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DOI: 10.1515/fbgp-2018-0002

LINGULATE BRACHIOPODS OF TREMADOCIAN AGE FROM THE ABANDONED GABRIELA MINE (KRUŠNÁ HORA, CENTRAL BOHEMIA, CZECH REPUBLIC)

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Abstract: *Lingulate brachiopods are described from a lithic sandstone referred to the upper part of the Třenice Formation. Loose blocks were sampled from a dump of abandoned Gabriela Mine in Krušná Hora Hill near Beroun, Central Bohemia. Apart of the Acrotreta aff. grandis Klouček, 1919, genera Teneobolus, Rosobolus, Broeggeria, Rowellella and Siphonobolus are distinguished. Comments to their ontogeny, affinity, stratigraphical and spatial occurrences and taphonomy are discussed.*

Key words: Lingulata, Siphonotretida, Acrotretidae, taxonomy, Tremadocian, Krušná hora, Central Bohemia

INTRODUCTION

The majority of information on taxonomy, stratigraphical and spatial distibutions of lingulate brachiopods of Early Ordovician age in the Czech Republic came from the western part of the Barrandian, especially from a small area between Rokycany and Komárov (Koliha, 1924; Havlíček, 1982a; Mergl, 2002). The most diverse lingulate assemblage with eighteen species in a single layer has been observed in reddish aleuropelites of the Olešná Member (Klabava Formation) in vicininty of Strašice, which are likely of the Floian age (Mergl, 1995, 2002). However, first reports of lingulates in the Barrandian are of much earlier data and they came from different area. The iron-ore mining in Krušná Hora Hill north of Beroun was a rich source of the earliest described lingulates from the Central Bohemia. Lipold (1863) reported from Krušná Hora Hill large zhanatellid *Lingula Feistmanteli*, in that time as *nomen nudum*. This first report was followed by Vála & Helmhacker (1872, 1874) who reported the same species. First illustrations of brachiopods from Krušná Hora Hill came in Barrande (1879a). He illustrated *Lingula Feistmanteli* Barr., *L. expulsa* Barr., *Discina secedens* Barr. and *D. socialis* Barr. Next authors (Katzer, 1892; Jahn, 1904a, 1904b; Koliha, 1918, 1924) greatly repeated observations made by Barrande (1879a, 1879b) and listed few additional species, generally poorly determined lingulates. These species were nearly completely revised by Mergl (1981) and Havlíček (1982a) followed by their synopsis by Mergl (2002). Updated lists of fossils from all localitites of the Třenice Formation in Krušná Hora Hill has been presented by Kraft *et al.* (2013). Recently, a loose block observed at the dump of the abandoned Gabriela Mine in SW part of the Krušná hora Hill yielded the lingulate association previously unknown from the area.

MATERIAL

The studied material studied is housed in the palaeontological collections of the University of West Bohemia at Plzeň (PCZCU).

GEOLOGICAL SETTING

The Lower and early Middle Ordovician in Krušná Hora Hill form a narrow synclinal faulted structure, which is separated from the main part of the Prague Basin synform tectonicaly by several kilometres broad strip of the Proterozoic rocks (Petránek, 1974). The first historical reports about mining of iron ores of the Šárka Formation (Darriwilian) came from 15th century, although traces after primitive mining are even older. The culmination of mining came at 18th and in 19th cen-

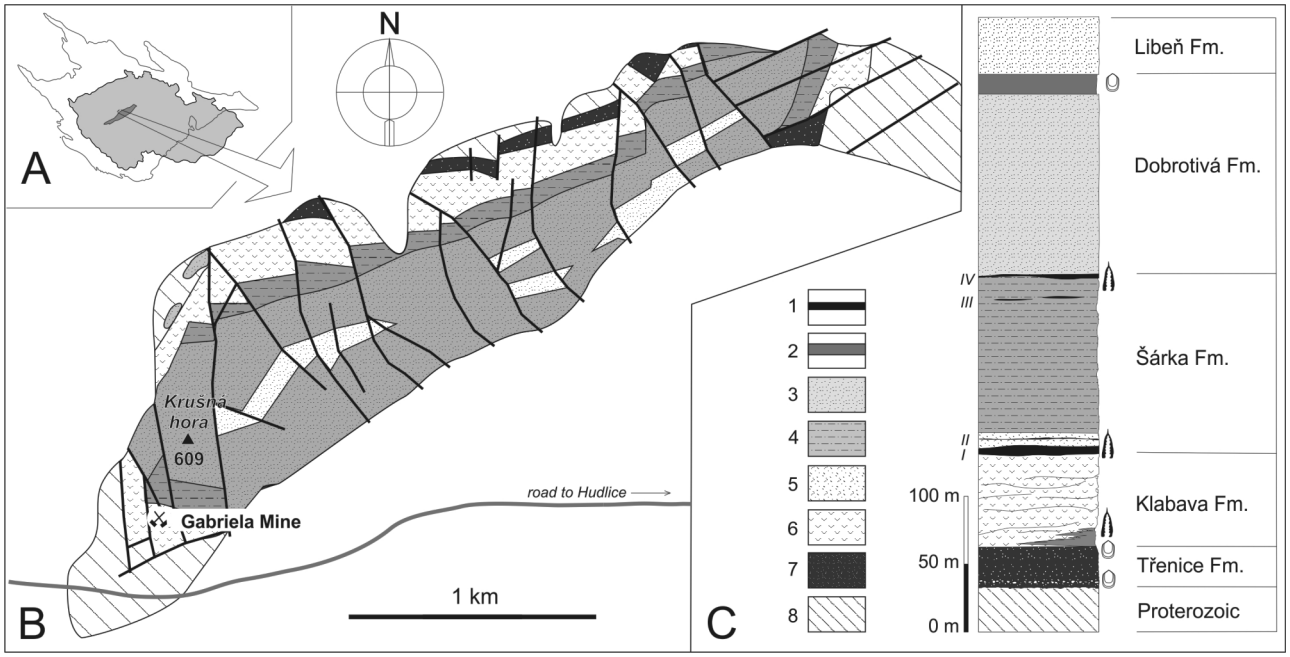


Figure 1. *Schematic maps showing location of the Prague Basin in the Barrandian area in the Czech Republic with a small area of the Krušná hora (A), outcropping the Proterozoic and Ordovician rocks in the Krušná Hora area (B), and simplified stratigraphy of the Krušná hora area (after Petránek, 1974). Levels with graptolite and lingulate brachiopod fauna are indicated, based on data of Bouček (1973) and Bouček & Svoboda (1946). Level with new fauna marked by shell with black triangle. Explanation: 1 – iron-ores (with particular mined beds marked by Latin numbers I, II, III and IV), 2 – shale, 3 – quartzose sandstone, 4 – shales alternating with sandstones, 5 – submarine basalts, 6 – basalt tuffs and aglomerates, 7 – lithic sandstone and conglomerate, 8 – Precambrian shale.*

tury (Dubanský & Weber, 1964). Mining activity ended in 1968 and only shallow pits and dumps can be observed there at present.

Lithic and quartzose sandstones, named "Dichte Grauwacke" in old mining documents from mid of 19th Century (Lipold, 1863) are the oldest Ordovian rocks in the Krušná hora area. This pale grey-green coloured sandstone, with thickness about 50 metres was the main source of fossils in the 19th Century. Large zhanatellid *Hyperobolus feistmanteli* (Barrande, 1879), associated with less abundant *Expellobolus expulsus* (Barrande, 1879) and rare *Orbithele secedens* (Barrande, 1879) are characteristic fossils of this lithic sandstone. These species of a low diversified *Hyperobolus* Community (Havlíček, 1982b) proliferated on shallow-water marine flat shoal that was supplied by sorted quartz sand from nearby Cambrian volcanites (Kettner, 1916; Kukal, 1963). The cherts of the subsequent Mílina Formation, in western part of the Prague Basin characterized by minute lingulates of the *Thysanotos–Leptembolon* Association (Havlíček, 1982a; Mergl, 2002), have not been observed in the Krušná hora Hill area. The Třenice Formation is followed by more than 100 m thick Klabava Formation (Floian to Dapingian) built by tuffitic shales, tuffites, and basalt agglomerates of the Komárov Complex. The Ordovician succession follows by the Šárka Formation (Darriwilian) with basalts, their tuffs and several levels of oolithic ferrolites, the Dobrotivá Formation (Darriwilian) represented mainly by Skalka Quarzite and the Řevnice Quartzite of the Libeň Formation (lower Sandbian), which is the youngest Ordovician unit in the Krušná Hora area (Figure 1). Diverse graptolites, which indicate an exact age of the iron layers in the Šárka Formation were observed in Krušná hora by Bouček (1944, 1973).

The abandoned Gabriela Mine is situated at SW foot of Krušná Hora Hill. Bouček (1973) reported from this site graptolite *Expansograptus extensus* (Hall, 1865). Mergl (2002) reported rare occurrence of brachiopod *Hyperobolus feistmateli* (Bar-

rande, 1879) from the pale grey-green lithic sandstone derived from the Třenice Formation. Recently, a loose block of greenish quarzitic sandstone yielded the distinct lingulate association, with dominance of acrotretoid and siphonotretid brachiopods.

SYSTEMATIC PART

Abbreviations used for description: DVl – dorsal valve length, DVw – dorsal valve width, n – number of specimens.

Order Lingulida Waagen, 1885

Superfamily Discinoidea Gray, 1840

Family Obolidae King, 1846

Genus *Teneobolus* Mergl, 1995
Type species: *Teneobolus gracilis* Mergl, 1995; Klabava Formation, Floian, Ordovician; Bohemia.

Teneobolus bukovensis (Koliha, 1924)
Pl. I, figs 1–4

1924 *Lingulella Bukovensis* n. sp.; Koliha, p. 30 and 57, pl. 2, fig. 8.
1982a *Palaeoglossa bukovensis* (Koliha, 1924); Havlíček, p. 37, pl. 8, figs. 1–3 (non 4).
1995 *Teneobolus gracilis* sp. n. (partim); Mergl, p. 104, pl. 1, fig. 2.
2002 *Teneobolus bukovensis* (Koliha, 1924); Mergl, 26, pl 7, figs 1–6.

Material: One dorsal valve and two fragments.
Description: Shell elongate oval, approximately 10 mm long, with short dorsal pseudointerarea. Ventral valve is unknown in new material. Exterior bears fine flat growth bands of even size arranged in regular intervals, separated by filose concentric lines. These lines are less curved along the axial sector of the valve.
Remarks: Although poor in quality and number, the shells may be reliably referred to *Teneobolus bukovensis* due their size, outline and, especially, for characteristic external macroornament, which is the same with topotype specimens (Mergl, 2002, pl. 7, figs 3, 4) and unknown in any other early Ordovician obolid from the Prague Basin.
Occurrence: The species is known only from the Třenice Formation. Localities: Krušná hora, Gabriela Mine (rare); Zaječov (rare), Zbiroh, Bukov, quarries (moderately common).

Family Zhanatellidae Koneva, 1986

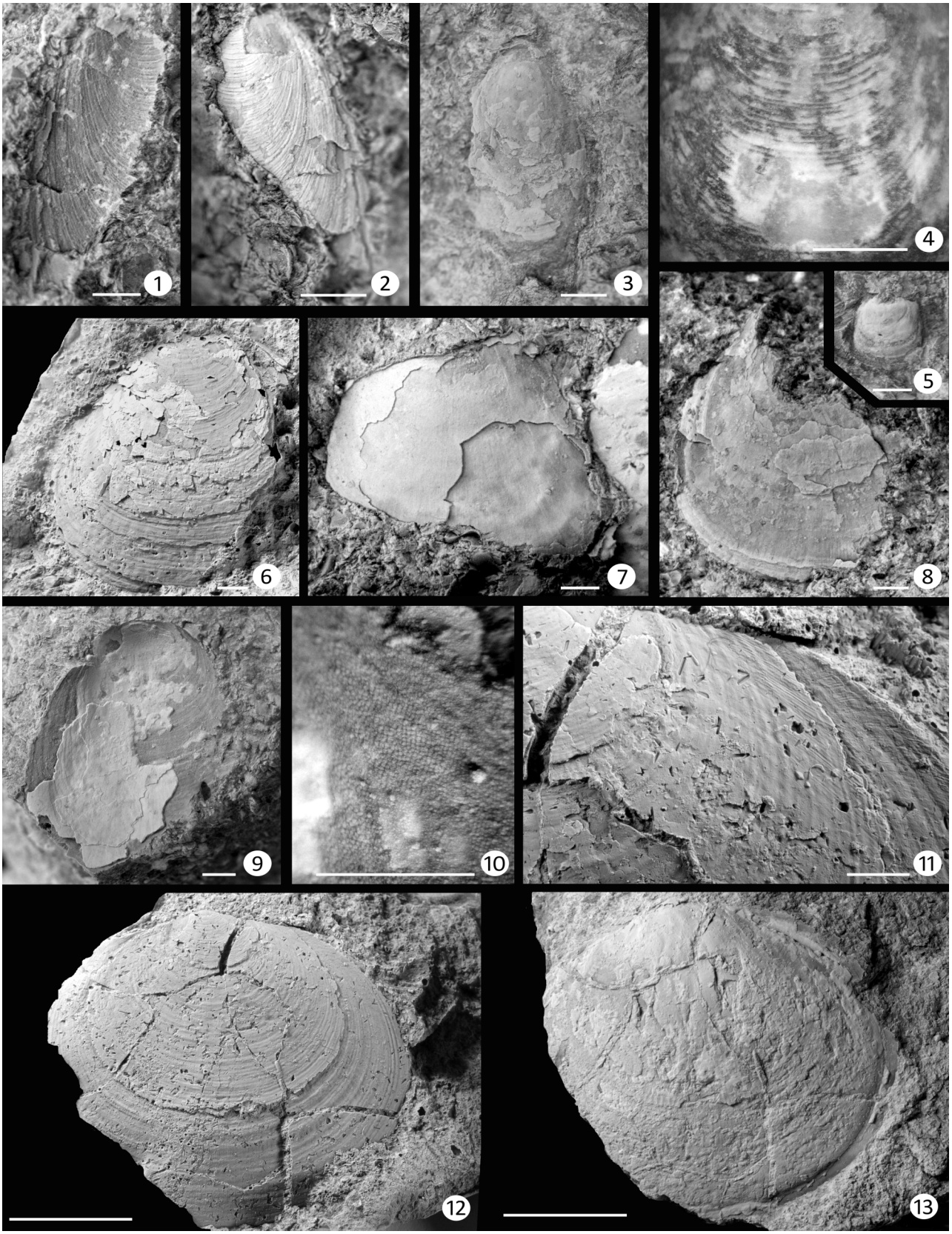
Genus *Rosobolus* Havlíček, 1982a
Type species: *Rosobolus robertinus* Havlíček, 1982a; Třenice Formation, Tremadocian, Ordovician; Bohemia.

***Rosobolus* sp.**
Pl. I, figs 6–10

Material: Three ventral and two dorsal valves, all incomplete.
Description: Shell is moderate thick, 10 mm wide, subpentagonal, with maximum width at its anterior third. Dorsal valve is subpetagonal, with rounded posterior margin, evenly convex in transverse profile and more convex posteriorly rather than anteriorly along its axial plane. Ventral valve has moderately acuminate beak having distinct pedicle groove. Interior of the dorsal valve has large elongate oval impressions of central muscles. Interior of the ventral valve has a small broadly trapezoidal visceral area. *Vascula lateralia* are widely divergent in their proximal parts.

Exterior with few growth bands bordered by short growth lamellae. The bands between growth lamellae are nearly smooth having weak marks of concentric growth or scars of a mantly injury. Microornament of very fine rhombic pits arranged in regular oblique intersecting rows is distinct over the entire shell exterior.
Remarks: The microornament of very small regularly arranged pits is a diagnostic feature of the genus (Popov & Holmer, 2000; fig. 29: 1d). Other features (size, convexity, outline) are also similar to *Rosobolus robertinus* Havlíček, 1982a from the Třenice Formation in Holoubkov. The main difference is a poor impression of central muscles into the shell interior and less distinct visceral field in the material from the Gabriela Mine. However internal features in the type locality are often diagenetically accentuated. *Rosobolus magnus* Mergl, 2002 from the Třenice Formation is larger than the valves from Gabriela Mine, having less triangular outline and deeply impressesed ventral muscle scars. External microornament of *R. magnus* is unknown due to the preservation in the coarse-grained lithic sandstone. Therefore, the shells of *Rosobolus* from Gabriela Mine is better to determine to the generic level only. Better and much numerous shells of *Rosobolus magnus, R. robertinus, R.* sp. from Gabriela Mine, and

Plate I



R. sp. from other stratigraphic levels (Mergl 2002, p. 38, pl. 18, figs 9, 11, 12) are necessary to elucidate affinites between these moderately-sized zhanatellids.
Occurrence: Tremadocian, Třenice Formation. Locality: Gabriela Mine (rare).

Genus *Rowellella* Wright, 1963
Type species: *Rowellella minuta* Wright, 1963; Portrane Limestone, Katian, Ordovician; Ireland.

***Rowellella* ? sp.**
Pl. I, fig. 5

Material: One valve.
Remarks: Only one minute dorsal valve 1 mm wide was observed. The shell is subrectangular, parallel-sided, having steeply sloping flanks and lacking the apical part. Poorly preserved external mould shows distinct concentric lamellae. Although very rare in the locality, these features are distinct and consistent with diagnostic features of the genus. The valve is similar to subrectangular specimens of *Rowellella distincta* Bednarczyk & Biernat, 1978, which is a common species in the lower part of the Olešná Member (Floian) of the Klabava Formation.
Occurrence: The valve represents the first known occurrence of the genus in the Třenice Formation. Other occurences of the genus in the Barrandian come from stratigraphically youger beds (Floian: Olešná Member, Klabava Formation, and Darriwilian: Šárka Formation; Mergl, 1995, 2002).

Family Elkaniidae Walcott & Schuchert, 1908

Genus *Broeggeria* Walcott, 1902
Type specie: *Obolella salteri* Holl, 1865; White-leaved-Oak Shales, Furongian, Cambrian, South Wales.

***Broeggeria* sp.**
Pl. I, figs 11–13

Material: One dorsal valve.
Description: The dorsal valve is thin-shelled relative to size, 28 mm wide and 23 mm long (DVw/DVl = 1.22), subcircular in outline, rectimarginate, weakly convex in transverse and axial profiles, with maximum width at midlength. The posterior margin and sides are evenly rounded. Dorsal pseudointerarea is short, almost orthocline, with small propareas. Impressions of muscles are weakly defined except for narrow subparallel central scars confined to anteriorly extened visceral area.
The shell is ornamented by fine concentric growth lines, extended into few coarser concentric lamellae. Fine radial rays are present in posterolateral sectors of the valve (Pl. I, fig. 11). Fine microornament was not observed.
Remarks: The valve cannot be referred to any of known Tremadocian species from the Barrandian area (Mergl, 2002). The shell outline, convexity and the observed internal structures are consistent with attribution to *Broeggeria* Walcott, 1902 of the Elkaniidae Walcott & Schuchert, 1908. However, the shell size is much than twice bigger than recorded maximum size in *Broeggeria salteri* (Holl, 1865) (see Popov & Holmer, 1994). *Broeggeria ferraria* Mergl, 2002 from haematite at Holoubkov referred to the upper part of the Třenice Formation (Mergl, 2009) is a smaller species having a distinct dorsal median ridge that was not observed in the specimen from Gabriela Mine.
Occurrence: Tremadocian, Třenice Formation. Locality: Gabriela Mine (rare).

Plate I, 1–4 – *Teneobolus bukovensis* (Koliha, 1924). Tremadocian, Třenice Formation, dump of abandoned Gabriela Mine, Krušná hora, Barrandian. Bar = 1 mm; 1, 2) Incomplete ventral (?) valve, external and internal moulds with partly preserved shell, PCZCU 2234; 3) Dorsal valve, internal mould, PCZCU 2235; 4) Dorsal valve, external mould showing macroornament, uncoated, PCZCU 2236; **5 – *Rowellella* sp.**, Tremadocian, Třenice Formation, dump of abandoned Gabriela Mine, Krušná hora, Barrandian. Bar = 1 mm. Dorsal valve, internal mould with partly preserved shell, PCZCU 2237a; **6–10 – *Rosobolus* sp.**, Tremadocian, Třenice Formation, dump of abandoned Gabriela Mine, Krušná hora, Barrandian. Bar = 1 mm (6–9), and 0,5 mm (10); 6) Dorsal vave, external mould with partly preserved shell, PCZCU 2238; 7) Ventral valve, internal mould with partly preserved shell, PCZCU 2237b; 8) Ventral valve, internal mould with partly preserved shell, PCZCU 2239. 9, 10 – dorsal valve, external mould with partly preserved shell, and detail of microornament PCZCU 2240; **11–13 – *Broeggeria* sp.**, Tremadocian, Třenice Formation, dump of abandoned Gabriela Mine, Krušná hora, Barrandian. Bar = 1 mm (fig. 11) and 10 mm (Figs 12, 13). Dorsal valve, internal mould (12), external mould (13) and latex casts of macroornament (11), PCZCU 2196.

Superfamily Acrotheloidea Walcott & Schuchert, 1908

Family Acrothelidae Walcott & Schuchert, 1908

Subfamily Acrothelinae Walcott & Schuchert, 1908

Genus *Orbithele* Sdzuy, 1955
Type species: *Discina contraria* Barrande, 1868; Leimitz Shale, Tremadocian, Ordovician; Bavaria.

Orbithele discontinua (Mergl, 1981)
Pl. II, figs 10, 11, 13, 14
1927 *Orbiculoidea sodalis* var. *undulosa* (Barr.); Růžička, p. 9.
1981 *Orbithele discontinua* sp. n.; Mergl, p. 288, pl. 1, figs 1–8.
2002 *Orbithele discontinua* Mergl, 1981; Mergl, p. 48, pl. 25, figs 1–11, 13, 14.

Material: One dorsal and five ventral valves preserved as minute fragments.
Description: See Mergl (2002).
Remarks: New material shows the same complex ornament of irregular fila with pustules described by Mergl (2002). New shells fall within the size range of the species noted by Mergl (2002). Larger and coarsely rugellate *Orbithele secedens* (Barrande, 1879) is known also from the Krušná hora mines (Barrande, 1879; Mergl, 2002) but this species is associated with *Hyperobolus feistmanteli* and likely stratigraphically preceded *O. discontinua* Mergl, 1981.
Occurrence: The species is known only in the Třenice Formation. Localities: Cheznovice, Žlebec (rare); Holoubkov, V Ouzkém (common); Krušná Hora, Gabriela Mine (common); Skomelno, Na Solích (common).

Order Acrotretida Kuhn, 1949

Superfamily Acrotretoidea Schuchert, 1893

Family Acrotretidae Schuchert, 1893

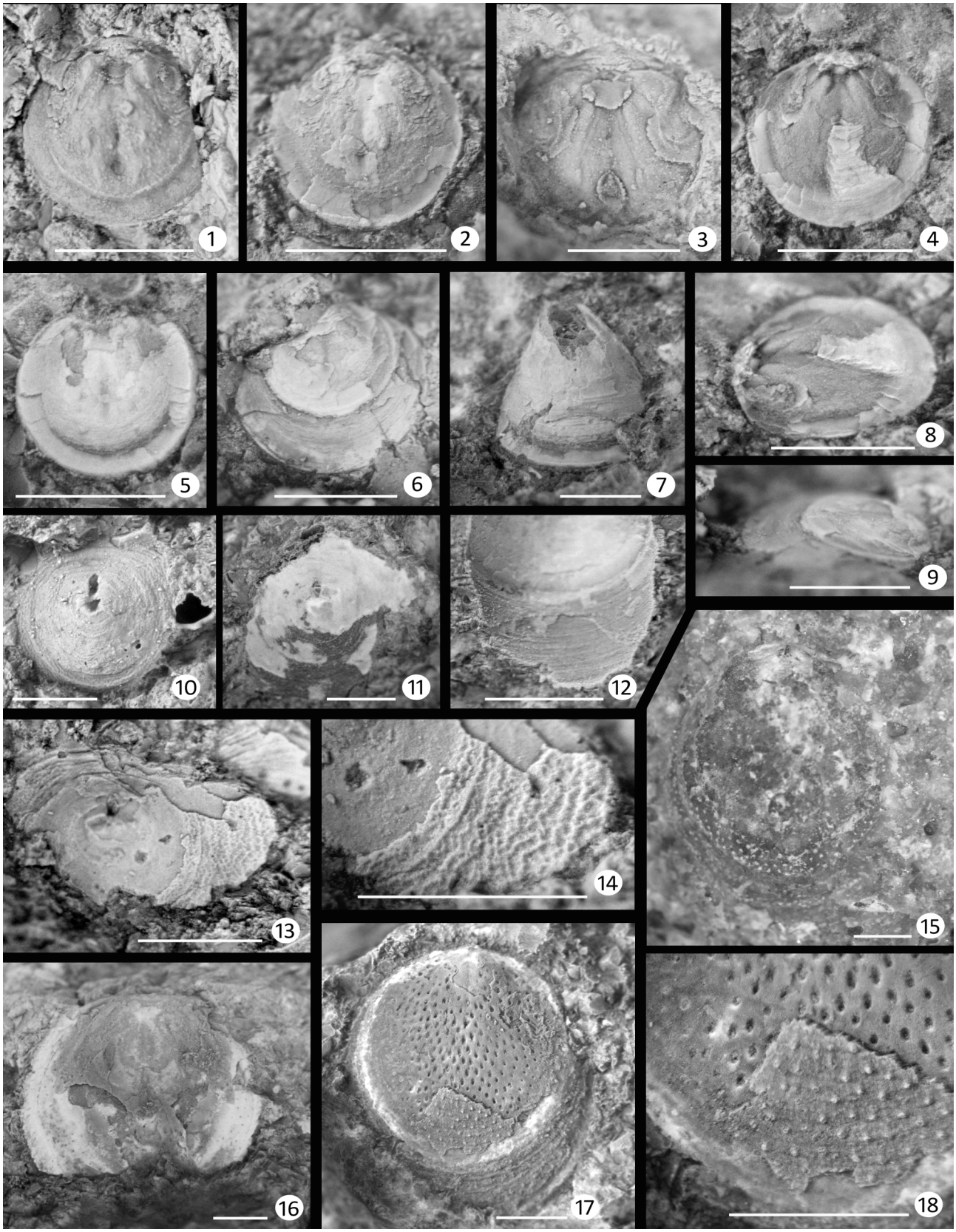
Genus *Acrotreta* Kutorga, 1848
Type species: *Acrotreta subconica* Kutorga, 1848; Floian (regional Billingen Stage); Ordovician, environs of St. Petersburg, Russia.

Acrotreta* aff. *grandis Klouček, 1919
Pl. II, figs 1–9, 12

Material: Fifteen dorsal and three ventral valves.
Description: Shell is thick-walled, 1.6 mm wide in the largest individual. Dorsal valve is circular in outline (DVw/DVl = 1.019, min. = 0.928, max. = 1.126, n = 11), moderately convex in transverse and axial profiles, without trace of sulcus. Dorsal pseudointerarea is anacline, broadly triangular, large (length of pseudointerarea = 15 % of DVl), with broadly triangular median groove and narrow small propareas. Median buttres is small. Dorsal median septum is low and broad, evenly high along its length, extending anteriorly to almost 75% of DVl. Cardinal muscle scars are large, occuppying almost the entire posterolateral corners of the shell floor, leaving only a narrow marginal strip along posterolateral valve floor. Anterocentral muscle scars are small and weakly impressed along the median ridge. *Vascula lateralia* are widely divergent, with broad distinctly impressed proximal parts. The distal portitions are obscure. The deeply concave floor of the dorsal valve is surrounded by a broad brim along sides and frontal parts of the valve. Ventral valve is acutely conical, with catacline pseudointerarea. Short pedicle tube piercing the apex is supported by short median ridge.

Plate II, 1–9, 12 – *Acrotreta* aff. *grandis* Klouček, 1919. Tremadocian, Třenice Formation, dump of abandoned Gabriela Mine, Krušná hora, Barrandian. Bar = 1 mm; 1) Dorsal valve, internal mould, PCZCU 2241; 2) Dorsal valve, internal mould, PCZCU 2242; 3) Dorsal valve, internal mould, PCZCU 2243; 4, 8) Dorsal valve, internal mould with partly preserved shell, and the same in oblique view, PCZCU 2244; 5) Dorsal valve, internal mould with partly preserved shell, PCZCU 2245; 6, 9) Dorsal valve with original shell showing exterior, and the same in oblique view showing shell convexity, PCZCU 2246; 7, 12) Ventral valve with broken apex and original shell, and its external mould showing macroornament, PCZCU 2247; **10, 11, 13, 14 – *Orbithele discontinua*** Mergl, 1981. Tremadocian, Třenice Formation, dump of abandoned Gabriela Mine, Krušná hora, Barrandian. Bar = 1 mm; 10) Ventral valve, latex cast of exterior, PCZCU 2248; 11) Ventral valve, external mould, PCZCU 2249; 13, 14) Ventral valve, internal mould and detail of macroornament on early postlarval shell, PCZCU 2250; **15–18 – *Siphonobolus simulans*** (Růžička, 1927). Tremadocian, Třenice Formation, dump of abandoned Gabriela Mine, Krušná hora, Barrandian. Bar = 1 mm; 15) Ventral valve, external mould, uncoated, showing concentric lines of uniformly sized spines, PCZCU 2251; 16) Dorsal valve with partly preserved shell showing holes after broken spines, external mould, PCZCU 2249; 17, 18) Ventral valve with partly preserved shell showing inner opening of spines (17), and detail of exterior with bases of spines (18), PCZCU 2237c.

Plate II



Ornamentation consists of fine concentric fila of uniform size with ten fila per 0.1mm. Prominent concentric lamellae may form moderate stepped side profile.

Remarks: All available shells, almost exclusively the dorsal valves, are of nearly the same size and shape (Fig. 2), having unusually thick shell relative to their size. The dorsal valves are similar to those of *Acrotreta grandis* Klouček, 1919 and related to the chronologically subsequent large acrotretids (*A. foetida* Mergl, 2002, A. *scabra* Mergl, 2002) from the Prague Basin. However, the mentioned three species are about three times larger and the convexity of their dorsal valves is less prominent, internally leaving only a weakly concave floor, different from a deeply concave dorsal valve of *A.* aff. *grandis*. This size difference between shells of *A.* aff. *grandis* and *A. grandis* cannot be related only to age of the individuals because the dorsal valves of *A.* aff. *grandis* are distinctly thick-walled unlike to relatively thin-walled *A. grandis* of comparable size. There are little doubts, that *A. grandis* and *A.* aff. *grandis* are closely related species. Unfortunately, the modes of preservation of *A. grandis* and *A.* aff. *grandis* restrict the data about shell microornament, nature of the larval shells and other important morphological features. *Acrotreta dissimilis* (Biernat, 1973) from Tremadocian chalcedonites of Poland has a shorter and narrower dorsal median septum. The microornament with small pustules illustrated by Holmer & Biernat (2002; fig. 7 O) was not observed in *A.* aff. *grandi* but this may be due to a poor preservation of the latter taxon in the lithic sandstone.

Specimens referred to *Dactylotreta* sp. from the Třenice Formation near Cheznovice (Mergl, 2012) cannot be referred to *A.* aff. *grandis*. Available dorsal valves from Cheznovice, Žlebec (Kraft *et al.* 2013) display thin dorsal median septum but their preservation in lithic sandstone is very poor and not suitable for more accurrate comparison.

Occurrence: Tremadocian, Třenice Formation. Locality: Gabriela Mine (abundant).

Order Siphonotretidae Kutorga, 1848

Superfamily Siphonotretoidea Kutorga, 1848

Family Siphonotretidae Kutorga, 1848

Subfamily Siphonotretinae Kutorga, 1848

Genus *Siphonobolus* Havlíček, 1982a

Type species: *Siphonotreta simulans* Růžička, 1927; Třenice Formation, Tremadocian, Ordovician; Bohemia.

Siphonobolus simulans (Růžička 1927)

Pl. II. figs 15–18, Pl. III, figs 1–13.

1927 *Siphonotreta simulans* n. sp.; Růžička, p. 7, pl. 1, figs 10–12.

1927 *Obolus complexus* Barr.; Růžička, p. 4.

1982a *Siphonobolus simulans* (Růžička, 1927); Havlíček, p. 62, pl. 11, figs 1–7, text-fig. 12.

2002 *Siphonobolus simulans* (Růžička, 1927); Mergl, p. 62, pl. 39, figs 11–15.

2012 *Siphonobolus simulans* (Růžička, 1927); Mergl, p. 141, pl. 2 D, E, CH.

Material: Twenty-five ventral and five dorsal valves.

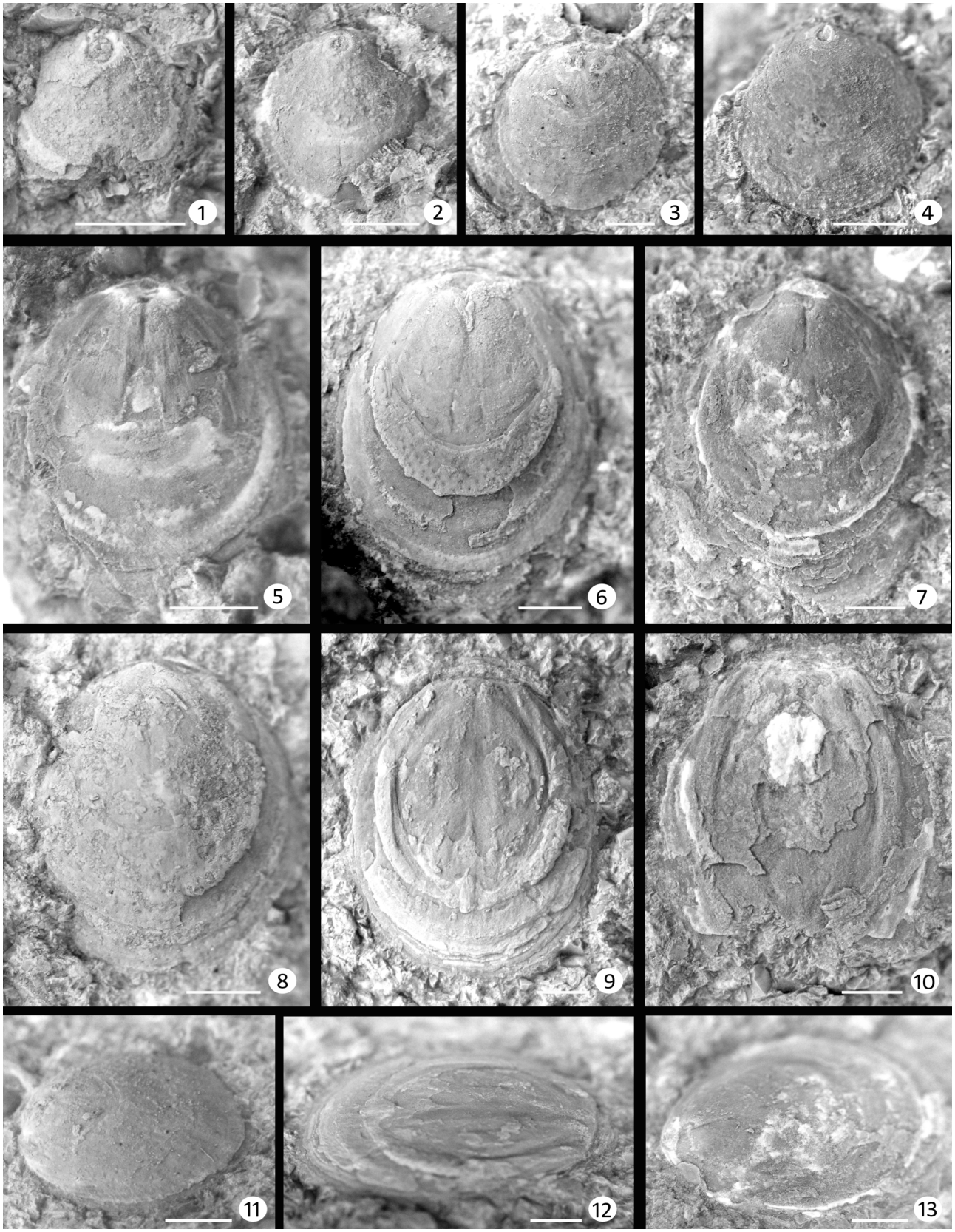
Description: See Havlíček (1982a) and Mergl (2002).

Remarks: *Siphonobolus simulans* is rare species in the type locality at Holoubkov (V Ouzkém). In addition, the preservation in quartzitic haematite emphasized some internal features and suppressed others. New material although not perfectly preserved makes possible some corrections.

The young specimens observed in the new material show a large pedicle opening with a very short pedicle tube in the thin shell and no traces of the median septum (Pl. III, fig. 4). The shell is thus similar to *Acanthambonia* Cooper, 1956. With subsequent growth, the tube becomes long and thin and short median septum becomes to develop, supporting and stabilizing the ventral side of the pedicle tube on the valve floor (Pl. III, figs 3, 5). The outline of the shell also changed during the ontogeny. The almost circular shell in small specimens (Pl. III, fig. 4) becames a distinctly elongate oval in adults (Pl. III, fig. 7).

Plate III, *Siphonobolus simulans* (Růžička, 1927). Tremadocian, Třenice Formation, dump of abandoned Gabriela Mine, Krušná hora, Barrandian. Bar = 1 mm; 1) Small ventral valve, internal mould, PCZCU 2253; 2) Small ventral valve, internal mould, PCZCU 2254; 3, 11) Small ventral valve, internal mould, and the same in oblique view, PCZCU 2255; 4) Small ventral valve, internal mould, PCZCU 2256a; 5) Ventral valve, internal mould, PCZCU 2257; 6) Ventral valve, internal mould, PCZCU 2258; 7, 13) Ventral valve, internal mould, and the same in oblique view PCZCU 2256b; 8) Ventral valve, internal mould, PCZCU 2251; 9, 12) Dorsal valve, internal mould, and the same in oblique view, PCZCU 2259; 10) Dorsal valve, internal mould, PCZCU 2260.

Plate III



Ontogenic development of the ventral median ridge iterated the evolution of the genus.

The Furongian *Siphonobolus priscus* Popov, Holmer, Bassett et Ghobadi Pour, 2009 from the Shirgesht Formation of the Derenjal Mountains of Iran lacks the median septum in the ventral interior. Noteworthy, the stratigraphically subsequent *Siphonobolus kalshanensis* Popov, Holmer, Bassett et Ghobadi Pour, 2009 from the same formation and area has clearly developed median ridge (Popov *et al.* 2009, fig. 5J). However, presence of the ventral median ridge is not likely the universal novellity of the genus developed near the base of the Tremadocian. The species *Siphonobolus uralensis* (Lermontova, 1933), which is the late Tremadocian to Floian in age (Kidryas Formation, Ural Mountains) also lacks the ventral median ridge (Popov & Holmer, 1994). Unlike to *Siphobolus priscus* and *S. uralensis*, the new material of the mid- to late Tremadocian *S. simulans* show a distinct ventral median ridge. This feature indicates a closer relationship of *S. simulans* to the earlier but also Gondwanan *S. kalhamensis* than approximately coeval *S. uralensis* from the margin of Baltica.

Exterior of *Siphonobolus* is characterised by fine spines of uniform size arranged in concentric bands (Pl. II, fig. 15). The spines are internally opened by minute holes resting on minute knob-like pads on valve floor (Pl. II, fig. 17). Externally, the spines are very low angled toward shell surface. Uniform size and higher density of spines distinguish the genus from *Eosiphonotreta* Havlíček, 1982a, which has spines of uneven size (see also Mergl, 2002, pl. 40, fig. 10).

Presence of the ventral median septum distinguishes *Siphonobolus* from *Eosiphonotreta, Siphonotretella* Popov et Holmer 1994 and *Celdobolus* Havlíček, 1982a. Dorsal pseudointerarea is remarkably high in *Siphonobolus* (Pl. III, figs 9, 12) featuring the pseudointerarea of *Celdobolus*.

Occurrence: The species is known only in the Třenice Formation (Tremadocian). Localities: Cheznovice, Žlebec (rare); Holoubkov, V Ouzkém (common); Krušná Hora, Gabriela Mine (common).

DISCUSSION

Age of fauna

The taxonomic composition of lingulate brachiopod fauna observed in the dump of the Gabriela Mine is remarkable by a dominance of siphonotretid *Siphonobolus simulans*. This species is known only from the Třenice Formation. Small obolid *Teneobolus bukovensis* is known from the Třenice and Mílina formations, but in the latter unit is very rare. *Rosobolus* is common species in the Třenice Formation, but its stratigraphical range is much longer, with the latest known species from the upper part of the Klabava Formation (Dapingian). In summary, an absence of large species *Hyperobolus feistmanteli* and *Expellobolus expulsus*, the index taxa for the Třenice Formation coming from the Krušná Hora Hill mines, which are common in grey-green lithic sandstones in dump of Gabriela Mine, indicate that the sandstone with *Siphonobolus simulans* is likely younger than that bearing *Hyperobolus feistmanteli*. Correspondingly, a suggested stratigraphical level with the new fauna is the upper part of the Třenice Formation. This suggestion is in agreement with occurrence of *Siphonobolus simulans* at Holoubkov locality and in the Cheznovice area. In these two localities this species occurs in the upper part of the Třenice Fomation together with eoorthids but before an onset of the *Thysanotos-Leptembolon* Association, which subsequently persisted in the SW part of the basin into the Floian or even the Dapingian (Olešná Member). *Acrotreta* aff. *grandis* is not known from other localities. Acrotretoids of the Mílina Formation and the Olešná Member are sufficiently known (Mergl, 1995, 2002). Indeed, the absence of *A.* aff. *grandis* in cherts of the Mílina Formation indirectly supports an older age of the lithic sandstone with lingulates from Gabriela Mine.

Taphonomy and environment

New association is preserved in the lithic sandstone. Monocrystalline quartz grains, angular to subangular and subequal size (Figure 2) are associated with microcrystalline aphanitic volcanics and small fragments of phosphatic shells. Strong fragmentation, uneven orientation of shells and absence of characteristic sedimentary structures could be explained by transport and deposition the sandstone bed from a debris flow.

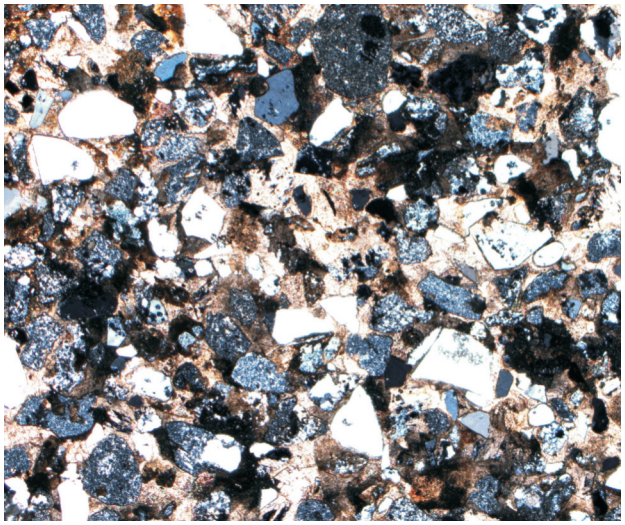


Figure 2. *Photomicrograph of lithic sandstone from Gabriela mine with subangular monocrystalline quartz and lithic fragments*

The presence of epifaunal microbrachiopods (*Acrotreta, Rowellella*), epifaunal fixo-sessile macrobrachiopods (*Siphonobolus, Orbithele*) and likely semiinfaunal to infaunal taxa (*Rosobolus, Teneobolus*) indicate tiering in more levels on stable substrate, both firm substrate (rock, algal mats, kelp surface?) and motile sand. In summary, the favourable and relatively stable environment inhabited by moderately diverse micro- and macrobrachiopods was affected by a flow of coarse volcanogenic debris. Therefore, the newly observed brachiopod occurrence is assumed to be allochtonous unlike to parautochtonous occurrences of *Hyperobolus* in the lithic sandstone in another stratigraphic levels. Unlike to newly described fauna, the shells of *Hyperobolus feistmanteli* are generally oriented parallel to bedding planes and are less intensively fragmented indicating only moderate transport and wave and current generated orientation in sand dunes (Hroch *et al.* 2012).

CONCLUSION

New fauna observed in dump of the abandoned Gabriela Mine referred to the Třenice Formation differs from local famous lingulate fauna with *Hyperobolus feistmanteli*, which is the most common fauna in the grey-green lithic sandstone in the area. The new fauna is dominated by acrotretid *Acrotreta* aff. *grandis* and siphonotretid *Siphonobolus simulans*. Presence of *Rosobolus, Teneobolus* and *Orbithele* makes this association similar to roughly coeval fauna from SW part of the Prague Basin. Mode of preservation indicates that the deposition of the lithic sandstone with the new fauna was likely from a debris flow.

ACKNOWLEDGEMENTS

This is contribution to IGCP Project 653: The onset of the Great Ordovician Biodiversity Event. I thank Leonid Popov (Cardiff) and Lars E. Holmer (Uppsala) for critical comments and some suggestions on the manuscript.

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