GEOLOGIJA *37*, *38*, 153–171 (1994/95), Ljubljana
https://doi.org/10.5474/geologija.1995.006

Lower Permian conodonts from the Karavanke Mts. (Slovenia)

Stanko Buser
Geological Department, Faculty of Natural Sciences
and Engineering, University of Ljubljana,
Aškerčeva 2, SI-1000 Ljubljana, Slovenia

Holger C. Forke
Institute of Paleontology, University of Erlangen
Loewenichstr. 28, 91054 Erlangen, Germany

Abstract

The first conodont fauna (4 species) from the "Trogkofel Limestones" of the Karavanke Mts. (Dolžanova soteska) is described and correlated with the fusulinids (3 species) within the same sample. The occurrence of *Streptognathodus* cf. *simplex*, *Streptognathodus* cf. *elongatus* and *Diplognathodus expansus?* together with *Dutkevitchia complicata* indicates a higher age (Asselian) of these limestones than previously thought, because even the Upper Pseudoschwagerina Limestone (Sakmarian) of the Carnic Alps already yields a *Sweetognathus* fauna. To avoid misunderstanding in correlations the name "Dolžanova soteska limestone member" is introduced for the white, pale red to red limestone unit, described as "Trogkofel Limestone" in previous literature.

IUGS UNESCO P 359

Introduction

Previous work

The classical locality of Permian beds and fossils in Dolžanova soteska ("Teufelsschlucht" in German) in the Karavanke Mts. is situated in the Tržiška Bistrica valley, about 3 km NE of the town of Tržič in NW Slovenia (Fig. 1). In it the well exposed profile occurs in the Upper Carboniferous clastic beds, light grey, pale red and red "Trogkofel" limestones, dark, bedded limestones, Tarvisio breccia, Gröden clastics and Upper Permian dolomites and rauhwackes. Although almost a century passed since the first systematic geological studies of these beds, the correct stratigraphic attribution of the up to now improperly named light grey, pale red and red "Trogkofel" limestone unit remained still unresolved.

Since Geyer (1895) described the stratigraphy of the Carnic Alps, it was generally accepted that the limestones of the Trogkofel are Early Permian in age. At this time the Rattendorf Group (Lower Pseudoschwagerina Limestone, Grenzland Formation,

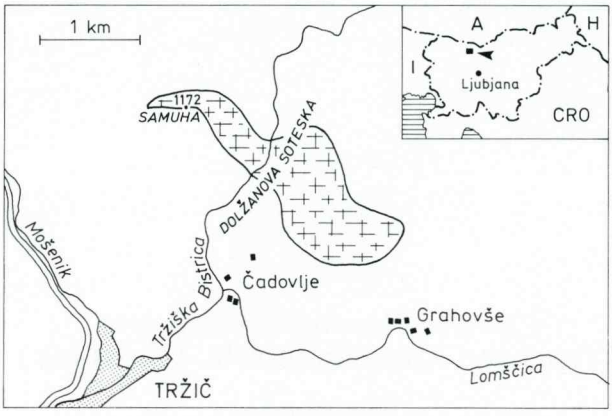


Fig. 1. Location sketch-map and detailed position of the Dolžanova soteska limestone

Upper Pseudoschwagerina Limestone) didn't exist and he included in his definition of the Trogkofel Limestone also the underlying dark or red, bedded limestones (now Upper Pseudoschwagerina Limestone). The fossils (mostly brachiopods), on which the biostratigraphic correlations were based, mainly came from these bedded limestones below.

Three years later Schellwien (1898a) described a fauna from the limestones of the Dolžanova soteska, which he compared with the limestones of the Trogkofel area (sensu Geyer). Between the rich brachiopod fauna, which he later described in his monography (Schellwien, 1900), he also found three ammonoids *Agathiceras* aff. *uralicum* Karpinsky, *Popanoceras (Stacheoceras)* n. sp., *Thalassoceras? microdiscus* Gemmellaro. But unfortunately there is neither a description nor a picture of these ammonoids.

In the 1930's Heritsch, Kahler & Metz discovered Permian fossils *(Sphaeroschwagerina)* of the Grenzland Formation (Heritsch & Kahler, 1932) in the Carnic Alps and clarified the stratigraphy of the different lithostratigraphic units. They established the Rattendorf Group between the Upper Carboniferous Auernig Group and the Trogkofel Limestone s. str. (Tab. 1).

Heritsch (1933, 1938, 1939, 1943) treated fusulinid foraminifera, corals and trilobites from the limestones of the Dolžanova soteska and performed the revision of Schellwien's work (1990) on brachiopods. The limestones were believed to belong to the Trogkofel Limestone (Heritsch, 1938), because of the strong lithologic similarities. Kahler F. and Kahler G. (1937, 1941) described *"Pseudoschwagerina" carniolica* from the dark, bedded limestones in the Dolžanova soteska and *"Pseudoschwagerina" citriformis* from a chunk of limestone in the scree of the "Trogkofel" limestones. Further studies on fusulinids were presented by Kochansky-Devidé (1956, 1964). An important contribution to stratigraphy and study of fossil assemblage in Permian beds especially from the "Trogkofel" limestone in Dolžanova soteska was provided by Ramovš (1961, 1963, 1966, 1968, 1969, 1980), the extraordinary authority on it. The rare trilobites from the "Trogkofel" limestone were studied by Hahn et al. (1970).

Table 1. Historical review of the lithostratigraphic subdivisions in the Carnic Alps and correlation with the Dolžanova soteska limestone

Lithostratigraphic units in the Upper Carboniferous-Lower Permian of the Carnic Alps									stratigraphical correlation of the Dolžanova soteska limestone with the Carnic Alps
GEYER, 1895		HERITSCH et al., 1932			KAHLER, 1986; FORKE, 1995				
PERMIAN TROGKOFEL LIMESTONE	PERMIAN	TROGKOFEL LIMESTONE		PERMIAN	TARVIS BRECCIA	TROGKOFEL GROUP	ARTINSKIAN	PERMIAN	previous authors
					GOGGAU LIMESTONE				
					TRESSDORF LIMESTONE				
					TROGKOFEL LIMESTONE				
		UPPER PSEUDOSCHWAGERINA LIMESTONE	RATTENDORF GROUP		UPPER PSEUDOSCHWAGERINA LIMESTONE	RATTENDORF GROUP	SAKMARIAN		
UPPER CARB. CLASTIC BEDS AND LIMESTONES	CARBONIFEROUS	GRENZLAND FORMATION			GRENZLAND FORMATION		ASSELIAN		this paper
		LOWER PSEUDOSCHWAGERINA LIMESTONE			LOWER PSEUDOSCHWAGERINA LIMESTONE				
		AUERNIG GROUP		CARBONIFEROUS	AUERNIG GROUP		UP.MOSC. - GZHELIAN	CARBONIFEROUS	

The stratigraphic subdivision and regional extension of the larger part of the Permian beds in the Karavanke Mts. were elaborated during investigations for the new geological map by Buser and Cajhen in 1978. Buser (1974, 1980) established the position of the "Trogkofel" limestone in Dolžanova soteska below the dark bedded limestones with *Sphaeroschwagerina*. Interesting for stratigraphy is the work by Pečar (1987) who determined a new brachiopod species in the "Trogkofel" limestone and ascertained that the Upper Carboniferous quartz conglomerate is overlain by the "Trogkofel" limestone.

All mentioned researchers of Permian beds in Dolžanova soteska assigned the grey, pale red to red limestones to the Trogkofel Stage without hesitation, which in the type region of the Carnic Alps is of latest Sakmarian to Artinskian age. Buser (1974, 1980) and Pečar (1987) established the position of this limestone between the quartz conglomerate and the overlying dark bedded limestones with *Sphaeroschwagerina*. However, they did not deduce from this fact the possibility that the "Trogkofel" limestones of the Dolžanova soteska do not correlate with the true Trogkofel limestones in age.

Geological setting of Dolžanova soteska

The Upper Carboniferous and Permian beds outcrop in Dolžanova soteska in a 10km long and 3km wide east-west trending belt (Fig. 1). In spite of the very complicated structure of the Karavanke Mts. this belt of younger Paleozoic beds is of

relatively simple tectonics. A major obstacle to observations is the dense cover of several metres of weathering residue and of limestone slope talus. However, in the Dolžanova soteska the considered beds are well exposed, as the gorge cut deep into the rock sequence.

The Upper Carboniferous beds dip southwest below the Permian beds, therefore in the gorge from south to north gradually older beds are exposed. The Upper Carboniferous marine molasse beds are developed as shales, quartz sandstones and conglomerates with several metres thick intercalations of black limestones.

In Dolžanova soteska the predominantly massive quartz conglomerate, consisting of pebbles of quarzite and subordinately lydite in the upper part, attains about 180m thickness. The conglomerate is overlain by a 30cm thick black calcarenitic limestone with numerous crinoid fragments. The contact between conglomerate and limestone is uneven, very wavy and the conglomerate is intensely weathered and limonitized along the contact with the limestone. Laterally a 30cm thick sheet of quartz sandstone appears between the conglomerates and limestones. In the basal part of the calcarenitic limestone also quartz pebbles occur (Fig. 2). The uneven and limonitized surface of the conglomerate most probably represents an erosion that occured during the uplift of the sea bottom as a result of the tectonic phase near the boundary between the Upper Carboniferous and Lower Permian (Buser, 1974, 1980).

1m of grey limestone lies above the calcarenitic limestone that interbeds with up to several cm thick sheets of dark marl and shale. Upwards a 1 m thick bed of dark grey biomicritic limestone follows. This limestone has the same dip as the basal contact plane in the conglomerate (212/75). Above the biomicritic limestone 50cm

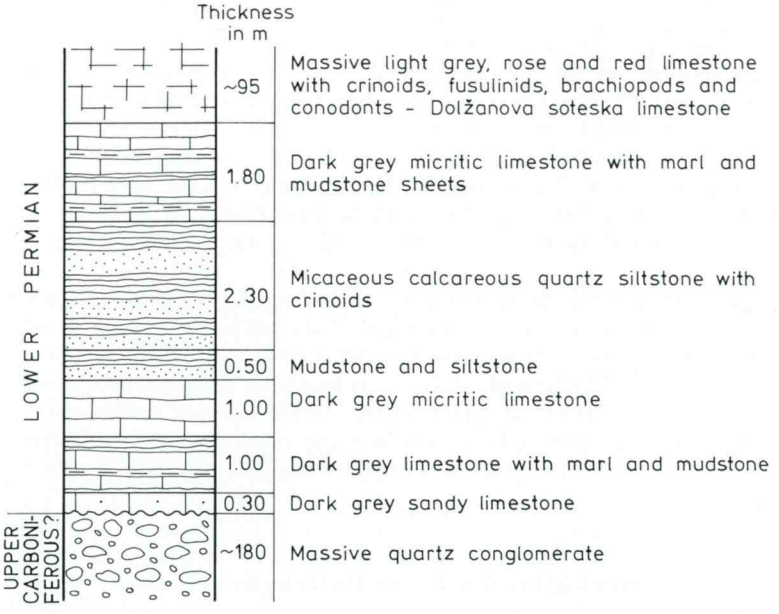


Fig. 2. Detailed stratigraphic column at the transition from the underlying quartz conglomerate to the lower part of the Dolžanova soteska limestone

of black mudstone is interbedded with micaceous siltstone. 230cm of grey micaceous siltstones follow, which are tectonically strongly deformed and folded. The siltstone is covered by a 180cm thick package of dark grey mudstone and marl. In limestones within the mudstone very numerous crushed brachiopod valves occur. It is most probable that Pečar (1987) found the brachiopod *Capillomesolosus heritschi* in these beds, which is, however, more frequent in the red and pale red limestones of Dolžanova soteska.

The content of mudstones decreases in the grey limestone, which passes into light grey, pale red and red massive limestones that have been called up to now "Trogkofel" limestones. This limestone is the main subject of this investigation and is called Dolžanova soteska limestone further on. The horizon, in which the colour changes, is not more than 2m thick. Upwards greyish to pale red limestones follow, which pass into the characteristic red limestones. In the latter the rich fauna of brachiopods as well as crinoids and common fusulinids occur. Schellwien's (1900) brachiopods originated from an ancient quarry 150m north of the upper bend of the road through Dolžanova soteska. The limestones form more than 100m high cliffs on the eastern side of the road. The limestone continues westwards across the Tržiška Bistrica. The length of the outcropping belt of limestone that is on the average 95m thick amounts to about 2.5km.

The Dolžanova soteska limestone is of intense red colour in its highest part. From this limestone the samples for conodonts were collected in the steep cliff several ten metres above the road and above the abandoned quarry.

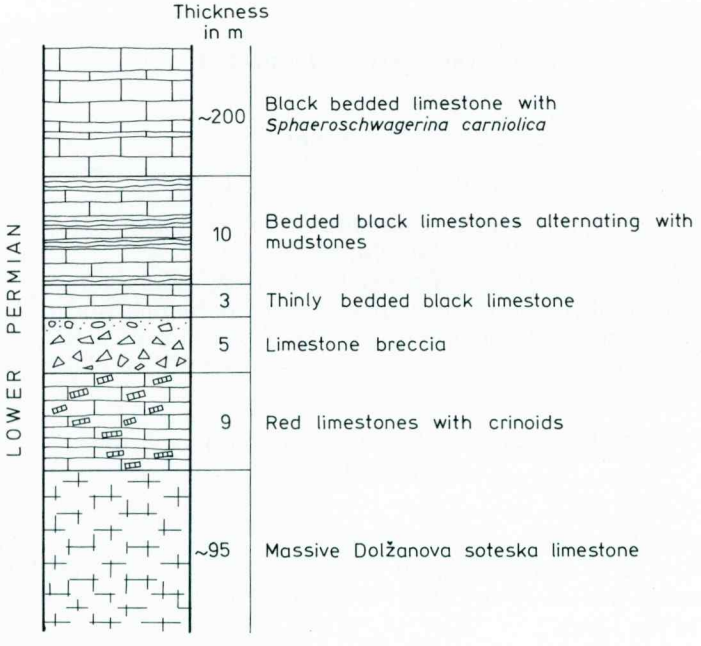


Fig. 3. Detailed stratigraphic column from the upper part of the Dolžanova soteska limestone

The stratigraphic position of the considered Dolžanova soteska limestone can be observed about 100m above the road and the abandoned quarry, since the intermediate area is covered by limestone rubble. Here the meat red limestone is overlain by brownish and greyish platy crinoid limestone that passes upwards into cinnabar red crinoid limestone (Fig. 3). On the upper surface of the limestone beds thin coatings of red-violet silty mudstone occur. This limestone is about 4m thick. Upwards about 5m of grey red thicker bedded limestones follow. The crinoid limestone is overlain by 5m of limestone breccia that consists of 5 to 30cm sized fragments of biomicritic and crinoid limestone with brownish grey calcareous-siliceous cement. Laterally, quartz conglomerate and sandstone of approximately 1.5m thickness may occur above the breccia.

The breccia is overlain by 3m of micritic dark grey limestone that is covered by a 10m thick package of black limestone in alternation with black shale. The rock outcrops at the upper road curve. Upwards an about 200m thick succession of grey, thick bedded limestones with abundant *Sphaeroschwagerina* follows. The type locality of *Sphaeroschwagerina carniolica* (Kahler & Kahler, 1937) is situated in this limestone at this upper bend of the road. The characteristic pyramids of the Dolžanova soteska, and also the part of the rocks through which the road tunnel was driven about a century ago, consist of these dark bedded limestones.

The Lower Permian succession is terminated by a clastic sequence of interbedded quartz sandstones, conglomerates and shaly mudstones. The Middle Permian Tarvisio breccia and the violet-red clastics of the Gröden Formation were deposited above these clastics.

Systematic paleontology

Conodonts

Classification after Sweet, 1988

Phylum **Conodonta** Pander, 1856
Class **Conodonta** Branson, 1938
Order **Ozarkodinida** Dzik, 1976
Family Idiognathodontidae Harris & Hollingsworth, 1933
Genus *Streptognathodus* Stauffer & Plummer, 1932
Type-species *Streptognathodus excelsus* Stauffer & Plummer, 1932

Streptognathodus cf. *simplex* Gunnell, 1933
Pl. 1, figs. 3–6

Material: 18 specimen DSB 5, 8, 10, 11, 12, 13, 14, 21, 27, 30, 32, 33.

Description: – Carminiscaphat with a slender, lanceolate platform. Specimen have a inward-downward trending curvature of platform immediately posterior to the end of the carina.

- Free blade long with 8–10 denticles, the second and third are the largest.
- Carina short and fused, 1–2 separated nodes are sometimes developed posterior to carina.

- Platform is divided by a median groove and possesses transverse ridges, which may pass sometimes the median groove, especially in the posterior part. On the anterior part of parapets nodes or small costae are developed and separated from the carina or fixed blade by deep furrows. The parapet of the inner side is usually somewhat longer than the outer one.
- Oral surface of carina, transverse ridges and accessory nodes with a honeycomb ultrastructure.

Sample no.	Weight in g	Total	*Diplogn. expansus?*	*Hindeodus minutus*	*Streptogn.* cf. *simplex*	*Streptogn.* cf. *elongatus*	Unidentified Pa elements	Ramiform elements
DSB	4160	79	1	1	18	13	31	13

Streptognathodus cf. *elongatus* Gunnell, 1933
Pl. 1, figs. 7–9

Material: 13 specimen DSB 3, 4, 6, 15, 16, 20, 23, 25, 26, 31.

Description: – Carminiscaphat with a lanceolate platform. Specimen have a inward-downward trending curvature of platform immediately posterior to the end of the carina.
- Free blade long with 8–10 denticles, by which the second and third are the largest.
- Carina short, fused, seldom a single node is developed posterior to the carina.
- Platform is divided by a median groove and possesses transverse ridges, which may pass sometimes the median groove, especially in the posterior part. On the anterior part of parapets nodes or small costae are developed and separated from the carina or fixed blade by deep furrows. The parapet of the inner side is usually somewhat longer than the outer one. The inner side of platform has a slight indentation in the anterior part, where the nodes are developed.
- 1–4 accessory nodes are attached at the inner side of the platform margin.
- Oral surface of carina, transverse ridges and accessory nodes with a honeycomb ultrastructure.

Discussion: *Streptognathodus* cf. *elongatus* is distinguished from *Strept.* cf. *simplex* in a somewhat slender, elongate platform, which lacks an indentation and accessory nodes. Ellison (1941) regarded *Streptognathodus simplex* and *Strept. elongatus* as synonymous. Kozur and Mostler (1976) stated that the holotype of *Streptognathodus elongatus* has accessory nodes, but *Streptognathodus simplex* has not. They considered that *Streptognathodus simplex* is intermediate in his morphological features between *Streptognathodus elegantulus* Stauffer and Plummer, 1932 with a deeper, more V-shaped median trough, longer carina and shorter transverse ridges and *Streptognathodus barskovi* Kozur, 1976 with a shallow groove, broad platform and small, long transverse ridges.

Streptognathodus nodulinearis Chernykh and Reshetkova, 1986 is similar in the development of accessory nodes to *Streptognathodus elongatus*.

In a preliminary report about the conodonts of the C/P boundary type section (Aidaralash, Southern Urals) Chernykh and Ritter (1994) suggested a subdivision of streptognathodontid morphotypes because of the phyletic development of acces-

sory nodes. Our specimen could be assigned to the unornamented and pseudo-nodular morphotype, which occurs there immediately below the C/P boundary.

Family Anchignathodontidae Clark, 1972
Genus *Hindeodus* Rexroad & Furnish, 1964
Type-species *Spathognathodus cristulus* Youngquist & Miller, 1949

Hindeodus minutus (Ellison, 1941)
Pl. 1, fig. 2

*1941 *Spathodus minutus* Ellison n. sp. – Ellison, S. 120, Taf. 20, Fig. 50–52.
1973 *Spathognathodus minutus* (Ellison, 1941) – Merrill, S. 305–308, Taf. 1, Fig. 1–14, Taf. 2, Fig. 1–28.
1975 *Anchignathodus minutus* (Ellison, 1941) – Behnken, S. 297, Taf. 1, Fig. 16–18, USA, Leonardian.
1975 *Ozarkodina minuta* (Ellison, 1941) – Perlmutter, S. 102–103, Taf. 2, Fig. 26–30, Kansas, Penn.-Permian.
1986 *Anchignathodus minutus* (Ellison, 1941) – Ritter, S. 146, Taf. 4, Fig. 1, 5, USA, Wolfcampian.
1989 *Hindeodus minutus* (Ellison, 1941) – Wang & Higgins, S. 279, Taf. 13, Fig. 6, 7, S-China, Karbon + Perm.
1991 *Hindeodus minutus* (Ellison, 1941) – Brown et al., without description, Taf. 2, Fig. 12, 13, Illinois Basin, Desmoinesian (Pennsylvanian).

Material: 1 specimen DSB 1.
Description: – Carminiscaphat.
– Free blade short and thin.
– Cusp high with a triangulate form and a fine striation on the surface. Transition from cusp to the denticles of the carina with a distinct step. Carina possesses 11 discrete denticles.
– Oral surface of platform smooth.
– Basal cavity widest anteriorly.

Family Sweetognathidae Ritter, 1986
Genus *Diplognathodus* Kozur & Merrill, 1975
Type-species *Spathognathodus coloradoensis* Murray & Chronic, 1965

Diplognathodus expansus? (Perlmutter, 1975)
Pl. 1, fig. 1

*1975 *Ozarkodina expansa* Perlmutter n. sp. – Perlmutter, S. 98–99, Taf. 3, Fig. 1–16, Kansas, Council Grove Group, Pennsylvanian.
1990 *Diplognathodus expansus* (Perlmutter, 1975) – Ding & Wan, without description, Taf. 3, Fig. 6, 12–13, 15–18, 20–22, N-China, Taiyuan Fm.
1990 *Diplognathodus* n. sp.? H – V. Bitter & Merrill, Taf. 4, A–L, (Material Perlmutter).

Material: 1 specimen DSB 2.

Description: – Carminiscaphat.

- Free blade thin, with a cusp and 4 denticles, decreases in height posteriorly. The transition to the carina takes place without a distinct step in height.
- The posterior part is developed as a spatulate carina without pustulose ultrasculpture.
- Oral surface of platform is smooth, margin of platform is wavy.
- The basal cavity is expanded.

Remarks: The type Pa elements of *Diplognathodus expansus* were reexamined by V. Bitter & Merrill (1990) under SEM. The holotype and some of the paratypes have a pustulose ultrasculpture on the carina and were therefore assigned to the genus *Sweetognathus*. The other specimen without pustulose ultrasculpture were left as *Diplognathodus* n. sp.? H. As described in Forke (1995) some specimen of *Diplognathodus expansus*? in the material of the Upper Pseudoschwagerina Limestone (Sakmarian) of the Carnic Alps bear a single row of secondary pustules on the spatulate carina.

Fusulinids

Order **Foraminiferida** Eichwald, 1830
Suborder **Fusulinina** Wedekind, 1937
Superfamily Fusulinacea V. Möller, 1878
Family Boultoniidae Skinner & Wilde, 1954
Subfamily Boultoniinae Skinner & Wilde, 1954
Genus *Boultonia* Lee, 1927
Type-species *Boultonia willsi* Lee, 1927

Boultonia willsi Lee, 1927
Pl. 2, fig. 4

*1927 *Boultonia willsi* Lee, n. sp. – Lee, S. 10–11, Taf. 2, Fig. 1–4, N-China.
1970 *Boultonia willsi* Lee, 1927 – Kochansky-Devidé, S. 230, Taf. 4, Fig. 7–16, Westkarawanken, ob. Rattendorfer Schichten, Trogkofelkalk?.
1980 *Boultonia willsi* Lee, 1927 – Kahler F. & Kahler G., S. 190, Taf. 1, Fig. 6, Forni Avoltri (Carnia).

Material: Several slightly oblique sections DSB 1.

Occurrence: Common together with *Dutkevitchia complicata* and *Quasifusulina* cf. *tenuissima* in the Dolžanova soteska limestone member.

Description: – Shells of small size, elongate-fusiform with a minute proloculus (25 µm), first whorl almost round, later increases markedly in length. 4–5 volutions in mature specimen.

- Wall is thin, two-layered with a dark outer layer (tectum), and light inner layer (diaphanotheca?).
- Septa are very thin and regularly fluted.
- Chomata are distinct in the later whorls.

Family Fusulinidae V. Möller, 1878
Subfamily Fusulininae V. Möller, 1878
Genus *Quasifusulina* Chen, 1934
Type-species *Fusulina longissima* V. Möller, 1878

Quasifusulina cf. *tenuissima* (Schellwien, 1898)
Pl. 2, fig. 3

Material: 3 axial sections DSB 1 [3], DSB 2, DSB 3, 1 subaxial section DSB 1 [2].

Occurrence: Common together with *Dutkevitchia complicata* and *Boultonia willsi* in the Dolžanova soteska limestone member.

Description: – Shell cylindrical with bluntly rounded poles. Species reaches length of 6–7mm and diameter of 1.7–1.8mm in 4–5 volutions, giving a form ratio of ~3.4.
- Proloculus large (~400µm), sometimes ovoid or dent in the middle part.
- Spirotheca is composed of a tectum and a thin keriotheca? with uneven thickness.
- Septal fluting is moderately and regular across the entire shell. In axial sections therefore round arches appear.
- Chomata and phrenothecae are absent.
- The conspicuous axial fillings are characteristic for the genus, which are developed in this species almost in all volutions.

No.	L(mm)	W(mm)	L/W	Pr	1	2	3	4	5	6	7	8	Whorl.
DSB 1 [3]	5,82	1,68	3,46	400	75	105	120	180					WH(µm)
				25	20	20	20	30					WS(µm)
DSB 3 [1]	6,72	1,8	3,73	390	60	140	135	165	200				WH(µm)
					25	15	25	25	30				WS(µm)

Family Schwagerinidae Dunbar & Henbest, 1930
Subfamily Schwagerininae Dunbar & Henbest, 1930
Genus *Dutkevitchia* Leven & Shcherbovich, 1978
Type-species *Rugosofusulina devexa* Rauzer-Chernoussova, 1937

Dutkevitchia complicata (Schellwien, 1898)
Pl. 2, figs. 1, 2

*1898 *Fusulina complicata* Schellwien, n. sp. – Schellwien, S. 249–50, Taf. 20, Fig. 1–7, Karawanken.
1972 *Rugosofusulina complicata complicata* (Schellwien, 1898) – Bensh, S. 80–81 (russ.), Taf. 17, Fig. 2, 3, Süd-Fergana, Karatschatyr.
1980 *Dutkevitchia complicata* (Schellwien, 1898) – Leven & Shcherbovich, ohne Beschreibung, Taf. 8, Fig. 7, Darwas.
1986 *Dutkevitchia complicata* (Schellwien, 1898) – Isakova & Nazarov, S. 42–43 (russ.), Taf. 7, Fig. 3, S-Ural, Assel.

1989 *Rugosofusulina complicata* (Schellwien, 1898) – Zhang et al., ohne Beschreibung, Taf. 1, Fig. 1, 3, 4, 8, 10, 11, N-China, Taiyuan Fm.

1993 *Dutkevitchia complicata* (Schellwien, 1898) – Vachard, S. 100, 102, Taf. 4, Fig. 4, 9, Griechenland, Mt. Beletsi.

Material: 3 axial sections DSB 1 [1], [2], [4].

Occurrence: Frequent together with *Quasifusulina* cf. *tenuissima* and *Boultonia willsi* in the Dolžanova soteska limestone member.

Description: – Subcylindrical to nearly ovoid species with rounded poles, attains length from 7–9mm and width about 3mm in 4–5 volutions (L/W = 2.4–3.14).
- Proloculus large (300–420μm) with a thick wall (40μm). First 2–3 whorls almost globose, in later whorls the shape becomes more elongated.
- Spirotheca is composed of a tectum with a smallscaled rugosity and a coarse alveolar keriotheca. Wall thickness on average from 30μm in the first up to 90μm in the last whorl.
- Septa deep and strongly fluted throughout the whole chambers. The septal arches reach in axial sections from bottom to top of the chamber, are thickened in the upper part and have steep flanks.
- Chomata are absent, phrenothecae can sometimes occur.

Remarks: *Dutkevitchia complicata* was described by Schellwien (1898b) from Tržič, Slovenia (which is the next town on the street from Dolžanova soteska), because he didn't know the exact "locus typicus".

Schellwien mentioned that they occur together with *Quasifusulina tenuissima* in grey to yellowish limestones.

No.	L(mm)	W(mm)	L/W	Pr	1	2	3	4	5	6	7	8	Whorl.
DSB 1 [1]	9,6	3,06	3,14	300	150	200	330	360					WH(μm)
				40	30	45	60	65					WS(μm)
DSB 1 [2]	7,8	2,7	2,89	330	90	210	405	375					WH(μm)
				40	30	45	70	90					WS(μm)
DSB 1 [4]	7,2	3,0	2,40	420	105	255	255	330	340				WH(μm)
				35	25	45	60	75	90				WS(μm)

Faunal affinity and stratigraphic correlations

The stratigraphic occurrence of the genus *Dutkevitchia* is not well defined at the moment. However, the similar *Dutkevitchia dastarensis* (Bensh, 1972) was found in the "Obere kalkarme Schichtgruppe" (Auernig-Group) of the Garnitzen Section by Kahler F. and Kahler G. (1982). *Dutkevitchia expansa* (Lee, 1927), which has conspicious axial fillings in the inner volutions, occurs in the Lower Pseudoschwagerina Limestone. *Dutkevitchia complicata* is described from a red limestone in the Trogkar Section (assigned to the Trogkofel limestone) by Forke (1995), where it occurs together with *Robustoschwagerina* sp. This form differs from herein described species in having a more elongate, subcylindrical shape in the outer volutions. The occurrences of the genus *Dutkevitchia* are well correlatable with the C/P boundary type sections in Southern Urals and especially the Darvaz region as well as with Chinese

Fig. 4. Bioclastic wackestone with echinoderm fragments, fusulinids, brachiopodes and ostracods, × 10

sections, where they are reported from Uppermost Carboniferous to Sakmarian deposits. *Dutkevitchia complicata* seems to be restricted to the Asselian and Sakmarian.

The absence of the genus *Sphaeroschwagerina* in the studied material, which is the index fossil of the Asselian seems to depend on facies. Kahler F. and Kahler G. (1941) described *Sphaeroschwagerina citriformis* from a loose chunk of the Dolžanova soteska limestone. The dark limestones above yield *Sphaeroschwagerina carniolica* (Kahler & Kahler, 1937). Closely similar species (cf. Rauzer-Chernoussova, 1960) were often assigned by Russian and also Japanese researchers to *Sphaeroschwagerina pavlovi* (Rauzer-Chernoussova, 1938), which is a widespread Asselian fusulinid. *Sphaeroschwagerina carniolica* is also common in the Grenzlandformation of the Carnic Alps.

The fusulinid genus *Quasifusulina* as well as the conodont *Hindeodus minutus* are long-ranging species (Carboniferous -Permian) and have therefore no stratigraphical value.

Diplognathodus expansus? (some with a single row of nodes on the carina) are found together with *Sweetognathus* in the Upper Pseudoschwagerina Limestone and Trogkofel limestone? (Forke, 1995). *Diplognathodus expansus* (*Dipl.* n. sp.? H by V. Bitter & Merrill, 1990) is recorded from the Bennett Shale to the Crouse Limestone (Council Grove Group) in Kansas, U.S.A.. In North China *Diplognathodus expan-*

Fig. 5. Bioclastic wackestone with fusulinids, and large fragments of phylloid algae (*Eugonophyllum* sp.). Internal structure mostly dissolved and filled with fine peloidal micrite, × 10

sus (with some uneven secondary pustules on the spatula; Ding & Wan, 1990, p. 135) appears in the upper part of the *Streptognathodus elongatus-S. wabaunsensis-S. fuchengensis* assemblage zone, which correlates with the *Sphaeroschwagerina* fusulinid zone. Neither in the Southern Urals type sections nor in the South China sections (Wang & Higgins, 1989; Wang, 1994) the genus *Diplognathodus* is reported from Gzhelian to Lower Sakmarian deposits.

Because no universally accepted taxonomy exists for the Upper Carboniferous-Lower Permian *Streptognathodus*, it is difficult to give a precise correlation for this species. Therefore, independent on exact taxonomic assignation, the widest range of *Streptognathodus elongatus* and *Streptognathodus simplex* is from Upper Carboniferous (base of Gzhelian) to Lower Permian (Sakmarian) strata.

Microfacies

Several additional samples were thin sectioned for microfacies study. They indicate a wide variety of shallow subtidal to intertidal? platform carbonates.

The thin sections of the sample from where the conodonts and fusulinids were obtained, are bioclastic wackestones. The bioclasts are mostly echinoderm fragments, as well as common fusulinids, smaller foraminifera, bryozoans, brachiopods and ostracods (Fig. 4). Large, unbroken phylloid algal blades are present, but their internal parts are normally not preserved (Fig. 5). They appear as moulds, filled with sparry calcite or fine peloidal micritic sediment after dissolution, showing geopetal

structures, which could be also seen in some shelter pores of brachiopods. The phylloid algae were encrusted by *Tubiphytes* or red algae (*Claracrusta* sp.). Sponges, gastropods and trilobites are rare. Conspicious is the strong bioturbation (agglutinated worm tubes) of the sediment.

Conclusions

Although a latest Carboniferous age could not be strictly excluded for the grey, pale red and red limestones, an Asselian to earliest Sakmarian age seems more likely, because *Diplognathodus expansus?* as well as *Dutkevitchia complicata* are reported only from Lower Permian deposits at the moment. If the contact to the overlying dark, bedded limestones is sedimentary indeed, the upper range is limited because of the occurrence of *Sphaeroschwagerina carniolica* (Asselian). Compared to the Carnic Alps these limestones are older than the Trogkofel limestones of the type locality and even as the Upper Pseudoschwagerina Limestone, which yields *Sweetognathus inornatus* and *Sw.* aff. *whitei* without any species of *Streptognathodus*. Therefore the grey, pale red and red limestones from which the conodonts and fusulinids were obtained can not be called "Trogkofel" limestones no longer, but should be named after the Dolžanova soteska – the Dolžanova soteska limestone.

References

Buser, S. 1974: Neue Feststellungen im Perm der westlichen Karawanken. – Carinthia II, *84*, 27–37, Klagenfurt.

Buser, S. 1980: Guidebook to basic geological map of Yugoslavia 1:100000, sheet Celovec (Klagenfurt). – Zvezni geološki zavod, 1–62, Beograd.

Buser, S. & Cajhen, J. 1978: Basic geological map of Yugoslavia 1:100000, sheet Celovec (Klagenfurt). – Zvezni geološki zavod, Beograd.

Chernykh, V. V. & Ritter, S. M. 1994: Preliminiinary biostratigraphic assessment of conodonts from the proposed Carboniferous-Permian boundary stratotype, Aidaralash creek, Northern Kasakhstan. – Permophiles, *25*, 4–6, 1 tab., Calgary.

Ding, H. & Wan, S. 1990: The Carboniferous-Permian event-stratigraphy in the south of the North China platform. – Cour. Forsch.-Inst. Senckenberg, *118*, 131–156, 10 Abb., 1 tab., 4 pl., Frankfurt/Main.

Ellison, S. 1941: Revision of the Pennsylvanian conodonts. – J. Paleont., *15*/2, 107–143, 4 fig., 4 pl., Tulsa, Oklahoma.

Forke, H. 1995: Biostratigraphie und Mikrofazies im Unterperm der Karnischen Alpen. – Jb. Geol. B.-A., *138*/2, 200–297, 23 pl., Wien.

Geyer, G. 1895: Über die geologischen Verhältnisse im Pontafeler Abschnitt der Karnischen Alpen. – Jahrb. der k. k. geol. Reichsanstalt, *46*, 127–233, 9 fig., Wien.

Hahn, G., Hahn, R. & Ramovš, A. 1970: Perm-Trilobiten aus Slovenien, NW-Jugoslawien. – Senckenbergiana lethaea, *51*, 311–333, Frankfurt/Main.

Heritsch, F. 1933: Rugose Korallen aus dem Trogkofelkalk der Karawanken und der Karnischen Alpen. – Prirodosl. razprave, *2*, 42–55, Ljubljana.

Heritsch, F. 1938: Die stratigraphische Stellung des Trogkofelkalkes. – N. Jb. Min. Geol. Pal., Beil. Bd. *79*, 63–186, Stuttgart.

Heritsch, F. 1939: Karbon und Perm in den Südalpen und Südosteuropa. – Geol. Rundschau, *30*, 529–588, Stuttgart.

Heritsch, F. 1943: Das Paläozoikum. – Bd. 1, in: Heritsch, F. & Kühn, O.: Die Stratigraphie der geologischen Formationen der Ostalpen, Berlin (Bornträger).

Heritsch, F. & Kahler, F. 1932: Die stratigraphische Gliederung der Naßfeldschichten. – Anz. der Akademie der Wissenschaften, math.-naturwiss. Kl. 1932, Wien.

Kahler, F. & Kahler, G. 1937: Beiträge zur Kenntnis der Fusuliniden der Ostalpen: Die Pseudoschwagerinen der Grenzlandbänke und des oberen Pseudoschwagerinenkalkes. – Palaeontographica, Abt. A, *87*, 1–44, 2 tab., 3 pl., Stuttgart.

Kahler, F. & Kahler, G. 1941: Beiträge zur Kenntnis der Fusuliniden der Ostalpen: Die Gattung *Pseudoschwagerina* und ihre Vertreter im Unteren Schwagerinenkalk und im Trogkofelkalk. – Palaeontographica, Abt. A, *92*, 59–98, 2 tab., 2 pl., Stuttgart.

Kahler, F. & Kahler, G. 1980: Fusuliniden aus den Kalken der Trogkofel-Schichten der Karnischen Alpen. – Carinthia II., Sonderheft, *36*, 183–254, 9 Taf., Klagenfurt.

Kahler, F. & Kahler, G. 1982: Beiträge zur Kenntnis der Fusuliniden der Ostalpen. Oberkarbonische Fusuliniden der Karnischen Alpen. – Palaeontographica, Abt. A, *77/4–6*, 89–128, 3 pl., 2 figs., Stuttgart.

Kochansky-Devidé, V. 1956: Pregled dosadašnjih istraživanja fuzulinida Jugoslavije. – 1. jugoslav. geol. kongres Bled 1954, 139–151, Ljubljana.

Kochansky-Devidé, V. 1964: Die Mikrofossilien des jugoslawischen Perms. – Paläont. Z., *38*, 180–188, Stuttgart.

Kozur, H. & Mostler, H. 1976: Neue Conodonten aus dem Jungpaläozoikum und der Trias. – Geol. Paläont. Mitt. Innsbruck, Bd. *6/3*, 1–33, 4 pl., Innsbruck.

Pečar, J. 1987: Upper Carboniferous and Permian mesolobid chonetacean brachiopods of Karavanke Mountains (Yugoslavia) and Carnian Alps (Italy). – Geologija *28/29*, (1985/86), 9–53, Ljubljana.

Ramovš, A. 1961: O stratigrafiji trogkofelskih apnencev v Jugoslaviji. – 3. kongres geologa Jugoslavije, Budva 1959, 93–103, Titograd.

Ramovš, A. 1963: Biostratigraphie der Trogkofel-Stufe in Jugoslawien. – N. Jb. Geol. Paläont. Mh., 382–388, Stuttgart.

Ramovš, A. 1966: Revision des *"Productus elegans"* (Brachiopoda) im ostalpinen Jungpaläozoikum. – N. Jb. Geol. Paläont. Abh., *125*, 118–124, Stuttgart.

Ramovš, A. 1968: Biostratigraphie der klastischen Entwicklung der Trogkofelstufe in den Karawanken und Nachbargebieten. – N. Jb. Geol. Paläont. Abh., *131/1*, 72–77, Stuttgart.

Ramovš, A. 1969: Karawankinae, nova poddružina produktid (Brachiopoda) iz alpskih zgornjekarbonskih in permijskih skladov. – Jeseniški zbornik Jeklo in ljudje, *2*, 251–268, Jesenice.

Ramovš, A. 1980: Fossil Life of the Tržič Area, Slovenia. – Tržiški zbornik, *2*, 81 p. (in slovenian). Društvo prijateljev mineralov in fosilov Tržič, Ljubljana.

Rauzer-Chernoussova, D. M. 1960: Revizija schvagerin s bliskimi rodami i graniza carbona i permi. – Voprosi mikropalaeont., akad. nauk SSSR, *4*, 3–32 (R), 6 Abb., 1 tab., Moskau (izd. nauka).

Schellwien, E. 1898a: Bericht über die Ergebnisse einer Reise in die karnischen Alpen und die Karawanken. – Sitzungsberichte der k. preuss. Akademie der Wissenschaften, phys.-math- Kl., 1898, 693–700, Berlin.

Schellwien, E. 1898b: Die Fauna des karnischen Fusulinidenkalks. Teil II. – Palaeontographica, *44*, 237–282, 8 pl., Stuttgart.

Schellwien, E. 1900: Die Fauna der Trogkofelschichten in den Karnischen Alpen und den Karawanken. Abh. Geol. Reichsanst., *16*, 1–122, Wien.

Sweet, W. C. 1988: The Conodonta: morphology, taxonomy, paleoecology and evolutionary history of a long-extinct animal phylum. – Oxford Monographs on Geology and Geophysics, *10*, 212 p., Oxford.

Von Bitter, P. H. & Merrill, G. K. 1990: Effects of variation on the speciation and phylogeny of *Diplognathodus*. – Cour. Forsch.-Inst. Senckenberg, *118*, 105–129, 4 fig., 6 pl., Frankfurt/Main.

Wang, Z. 1994: Early Permian conodonts from the Nashui section, Luodian of Guizhou. – Palaeoworld, *4*, 203–224, 2 fig., 4 pl., Nanjing (University press).

Wang, Z. & Higgins, A. C. 1989: Conodont zonation of the Namurian-Lower Permian strata in South Guizhou, China. – Palaeontologica Cathayana, *4*, 261–291, 1 fig., 4 tab., 17 pl., Beijing (Science Press).

Plate 1

1 Diplognathodus expansus? (Perlmutter, 1975)
1a Lateral view, DSB/1 [1], × 160
1b Upper view of spatulate carina showing lack of a pustulose ultrasculpture, DSB/1 [1], × 600

2 Hindeodus minutus (Ellison, 1941)
Lateral view, DSB/1 [2], × 80

3–6 Streptognathodus cf. *simplex* Gunnell, 1933
3a Upper view, DSB/1 [11], × 80
3b Lateral view, DSB/1 [11], × 80
4–6 Upper views of different growth stages, DSB/1 [5], × 80, DSB/1 [12], DSB/1 [14], × 120

7–9 Streptognathodus cf. *elongatus* Gunnell, 1933
7 Upper view of a juvenile specimen, DSB/1 [26], × 120
8a Lateral view, DSB/1 [3], × 80
8b Upper view, DSB/1 [3], × 80
8c Enlarged part of accessory nodes, DSB/1 [3], × 400
9a Upper view, DSB/1 [4], × 80
9b Enlarged part of weakly developed accessory nodes, DSB/1 [4], × 300

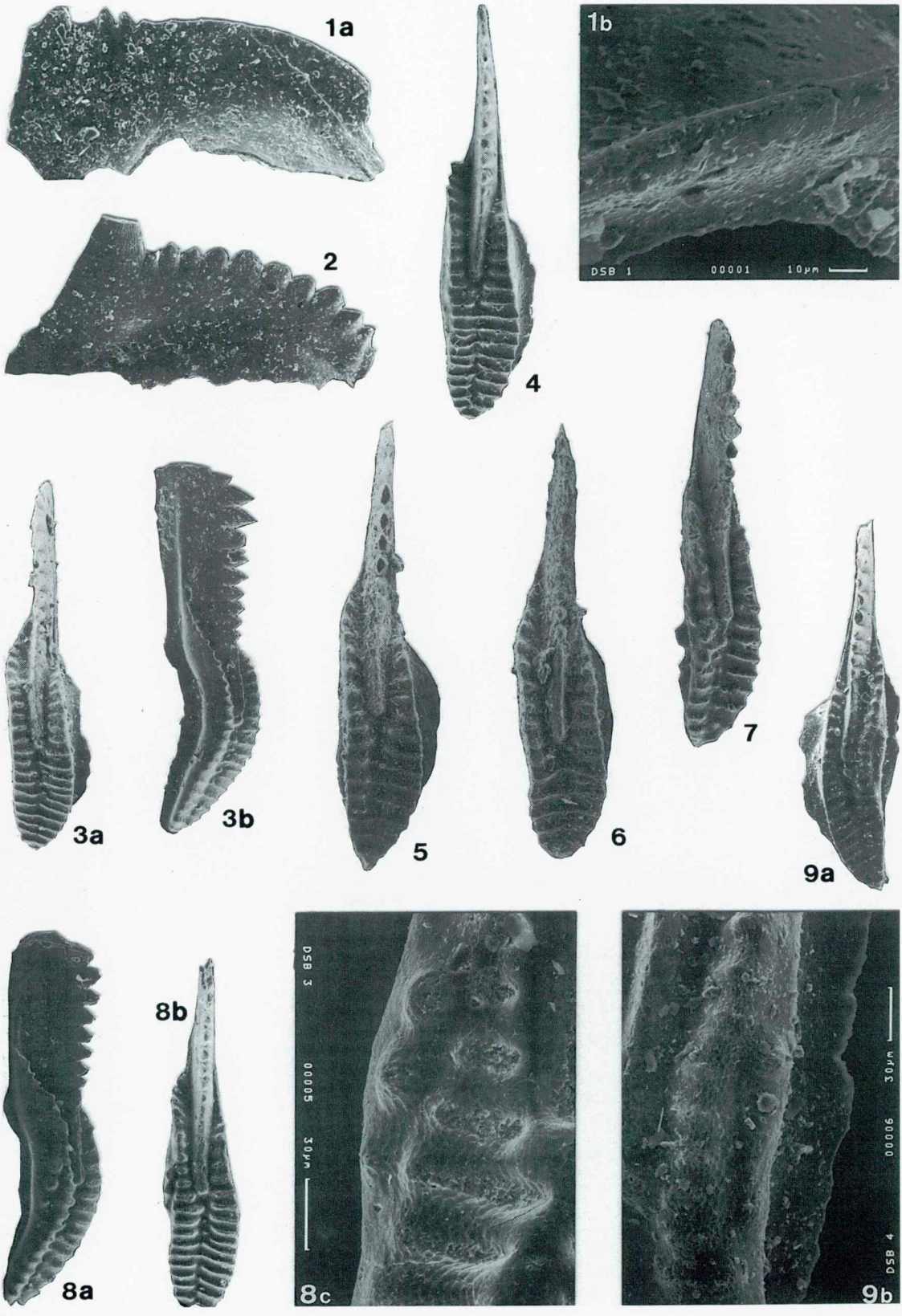
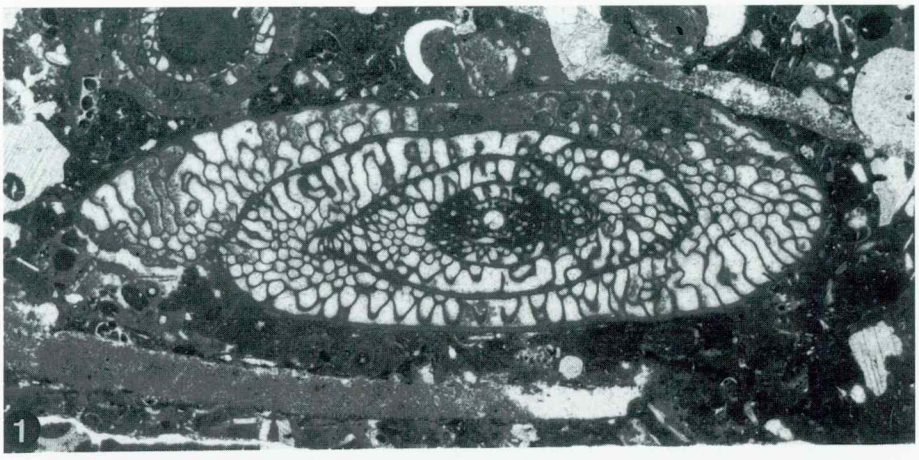

1a
1b
DSB 1
00001
10µm
2
4
3a
3b
5
6
7
9a
8a
8b
8c
DSB 1
00005
30µm
9b
DSB 4
00006
30µm

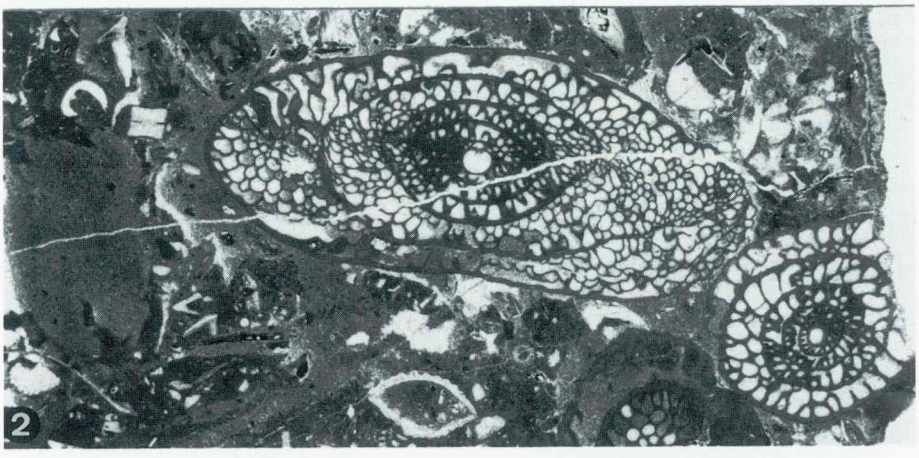
Plate 2

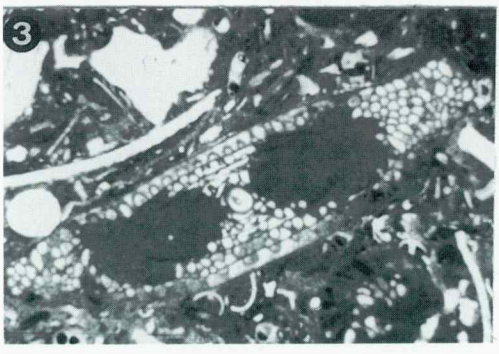
1,2 Dutkevitchia complicata (Schellwien, 1898)
1 Slightly oblique section DSB/1 [1], × 10
2 Axial and sagittal section DSB/1 [4], × 10

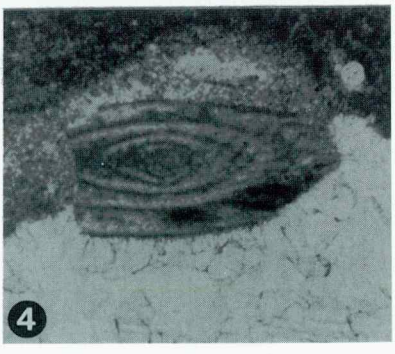
3 Quasifusulina cf. *tenuissima* (Schellwien, 1898)
Axial section DSB/3, × 10

4 Boultonia willsi Lee, 1927
DSB/2, × 50


1


2


3


4