone of the Luodianian Stage. In the Guizhou Province, this zone is characterized, along with the zonal species, by the following fusulinids, most typical of the Davaly Formation: *Misellina (Misellina) parvicostata* (Deprat), *Darvasites ordinatus* (Chen), *Chalaroschwagerina vulgaris* (Schellwien and Dyhrenfurth) (Xiao et al., 1986).

The basal part of the Asni Formation may be correlated to the *Misellina claudiae* Zone of the Luodianian Stage, which contains highly developed *Misellina*, *Armenina*, and *Yangchienia* (Xiao et al., 1986). The middle part of the Asni Formation corresponds to the lower half of the *Neoschwagerina simplex - Cancellina* (=*Presumatrina*) *neoschwagerinoides* Zone recognized as the Xiangboan Stage (Sheng & Jin, 1994) or the Maklaya (=*Cancellina*) *elliptica* Zone of the Guizhou Province (Xiao et al., 1986). Zhu & Zhang (1994) identified this zone as the *Cancellina dutkevichi* Zone. The upper part of the Asni Formation, with *Presumatrina neoschwagerinoides* (Deprat) and *Pseudodoliolina ozawai* Yabe and Hanzawa, correlates approximatively to the upper half of the Xiangboan Stage or the *Cancellina liuzhiensis* and *Neoschwagerina simplex* zones of the Guizhou sections (Xiao et al., 1986).

Chinese stratigraphers consider the Luodianian and Xiangboan stages to constitute the Chihsian Subseries (Sheng & Jin, 1994). Many sections of South China show that these deposits overlap transgressively the underlying strata, as observed in the Transcaucasia and the southeastern Pamirs. The Gnishik Formation of the Transcaucasian Permian can be correlated approximately to the Kuffengian Stage of the Chinese scale. The correspondence of the Arpa and most of the Khachik Formations to the Lengwuan Stage is more certain. Similar to the Arpa Formation, the lower zone of this stage (the *Yabeina gubleri* Zone) (Xiao et al., 1986) is marked by the first occurrence of *Kahlerina* and the presence of highly developed *Chusenella*, such as *Chusenella ishanensis* Hsu similar to *Ch. abichi* (A. M.-Maclay) of the Transcaucasia (Sheng, 1963). The Khachik Formation (without the Chanahchy Beds) can be correlated to the *Neomisellina multivoluta* Zone.

The Chanahchy Beds of the Khachik Formation are well correlated on the basis of fusulinids with the lower part of the Wuchiapingian Stage of the Lopingian Series of the Chinese scale. These subdivisions contain many common characteristic species of *Codonofusiella*, such as *C. kwangsiana* Sheng, *C. kueichowensis* Sheng, *C. lui* Sheng, etc. The Akhura Formation lacks fusulinids, but is well correlated to the South China sections by means of conodonts and ammonoids. The conodont *Clarkina leveni* Zone, the lowest zone of the Akhura Formation, is identified in the middle part of the Wuchiapingian Stage. The *Clarkina subcarinata* Zone is recognized at the base of both the Dorashamian Stage of the Transcaucasia and the Changsingian Stage. The correlations between the upper boundaries of these stages are not so certain. Until recently, the *Paratirolites kittli* Zone was considered to be the upper cephalopod zone of the Dorashamian Stage. However, according to the Chinese scale, there are three additional cephalopod zones recognized between this zone and the base of the Triassic. These zones were supposed to be missing in the Transcaucasian sequence, which thus appeared to be incomplete (Zhao et al., 1978, 1981). However, Zakharov

PLATE 9

All x 15

Fig. 1 - *Verbeekina* cf. *verbeeki* (Geinitz). Oblique section, GIN 4768/148; lower part of Khachik Formation.

Fig. 2, 4 - *Armenina salgirica* A. Miklukho-Maclay. Axial and sections, GIN 4768/152 and 4768/153; lower and middle part of Asni Formation.

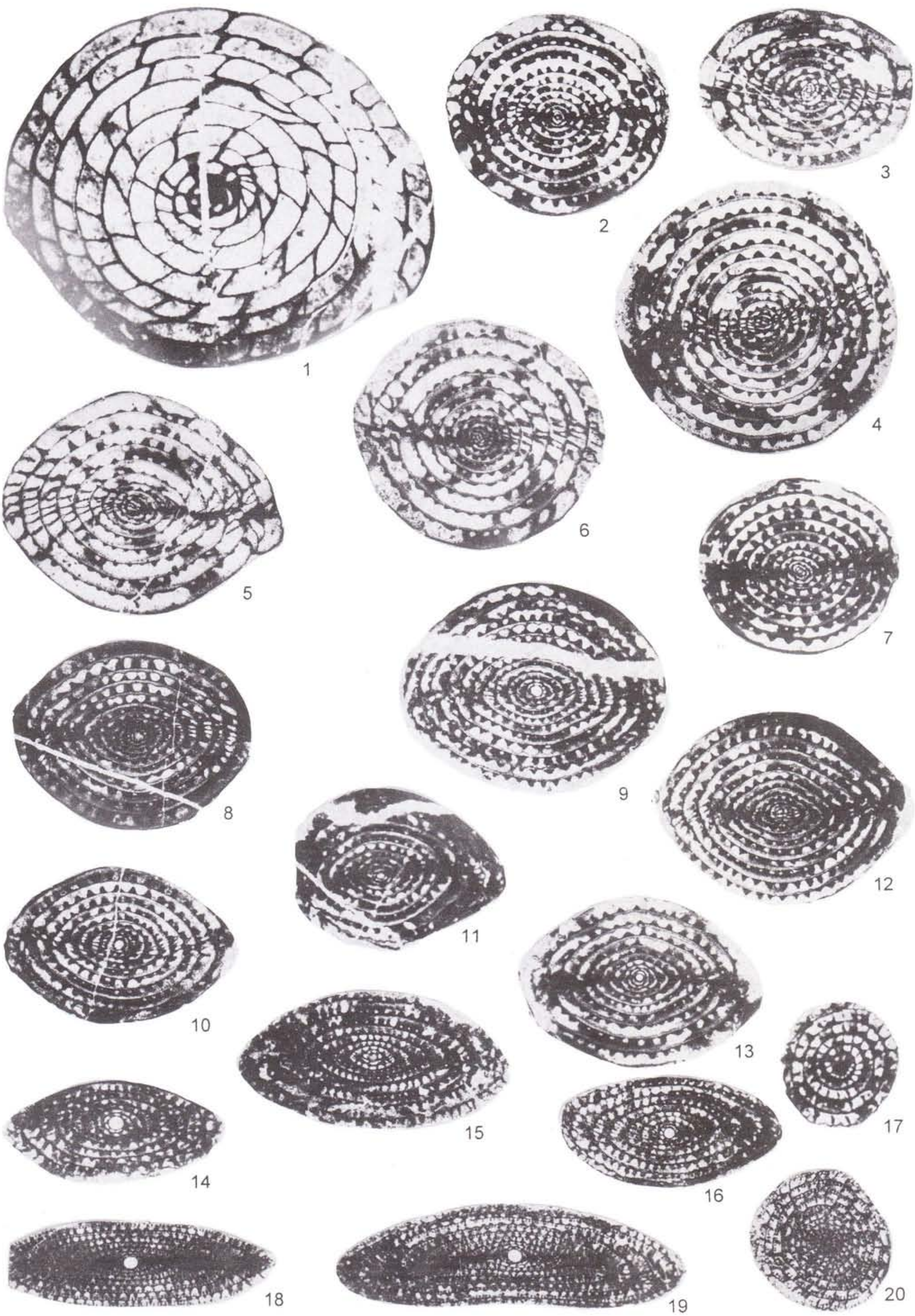
Fig. 7 - *Armenina urtzensis* Leven. Axial section, GIN 4768/154; lower part of Asni Formation.

Fig. 8-12 - *Cancellina armenica* n. sp. axial sections, GIN 4768/16, 4768/155 (holotype), 4768/156, 4768/56 and 4768/157; middle part of Asni Formation.

Fig. 13 - *Cancellina primigena* Hayden. Axial section, GIN 4768/13; middle part of Asni Formation.

Fig. 14-17 - *Presumatrina neoschwagerinoides* (Deprat). 14-16 - axial sections, GIN 4768/158, 4768/159 and 4768/160; 17 - sagittal section, GIN 4768/158; upper part of Asni Formation.

Fig. 18-20 - *Sumatrina vediensis* n. sp. 18, 19 - axial sections, GIN 4768/161 and 4768/162 (holotype); 20- sagittal section, GIN 4768/163; lower part of Arpa Formation.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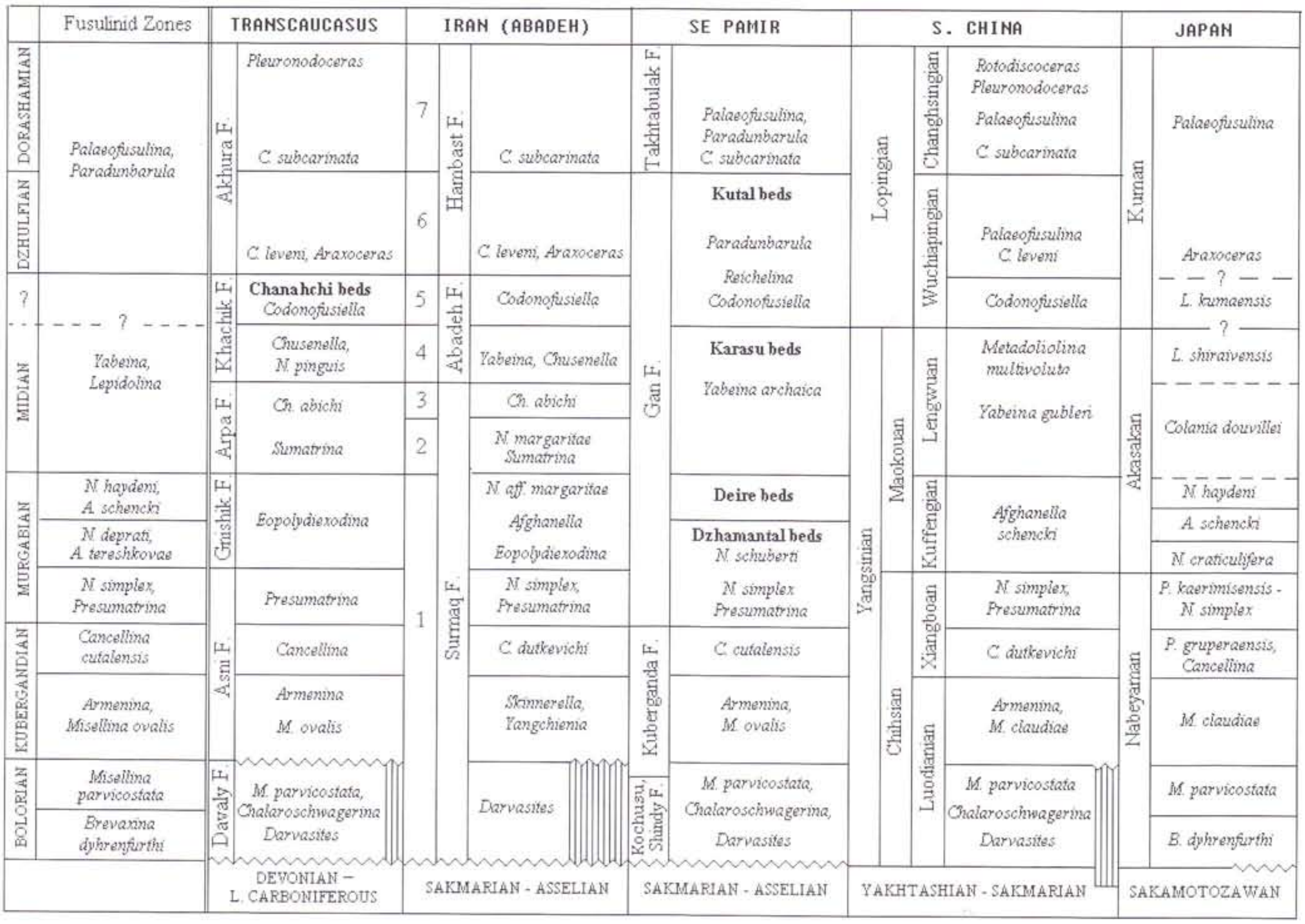

Fig. 3 - Correlation of the main Permian sections of Tethys.

(1988) distinguished the *Pleuronodoceras occidentale* Zone, the middle of the missing zones, at the base of the red clays separating the limestones with *P. kittli* from the beds with Triassic ammonoids and bivalves in the Dorasham section. Therefore, there are strong grounds to believe that the upper part of the red clays corresponds to the upper cephalopod zone. It should be noted that the upper zones of the Changsingian Stage have not been established with sufficient reliability and their number, scope, and boundaries need to be more precisely defined.

Japan.

According to the formally adopted stratigraphic scale, the Permian of Japan is composed of four stages in the upper part of the section: Sakamotozawan, Nabeiyaman, Akasakan, and Kuman. The Permian sequence of the Transcaucasia corresponds in age to the three upper stages. The refined correlation of this sequence is achieved in the fusulinid-bearing calcareous Akiyoshi series, located in the Yamaguchi Prefecture of the southwestern part of the country. The correlation is based on the detailed fusulinid zonation (Ozawa & Kobayashi, 1990). The Transcaucasian Davaly Formation with *Misellina parvicostata* (Deprat) corresponds primarily to the *Misellina parvicostata* Zone (AK 39) of the Akiyoshi section. The basal part of the formation is likely to correspond to the *Pseudofusulina fusiformis - Brevaxina dyhrenfurthi* Zone (AK 38) (Fig. 3).

The lower part of the Asni Formation, with developed *Misellina* and *Armenina*, can be correlated with the *Misellina claudiae* Zone (AK 40) of the Akiyoshi section. The *Parafusulina* (=*Skinnerella*) *gruperaensis* Zone (AK 41) that follows is an equivalent of the middle part of the Asni Formation, as demonstrated by the occurrence of *Cancellina* (Maklaya, according to the Japanese terminology) in both rock intervals. The uppermost beds of the Asni Formation, with *Presumatrina neoschwagerinoides* (Deprat), is correlated approximately to the *Parafusulina kaerimisensis* Zone (AK 42) because this zone contains *Neoschwagerina simplex* Ozawa, which is associated with *P. neoschwagerinoides* in many sections of the Pamirs and South China. Toriyama (1958) assigned all listed zones to the Nabeyaman Stage, which is distinguished from the Sakamotozawan Stage by the presence of *Misellina*. This is confirmed by the data of Kanmera & Mikami (1965) showing that the Sakamotodzawa Formation contains no *Misellina* in the type section of the Sakamotozawan Stage near Kitakami. However, according to Choi (1973), *Misellina* is spread throughout the section of this formation. In this context, the Japanese scale obviously needs to be revised. No direct evidence is available for the correlation of the Gnishik, Arpa and Khachik formations of the Transcaucasia with the Akiyoshi section. Supposedly, the Gnishik Formation is correlative of the *Neoschwagerina craticulifera* (AK 43), *Afghanella schencki - Verbeekina verbeeki* (AK 44), and *Neoschwagerina haydeni* (AK 45) zones.

The Arpa Formation may be correlated to the *Colania douvillei* (AK46) Zone due to the occurrences of *Kahlerina* and highly developed *Sumatrina* and *Codonofusiella*. Part of the Khachik Formation and, probably, the upper half of the Arpa Formation are conventionally correlated to the *Lepidolina multiseptata shiraiwensis* (AK 47) Zone, which crowns the Akiyoshi limestone section.

Stratigraphically higher parts of the Permian sequence are exposed in the Kitakami Mountains in the southeastern Honshu Island, where the Kuman Stage corresponding to the Toyema Formation is well represented. This formation is underlain by the Iwaizaki Limestones containing fusulinids of the *Lepidolina multiseptata shiraiwensis* Zone. The lower part of the Toyema Formation bears the most advanced fusulinids of the *Lepidolina kumaensis* Zone. Finding layers correlative with this zone in the Transcaucasian sequence is the main problem regarding the location of the boundary between the Guadalupian and Lopingian Series of the Permian System in the fusulinid zonation. However, it is still a subject of discussion. The following three alternatives are currently being considered: (1) the *L. kumaensis* Zone is older than the Chanahchy Beds of the Transcaucasia (Nakazawa, 1978; Kotlyar, 1994); (2) this zone corresponds approximately to these beds (Leven, 1980; Kotlyar et al., 1983), and (3) this zone is younger than the beds and corresponds to the lower part of the Dzhulfian Stage or to the entire stage, i.e., the lower half of the Akhura Formation (Toriyama, 1973; Ozawa, 1975). Rather subjective arguments in favor of these alternatives already have been discussed in the literature (Leven, 1996). The third alternative is the least likely, since typical early Dzhulfian ammonoids such as *Araxoceras* cf. *kiangsiensis* Chao and *A.* cf. *rotoides* Ruzhentsev were found above the beds with *L. kumaensis* in a section of the Kitakami Mountains (Murata & Bando, 1975). The upper part of the Toyema yielded *Palaeofusulina* and *Colaniella* characteristic of the Changsingian Stage of China and were correlated with the Dorashamian Stage or the upper half of the Akhura Formation of the Transcaucasia by means of conodonts and ammonoids.

Conclusions.

1. The Permian sequence of the Transcaucasia is represented by the middle (Guadalupian) and upper (Lopingian) Series; the deposits of the lower (Cisuralian) Series crop out only in the far northwest of this region.

2. The Bolorian, Kubergandian, Murgabian, Midian, Dzhulfian and Dorashamian Stages of the Tethyan scale are recognized in the sequence by means of fusulinids as well as ammonoids and conodonts in the upper series. All stages, except for the Midian, can be subdivided into zones.

3. Based on the fusulinid assemblages, which are also typical of other Tethyan areas, the stages and zones of the sequence are correlated reliably with those of the most complete Permian sequences of this biogeographic region (Iran, southeastern Pamirs, South China and Japan).

4. The close similarity between the Permian sequences of the Transcaucasia and Iran suggests the existence of a single carbonate platform depositional environment in the Gondwana shelf during this time interval. Analogous extensive carbonate platforms were formed in the Middle and Late Permian time in southern Afghanistan and southeastern Asia (South China, Indo-China).

5. Permian sequences of the carbonate platforms of all mentioned regions are characterized by the following common features: (1) the Permian carbonate series show transgressive overlapping and begin with the deposits of Kubergandian or, less frequently, Bolorian (probably late Yakhtashian-Bolorian) age; (2) they are represented mostly by thick limestones produced by benthic fossils, predominantly algae and foraminifers; (3) an abrupt change in sedimentation occurred in the transitional Guadalupian-Lopingian time interval, when a relatively thin clayey and carbonate series, composed mainly of micritic limestone varieties began to accumulate in many regions. Previously predominant benthic organisms were replaced by nektonic-benthic, nektonic and planktonic organisms. This event was preceded by a short-term sea regression most pronounced in South China.

6. The sedimentation change was accompanied by a significant biotic crisis, which terminated at the Permian-Triassic boundary and resulted in the extinction of dominant larger specialized fusulinids of the Schwagerinida and Neoschwagerinida orders. Only eurybiontic smaller fusulinids of the Shubertellida, Ozawainellida, and Staffellida orders survived temporarily but eventually became also extinct. A bloom of the Schubertellida order was recorded only in South China during the Dorashamian (Changsingian) age. Ammonoids, corals, bryozoans, and many other fossil groups underwent analogous events near the Guadalupian-Lopingian boundary.

Description of the new species of fusulinids.

Order Schubertellida Skinner, 1931

Family *Schubertellidae* Skinner, 1931

Genus *Codonofusiella* Dunbar et Skinner, 1937

Codonofusiellla (?) vediensis n. sp.

Pl. 3, fig. 9-13

Holotype. Specimen number GIN 4768/56; subaxial section; Vedy, Transcaucasus; Middle Permian, Murgabian.

Material. 4 subaxial, 5 oblique, tangential and sagittal sections.

Description. Shell minute, fusiform, with straight to convex lateral slopes and bluntly pointed poles; mature specimens have 4.5 to 5 volutions. Such individuals measure 0.65 to 0.87 mm. in length and 0.28 to 0.5 mm. in diameter; form ratio varies from 1.7 to 2.7. The first 2 volutions are lenticular and coiled askew to later ones. The coiling is relatively closely spaced for the first 3 to 4 volutions. The height of the final volution increase sharply, attaining a trumped-like form. Spirotheca thin, composed of tectum and thin light protheca; in 4th whorl its thickness measures 0.014 to 0.016 mm. Septa plane in the middle part of shell and moderately fluted towards to poles. Proloculus minute with a diameter 0.02 mm. Tunnel low and moderately wide; chomata low and narrow.

Discussion. *Codonofusiella* (?) *vediensis* n. sp. resembles *C. simplex* Leven from Afghanistan, but differs from that species in its slightly larger size, larger form ratio and somewhat narrower chomata. Both species compared were found stratigraphically lower than other known species of *Codonofusiella*. The former species are similar to species of genus *Schubertella*, which may be there ancestor. The majority of other representatives of this genus is likely to originate from *Dunbarula* or *Boultonia*. If so, the described species should be assigned to a new genus.

Occurrence and age. Vedy, Asni Formation; Middle Permian, Upper Kubergandian.

Order Schwagerinida Solovieva, 1985

Family *Pseudofusulinidae* Dutkevich, 1934

Genus *Chalaroschwagerina* Skinner et Wilde, 1965

Chalaroschwagerina davalensis n. sp.

Pl. 4, fig. 5, 6

Holotype. Specimen number GIN 4768/74; axial section; Sarypap Hill; Transcaucasus; Lower Permian, Bolorian.

Material. 2 axial sections.

Description. Shell inflate fusiform, with straight to convex lateral slopes and bluntly rounded poles. Mature shells have 5.5 to 6 volutions. Such individuals measure 6 to 6.5 mm. in length and 3.6 to 4.45 mm. in diameter; form ratio 1.5 to 1.7. First 3 whorls rather tightly coiled, after which shell expands and becomes loosely coiled. Spirotheca composed of tectum and coarse keriotheca, 0.1 to 0.125 mm. thick in fifth whorl. Phrenothecae well developed. Septa strongly fluted from pole to pole. Septal fluting is not regular; septal loops rather rounded and have different height and size. Proloculus large, its outside diameter 0.2 to 0.35 mm. Tunnel low and narrow. Chomata is absent.

Discussion. *Chalaroschwagerina davalensis* n. sp. resembles *Ch. globosa* (Schellwien et Dyhrenfurth), but differs in having a more tightly coiled inner whorls and less regularly septal fluting.

Occurrence and age. Sarypap Hill, Davaly Formation; Lower Permian, Bolorian.

Genus *Pseudofusulina* Dunbar et Skinner, 1931

Pseudofusulina arpaensis n. sp.

Pl. 5, fig. 2-4

Holotype. Specimen number GIN 4768/88; axial section; Arpa, Transcaucasus; Middle Permian, Midian.

Material. 15 axial sections.

Description. Shell moderately large, fusiform to inflated fusiform, with rather sharply pointed poles. Mature specimens have about 7 to 8 volutions and measure 8.5 to 11.5 mm. in length and 3.3 to 4.25 mm. in diameter; form ratio 2.6 to 2.95. Coiling is tester in first two or three whorls than in subsequent ones. Spirotheca composed of tectum and coarse keriotheca, 0.11 to 0.14 mm. thick in last two volutions. Septa thin, intensively and rather regularly fluted from pole to pole. Septal folds narrow and high, reaching to tops of septa. Axial filling present in polar areas of first three to four tightly coiled whorls. Proloculus rather small, its outside diameter 0.14 to 0.25 mm. Tunnel low and narrow.

Discussion. *Pseudofusulina arpaensis* n. sp. differs from another pseudofusulinas in having test coiled inner volutions and regularly fluted septa. In this respect our species bears resemblance to some *Chusenella*, such as *Ch.* (*Sosioella*) *intermedia* Skinner et Wilde from Sicily, but last have minute proloculus, more test coiled juvenarium and weaker septal fluting in the first volutions.

Occurrence and age. Arpa, Arpa Formation and lower part of Khachik Formation; Middle Permian, Midian.

Pseudofusulina araxensis n. sp.

Pl. 5, fig. 6, 9, 10

Holotype. Specimen number GIN 4768/90; axial section; Arpa, Transcaucasus; Middle Permian, Midian.

Material. 9 axial sections.

Description. Shell elongate fusiform, with convex lateral slopes and bluntly pointed poles. Mature individuals have 6 to 7 volutions and measure 9 to 11.5 mm. in length and 2.9 to 3.5 mm. in diameter; form ratio varies from 3 to 3.8. Coiling is tester in first two or three volutions than in subsequent ones. Spirotheca composed of tectum and coarsely alveolar keriotheca, measures 0.1 to 0.12 mm. in thickness in outer volutions. Septa intensely fluted throughout shell. Septal folds wide, commonly about 0.7 as high as chamber. Secondary deposits present along axis in first 3 whorls. Proloculus small and moderate size, its outside diameter 0.17 to 0.4 mm. Tunnel low and not very wide. Chomata very weak, present only on prololculus and first one or two whorls.

Discussion. *Pseudofusulina araxensis* n. sp. is similar to *P. arpaensis* n. sp., but differs in its longer shell, greater form ratio, and more wide and low septal folds.

Occurrence and age. Arpa, Arpa Formation and lower part of Khachik Formation; Middle Permian, Midian.

Pseudofusulina pjatakovae n. sp.

Pl. 4, fig. 12, 16

Holotype. Specimen number GIN 4768/79; axial section; Arpa, Transcaucasus; Middle Permian, Midian.

Material. 3 axial and 4 oblique sections.

Description. Shell moderate of size, fusiform to thickly subcilindrical, with convex lateral slopes and bluntly rounded poles. Adult shells have 5.5 to 6.5 volutions and measure 8 to 9 mm. in length and

2.7 to 3.1 mm. in diameter. Outer 3 to 3.5 whorls rather loosely coiled. Form ratio 2.8 to 2.9. Spirotheca composed of tectum and coarsely alveolar keriotheca; thickness in fifth volution 0.085 to 0.095 mm. Septa intensely but irregularly fluted throughout shell. Septal folds are different in size, but mostly high, reaching to tops of septa. Proloculus moderate in size, its outside diameter 0.19 to 0.21 mm. Tunnel low and not very wide. Weak chomata present only on proloculus. Axial filling weak and confined to tightly coiled whorls of juvenarium.

Discussion. *Pseudofusulina pjatakovae* n. sp. is similar to *P. arpaensis* n. sp. but differs in its irrregular septal fluting.

Occurrence and age. Arpa, Apra Formationa and lower part of Khachik Formation; Middle Permian, Midian.

It is named for Dr. M.V. Pjatakova.

Genus *Rugosochusenella* Skinner et Wilde, 1965

Rugosochusenella davalensis n. sp.

Pl. 5, fig. 7, 11, 12

1992 *Rugosochusenella zelleri* Skinner et Wilde. In: Leven et al., 1992, p. 90, pl. 25, fig. 7.

Holotype. Specimen number GIN 4768/47; axial section; Sarypap, Transcaucasus; Lower Permian, lowermost Kubergandian.

Material. 3 axial and several tangential and oblique sections.

Description. Shell elongate fusiform to subcylindrical, with bluntly to sharply pointed poles. Adult shells have 6.5 to 9 volutions and measure 5 to 8.2 mm. in length and 1.3 to 2.2 mm. in diameter; form ratio 3.4 to 3.8. The first 3 to 4.5 volutions are coiled very tightly; succeeding whorls are somewhat looser and the chambers increase gradually in height. Spirotheca composed of tectum and coarsely alveolar keriotheca; it is thin in juvenarium, thickening thereafter as much as 0.07 to 0.11 mm. in last two vulutions. Septa irregularly fluted from pole to pole. Septal folds are rounded and low, and commonly do not join one another. Tunnel low and not very wide. Small chomata present in the first 3.5 to 4.5 volutions. Axial filling is moderately to well developed.

Discussion. *Rugosochusenella davalensis* n. sp. differs from the *R. zelleri* Skinner et Wilde in its fluted septa.

Occurrence and age. Sarypap Hill, Davaly Formation and lower part of Asni Formation; Lower Permian, Bolorian; Middle Permian, lowermost part of Kubergandian.

Order Neoschwagerinida Minato et Honjo, 1966

Family *Misellinidae A.* Miklukho-Maclay, 1958

Genus *Misellina* Schenck et Thompson, 1940

Subgenus *Misellina* Schenck et Thompson, 1940

Misellina (Misellina) caucasica n. sp.

Pl. 8, fig. 20, 21

Holotype. Specimen number GIN 4768/144; axial section; Sarypap Hill, Transcaucasus; Middle Permian, lowermost part of Kubergandian.

Material. 3 axial and several tangential and oblique sections.

Description. Shell small, ovoid. Adult specimens 6.5 to 8.5 volutions and measure 2.1 to 2.5 mm. in length and 1.4 to 1.7 mm. in diameter; form ratio 1.5. Spirotheca composed of tectum and fine alveolar keriotheca 0.028 to 0.03 mm. thick in last volutions. Septa unfluted. Parachomata well developed throughout the shell, commonly about 0.5 as half as chamber. Proloculus spherical, its outside diameter 0.08 to 0.125 mm.

Discussion. *Misellina (Misellina) caucasica* n. sp. is similar in general appearance to *M. (M.) claudiae* (Deprat), but differs in its more elongated shell and thinner parachomata. Described species differs from *M. (M.) ovalis* (Deprat) in its smaller size and less elongated shell.

Occurrence and age. Sarypap Hill, base of Asni Formation; Middle Permian, lowermost part of Kubergandian.

Family *Neoschwagerinidae* Dunbar et Condra, 1927

Genus *Cancellina* Hayden, 1909

Subgenus *Cancellina* Hayden, 1909

Cancellina armenica n. sp.

Pl. 9, fig. 8-12

Holotype. Specimen number GIN 4768/155; Vedy, Transcaucasus; Middle Permian, Upper Kubergandian.

Material. 5 axial and 4 subaxial and tangential sections.

Description. Shell inflated fusiform to sub-ovoid, with convex lateral slopes and bluntly rounded poles. Adult specimens 3.0 to 3.5 mm. in length and 2.4 to 2.5 mm. in diameter; form ratio 1.3 to 1.45. Number of volutions 10 to 11.5. Spirotheca composed of tectum and fine alveolar keriotheca 0.35 to 0.45 mm. in last two whorls. Wide and short primary transverse septula developed in all volutions, beginning from third to fourth ones. Axial septula are absent. Septa unfluted. Parachomata wide in the base and sharpened in the top and commonly don't contiguous to transversal septula. Proloculus spherical, its outside diameter 0.1 to 0.15 mm.

Discussion. *Cancellina armenica* n. sp. differs from *C. primigena* Hayden in its larger size and more numerous volutions, and more influted shell. Described species is similar to *C. cutalensis* Leven, but parachomata of latter are lower and wider.

Occurrence and age. Vedy, middle part of Asni Formaton; Middle Permian, Upper Kubergandian.

Family *Sumatrinidae* Silvestri, 1933

Genus *Sumatrina* Volz, 1904

Sumatrina vediensis n. sp.

Pl. 9, fig. 18-20

Holotype. Specimen number GIN 4768/162; Vedy, Transcaucasus; Middle Permian, Lower Midian.

Material. 3 axial, 2 sagittal and 2 oblique sections.

Description. Shell subcylindrical with bluntly pointed poles.Mature specimens have 8 to 10 volutions and measure 4.5 to 5,4 mm. in length and 1.27 to 2 mm. in diameter; form ratio 2.7 to 3.36. Spirotheca composed of single compact layer, measuring about 0.015 mm. Septa influted. Primary transverse septula pendant-shaped, usually connected with the tops of the parachomata. Secondary transverse septula short, slightly thickened at their lower margin, usually one intercalated between the adjacent primary trransverse septula in the inner volutions, but two or three occuring in the outermost volutions. Number of axial septula between the adjacent septa measure three or four in the outermost volutions. Parachomata low, about 1/3 as high as chamber. Proloculus spherical, its outside diameter 0.18 to 0.25 mm.

Discussion. *Sumatrina vediensis* n. sp. has intermediate shape of shell between *S. annae* Volz and *S. longissima* Deprat. Besides, described species differs from them in having more compact spiral and, correspondingly, less size of shell.

Occurrence and age. Vedy, base of Arpa Formaton; Middle Permian, Lowermost Midian.

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