

REVIEW OF THE CONODONTS OF THE SAKMARIAN STRATOTYPE SECTION (SOUTH URALS)

TATYANA N. ISAKOVA

Isakova, T.N. 1998. Review of the conodonts of the Sakmarian stratotype section (South Urals). In: H. Szaniawski (ed.), Proceedings of the Sixth European Conodont Symposium (ECOS VI). — *Palaeontologia Polonica* **58**, 261–271.

The analysis of successive conodont assemblages at the Sakmarian stratotype section has revealed the following succession of conodont zones that can be correlated with the previously defined fusulinid zones: (1) *Streptognathodus constrictus* Zone corresponding to the *Sphaeroschwagerina moelleri*–*Pseudofusulina fecunda* fusulinid Zone; (2) *Mesogondolella striata*–*M. pseudostriata* Zone corresponding to *Sphaeroschwagerina sphaerica*–*Pseudofusulina firma* fusulinid Zone; (3) *M. uralensis* Zone corresponding to two fusulinid zones: *Pseudofusulina moelleri* and *Pseudofusulina verneuli*; and (4) *Mesogondolella bisselli* Zone corresponding to the Sterlitamakian regional stage.

Key words: Conodonts, Fusulinina, stratotype, Sakmarian, Early Permian, Urals, Russia.

Tatyana Nikolaevna Isakova, Geological Institute, Russian Academy of Sciences, Pyzhevsky per., 7, Moscow, 109017, Russia.

Received 21 January 1997, accepted 27 November 1997



INTRODUCTION

The Sakmarian stage was established by RUZHENTSEV (1936, 1950, 1951). Its type section (stratotype) is located on the right bank of the Sakmara River, north of Kondurovka Station. The lower part of the section is assigned to the Asselian stage, whereas the upper part (the Sakmarian stage) is represented by the Tastubian and Sterlitamakian regional stages. A layer-by-layer description was presented by RUZHENTSEV (1951) who described ammonoids and subdivided the section into six formations: Uskalyk and Kurmain formations in the Asselian and Karamurun, Sarabil, Maloik and Kondurov formations in the Sakmarian. RAUSER-CHERNOUSSOVA (1965) defined fusulinid zones for both the Asselian and Sakmarian parts of the section. Lower Permian conodonts were first recovered from the South Urals by KOZUR and MOSTLER (1976) and KOZUR (1978) who described several species ranging in occurrence from Asselian to Artinskian deposits. MOVSHOVICH *et al.* (1979) and ISAKOVA (1989) reported conodonts from the Sakmarian stratotype section (Table 1). Intensive studies of the Lower Permian conodonts of the South Urals made it possible to establish the detailed conodont zonation for this region (BARSKOV *et al.* 1981; BARSKOV 1984; AKHMETSHINA *et al.* 1984; MOVSHOVICH 1984; ISAKOVA and NAZAROV 1986; CHERNYKH and CHUVASHOV 1986; RESHETKOVA and CHERNYKH 1986; CHERNYKH and RESHETKOVA 1987, 1988; CHUVASHOV *et al.* 1990; KOZUR 1995, 1996; BARSKOV and REIMERS 1996; CHERNYKH and RITTER 1997). The most detailed Asselian and Sakmarian zonal scheme (Table 2) was proposed by CHERNYKH (1986, 1988). It was based on the analysis of stratigraphic ranges and evolution of new species of *Streptognathodus* and *Mesogondolella* discovered in Lower Permian deposits of the western slopes of Urals and the pre-Urals Region. However, the chronostratigraphic validity of conodont zones is debatable, especially because their correlation with fusulinid zones is poorly proven (hardly any of the conodont zones have been cross-correlated to the coeval fusulinid assemblages).

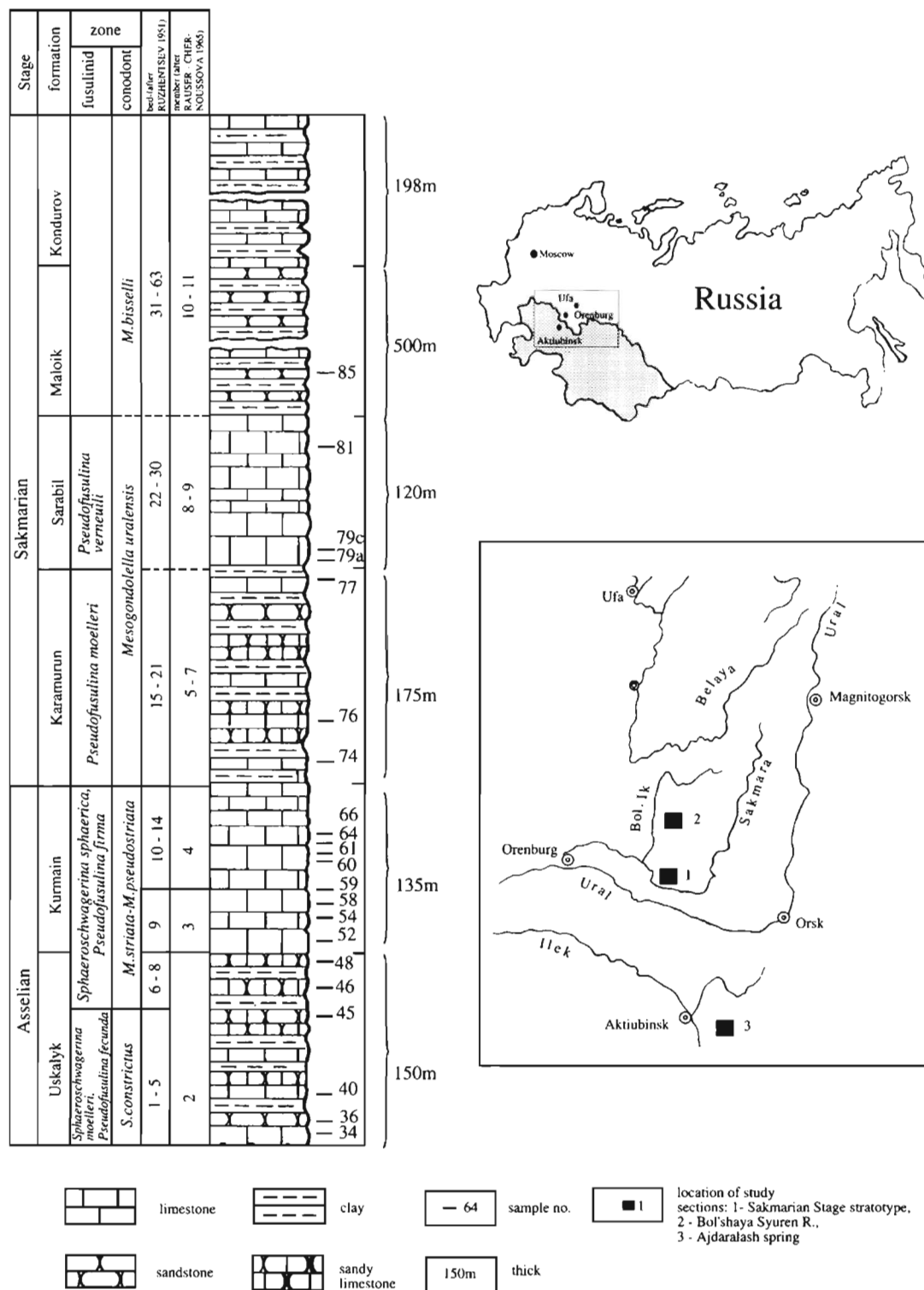
This paper documents the conodonts of the Sakmarian stratotype section and correlates the conodont zones with the Lower Permian fusulinid zones of the Urals.

CONODONT DISTRIBUTION AND OTHER CHARACTERISTICS OF THE SAKMARIAN STRATOTYPE SECTION

My investigation indicates that within the Sakmarian stratotype section (Fig. 1) there are 21 levels that contain conodont fauna. The conodonts are abundant in the Asselian sediments (the lower part of the section), but less common in the Sakmarian, where they are confined primarily to the Tastubian regional stage (Karamurun and Sarabil formations). Conodonts are rare in the Sterlitamakian regional stage. Samples collected to obtain conodonts provided also fusulinids that allowed for cross-correlation of my data with "beds" established by RUZHENTSEV (1951) and "members" recognized by RAUSER-CHERNOUSSOVA (1965).

The lower part of the section corresponds to beds 1–5 of the Uskalyk formation (after RUZHENTSEV) or to lower part of member 2 (after RAUSER-CHERNOUSSOVA). It is composed of limestones, sandy limestones, and clays. The limestone beds (samples 34, 36, 40, 45) are thin and contain *Streptognathodus simplex* GUNNEL, *S. elongatus* GUNNEL, *S. wabaunsensis* GUNNEL, *S. nodularis* CHERNYKH *et* RESHETKOVA, *S. barskovi* KOZUR, *S. longissimus* CHERNYKH *et* RESHETKOVA, as well as isolated fragments of *Mesogondolella* sp. tentatively assigned to the *M. bisselli* group. The beds were attributed by RAUSER-CHERNOUSSOVA (1965) to the *Sphaeroschwagerina moelleri*–*Pseudofusulina fecunda* Zone. This part of the section also contains fusulinids *Sphaeroschwagerina constans* SHERBOVICH, *S. shamovi* SHERBOVICH, *Pseudoschwagerina beedei uralensis* RAUSER, *Pseudosch. aktjubensis* RAUSER, *Pseudofusulina paragregaria* RAUSER, *Ps. decurta* KORZHENEVSKY which are indicative of Middle Fusulinid Zone of the Asselian. This part of the section is about 100 m thick.

The beds 6–8 (after RUZHENTSEV) or the upper part of member 2 (after RAUSER-CHERNOUSSOVA) are composed of limestones, sandy limestones and clays with dark platy-limestone intercalations (samples 46, 48). The conodonts include *Mesogondolella longifolia* CHERNYKH (Pl. 1: 15), *M. striata* CHERNYKH *et* RESHETKOVA, *M. foliosa* CHERNYKH *et* RESHETKOVA, as well as *Streptognathodus elegantulus* STAUFER *et* PLUMMER, *Idiognathodus delicatus* GUNNEL, and *Neognathodus* sp. However, considering that redeposi-



tion was common in the Early Permian in the South Urals area (ROZOVSKAYA 1952; RAUSER-CHERNOUSSOVA 1965), the above species, common also in older strata, were most likely reworked. This interval is characterized by the following fusulinids: *Pseudofusulina* aff. *firma* SHAMOV, *P. delicata* KORZHENEVSKY, and *P. postpusilla* BENS. This part of the section is about 50 m thick.

Table 1
Litho- and biostratigraphic subdivision of the Sakmarian stratotype section.

RUZHENTSEV 1951 (Ammonoids)			RAUSER-CHERNOUSSOVA 1965 (Fusulinids)		MOVSHOVICH <i>et al.</i> 1979 (Conodonts)	ISAKOVA 1989 (Conodonts)	This paper (Conodonts)
Lower Permian	Sakmarian	Kondurov fm.	Sterlitamakian		<i>Neogondolella</i> <i>bisselli</i> , <i>Idiognathodus</i> <i>delicatus</i> , <i>Caenodontus</i> sp. complex Zone	<i>Sweetognatus</i> <i>withei</i> Zone	<i>Mesogondolella</i> <i>bisselli</i> Zone
		Maloik fm.					
		Sarabil fm.	Tastubian	<i>Pseudofusulina</i> <i>verneuili</i> Zone		<i>Mesogondolella</i> <i>bisselli</i> Zone	<i>Mesogondolella</i> <i>uralensis</i> Zone
		Karamurun fm.		<i>Pseudofusulina</i> <i>moelleri</i> Zone			
	Asselian	Kurmain fm.	<i>Sphaeroschwagerina</i> <i>sphaerica</i> , <i>Pseudofusulina</i> <i>firma</i> Zone			<i>Mesogondolella</i> <i>striata</i> Zone	<i>Mesogondolella</i> <i>striata</i> , <i>M.</i> <i>pseudostriata</i> Zone
		Uskalyk fm.	<i>Sphaeroschwagerina</i> <i>moelleri</i> , <i>Pseudofusulina</i> <i>fecunda</i> Zone			<i>Mesogondolella</i> <i>dentiseparata</i> , <i>Streptognathodus</i> <i>constrictus</i> Zone	<i>Streptognathodus</i> <i>constrictus</i> Zone

Higher up, the section consists of dark massive aphanite limestones (Kurmain Formation) that correspond to the RUZHENTSEV bed 9 or RAUSER-CERNOUSSOVA member 3. These limestones are interbedded with dark cherts (up to 5 cm thick), or rarely, with sandy limestones rich in organic detritus. The rare, sandy limestone interbeds (samples 52, 54, 58, 59) yielded *Streptognathodus fusus* CHERNYKH *et* RESHETKOVA, *S. constrictus*, small specimens of *S. simplex*, as well as specimens of *Mesogondolella* aff. *obliquimarginata* CHERNYKH, *M. simulata* CHERNYKH *et* RESHETKOVA, *M. longifolia*, *M. striata*, *Neognathodus dilatus* (STAUFER *et* PLUMMER), *Streptognathodus elegantulus*, and *Idiognathodus toretzianus* KOZITSKAYA. Note, that these species were also found in older samples (46, 48, see above), and most likely were redeposited from older strata. The member 3 was tentatively correlated to the lowermost part of the Upper Fusulinid Zone of the Asselian, though its non-typical fauna is more similar with the Middle Fusulinid Zone assemblage, and lacks Upper Zone forms (RAUSER-CERNOUSSOVA 1965: p. 11). These limestones are about 100 m thick.

Higher up the section (samples 60, 61, 64, 66), massive aphanite limestones are replaced by a breccia-like limestone with fragments of bryozoa, foraminifers, crinoid, pseudoolites and limestone pebbles (these strata correspond to RUZHENTSEV's beds 10–14 and RAUSER-CERNOUSSOVA's member 4). The breccia-like limestone contains small specimens of *Streptognathodus postfusius* CHERNYKH *et* RESHETKOVA, *S. fusius*, *S. constrictus*, *Mesogondolella longifolia*, abundant forms transitional to *M. lata* CHERNYKH as well as *M. striata*, *M. pseudostriata* (Pl. 1: 11,12), *M. foliosa*. The fusulinid assemblage comprises *Pseudofusulina firma*, *Ps. sphaerica* RAUSER *et* BELJEV, *Ps. delicata* KORZHENEVSKY., and *Ps. sulcata* KORZHENEVSKY. According to RAUSER-CERNOUSSOVA (1965), half or two-thirds of the fusulinid species found in the limestones of the member 4 are redeposited. Only the presence of such fusulinids as *Pseudofusulina firma* and *Ps. sphaerica* justifies the correlation of the deposits of member 4 with the *Sphaeroschwagerina sphaerica*–*Pseudofusulina firma* Zone (the uppermost fusulinid zone of the Asselian). The conodont assemblage recognized in this part of the section indicates that considerable redeposition must have occurred. This is indicated by the following older forms: abundant *Declinognathodus noduliferus* (ELLISON *et* GRAVES.), *Idiognathodus magnificus* KOZITSKAYA, *Idiog.* aff. *toretzianus*, *Idiog. obliquus* KOSSENKO *et* KOZITSKAYA, *Idiognathoides sinuatus* (HARRIS *et* HOLLINGSWORTH), *Id. corrugatus* (HARRIS *et* HOLLINGSWORTH), and *Streptognathodus elegantulus*. This part of the section is about 35 m thick.

The limestones of the Kurmain Formation are covered by more clayey deposits of the Karamurun Formation that belong to the lowermost Tastubian regional stage. This sequence, the RUZHENTSEV's beds 15–21 or RAUSER-CERNOUSSOVA's members 5–7, consist of clayey sandstone interbeds and detrital

Table 2
Asselian and Sakmarian zonal subdivision of the Urals.

	Fusulinid zones	Conodont zones						
	Scheme of the Urals BREJVEL <i>et al.</i> 1980	MOVSHOVICH 1984	BARSKOV 1984	ISAKOVA 1989	AKHMETSHINA 1990	CHERNYKH 1986, 1988; CHERNYKH and RESHETKOVA 1990		KOZUR 1995
Sakmarian	<i>P. uralensis</i>	<i>M. bisselli</i>	<i>Sweetognathus</i>	<i>S. withei</i>	<i>S. merrilli</i>	<i>S. primus</i>	<i>M. bisselli–M. visibilis</i>	<i>M. bisselli–M. visibilis</i>
	<i>P. verneuili</i>	<i>St. simplex</i> <i>S. merrilli</i>	<i>M. bisselli</i>	<i>M. bisselli</i>	<i>M. bisselli</i>		<i>M. lata</i>	<i>M. obliquimarginata</i> <i>S. merrilli</i>
	<i>P. moelleri</i>						<i>M. uralensis</i>	
Asselian	<i>Sp. sphaerica</i> <i>P. firma</i>	<i>St. simplex</i> <i>St. wabaunsensis</i> <i>St. elongatus</i>	<i>St. barskovi</i>	<i>M. striata</i>	<i>St. postfusus</i>	<i>St. postfusus</i>	<i>M. pseudostrata</i> <i>M. striata</i>	<i>St. postfusus</i>
	<i>M. dentiseparata</i> <i>St. constrictus</i>			<i>St. constrictus</i>	<i>St. fusus</i>	<i>M. simulata</i>	<i>St. constrictus</i>	
			<i>St. cristellaris</i>		<i>St. cristellaris</i> <i>St. wabaunsensis</i>	<i>St. barskovi</i> <i>St. invaginatus</i>		
	<i>Sp. vulgaris</i> <i>S. fusiformis</i>		<i>St. wabaunsensis</i>		<i>St. alius</i> <i>St. wabaunsensis</i>		<i>St. elongatus</i>	

P. – *Pseudofusulina*, *S.* – *Sweetognathus*, *Sp.* – *Sphaeroschwagerina*, *St.* – *Streptognathodus*.

limestones in its lower part and interbeds of aphanite and detrital limestones and marls in its upper part. The conodont assemblage (samples 74, 76, 77) is dominated by species of *Mesogondolella*: *M. uralensis* CHERNYKH, *M. lata* CHERNYKH (Pl. 1: 17, 18), *M. obliquimarginata* CHERNYKH, and *M. spp.* Among fusulinids, there usually occur *Pseudofusulina moelleri* (SCHELLWIEN), *P. sulcata* (typical of the Tastubian), *P. ishimbajevi* KORZHENEVSKY (abundant) and other species that belong to the zonal assemblage of the *Pseudofusulina moelleri* Zone of the Sakmarian. This part of the section is about 175 m thick.

The next interval of the section – beds 22–30 of RUZHENTSEV or members 8–9 of RAUSER-CHERNOUSOVA – is composed of limestones of the Sarabil Formation (the uppermost Tastubian). The sequence includes aphanitic limestones with cherty interbeds and detrital and crinoid-fusulinid varieties containing isolated specimens of *Streptognathodus constrictus* and *S. postfusus*. The conodont assemblage (samples 79a, 79c, 81) is dominated by *Mesogondolella* represented by *M. obliquimarginata*, *M. lata*, *M. uralensis* (Pl. 1: 19). *Declinognathodus* sp., *Idiognathodus* sp., and *Neognathodus columbiensis*, all found in this assemblage are redeposited.

The limestones of the Sarabil Formation were assigned to the *Pseudofusulina verneuili* Zone of the Sakmarian by RAUSER-CHERNOUSOVA (1965). This is also confirmed in this study. The limestones contain *Pseudofusulina* ex gr. *verneuili* (MOELLER) and *P. blochini* KORZHENEVSKY. This part of the section is about 120 m thick.

The upper part of the section – beds 31–63 of RUZHENTSEV or members 10, 11 of RAUSER-CHERNOUSOVA – is composed of sandy-clayey deposits of the Maloik Formation or the Sterlitamakian. These rocks consist of clayey layers with numerous sandstone interbeds and rare limestones. Among the rare conodont remains (sample 85), *Mesogondolella bisselli* can be recognized (Pl. 1: 20). The interbeds with fusulinids are also uncommon. RAUSER-CHERNOUSOVA (1965) indicated the presence of *Pseudofusulina* ex gr. *schellwieni* VISSARIONOVA, *P. uralensis* RAUSER, *P. callosa* RAUSER, *P. plicatissima* RAUSER and other species in this unit. In the uppermost part of the section (the Kondurov Formation) conodonts are absent.

In summary, the Asselian and Sakmarian stages contain abundant conodonts. Their vertical distribution throughout the section (Table 3) makes it possible to identify a succession of conodont zones.

BIOSTRATIGRAPHY

The assemblage of conodonts obtained from deposits of the Uskalyk Formation and assignable to the *Sphaeroschwagerina moelleri* and *Pseudofusulina fecunda* fusulinid zones of the Asselian defines the oldest of the described conodont zones. It includes *Streptognathodus barskovi*, *S. wabaunsensis*, *S.*

Table 3
Distribution of conodonts in the Sakmarian stratotype section.

Zone	fusulinid	<i>S. moelleri</i> <i>P. fecunda</i>				<i>Sphaeroschwagerina sphaerica</i> <i>Pseudofusulina firma</i>										<i>P. moelleri</i>	<i>P. vermeili</i>				<i>Sterlitamakian</i>
	conodont	<i>Streptognathodus constrictus</i>				<i>Mesogondolella striata– M. pseudostrata</i>										<i>Mesogondolella uralensis</i>				<i>M. bisselli</i>	
Sample no.		34	36	40	45	46	48	52	54	58	59	60	61	64	66	74	77	79a	79c	81	85
<i>Streptognathodus longissimus</i>		4	1	1	1																
<i>S. simplex</i>		5	2	4	1						cf.										
<i>S. elongatus</i>		3	2																		
<i>S. asselicus</i>		aff.	1	1	1																
<i>S. wabaunsensis</i>		cf.	2	2																	
<i>S. nodulinear</i>		cf.		1																	
<i>S. barskovi</i>			1																		
<i>S. alius</i>		2	5	cf																	
<i>S. constrictus</i>		aff.	2		1						1		1					2*?	1*?		
<i>S. fusus</i>						cf.		1					aff.								
<i>S. posfus</i>														1				4*?		2*?	
<i>S. simplex-constrictus</i>			2	2																	
<i>S. simplex-asselicus</i>					1						1										
<i>Mesogondolella foliosa</i>						3	1					1			1					1*?	
<i>M. striata</i>						4	3				cf.				2						
<i>M. pseudostrata</i>							cf.								2						
<i>M. longifoliosa</i>							3		1	2					1					cf.	
<i>M. obliquimarginata</i>									1							1	1	1			cf.
<i>M. simulata</i>								2													
<i>M. uralensis</i>														aff.		1		1	2	1	
<i>M. lata</i>															1	3	7	1			
<i>M. bisselli</i>																					2
<i>Mesogondolella</i> sp.				1																	
<i>S. elegantulus</i>				2*	1*				3*		2*	1*									
<i>Idiognathodus</i> sp.			3*	1*		1*		6*	3*		4*	2*	3*	5*	1*			6*	5*	6*	
<i>Neognathodus</i> sp.						2*			1*		1*								1*		
<i>Cavusgnathus</i> sp.								2*	1*												
<i>Ideognathoides</i> sp.											3*				2*						
<i>Declinognathodus</i> sp.											1*	1*							cf.		
<i>Gondolella</i> sp.									1*									4*		1*	

* – presumably redeposited.

simplex, *S. asselicus*, *S. constrictus*, and *Mesogondolella* sp. The first three species were used to define the *Streptognathodus barskovi* assemblage zone established by KOZUR and MOSTLER (1976) and were also identified in the sections of pre-Urals Region (MOVSHOVICH *et al.* 1979). The species *Streptognathodus barskovi* was described by KOZUR and MOSTLER (1976) from the Upper Fusulinid Zone of the Asselian, and was used by KOZUR (1978) to define the *Streptognathodus barskovi* Zone. Subsequently, BARSKOV *et al.* (1981), AKHMETSHINA *et al.* (1984), and ISAKOVA and NASAROV (1986) reported new finds of this

species in the South Urals and pre-Caspian sections. The *Streptognathodus constrictus* conodont Zone (CHERNYKH 1986) correlates with the *Sphaeroschwagerina moelleri*–*Pseudofusulina fecunda* Fusulinid Zone. The co-occurrence of *Streptognathodus constrictus* and the zonal fusulinid association of the Middle Asselian Zone was mentioned by CHERNYKH (1988). Our data obtained from the Sakmarian Stage stratotype confirm those observations.

Mesogondolella bisselli recovered from the Sakmarian (KOZUR 1978; MOVSHOVICH *et al.* 1979) was formerly believed to be the oldest *Mesogondolella*. However, ISAKOVA and NAZAROV (1986) and CHERNYKH and RESHETKOVA (1987) recognized an earlier appearance of *Mesogondolella* at the base of the Middle Fusulinid Zone of the Asselian. According to CHERNYKH and RESHETKOVA (1986, 1987) and CHERNYKH (in CHUVASHOV *et al.* 1990), *Mesogondolella adentata*, *M. belladontae*, *M. dentiseparata*, and *M. simulata* are confined mainly to the *Sphaeroschwagerina moelleri*–*Pseudofusulina fecunda* Fusulinid Zone. The last of the above *Mesogondolella* species presumably existed in the Upper Asselian Fusulinid Zone times as well. Thus, the *Mesogondolella* sp. fragments I have found in *Streptognathodus*-dominated conodont assemblage, in the lower part of the studied section, do not contradict the correlation of this assemblage with the Middle Asselian Fusulinid Zone.

As a whole, the discussed Middle Asselian conodont assemblage from the Sakmarian stratotype section is similar to that of the Uralian *Streptognathodus constrictus* Zone (CHERNYKH and RESHETKOVA 1987) and the conodont assemblages of the pre-Caspian depression (AKHMETSHINA 1990). Its stratigraphic boundaries coincide with those of fusulinid zonal associations of the Middle Asselian *Sphaeroschwagerina moelleri*, and *Pseudofusulina fecunda* Zone.

In the uppermost Uskalyk Formation, the *Streptognathodus*-dominated assemblage of the *Streptognathodus constrictus* Zone is replaced by the *Mesogondolella*-dominated assemblage with abundant *Mesogondolella* and rare *Streptognathodus asselicus*, and *S. constrictus*. The overlying deposits are also *Mesogondolella*-dominated.

The next conodont assemblage occurs in the upper parts of the Uskalyk and Kurmain formations and contains small specimens of *Streptognathodus* as well as *Mesogondolella striata*, *M. foliosa*, and *M. longifolia*. The *Mesogondolella* assemblage comprises species typical of the *Mesogondolella striata* and *Mesogondolella pseudostriata* conodont zones which correspond to the *Streptognathodus postfusus* Zone of CHUVASHOV *et al.* 1990. *Mesogondolella striata* was first reported from sections exposed along the Usolka River (South Urals, Bashkiria), within the *Sphaeroschwagerina sphaerica*–*Pseudofusulina firma* Zone (CHERNYKH and CHUVASHOV 1986; CHERNYKH and RESHETKOVA 1987). The stratigraphic position of *M. foliosa*, described from a single sample from the Asselian deposits exposed along the Seleuk River (South Urals, Bashkiria) has not been confirmed by fusulinids. Our material yielded *Mesogondolella striata* and *M. foliosa* associated with a fusulinid assemblage including *Pseudofusulina firma*, *Ps. delicata*, *Ps. sulcata* and other species characteristic of the *Sphaeroschwagerina sphaerica*–*Pseudofusulina firma* fusulinid zone.

Thus, the presence of the above conodont assemblage in the studied section makes it possible to recognize *Mesogondolella striata* and *M. pseudostriata* conodont zones corresponding to the *Streptognathodus postfusus* Zone and treat them as analogs of the *Sphaeroschwagerina sphaerica* and *Pseudofusulina firma* fusulinid zones.

The Sakmarian stratotype section is mainly dominated by *Mesogondolella*. Its lower part – the Tastubian – contains three morphologically similar species of *Mesogondolella*: *M. uralensis*, *M. lata* and *M. obliquimarginata*. As a whole, the identified assemblage is similar to that of the Tastubian “Krasnousolsk” section in which an association of fusulinids was found – *Pseudofusulina verneuili*, *P. conspicua*, *P. ishimbajevi*, *P. cf. fixa*, etc. (CHUVASHOV *et al.* 1990). My material has yielded the above conodont assemblage, but with depleted composition. *Mesogondolella uralensis*, *M. aff. obliquimarginata*, and *Mesogondolella* sp. occur in the upper part of the Karamurun Formation in association with *Pseudofusulina moelleri*, *P. sulcata*, and *P. ishimbajevi*, typical of the *Pseudofusulina moelleri* Fusulinid Zone. A diverse of conodont fauna has been determined in the Sarabil Formation: including the above conodont assemblage associated with *Pseudofusulina ex gr. verneuili*, and *P. blochini*. RAUSER-CHERNOUSSOVA (1965) indicated in this assemblage *Pseudofusulina verneuili*, *P. paraverneuili* VISSARIONOVA, *P. aff. fixa* KIREEVA, *P. truncatella* KIREEVA, *P. blochini* and other forms typical of the *Pseudofusulina verneuili* Zone, of the Sakmarian. Thus, the above conodont assemblage – the only one known from the Tastubian regional stage of the Sakmarian stratotype section – permits to recognize the *Mesogondolella uralensis* conodont zone analogous to two fusulinid zones: *Pseudofusulina moelleri* and *Pseudofusulina verneuili*.

The least diverse conodont fauna with occasional *Mesogondolella bisselli*, recovered from deposits of the Maloik Formation, has been recognized in the Sterlitamakian regional stage. In the pre-Urals region, *Mesogondolella bisselli* has earlier been found in the uppermost Tastubian (MOVSHOVICH *et al.* 1979). According to CHUVASHOV *et al.* (1990), this species usually occurs in the Sterlitamakian where it is associated with *Sweetognathus primus* CHERNYKH, and *Adetognathus* sp. Stratigraphically below this conodont assemblage, there occur fusulinids typical of Sterlitamakian: *Pseudofusulina karagasensis* RAUSER, *P. urdalensis* RAUSER, and *P. plicatissima* RAUSER.

It is rather difficult to subdivide the Tastubian and Sterlitamakian stages on conodonts because conodont elements are rather scarce in the Sakmarian. KOZUR (1978) and MOVSHOVICH (1984) recognized one zone assemblage (*Mesogondolella bisselli*, *Streptognathodus simplex*, *Sweetognathus merrilli*) in the Sakmarian. CHUVASHOV *et al.* (1990) established three conodont zones in the Sakmarian including (from bottom to top): *Mesogondolella uralensis*, *M. lata*, and *M. bisselli*–*M. visibilis* (*Sweetognathus primus*). KOZUR (1996) established two Sakmarian conodont zones, the Tastubian *Mesogondolella obliquimarginata*–*Sweetognathus merrilli* Zone and the Sterlitamakian *M. bisselli*–*M. visibilis* Zone. The Sakmarian pelagic conodont scale is based on evolution of the *Mesogondolella* (CHERNYKH 1988).

The succession of the conodont assemblages illustrated by the Sakmarian stratotype section is also documented and supplemented by my materials from several other sections. The *Streptognathodus constrictus* Zone assemblage manifested best in other sections. It has been recognized in sections on both sides of Bolshaya Syuren River (South Urals) and is characterized by conodonts *Streptognathodus constrictus*, *S. barskovi*, *S. asselicus*, *S. simplex*, *Mesogondolella dentiseparata*, and *M. adentata*. The latter two *Mesogondolella* species have earlier been defined as *Gondolella* cf. *bisselli* (ISAKOVA and NASAROV 1986). Stratigraphic distribution of the above conodont assemblage corresponds to that of fusulinid zonal assemblage of *Sphaeroschwagerina moelleri* and *Pseudofusulina fecunda* represented in the section by the following species: *Pseudofusulina fecunda* SHAMOV *et* SCHERBOVICH, *Ps. subnathorsti* (LEE), *Pseudoschwagerina aktjubensis* RAUSER, *Sphaeroschwagerina* ex gr. *moelleri* (RAUSER), and others (ISAKOVA and NAZAROV 1986).

The *Streptognathodus constrictus* Zone is recognized in the section along the Ajdaralash Spring (South Urals). In bed 34 (numbered after CHUVASHOV *et al.* 1986) abundant *Streptognathodus constrictus* (Pl. 1: 1–2) was found (samples collected by DAVYDOV), as well as *S. fusus* (Pl. 1: 4–5), *S. asselicus*, *S. longissimus*, *S. barskovi* (Pl. 1: 6), *S. simplex*, *S. aff. postfusinus* (Pl. 1: 7), *S. fuchengensis* (Pl. 1: 3) and an isolated fragment of *Mesogondolella* cf. *dentiseparata*.

The *Mesogondolella striata* Zone is present on the left bank of Bolshaya Syuren River (South Urals) near the Verkhnyaya Sarabil village where *M. striata*, *M. foliosa* (Pl. 1: 10), *M. aff. intermedia* IGO, *M. obliquimarginata* (Pl. 1: 13, 14), and *M. pseudostriata* have previously been found. These *Mesogondolella* species were synonymized and defined as *Mesogondolella* ex gr. *bisselli* and *M. bisselli* (ISAKOVA and NAZAROV 1986).

The *Mesogondolella uralensis* Zone is also recognized on the left side the of Bolshaya Syuren River. It is defined by the occurrence of *M. striata*, *M. uralensis*, *Mesogondolella* sp. These forms are transitional to *Mesogondolella bisselli* (Pl. 1: 21, 22).

Stratigraphically higher, in the same section, *Mesogondolella bisselli* has been identified in association with *Sweetognathus* sp. (Pl. 1: 8), similar to *S. withei* (RHODES).

REFERENCES

- AKHMETSHINA, L.Z. (Ahmetšina, L.Z.) 1990. Conodonts of Carboniferous and Permian boundary deposits in the pre-Caspian Depression eastern margin [in Russian]. — *Bulleten Moskovskogo Obsesta Ispytatelej Prirody, Otdel geologičeskij* **65**, 80–88.
- AKHMETSHINA, L.Z. (Ahmetšina, L.Z.), BARSKOV, I.S., and ISAKOVA, T.N. 1984. Conodonts of Gzhelian, Asselian, and Sakmarian stages (the Russian Platform, South Urals, pre-Caspian depression) [in Russian]. In: V.V. Menner and A.D. Grigoreva (eds), Upper Carboniferous of the USSR, 51–53. Nauka, Moskva.
- BARSKOV, I.S. 1984. The conodont zonal scale of the Upper Carboniferous and Lower Permian Asselian stage and the problems of its improvement [in Russian]. In: V.V. Menner and A.D. Grigoreva (eds), Upper Carboniferous of the USSR, 102–106. Nauka, Moskva.
- BARSKOV, I.S., ISAKOVA, T.N., and SCHASTLIVSEVA, N.P. (Sčastlivceva, N.P.) 1981. The boundary-bed conodonts of the Gzhelian and Asselian stages (South Urals) [in Russian]. — *Izvestiâ Akademii Nauk SSSR. Seriâ geologičeskââ* **5**, 78–87.

- BARSKOV, I.S. and REIMERS, A.N. (Rejmers, A.N.) 1996. Carboniferous–Permian boundary as indicated by conodonts. — *Stratigraphy and Geological Correlation* **4**, 428–439.
- BREIVEL, M.G. (Brejvel', M.G.), PAPULOV, G.N., KHODALEVICH, A.N. (Hodalevič, A.N.) (eds) 1980. *Standard and Correlative Stratigraphic Scheme of the Urals* [in Russian]. Sverdlovsk.
- CHERNYKH, V.V. (Černyh, V.V.) 1986. The conodont-based zonal subdivision of the Asselian stage deposits [in Russian]. *Ezgodnik* 1985. *Akademi Nauk SSSR, Ural'skoe Otdelenie. Sverdlovsk*, 5–8.
- CHERNYKH, V.V. (Černyh, V.V.) 1988. The Lower Permian zonal scale based on the conodonts of *Neogondolella* genus [in Russian]. *Ezgodnik* 1987. *Akademi Nauk SSSR, Ural'skoe Otdelenie. Sverdlovsk*, 5–7.
- CHERNYKH, V.V. (Černyh, V.V.) and CHUVASHOV, B.I. (Čuvašov, B.I.). 1986. Conodonts of the Carboniferous–Permian boundary deposits in the Urals western slope [in Russian]. In: G.N. Papulov (ed.), *The Carboniferous–Permian boundary deposits in the Urals, pre-Urals region and Middle Asia*, 129–130. Nauka, Moskva.
- CHERNYKH, V.V. (Černyh, V.V.) and RESHETKOVA, N.P. (Rešetkova, N.P.). 1987. Biostratigraphy and conodonts of Carboniferous–Permian boundary deposits in western slope of South and Middle Urals [in Russian]. 45pp. *Akademi Nauk SSSR, Ural'skij Naučnyj Centr. Sverdlovsk*.
- CHERNYKH, V.V. (Černyh, V.V.) and RESHETKOVA, N.P. (Rešetkova, N.P.). 1988. The conodont-based zonal subdivision of Carboniferous–Permian boundary deposits in western slope of Middle and South Urals [in Russian]. In: B.I. Chuvashov (ed.), *Biostratigraphy and Litology of the Upper Paleozoic Urals*, 62–78. Akademia Nauk SSSR, Ural'skoe Otdelenie. Sverdlovsk.
- CHERNYKH, V.V. and RITTER, S.M. 1997. *Streptognathodus* (Conodonta) succession at the proposed Carboniferous–Permian boundary Stratotype section, Aidaralash Creek, Northern Kazakhstan. — *Journal of Paleontology* **71**, 459–474.
- CHUVASHOV, B.I., DUPINA, G.V., MISENCE, G.A. and CHERNYKH, V.V. (Černyh, V.V.). 1990. Typical sections of the Upper Carboniferous and Lower Permian west slope Urals and pre-Urals [in Russian]. 369 pp. Akademia Nauk SSSR, Sverdlovsk.
- ISAKOVA, T.N. 1989. Conodonts of the Asselian and Sakmarian stages in Southern Urals [in Russian]. — *Voprosy Mikropaleontologii* **30**, 58–65.
- ISAKOVA, T.N. and NAZAROV, V.B. 1986. The Late Carboniferous–Early Permian stratigraphy and microfauna of South Urals [in Russian]. 183 pp. Nauka, Moskva.
- KOZUR, H. 1978. Beiträge zur Stratigraphie des Perms. Teil II: Die Conodontenchronologie des Perms. — *Freiberger Forschungsheft* **334**, 85–161.
- KOZUR, H. 1995. Permian conodont zonation and its importance for the Permian Stratigraphic Standard Scale. — *Geologisch-Paläontologische Mitteilungen Innsbruck* **20**, 165–205.
- KOZUR, H. 1996. Some remarks to the Permian standard scale. — *Guadalupian II, Alpine, Texas, April 10–13, 1996. Abstracts*, 13–14.
- KOZUR, H. and MOSTLER, H. 1976. Neue conodonten aus dem Jungpaläozoikum und der Trias. *Geologisch-Paläontologische Mitteilungen Innsbruck* **6**, 1–33.
- MOVŠOVICH, V.E. (Movšovic, V.E.) 1984. Conodonts [in Russian]. In: G.V. Kotljarskiy and D.L. Stepanov (eds), *Main stratigraphic features of the USSR Permian system*, 263–269. Nedra, Leningrad.
- MOVŠOVICH, V.E. (Movšovic, V.E.), KOZUR, H., PAVLOV, A.M., and others 1979. Conodont complexes of the Lower Permian pre-Urals region and the problem of the Lower Permian deposits correlation [in Russian]. In: G.N. Papulov and V.N. Puchkov (eds), *The Urals conodonts and their stratigraphic significance*, 94–134. Sverdlovsk.
- RAUSER-CHERNOUSOVA, D.M. (Rauzer-Černousova, D.M.). 1965. Foraminifers of the Sakmarian stage stratotype section (R. Sakmara, South Urals) [in Russian]. 69pp. Nauka, Moskva.
- RESHETKOVA, N.P. (Rešetkova, N.P.) and CHERNYKH, V.V. (Černyh, V.V.). 1986. New species of the Urals western side [in Russian]. — *Paleontologičeskij Žurnal* **4**, 108–112.
- ROZOVSKAYA, S.E. (Rozovska, S.E.) 1952. Upper Carboniferous and Lower Permian fusulinids of South Urals [in Russian]. Materials from the Paleozoic fauna. Izdatel'stvo Akademii Nauk SSSR, 5–47. Moskva.
- RUZHENTSEV, V.E. (Ružencev, V.E.) 1936. New data on the stratigraphy of Carboniferous and Lower Permian deposits of the Orenburg and Aktyubinsk regions [in Russian]. — *Problemy Sovetskoy Geologii* **6**, 470–506.
- RUZHENTSEV, V.E. (Ružencev, V.E.) 1950. The Upper Carboniferous ammonites of Urals [in Russian]. 217 pp. Izdatel'stvo Akademii Nauk SSSR, Moskva.
- RUZHENTSEV, V.E. (Ružencev, V.E.) 1951. The Lower Permian ammonites of South Urals [in Russian]. 184 pp. Izdatel'stvo Akademii Nauk SSSR, Moskva.

REVIEW OF THE CONODONTS OF THE SAKMARIAN STRATOTYPE SECTION (SOUTH URALS)

PLATE I

Streptognathodus constrictus CHERNYKH *et* RESHETKOVA, 1986

1. Specimen 4766/1, Ajdaralash Spring, sample 9–34, × 100.
2. Specimen 4766/2, Ajdaralash Spring, sample 9–34, × 50.

Streptognathodus fuchengensis ZHAO

3. Specimen 4766/3, Ajdaralash Spring, sample 9–34, × 50.

Streptognathodus fusus CHERNYKH *et* RESHETKOVA, 1988

4. Specimen 4766/4, Ajdaralash Spring, sample 9–34, × 50.
5. Specimen 4766/5, Ajdaralash Spring, sample 9–34, × 50.

Streptognathodus barskovi (KOZUR, 1976)

6. Specimen 4766/6, Ajdaralash Spring, sample 9–34, × 50.

Streptognathodus aff. *postfus* CHERNYKH *et* RESHETKOVA, 1988

7. Specimen 4766/7, Ajdaralash Spring, sample 9–34, × 50.

Sweetognathus sp.

8. Specimen 4755/15, Bolshaya Syuren River, × 50.

Mesogondolella foliosa (CHERNYKH *et* RESHETKOVA, 1987)

9. Specimen 4766/8, the Sakmarian stratotype section, sample 79a, × 50.
10. Specimen 4766/9, Bolshaya Syuren River, × 50.

Mesogondolella pseudostriata (CHERNYKH, 1990)

- 11, 12. Specimens 4766/10–11 respectively, the Sakmarian stratotype section, sample 66, × 50.

Mesogondolella obliquimarginata (CHERNYKH, 1990)

- 13, 14. Specimens 4766/12–13 respectively, Bolshaya Syuren River, × 50.

Mesogondolella longifolia (CHERNYKH, 1990)

15. Specimen 4766/14, the Sakmarian stratotype section, sample 48, × 50.
16. Specimen 4766/15, Bolshaya Syuren River, × 50.

Mesogondolella lata (CHERNYKH, 1990)

- 17, 18. Specimens 4766/16–17 respectively, the Sakmarian stratotype section, sample 74, × 50.

Mesogondolella uralensis (CHERNYKH, 1990)

19. Specimen 4766/18, the Sakmarian stratotype section, sample 79c, × 50.

Mesogondolella bisselli (CLARK *et* BEHNKEN, 1971)

20. Specimen 4766/19, the Sakmarian stratotype section, sample 85, × 50.

Mesogondolella sp.

21. Specimen 4766/20, Bolshaya Syuren River, × 100.

Mesogondolella aff. *bisselli* (CLARK *et* BEHNKEN, 1971)

- 22a. Specimen 4766/21, Bolshaya Syuren River, × 50.
- 22b. Specimen 4766/22, surface reticulation, Bolshaya Syuren River, × 500.

