Paleoenvironmental dynamics in the southern Pannonian Basin during initial Middle Miocene marine flooding

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Abstract: Paleoenvironmental analysis based on foraminiferal distribution has been carried out on 44 sediment bulk samples from the locality Bogutovo selo near Ugljevik (NE Bosnia and Herzegovina). During the Middle Miocene the region was positioned on the southern margin of the Pannonian Basin and the Central Paratethys Sea. The studied section comprises ≈70-m-thick sedimentary succession dominated by marine marls and intercalated in its middle part by a single 14-m-thick limestone package. Marine succession superposes by angle discordance Oligocene coal-bearing deposits. The marker species allow correlation of the lower part of the section with the Early Badenian Upper Lagenidae Zone, whereas for the middle and upper part, the Middle Badenian *Spirorutilus* Zone was inferred. Integrating data from calcareous nannoplankton, the stratigraphic range has been limited to the time interval of 14.36–13.65 Ma (late NN5, late Langhian). The statistical agglomerative techniques applied to benthic foraminiferal distribution suggest the presence of six assemblages showing gradual transition from one to another. Their paleoenvironmental significance points to initial upward deepening of the depositional environment as a result of the Badenian transgression. This trend is interrupted by major sea-level-fall and switch to carbonate platform conditions in the middle part of the section. Subsequent sea-level-rise and increased primary production resulted in progressive reduction of oxygen content at the sea bottom in the upper part of the section. The stratigraphic position in the topmost NN5 Zone implies the correlation of the major sea-level-fall with the glacio-eustatic isotopic event Mi-3b astronomically dated to 13.82 Ma and coinciding with the base of the Serravallian.

Key words: Badenian, Pannonian Basin, Bosnia and Herzegovina, paleoecology, calcareous nannoplankton, benthic foraminifera.

Introduction

The data on the initial marine transgression in the southern Pannonian Basin System are still very scarce (Mandic et al. 2012). This fact makes the fine scale paleogeographical reconstructions problematic. Yet, not the sediment distribution, but particularly the precise age of the marine flooding is still a subject of discussion (Ćorić et al. 2009). Until recently the age of that flooding was uniformly reported as Karpatian (late Early Miocene — Pavelić 2001; Hajek-Tadesse et al. 2009), resulting in all major Paratethys reconstructions showing the southern Pannonian Basin already completely flooded at that time (Rögl & Steininger 1983; Rögl 1999; Popov et al. 2004). Beyond that the massive salt deposits at Tuzla in NE Bosnia and Herzegovina indicating a major regional paleoclimatic event and representing exactly this initial Miocene marine cycle are likely correlated with the late Early Miocene (Kováč et al. 2003). This paper contributes the current revision by Vrabac et al. (2011) providing evidence that in closest vicinity to that salt deposit the initial flooding was conversely more than 2.5 Myr younger.

The integrating benthic foraminifera and calcareous nannoplankton will be applied to provide the precise biostratigraphic dating of the initial marine flooding on the southern margin of the Pannonian Basin in NE Bosnia and Herzegovina (Fig. 1a–c). The quantified record of benthic foraminifera for about 65-m-thick succession will allow accurate documenta-tion of the sea-level change and paleoenvironmental history during the initial 0.5-Myr-interval of the Paratethys Sea in that region. Finally, it will be demonstrated that the observed events and trends correlate with Middle Miocene Climate Transition and Badenian Salinity Crisis. A brief comparison to other corresponding regional and global records will be provided.

Geological setting

The Paratethys (Fig. 2) developed during the Early Oligocene in Central and Southeastern Europe as a northern satellite sea of the Western Tethys Ocean. One of the crucial geodynamic events in its history was the origination of the Pannonian Basin System as a result of back-arc rifting triggered through eastward slab roll-back along the Carpathian arc during the late Early and Middle Miocene (Dilek 2006). First this event allowed the Paratethys Sea a deep southward transgression across Transdanubia and the Great Hungarian Plain into the northeastern margin of the Dinaride thrust-fold belt diminishing there a diversified continental environment of the Dinaride Lake System (Mandic et al. 2012; De Leeuw et al. 2012a). Hence during the early Middle Miocene the Central Paratethys Sea provided a picture of a large intracontinental archipelago with a narrow strait to the Mediterranean Sea in the West and a deeply indented coast on the South striking along the Dinaride margin (Fig. 2).
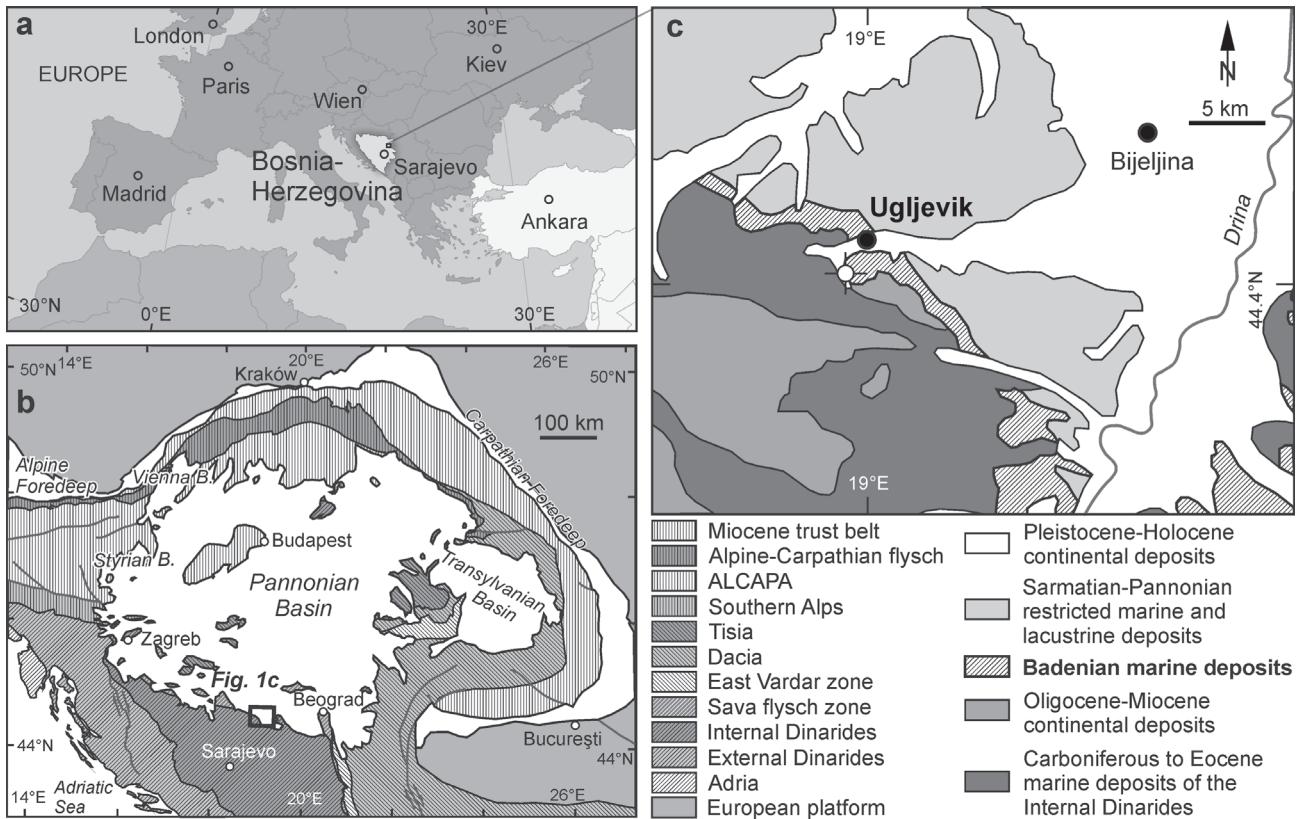
Fig. 1. Geographical and regional geological setting of the studied area. **a** — Geographical position in southeastern Europe (ArcGIS basemap). **b** — Geotectonic setting at the southern margin of the Pannonian Basin (modified after Schmid et al. 2008). **c** — Regional geological position of Section Prokoš/Bogutovo Selo SW of Ugljevik indicated (cross) in a detailed view of the Geological map of former Yugoslavia M 1 : 500,000.

Fig. 2. Paleogeographical setting showing position of Ugljevik in the southern Pannonian Basin and Central Paratethys during the Early Badenian (map by NHM Vienna).

The open-pit mine at Bogutovo Selo near Ugljevik in NE Bosnia and Herzegovina is positioned on the southern margin of the Pannonian Basin System (Fig. 1b). The region is located on the eastern slopes of the Mt Majevica and represents the westernmost tip of the Jadar thrust-sheet derived from the northern passive Adria margin, obducted in the Late Jurassic by the Vardar Ocean ophiolites (Schmid et al. 2008). Mt Majevica is a horst made of Paleogene flysch deposits related to the Sava back-arc ocean that was closed by the Middle Eocene collision between the Dinarides and the

Tisza Mega-Unit (Hrvatović 2006). The postorogenic intra-mountainous Ugljevik Basin developed in the Oligocene and was already characterized by fully continental deposition (Čičić 1964). The Paratethys marine marls and calcarenites follow by angle discordance on top of that Late Oligocene coal-bearing lacustrine series (Fig. 1c). The marine series are superposed then by restricted marine Sarmatian and finally by brackish Pannonian (Late Miocene) deposits completing the Paratethys depositional cycle (Fig. 3)

The Miocene foraminiferal fauna of Ugljevik is very well preserved and already qualitatively investigated by Pantić et al. (1964), Vrabac & Mihajlović (1990), Rundić et al. (2000) and Savić et al. (2000, 2005). Additional paleontological and geological data from the region are available from Miljuš (1961), Čičić (1961, 1964), Malez & Thenius (1985), and Vrabac et al. (1995), among others.

Material and methods

The sediment bulk samples ($\approx$150 g each) are washed by standard methodology through 0.063–0.250 mm mesh sieves. The dried material was iteratively portioned by the Reich microsplitter to get the standardized sample of about 300 foraminiferal specimens for plankton/benthos (P/B) ratio determination. Subsequently, this procedure was repeated

Age (Ma)	Chronostratigr.		Geomagnetic polarity	Biostratigraphy			Mediterran. calcareous plankton events	Centr. Parateth. Chronostratigr.		Sea level reconstr.	Central Paratethys biostratigraphy
				Planktonic foraminifera		Calc. nannop.					
	Epoch	Age	ATNTS04	M Zone	N Zone	NN Zo.		Stage	Subst.	3rd order Sequences	Eco/bio-zones
12	MIDDLE MIOCENE	Serravallian	C5			NN7	*Sphenolithus heteromorphus* LO	Sarmatian		TB2.6.	*Porosononion granosum*
			C5A	M9b	N12	NN6					*Elphidium hauerinum* *Elphidium reginum* *Anomalinoides dividens*
13								Kosovian		Ser3 TB2.5.	*Bulimina-Bolivina*
			C5AA	M9a			*Praeorbulina circularis*		Wielic.	Ser2 TB2.4.	*Spirorutilus*
			C5AB	M8	N11			Badenian		Ser1	Upper Lagenidae
14		Langhian	C5AC	M7	N10	NN5	*Helicosphaera waltrans* LCO *Praeorbulina glomerosa curva* *Praeorbulina glomerosa glomerosa* *Praeorbulina suturalis*		Moravian		Lower Lagenidae
			C5AD	M6	N9					TB2.3.	
15			C5B								
				M5b	N8						
16	EARLY MIOCENE	Burdigalian	C5C	M5a		NN4		Karpatian		Lan1	*Uvigerina graciliformis*
				M4b	N7					TB2.2.	
17				M4a							

Fig. 3. Stratigraphic correlation table and position of studied interval. Global chronostratigraphy after Hilgen et al. (2009), magnetostratigraphy and calcareous nannoplankton zones from Lourens et al. (2004a,b), planktonic foraminiferal zones from Wade et al. (2011), Mediterranean plankton bioevents from Iaccarino et al. (2011). The sea-level reconstruction follows Hilgen et al. (2009) except for the Lan1 boundary correlated with the isotope event at the Langhian base (see Iaccarino et al. 2011). Note its good agreement with the Central Paratethys pattern inferred by Strauss et al. (2006), contrasting the recent proposals of Hohenegger et al. (2009a,b). Revised correlation of Paratethys chrono- and biostratigraphy (Papp et al. 1978b; Piller et al. 2007) integrates results by De Leeuw et al. (2010, 2012b), Hohenegger & Wagreich (2011) and the present study.

to get about 300 specimens for quantitative and qualitative analysis of benthic assemblages. The taxonomic determination of the benthic foraminiferal species was based on criteria by Loeblich & Tappan (1987a,b) and Papp et al. (1978a), AGIP (1982), Papp & Schmid (1985), Haunold (1990), Cimerman & Langer (1991), Filipescu & Gîrbacea (1997), Cicha et al. (1998), Báldi (1999). The compilation of ecological preferences including the depth-range for benthic foraminifera is based on Murray (1991, 2006), Van Der Zwaan & Jorissen (1991), Sgarrella & Moncharmont Zei (1993), Kaiho (1994, 1999), Jorissen et al. (1995), Rathburn et al. (1996), De Stigter et al. (1998), Jannik et al. (1998), Den Dulk et al. (2000), Spezzaferri et al. (2002), Fontanier et al. (2002), Rögl & Spezzaferri (2003), Stefanelli (2004), Hohenegger (2005), Van Hinsbergen et al. (2005), Kouwenhoven & Van Der Zwaan (2006), Báldi (2006), Zágoršek et al. (2008), Holcová & Zágoršek (2008), Reolid et al. (2008),

Frezza & Carboni (2009), Pippérr & Reichenbacher (2010), De & Gupta (2010).

Prior to analysis of benthic foraminiferal assemblages, the taphonomic conditions have been investigated to extract autochthonous specimens for paleoecological interpretation. The presence of size-sorting, fragmentation, abrasion, corrosion, and the incongruence of stratigraphic ranges and paleoecological preferences have been checked following examples by Murray (1991) and Holcová (1999). After transported specimens (T) have been excluded from the analysis, the numbers of species (N) are defined, followed by calculation of percentage contributions for each sample to identify relative abundances and pinpoint the dominant species (Murray 1991). The multivariate agglomeration and statistical techniques applied to that data pinpointed changes in assemblage structure through the section. The Hierarchical Agglomerative Cluster Analysis and Non-metric Multidi-

mensional Scaling, both based on Euclidean distance dissimilarity measure have been conducted by means of PAST software (Hammer et al. 2001).

The paleo-depth fluctuations are investigated by plankton/benthos ratio (P/B; Murray 1991), modified plankton/benthos ratio (D1; Van Der Zwaan et al. 1990, 1999), and gradient analysis (D2; Hohenegger 2005; Báldi & Hohenegger 2008). The oxygen content of the bottom water (BFOI — Benthic Foraminiferal Oxygen Index) is calculated from relative abundances of oxic, suboxic and dysoxic foraminifera (Kaiho 1994, 1999). Species diversity of benthic foraminifera is expressed by four indices: Fisher α index (α), Shannon-Wiener index (H), Equitability (E), and Dominance (D). Fisher α index eliminates the influence of the sample size, Shannon-Wiener provides information of heterogeneity of the assemblage. Their specific values can indicate particular environmental conditions. Equitability describes similarity between species contributions whereas Dominance measures the evenness of the community (Murray 1991). The values of those diversity indices are calculated by PAST (PAleontology STatistic) software (Hammer et al. 2001). The environmental stress indicator (S) results from contribution of deep infaunal species in complete benthic assemblage as proposed by Van Hinsbergen et al. (2005). Finally, the calculation of high primary production indicators (HP) follows Spezzaferri et al. (2002).

In addition to benthic foraminifera, the calcareous nannoplankton distribution was analysed to support biostratigraphic evaluation. To identify biostratigraphical zone markers and get information about nannoplankton assemblages, smear slides were prepared from 28 samples using standard procedures and examined under light microscope (cross and parallel nicols) at 1000× magnification.

Section

The studied interval is represented by three overlapping partial sections (Fig. 4). Partial section 1 (WGS 1984 — Base: N44 40 23.7 E18 59 13.5, Top: N44 40 25.7 E18 59 13.5) includes the transgression boundary in the base and the dark clayey marker bed on top. The marker bed allows its straight-forward correlation with the partial section 2 (Base/Top: N44 40 25.1 E18 58 58.3). The latter is positioned 325 m to the West and includes interval from marker bed to the main carbonate body. Finally, the partial section 3 including the carbonate and the top marl is located about 50 m to the WNW (Base: N44 40 25.8 E18 58 56.3, Top: N44 40 27.0 E18 59 00.1). The outcrop area is located ≈2 km south of (Novi) Ugljevik and represents the southern slope of the Hill Prokoš. The section is about 70-m-long with its lowermost part still representing continental deposits. The superposed marine succession is three-folded with marl dominated intervals in lower (28 m) and upper (25 m) part and massive limestone (14 m) interval in its middle part.

The section starts with grey and olive green clayey interval (5 m). Chert intercalations are present in its lower part replaced upward by chert nodules and mudclusts. The topmost horizon (20–40 cm) comprising marine shell, sand and peb-

ble material from superposed interval is strongly bioturbated. The onlap horizon is marked by shell-accumulation composed of marine bivalves and gastropods in a greenish fine-sandy matrix. The lower boundary is sharp and erosive.

The lower marine unit starts with a fining upward interval (6 m) of greenish fine-sand and silty marl, followed by horizon (6 m) composed of greyish marl. The series bears rare sediment-floating mollusc remains such are thin-walled pectinid bivalves (e.g. *Cristatopecten badensis* (Fontannes, 1882), *Costellamussiopecten attenuatus* (Kojumdgieva, 1960)). Its uppermost part displays wood fragments and mass-occurrences of minute gastropod plankton (pteropods). An interval composed of dark grey marl (4 m) follows on top, bearing plant debris. It is superposed by a marl and silty marl horizon (7 m) bearing scattered sediment floating mollusc shells, mostly the articulated shells of infaunal bivalve *Corbula gibba* (Olivi, 1792). Occasional monotypic pteropod accumulations with *Vaginella austriaca* are additionally present therein. This faunal composition continues into the topmost part of the unit (5 m) where marl and silty marl is inter-bedded with corallinacean debris limestone. Calcarenite intercalations (<60 cm) have sharp lower and gradual upper boundaries and can display fining upward with larger components such are rhodoliths or oyster shells concentrated on the base.

The middle marine unit (14 m) represents single limestone interval composed mainly of corallinacean debris. The architecture is three-folded with homogeneous base and top (≈4 m) and thick-bedded middle part (>0.5 m). Their slightly undulated bed contacts are characterized through increased siliciclastic (clay and silt) component. Among fossil remains especially rhodoliths, coral clasts, and thick-walled bivalves are conspicuous.

The upper marine unit is dominated by marl occasionally intercalated by cm-thin calcarenites composed of fine-grained (fine-sand to silt) skeletal debris. Up to 10 cm thick clayey or silty tephra interbeds are additionally present. The unit starts with dark marl (2.5 m) with common corbulids and deep-water oysters (*Neopycnodonte navicularis* (Brocchi, 1814)). The contact to the previous unit is gradual, marked by fast upward-decrease of skeletal detritus and by strong bioturbation. The superposed marl horizon (4 m) is marked by pteropod mass-occurrences and grades upward to corbulid-bearing marl horizon (2.5 m). The marl succession is then interrupted by a thick calcarenite package (2 m) divided in two parts through marl inter-bed with mudclasts and skeletal detritus. The next horizon (4 m) is composed of dark marl characterized by common fish remains. Its lower part displaying increased clayey component grades upwards through a short laminated interval into monotonous marl of the upper part. Fine laminated pteropod marl (2 m) follows on top, superposed finally by a conspicuous interval (4 m) dominated by laminated diatomites with very scattered fish remains. The uppermost part of the section (4 m) is badly exposed but apparently displays the same facies.

The presented data imply the existence of two transgressive and one regressive interval within the marine succession. The lower unit starts with a fining upward sequence and suggests the initial deepening phase. With the introduction of increased plant debris followed by a coarsening upward trend, the re-
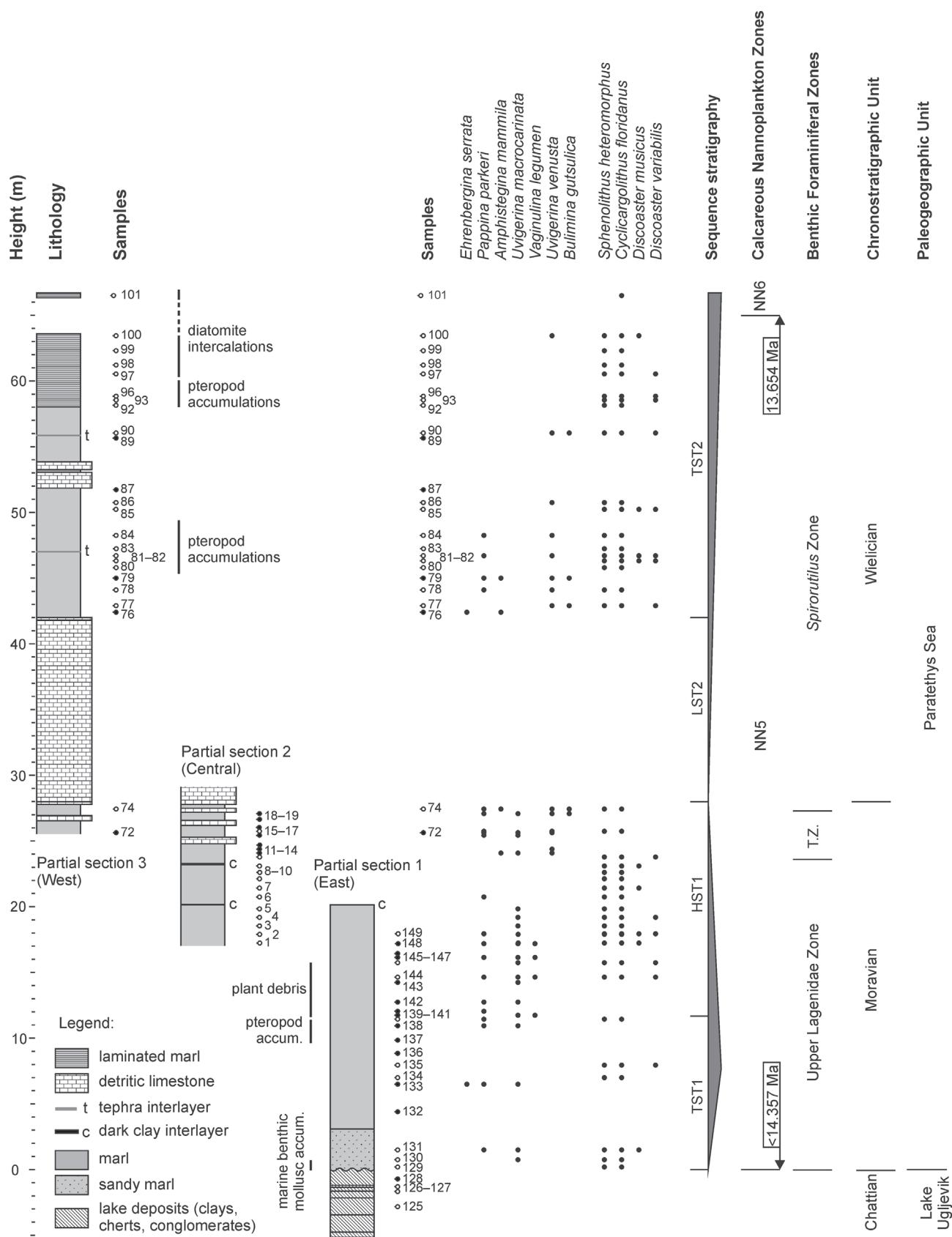
Fig. 4. Lithology, partial sections, sample position, biostratigraphic results and sequence stratigraphic interpretation. White dots point to samples where calcareous nannoplankton has been investigated. **T.Z.** — Transitional Zone.

gressive phase starts. The common presence of corbulids therein points to oxygen crises bound to increased organic matter input (Mandic & Harzhauser 2003). The calcarenites interpreted as proximal tempestites (Schmid et al. 2001) mark distinct depositional shallowing on top. The carbonate platform deposition of the middle unit proves finally the installation of shallow water conditions. In terms of sequence stratigraphy (Fig. 4), the boundary between the initial Transgressive System Tract (TST1) and subsequent High System Tract (HST1) can be defined with the start of plant debris deposition suggesting enhanced terrestrial influence through prograding coastal environments. The stable shallow water conditions of the middle unit represent in contrast the prolonged Low System Tract (LST2) with its base marking the start of the second depositional sequence. The very fast return to deeper water conditions on its top is associated with continuous input of skeletal debris. No trend to shallow water conditions can be detected upward and therefore the whole interval is tentatively regarded as single Transgressive System Tract phase (TST2). Note that similar diatomites from the Lower Miocene of Austria, investigated by geochemical and micropaleontological proxies were related to local upwelling conditions (Grunert et al. 2010). The inference was there supported by regionally absent fluvial deposits.

Assemblages

Calcareous nannoplankton

The lowermost part of the Ugljevik section comprising the lake sediments is barren of autochthonous calcareous nannoplankton (Fig. 4). This changes in the marine part of the section where blooms of small reticulofenestrids and very rare or absent discoasterids in calcareous nannoplankton assemblages in all investigated samples point to a depositional environment close to a paleo-coast.

All the assemblages (Fig. 5) are dominated by small reticulofenestrids (*Reticulofenestra minuta* Roth, 1970 and *R. haqii* Backman, 1978), which are very common in Badenian marine deposits of the Central Paratethys (Ćorić & Hohenegger

2008). The following occur regularly and continuously: *Coccolithus pelagicus* (Wallich, 1871) Schiller, 1930, *Helicosphaera carteri* (Wallich, 1877) Kamptner, 1954, *H. walbersdorfensis* Müller, 1974, *Holodiscolithus macroporus* (Deflandre, 1954) Roth, 1970, *Reticulofenestra gelida* (Geitzenauer, 1972) Backman, 1978, *R. pseudoumbilicus* (Gartner, 1967) Gartner, 1969, *Sphenolithus moriformis* (Brönnimann & Stradner, 1960) Bramlette & Wilcoxon, 1967 and *Umbilicosphaera jafari* Müller, 1974. The following are rare but continual: *Braarudosphaera bigelowii* (Gran & Braarud, 1935) Deflandre, 1947, *Calcidiscus leptoporus* (Murray & Blackman, 1898) Loeblich & Tappan, 1978, *Coronocyclus nitescens* (Kamptner, 1963) Bramlette & Wilcoxon, 1967, *Coronosphaera mediterranea* (Lohmann, 1902) Gaarder, 1977, *Cyclicargolithus floridanus* (Roth & Hay, 1967) Bukry, 1971, *Geminilithella rotula* Kamptner, 1956, *Pontosphaera multipora* (Kamptner, 1948) Roth, 1970, *Rhabdosphaera sicca* Stradner, 1963, and *Syracosphaera pulchra* Lohmann, 1902. The folowing are rare and irregularly found: *Cryptococcolithus mediaperforatus* (Varol, 1991) de Kaenel & Villa, 1996, discoasters (*Discoaster adamanteus* Bramlette & Wilcoxon, 1967, *D. deflandrei* Bramlette & Riedel, 1954, *D. musicus* Stradner, 1959, *D. variabilis* Martini & Bramlette, 1963, *D. exilis* Martini & Bramlette, 1963), *Hayella challengeri* (Müller, 1974) Theodoridis, 1984, *Micrantholithus* spp., *Thoracosphaera* spp. and *Triquetrorhabdulus* spp. Discoasterids from the section Ugljevik are very rare and can be compared with abundances observed in the Austrian part of the Alpine-Carpathian Foredeep (Ćorić & Rögl 2004) and in the Vienna Basin (Ćorić & Hohenegger 2008).

Foraminifera

Only 44 of 63 collected samples from the Ugljevik section proved suitable for the analysis of benthic foraminifera. Whereas in the lower part of the section (samples UG129–UG149) the benthic foraminifera are present in all available samples, in its upper part they are frequently absent or too scarce for statistical treatment. In contrast, the planktonic foraminifera are present in all samples except for UG14 and UG81, free of microfossils in consequence of diagenetic

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Fig. 5. Calcareous nannoplankton species from Ugljevik section. **1** — *Pontosphaera discopora* Schiller, 1925; UG8. **2** — *Coccolithus pelagicus* (Wallich, 1871) Schiller, 1930; UG144. **3** — *Pontosphaera multipora* (Kamptner, 1948) Roth, 1970; UG145. **4** — *Cyclicargolithus floridanus* (Roth & Hay, 1967) Bukry, 1971; UG90. **5–6** — *Discosphaera tubifera* (Murray & Blackman, 1898) Ostenfeld, 1900; UG101. **7–8** — *Helicosphaera carteri* (Wallich, 1877) Kamptner, 1954; UG145. **9** — *Discoaster formosus* Martini & Worsley, 1971; UG140; **10** — *Discoaster variabilis* Martini & Bramlette, 1963; UG90. **11** — *Discoaster exilis* Martini & Bramlette, 1963; UG82. **12** — *Discoaster musicus* Stradner, 1959; UG8. **13–14** — *Cryptococcolithus mediaperforatus* (Varol, 1971) de Kaenel & Villa, 1996; UG8. **15** — *Reticulofenestra gelida* (Geitzenauer, 1972) Backman, 1978; UG145. **16** — *Lithostromation perdurum* Deflandre, 1942; UG90. **17** and **24** — *Calcidiscus leptoporus* (Murray & Blackman, 1898) Loeblich & Tappan, 1978; UG93. **18** — *Helicosphaera walbersdorfensis* Müller, 1974; UG82. **19, 20** — *Geminilithella rotula* Kamptner, 1956; UG90. **21** — *Reticulofenestra pseudoumbilicus* (Gartner, 1967) Gartner, 1969; UG90. **22–23** — *Coronocyclus nitescens* (Kamptner, 1963) Bramlette & Wilcoxon, 1967; UG82. **25** — *Reticulofenestra minuta* Roth, 1970; UG93. **26** — *Rhabdosphaera sicca* Stradner, 1963; UG80. **27** — Ascidian spicule; UG93. **28–29** — *Micrantholithus bassiensis* Rade, 1977; UG8. **30–31** — *Umbilicosphaera jafari* Müller, 1974; UG145. **32** — *Holodiscolithus macroporus* (Deflandre, 1954) Roth, 1970; UG8. **33** — a — *Braarudosphaera bigelowii* (Gran & Braarud, 1935) Deflandre, 1947, b — *Cyclicargolithus floridanus* (Roth & Hay, 1967) Bukry, 1971; UG90. **34–35** — *Scyphosphaera pulcherrima* Deflandre, 1942; UG145. **36–37** — a — *Sphenolithus heteromorphus* Deflandre 1953, b — *Sphenolithus moriformis* (Brönnimann & Stradner, 1960) Bramlette & Wilcoxon, 1967; UG82. **38** — a — *Micrantholithus* sp., b — *Geminilithella rotula* Kamptner, 1956; UG90. **39** — *Coccolithus miopelagicus* Bukry, 1971; UG145.
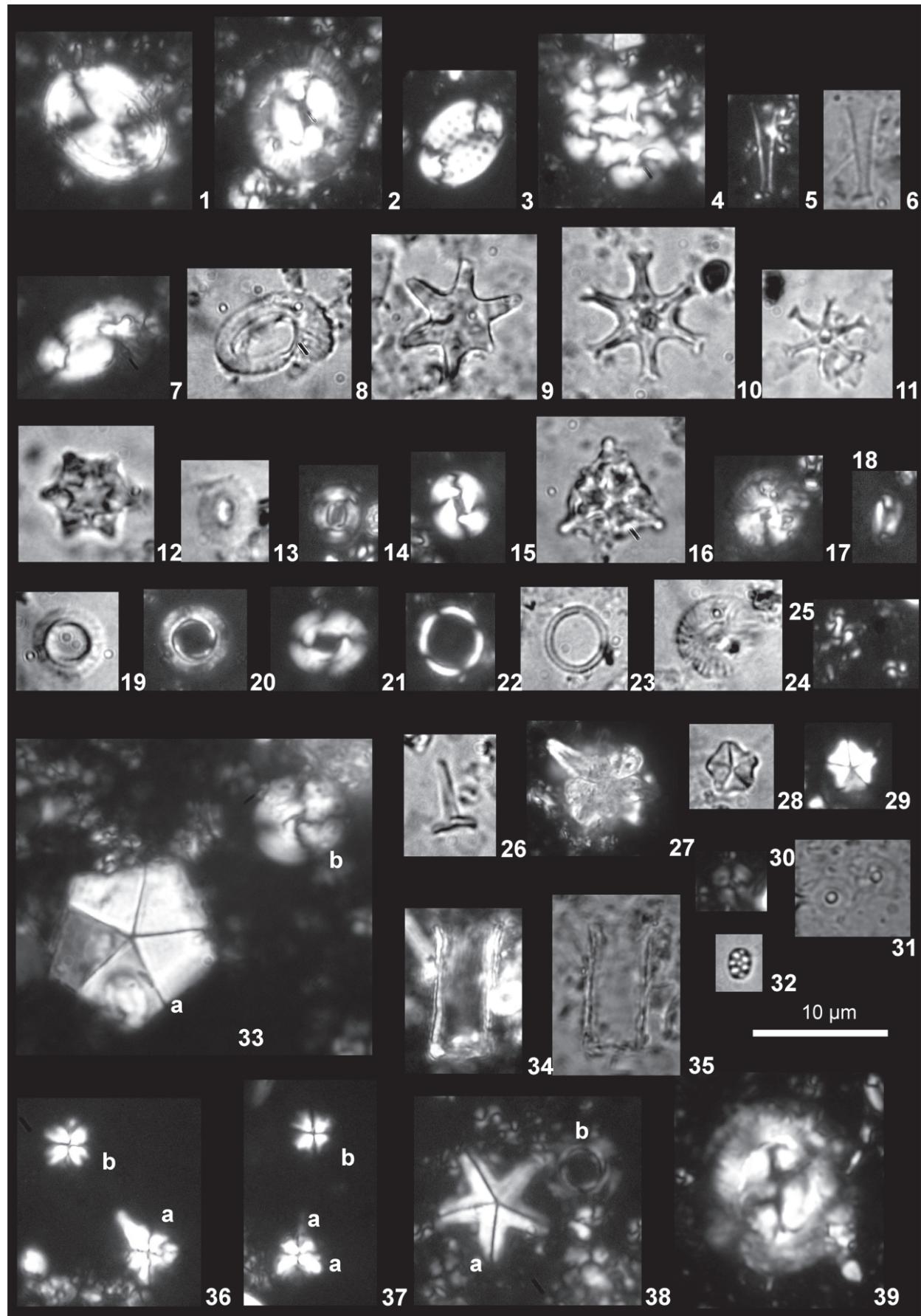
Table 1: Ecological and paleoecological predispositions of species: oxic preference, mode of life, stress marker, deep infauna, high primary productivity species. Data were compiled from Murray (1991, 2006), Van Der Zwaan & Jorissen (1991), Sgarrella & Moncharmont Zei (1993), Kaiho (1994, 1999), Jorissen et al. (1995), Rathburn et al. (1996), De Stigter et al. (1998), Jannik et al. (1998), Den Dulk et al. (2000), Spezzaferri et al. (2002), Fontanier et al. (2002), Rögl & Spezzaferri (2003), Stefanelli (2004), Hohenegger (2005), Van Hinsbergen et al. (2005), Kouwenhoven & Van Der Zwaan (2006), Báldi (2006), Zágoršek et al. (2008), Holcová & Zágoršek (2008), Reolid et al. (2008), Frezza & Carboni (2009), Pippérr & Reichenbacher (2010), De & Gupta (2010).

Taxon	Oxic preference	Mode of life	Stress marker	High primary productivity	Taxon	Oxic preference	Mode of life	Stress marker	High primary productivity
Spirorutilus carinatus (d'Orbigny)	O	E			*Bulimina gutsulica* Livental	D	I	x	
Martinottiella communis (d'Orbigny)	O	E			*Bulimina subulata* (Cushman & Parker)	D	I	x	
Semivulvulina pectinata (Reuss)	O	E			*Praeglobobulimina pyrula* (d'Orbigny)	D	I	x	x
Textularia sp.	S	I			*Pappina parkeri* (Karrer)	S	I		
Sigmoilinita tenuis (Czjzek)	O	E			*Uvigerina aculeata* (d'Orbigny)	D	I	x	x
Quinqueloculina buchiana	O	E			*Uvigerina grilli* Papp & Schmid	D	I	x	x
Quinqueloculina sp.	O	E			*Uvigerina macrocarinata* Papp & Turnovsky	D	I	x	x
Grigelis pyrula d'Orbigny	S	I			*Uvigerina pygmoides* Papp & Turnovsky	D	I	x	x
Pseudonodosaria brevis d'Orbigny	S	I			*Uvigerina semiornata* d'Orbigny	D	I		x
Laevidentalina boueana d'Orbigny	S	I			*Uvigerina venusta* Franzenau	D	I	x	x
Laevidentalina elegans d'Orbigny	S	I			*Angulogerina angulosa* (Williamson)	O	I		
Frondicularia sp.	S	I			*Trifarina brady* (Cushman)	S	I		
Amphimorphina haueriana Neugeboren	S	I			*Coryphostoma digitalis* (d'Orbigny)	S	I		
Plectofrondicularia digitalis (Neugeboren)	S	I			*Reusella spinulosa* (Reuss)	O	E		
Lenticulina calcar (Linné)	O	E			*Fursenkoina acuta* (d'Orbigny)	D	I	x	
Lenticulina inornata (d'Orbigny)	O	E/SI			*Sigmavirgulina tortuosa* (Brady)	S	I		
Lenticulina vortex (Fichtel & Moll)	O	E			*Orthomorphina* sp.	S	I		
Lenticulina sp.	O	E			*Neugeborina longiscata* (d'Orbigny)	S	I		
Amphycoryna badenensis (d'Orbigny)	S	I			*Siphonodosaria consobrina* (d'Orbigny)	S	I		
Saracenaria arcuata (d'Orbigny)	S	I			*Stilostomella adolphina* (d'Orbigny)	S	I		
Marginulina hirsuta (d'Orbigny)	S	I			*Valvulineria complanata* (d'Orbigny)	D	I	x	
Vaginulinopsis pedum d'Orbigny	S	I			*Rosalina obtusa* d'Orbigny	O	E		
Vaginulina legumen (Linné)	S	I			*Eponides repandus* (Fichtel & Moll)	O	E		
Hyalinonetrion clavatum d'Orbigny	S	I			*Sphaeroidina bulloides* D'Orbigny	D	I		
Oolina sp.	S	I			*Siphonina reticulata* (Czjzek)	O	E		
Lagena striata (d'Orbigny)	S	I			*Cibicidoides ungerianus* (d'Orbigny)	O	E/SI		
Lagena sp.	S	I			*Cibicidoides* sp.	O	E/SI		
Favulina hexagona (Williamson)	S	I			*Hanzawaia boueana* (d'Orbigny)	O	E		
Glandulina ovula d'Orbigny	S	I			*Lobatula lobatula* (Walker & Jacob)	O	E		
Fissurina sp.	S	I			*Asterigerinata planorbis* (d'Orbigny)	O	E		
Ceratocancris haueri (d'Orbigny)	S	I			*Amphistegina mammila* (Fichtel & Moll)	O	E		
Hoeglundina elegans (d'Orbigny)	S	E			*Nonionella turgida* (Williamson)	S	I		
Bolivina antiqua d'Orbigny	D	I	x		*Nonion commune* (d'Orbigny)	S	I		
Bolivina dilatata Reuss	D	I	x		*Melonis pompilioides* (Fichtel & Moll)	S	I		x
Bolivina hebes (Macfadyen)	D	I	x		*Pullenia bulloides* (d'Orbigny)	S	I		
Bolivina plicatella (Cushman)	D	I			*Chilostomella ovoidea* Reuss	D	I	x	
Bolivina pokorny Cicha & Zapletalova	D	I	x		*Oridorsalis umbonatus* (Reuss)	S	E		
Bolivina viennensis (Marks)	D	I	x		*Heterolepa dutemplei* d'Orbigny	O	E		
Cassidulina laevigata d'Orbigny	S	I			*Hanseniska soldanii* d'Orbigny	S	E		
Globocassidulina oblonga (Reuss)	O	I			*Ammonia beccarii* (Linné)	O	E/SI		
Ehrenbergina serrata Reuss	S	E?			*Pararotalia* sp.	O	E		
Bulimina buchiana d'Orbigny	D	I			*Elphidium fichtellianum* (d'Orbigny)	O	E/SI		
Bulimina elongata d'Orbigny	D	I	x		*Elphidium rugosum* (d'Orbigny)	O	E/SI		

Fig. 6. Some of the most abundant and representative benthic foraminiferal species from the Ugljevik section. **1** — *Lenticulina inornata* (d'Orbigny); side view, UG146. **2** — *Lenticulina calcar* (Linné); side view, UG146. **3** — *Siphonodosaria consobrina* (d'Orbigny); side view, UG79. **4** — *Bolivina dilatata* Reuss; side view, UG131. **5** — *Bolivina hebes* (Macfayden); side view, UG146. **6** — *Bolivina viennensis* (Marks); side view, UG79. **7** — *Globocassidulina oblonga* (Reuss); apertural side, UG79. **8** — *Bulimina elongata* d'Orbigny; side view, UG79. **9** — *Bulimina subulata* (Cushman & Parker); side view, UG79. **10** — *Praeglobobulimina pyrula* (d'Orbigny); side view, UG146. **11** — *Uvigerina pygmoides* Papp & Turnovsky; side view, UG79. **12** — *Uvigerina grilli* Papp & Schmid; side view, UG146. **13** — *Valvulineria complanata* (d'Orbigny); umbilical side, UG79. **14** — *Cibicidoides ungerianus* (d'Orbigny); umbilical side, UG79. **15** — *Cibicidoides ungerianus* (d'Orbigny); spiral side, UG131. **16** — *Lobatula lobatula* (Walker & Jacob); umbilical side, UG146. **17** — *Asterigerinata planorbis* (d'Orbigny); spiral side, UG79. **18** — *Nonion commune* (d'Orbigny); side view, UG131. **19** — *Melonis pompilioides* (Fichtel & Moll); side view, UG79. **20** — *Heterolepa dutemplei* d'Orbigny; spiral side, UG146.

Figs. 2–3, 10–12, 16, 19–20

200 μm

Figs. 1, 4–9, 13–15, 17–18

100 μm
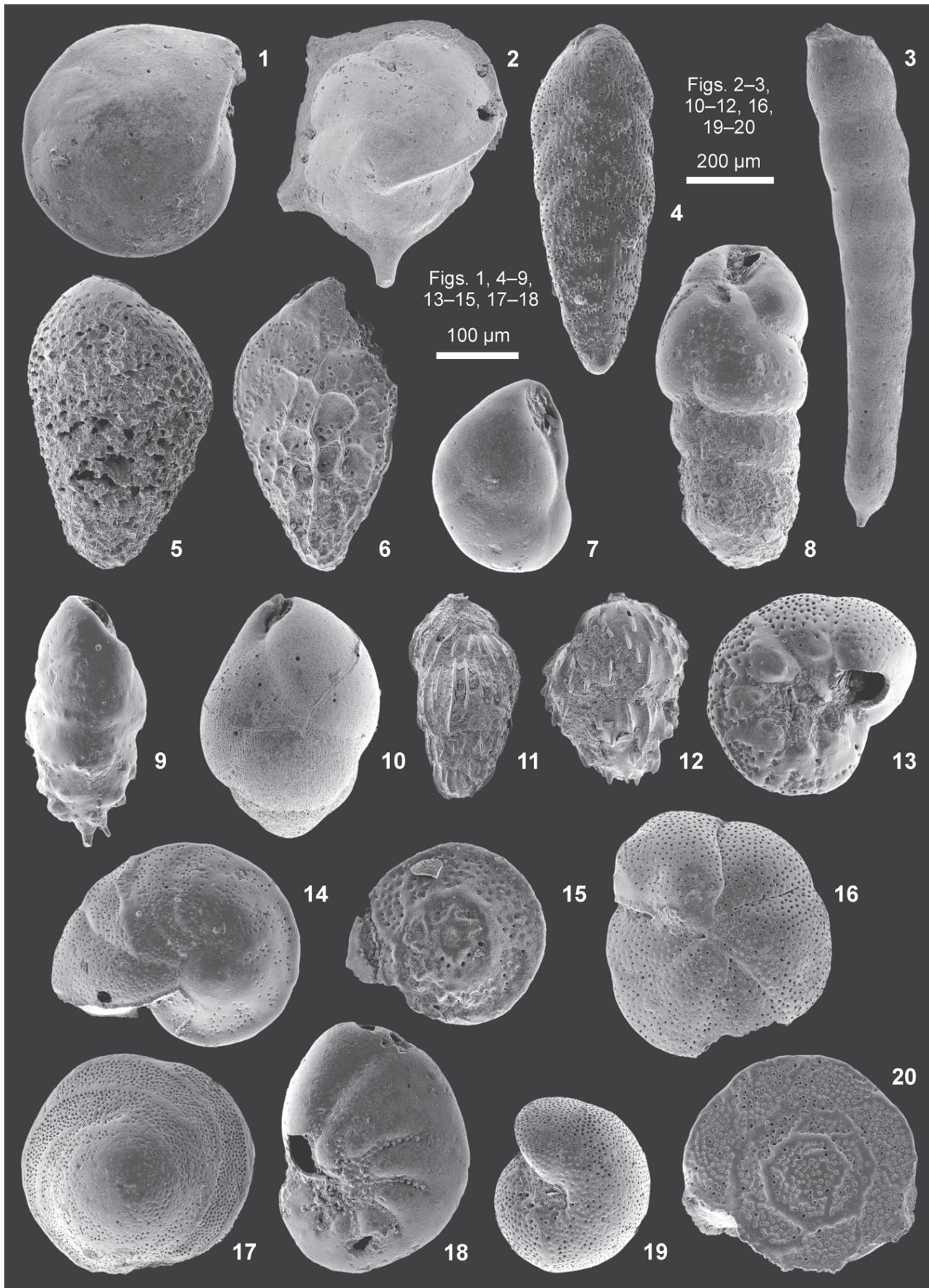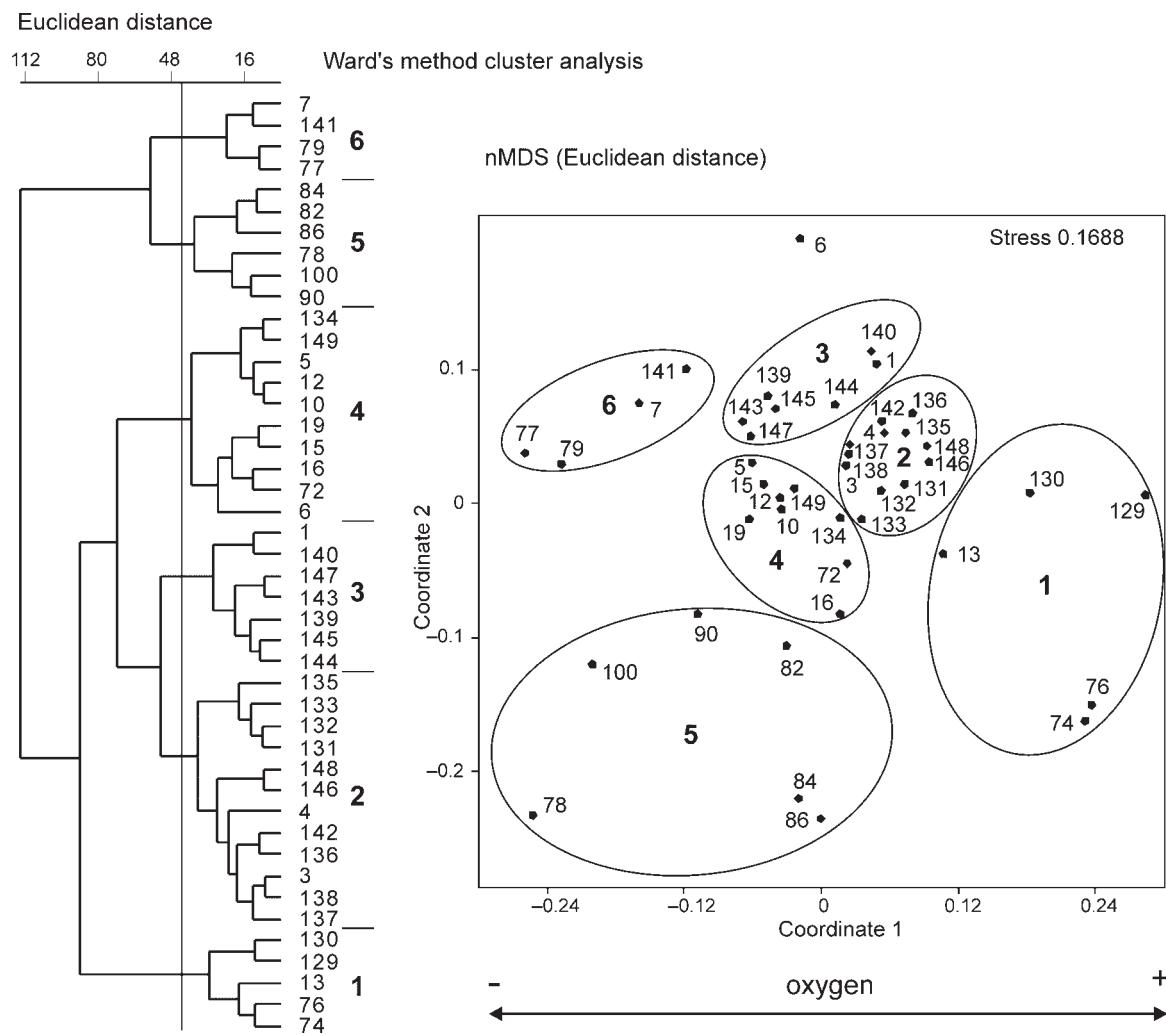
Fig. 7. Results of Cluster Analysis and Non-metric-Multidimensional Scaling analyses. Note the correlation of the Coordinate 1 in nMDS with the fluctuation of oxygen content.

leaching. Apart from foraminifera, scattered ostracods, small gastropods, bivalve fragments, echinoid spines and bryozoa remains are also present.

Altogether, 86 species of benthic foraminifera (Figs. 4, 6, and supplementary data) have been identified, mainly belonging to Rotalina. The contribution of agglutinated (<7 %) and hyaline (<4 %) foraminifera is minor. Benthic foraminifera are usually well preserved with no erosional marks or size sorting effects. Yet, based on sedimentological evidence combined with the ecological requirements of distinct species such are *Asterigerinata*, *Lobatula*, *Hanzawaia* abd *Elphidium*, their transport to a deeper water environment is evident in some of the investigated samples. The transitional samples close to the main carbonate interval (UG13, UG74 and UG76) comprising typical shallow water assemblages also include deeper water species (*Laevidentalina*, *Pullenia*, *Hoeglundina*).

Integrated Hierarchical Cluster Analysis and non-dimensional Multidimensional Scaling of benthic foraminifera quantitative data, allowed a clear extraction of six assemblages defined through the presence of dominant taxa

(Fig. 7). Their succession in the section implies gradual transitions from one to another (Fig. 8).

Cluster 1 — *Asterigerinata-Cibicidoides* assemblage: This cluster includes two analysed samples from the lowermost, and three samples from the middle part of the section. Dominant species are *Asterigerinata planorbis* (4–22 %) and *Cibicidoides ungerianus* (9–20 %); the common species are *Bolivina dilatata*, *Nonion commune* and *Lobatula lobatula*. The percentage contribution of planktonic foraminifera is in average 53 %. The mean depth of the depositional environment is 35 m after gradient analysis. Assemblage is moderately diverse (N=27; α=7; H=2.8; E=0.86) and shows moderate domination (0.08). It is characterized by the highest values for the benthic foraminiferal oxygen index (BFOI=73) (Fig. 9), and lowest percentages of stress (21 %) and high primary production indicators (3 %). 5 % of individuals are transported.

Cluster 2 — *Cibicidoides-Valvulineria* assemblage: It comprises the largest number of samples (12), all collected in the lower part of the section. Together with dominating *Cibicidoides ungerianus* (4–10 %) and *Valvulineria complanata*
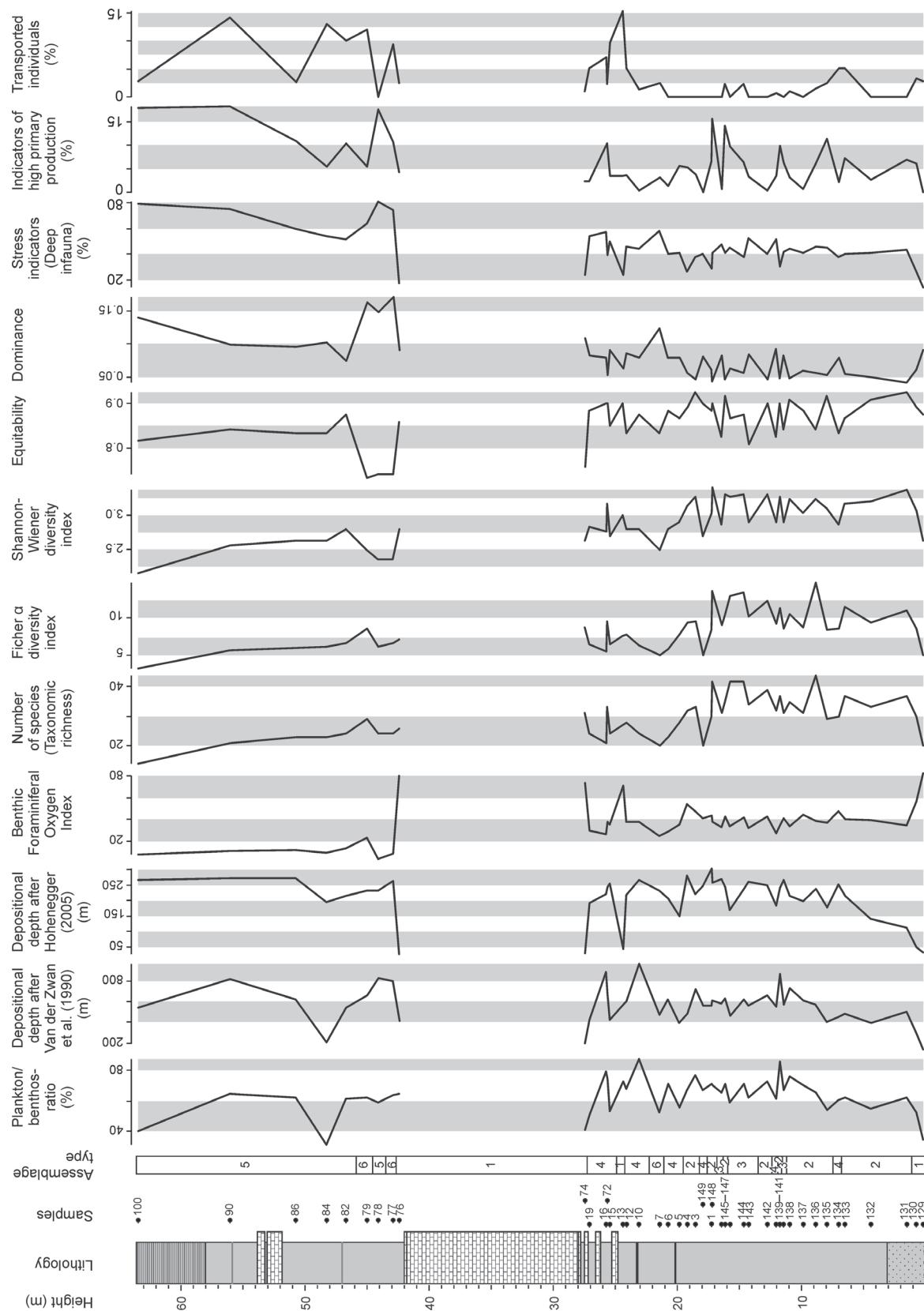
Fig. 8. Composite section showing position of investigated samples, and stratigraphic distribution of quantitative results from Cluster Analysis, nMDS, P/B ratio, paleodepth based on modified P/B ratio, paleodepth based on gradient analysis, BFOI, number of species, Fischer α index, Shannon-Wiener index, equitability, dominance, stress marker — deep infauna, high primary productivity, and transported species analyses. For lithology see legend in Fig. 4.

(4–9 %), also *Bolivina hebes* and *Bolivina antiqua* are common. The percentage of planktonic foraminifera is 67 %. The gradual upward increase of the depositional depth (213 m), and moderately low BFOI value are significant (41). The percentage of stress indicators is 41 %, of high primary production indicators 6 %, and of transported benthic foraminiferal tests 1 %. Among all assemblages this one shows the highest diversity values (N=36; α=11; H=3.2; E=0.9) and the weakest domination (0.05).

Cluster 3 — *Valvulineria-Lenticulina* assemblage: It includes 7 samples, all from the lower part of the section. The dominating species are *Valvulineria complanata* (8–21 %) and *Lenticulina inornata* (5–9 %). The following are also common: *Cibicidoides ungerianus*, *Cassidulina laevigata* and *Bulimina subulata*. The high planktonic foraminiferal percentage (69 %) and moderate BFOI are characteristic of the assemblage (37). The depositional depth by gradient analysis is 250 m. Compared with Cluster 2, the diversity of benthic community is equal or slightly lower (N=35; α=11; H=3.1; E=0.9), the dominance is slightly higher (0.07). The percentage of stress indicators is still high (41 %), whereas the contribution of high primary production indicators is 6 %. Transported individuals are less than 1 %.

Cluster 4 — *Valvulineria-Globocassidulina* assemblage: This cluster includes 2 samples from the lower part of the section and 8 samples from its middle part. The dominant species are *Valvulineria complanata* (9–17 %) and *Globocassidulina oblonga* (6–16 %), and the following are common: *Cassidulina laevigata*, *Bolivina dilatata*, *Bulimina*

subulata, *Bolivina antiqua* and *Cibicidoides ungerianus*. The percentage of planktonic foraminifera is 67 %. The depositional depth by gradient estimation is 225 m. The value of oxygen content at the sea bottom is 36. The percentage of stress indicators is 45 %, of high primary production indicators 4 %. The number of species and the value of the Fischer α index are decreased (N=26; α=7). The Shannon-Wiener index is 2.8, the dominance 0.08, and equitability 0.9. The percentage of transported tests is about 4 %.

Cluster 5 — *Bulimina-Valvulineria* assemblage: It includes 6 samples from the uppermost part of the section. The dominating species are *Bulimina subulata* (7–29 %), *Bulimina elongata* (6–19 %) and *Valvulineria complanata* (3–19 %). The common species are *Bolivina dilatata*, *Cassidulina laevigata* and *Uvigerina venusta*. This assemblage contains together with Cluster 1 the smallest percentage of planktonic foraminifera (53 %) and the smallest value of the oxygen content (9). The gradient analysis shows the depositional depth of 243 m. This assemblage is characterized by the smallest number of benthic foraminiferal species (22), and the lowest Fisher α (6) and Shannon-Wiener (2.5) indices. The value of equitability is decreased (0.8), while the domination is strongly increased (0.11). Furthermore it comprises the highest values of stress indicators (67 %), high primary production indicators (13 %), and transported tests (7 %).

Cluster 6 — *Valvulineria* assemblage: It includes 4 samples from different parts of the section. The dominating species is *Valvulineria complanata* (24–34 %). The following are also present: *Bolivina dilatata*, *Bulimina subulata* and *Cibici-*

Table 2: Dataset — Ranges and mean values of all paleoecological indicators for the inferred clusters (i.e. benthic foraminifera assemblages). **P** — Plankton/Benthos ratio, **D1** — paleodepth based on modified P/B ratio, **D2** — paleodepth based on gradient analysis, **BFOI** — Benthic Foraminiferal Oxygen Index.

Cluster assemblage	1 *Asterigerinata–Cibicidoides*		2 *Valvulineria–Cibicidoides*		3 *Valvulineria–Lenticulina*	
	range	mean	range	mean	range	mean
P (%)	34.46 – 72.87	53.03	53.85 – 77.40	67.01	59.12 – 86.09	68.98
D1 (m)	137.71 – 567.21	321.96	389.35 – 729.28	565.13	465.82 – 865.62	601.82
D2 (m)	24.79 – 48.9	35.4	112.34 – 282.10	212.62	169.91 – 302.94	250
BFOI	56.16 – 83.11	72.88	33.33 – 53.77	40.91	31.82 – 43.80	37
Number of species (N)	20 – 31	27	29 – 44	36	30 – 42	35
Fisher α – index (α)	4.953 – 8.735	7.367	8.311 – 13.640	10.758	8.372 – 13.410	10.543
Shannon- Wiener index (H)	2.622 – 3.045	2.8118	3.026 – 3.385	3.2104	2.856 – 3.282	3.0577
Equitability (E)	0.7641 – 0.9018	0.8589	0.8479 – 0.9296	0.9009	0.8148 – 0.9019	0.8598
Dominance (D)	0.0602 – 0.1080	0.0823	0.0415 – 0.0595	0.0498	0.0478 – 0.0834	0.0678
Stress indicators (%)	13.77 – 26.17	21	26.6 – 46.21	40.66	29.01 – 52.16	40.54
High productivity indicators (%)	0 – 6.09	3.25	0.36 – 15.55	6.42	0.73 – 9.86	6.09
Transported species (%)	1.01 – 15.23	4.95	0 – 5.14	1.02	0 – 2.32	0.38

Cluster assemblage	4 *Valvulineria–Globocassidulina*		5 *Bulimina–Valvulineria*		6 *Valvulineria*	
	range	mean	range	mean	range	mean
P (%)	50.86 – 87.76	66.91	30.81 – 64.57	52.99	52.38 – 64.06	60.1
D1 (m)	398.27 – 960.53	598.35	206.69 – 827.94	592.58	468.69 – 799.27	618.76
D2 (m)	148.2 – 265.80	225.3	195.70 – 273.70	242.7	183.85 – 262.90	227.56
BFOI	26.46 – 47.74	35.88	3.20 – 13.02	9.23	8.00 – 27.43	20.84
Number of species (N)	20 – 33	26	14 – 24	22	20 – 32	26
Fisher α – index (α)	4.994 – 9.575	6.892	3.117 – 6.522	5.539	4.902 – 9.115	7.273
Shannon- Wiener index (H)	2.692 – 3.153	2.8189	2.161 – 2.798	2.5225	2.370 – 2.877	2.5595
Equitability (E)	0.8376 – 0.9037	0.8739	0.7458 – 0.8804	0.8264	0.7415 – 0.8325	0.7875
Dominance (D)	0.0532 – 0.0899	0.0783	0.0746 – 0.1475	0.1094	0.0911 – 0.1713	0.137
Stress indicators (%)	37.36 – 57.77	45.05	51.59 – 81.46	67.13	52.03 – 74.80	62.25
High productivity indicators (%)	0 – 10.31	3.9	5.47 – 18.18	13.36	3.16 – 10.63	5.63
Transported species (%)	0 – 9.69	3.57	0 – 14.18	7.1	0.67 – 11.91	6.07
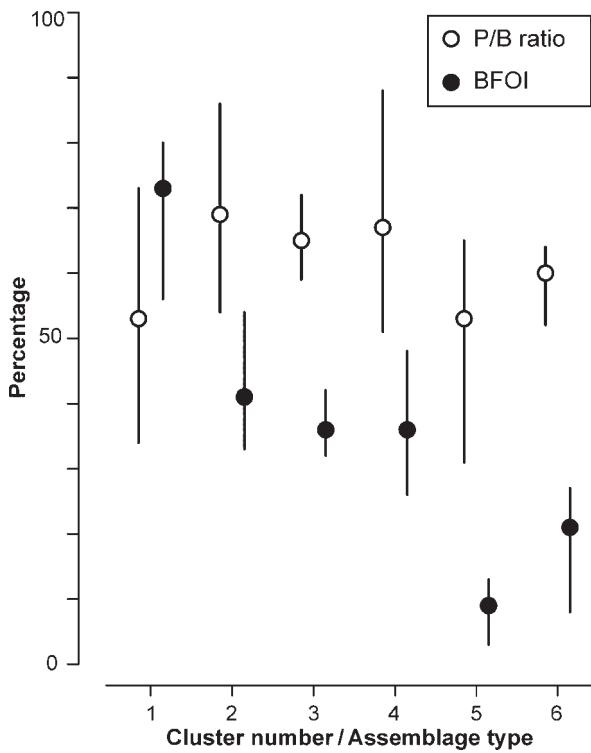
Fig. 9. Diagram showing mean and range of Benthos Foraminiferal Oxygen Index (BFOI) and Plankton/Benthos (P/B) ratio for single clusters. Note the stable P/B ratio and the decreasing trend in BFOI.

doides ungerianus. A moderate planktonic foraminiferal percentage of 60 % and low BFOI of 21 are characteristic of the assemblage. The depositional depth by gradient analysis is 228 m. This assemblage contains 26 benthic foraminiferal species, the Fisher α index is 7, and Shannon-Wiener index is 2.6. It is characterized by the lowest equitability (0.8) and highest dominance (0.14) values. The percentage of stress indicators is high (62 %), whereas the contribution of high primary production indicators is low-moderate 5 %. About 6 % of benthic foraminiferal tests are transported.

Stratigraphic position

Continuous occurrences of the calcareous nannoplankton zonal marker *Sphenolithus heteromorphus* Deflandre, 1953 and the absence of *Helicosphaera ampliaperta* Bramlette & Wilcoxon, 1967 in the middle and the upper part of the section allow the stratigraphical attribution to the nannoplankton Zone NN5 (Martini 1971). The extremely rare presence of *Helicosphaera waltrans* Theodoridis, 1984 in the lowermost samples (UG129 and UG131) of the section points to a stratigraphic position above its Last Common Occurrence (LCO) Datum dated by Di Stefano et al. (2008) at 14.357 Ma. The Last Occurrence (LO) of *S. heteromorphus*, indicates that the NN5/NN6 boundary, astronomically dated to 14.654 Ma by Abels et al. (2005), can be placed between samples UG100 and UG101 in the top of the studied interval (Figs. 3 and 4). The identified benthic foraminifera allow the zonation by the standard Central Paratethys ecozones (Grill 1941; Papp

et al. 1978a; Papp & Schmid 1985; Cicha et al. 1998). The analysed time interval includes two zones: Early Badenian (Moravian) Upper Lagenidae Zone and Middle Badenian (Wielician) *Spirorutilus carinatus* Zone (Figs. 3 and 4).

Within the benthic foraminifera assemblage the species with long stratigraphic ranges prevail, but many of them do not cross the Wielician boundary (Cicha et al. 1998). The Badenian marker species are *Ehrenbergina serrata*, *Pappina parkeri* and *Amphistegina mammila*. Two species: *Uvigerina macrocarinata* and *Vaginulina legumen* are restricted to the Moravian, while *Uvigerina venusta* belongs to the Wielician, and *Bulimina gutsulica* to the Wielician and Kosovian. Based on distribution of later species (Fig. 4) the sample interval from UG129 to UG10 is attributed to the Upper Lagenidae Zone, and the interval from UG74 to UG100 to the *Spirorutilus* Zone. The transitional zone defined between and including sample interval UG12 to UG19 is marked by the co-occurrence of *U. macrocarinata* and *U. venusta*. Its topmost sample (UG19) already documents the first occurrence of *B. gutsulica*. Following such definition the last occurrence of *Vaginulina legumen* recorded in UG148 distinctly precedes the Moravian upper boundary.

Depositional depth inference

The present study investigates depositional depth by combining three different methods. The P/B ratio defines the depositional environment, whereas the modified P/B ratio and gradient analyses, provide the depth inference in meters.

The plankton/benthos ratio is a commonly used indicator of depositional depth as percentage of planktonic foraminifera in the water column usually increases away from the coast toward the open-sea (Grimsdale & Morkhoven 1955; Murray 1991). Applying this principle the percentage of planktonic foraminifera within the fossil assemblage should be directly related to the depositional depth. Yet, many investigations showed that the P/B ratio is not only related to water depth but also to fluctuations of oxygen content at the sea bottom (Sen-Gupta & Machan-Castillo 1993; Jorissen et al. 1995; Jorissen 1999; Kouwenoven et al. 2003; Van Hinsbergen et al. 2005). Hence, the decrease of oxygen content results in increase of organic matter content in the bottom sediment (Gooday et al. 2000). That triggers the abundance decrease of less tolerant species, mostly these with an epifaunal mode of life (De Stigter et al. 1996). The species tolerating the low-oxygen conditions become distinctly more abundant (Jorissen 1999; Duijnstee et al. 2004). For the calculation of paleodepth after modified P/B ratio (corrected portion of plankton) exactly the deep infaunal species are excluded from the equation because under adverse conditions they can dominate the benthic community.

Paleodepth after gradient analysis is estimated on the basis of depth range of recent species of benthic foraminifera. It must be kept in mind that it is not realistic to construct such a scheme of depth zonation that is applicable in all regions of the world. Apparently the main problem is that the depth distribution of species depends largely on the regional frame and specific physical, chemical and biological parameters in each single region. From the theoretical point of view, the maxi-

mum abundance of any species must occur where its optimum environmental conditions are present (Murray 2006). Hence, prior to the paleoenvironmental reconstruction the presence of dominating and common species must be analysed in detail.

The proportion of planktonic foraminifera along the Ugljevik section ranges from 31 to 88 % (Fig. 8). Such P/B ratio range suggests deposition on the middle shelf down to the continental slope (Murray 1991). A similar result, only expressed in meters, is provided by the modified P/B ratio method (131–961 m). Such great depths do not fit with the composition of benthic assemblages, especially in parts of the section comprising shallow water assemblages. The vicinity of the coast-line indicated by calcareous nannoplankton, the sedimentary facies during shallow water phases and the paleogeographical setting make such inference still more improbable. Consequently the paleodepth ranging between 25 and 303 m inferred by the gradient analysis is the most realistic approximation of the original paleodepth.

Disagreement of the paleodepth calculations using modified P/B ratio and the paleodepth analyses from benthic assemblage composition and/or regional geological setting have been pinpointed many times for the Miocene marine deposits of the Central Paratethys (Crihan 2002; Spezzaferri et al. 2002; Hohenegger 2005; Báldi & Hohenegger 2008). The results of the present study confirm previous suggestions that the specific paleoecological conditions in semi-closed basins such is the Paratethys strongly influence the paleodepth estimation. They provide new evidence that much more realistic paleodepth estimations can be obtained by depth range distribution analysis of benthic foraminifera than from P/B ratio or modified P/B ratio methods.

In spite of difference of calculated depths, it is conspicuous that all three curves (Fig. 8) show similar relative deepening and shallowing trends especially in the lower and the middle part of the section. They provide evidence of gradual deepening of the depositional basin followed by the small scale oscillation of the sea level followed finally by the shallowing trend (much better visible from the P/B ratio and the modified P/B ratio). In the upper part of the section, the curves show different trends. The P/B ratio shows slight shallowing whereas the modified P/B ratio points to the beginning of slight deepening but also to a strong decrease of depositional depth for the sample UG84. In contrast, paleodepth based on the gradient analysis remains about the same as previously with only a very slight deepening signal. Such disagreement can be attributed to the prevailing low oxygen bottom conditions in this part of the section.

Paleoenvironmental history

Analysis of quantitative and qualitative data revealed changes in faunal composition in time reflecting fluctuating environmental conditions.

Late Moravian transgression (TST1)

The start of the marine transgression in the Ugljevik section is marked by the moderately diverse *Asterigerinata*-

Cibicidoides assemblage that lived in a highly oxic shallow water environment of the inner shelf at an approximate depth of 35 m. The species characteristic for that environment are *Asterigerinata planorbis* and *Cibicidoides ungerianus*, and the following are also frequent: *Bolivina dilatata* and *Lobatula lobatula*. *A. planorbis* and *L. lobatula* are typical shallow water foraminifera of the inner shelf (Murray 2006; Margreth et al. 2009). Within the assemblage the epifaunal herbivore and passive suspension feeder species prevail and oxic indicators, whereas the values for stress indicators and for high primary production are the lowest within the whole analysed section.

The transgression slowly prograded as indicated by the continuous increase of the planktonic foraminifera portion, decrease of the oxygen content at the sea bottom (medium oxic environment), the percentage increase of infaunal and detritivore benthic foraminifera species within the assemblages. Compared with the previous assemblage the percentage of stress and high primary production indicators are almost doubled. The more or less stable deeper water conditions of the outer shelf ($\approx$210 m) with characteristic *Cibicidoides-Valvulineria* assemblage establish prevailing during the whole Early Badenian interval. Therein the highly diverse assemblage (highest determined values of diversity indicators) is present with weakly developed domination. Apart from the species *Cibicidoides ungerianus*, the following are also common: *Valvulineria complanata*, *Bolivina hebes* and *Bolivina antiqua*. *C. ungerianus* prefers oligotrophic conditions of the middle to outer shelf, high water energy and stable physicochemical conditions (Murray 2006; Jorissen et al. 2007; Margreth et al. 2009). Considering the diversity and composition of this assemblage the environmental conditions can be classified as oligotrophic to mesotrophic with sufficient oxygen content and fair food diversity.

This typical assemblage is temporarily replaced by the *Valvulineria-Lenticulina* assemblage and to a much lesser amount by *Valvulineria–Globocassidulina*, and *Valvulineria* assemblage, depending on oscillation of depth, oxygen content or food quantity and quality. Considering most of the indicators, the *Valvulineria-Lenticulina* assemblage is similar to previous ones, except for slightly decreased oxygen content and increased dominance. Apart from the dominant *Valvulineria complanata*, the species *Lenticulina inornata* is also common implying environmental range from outer shelf to bathyal depths (Murray 2006; Pippér & Reichenbacher 2010). The presence of oxic and epifaunal forms and high diversity in that deep water facies (D2 = 250 m) suggests finally well ventilated bottom water.

The *Valvulineria* assemblage occurs at different positions within the succession and indicates mean depth of $\approx$ 230 m. This moderately diverse assemblage is marked by increased domination of *Valvulineria complanata* (in some samples even more than 30 %), while *Bolivina dilatata*, *Bulimina subulata* and *Cibicidoides ungerianus* are also present. Within that assemblage strong increase in domination and a high percentage of deep infaunal species occurs. That points to environmental conditions of increased stress, originating from a strong decrease of oxygen content at the sea bottom (BFOI = 21), and possibly marking the temporarily enhanced

organic matter input. The *V. bradyana* assemblage can be used as a good marker for eutrophic environments under fluvial influence (Frezza & Carboni 2009). The similar *Valvulineria complanata* assemblage has been found in deltaic regions of the rivers Rhone and Po (Murray 1991). Conclusively, the depositional interval with *Valvulineria* assemblage resulting from enhanced nutrient input could reflect an active river mouth in the vicinity of the studied area.

Moravian-Wielician transition (HST1 to LST2)

Within these deposits the *Valvulineria-Globocassidulina* assemblage prevails. Beside *Valvulineria complanata*, the following are also common: *Globocassidulina oblonga*, *Cassidulina laevigata*, *Bolivina dilatata*, *Bulimina subulata* and *Cibicidoides ungerianus*. Contributions of planktonic foraminifera together with paleodepth are similar to the interval of the previous *Cibicidoides-Valvulineria* assemblage. Further reduction of the oxygen content at the sea bottom is evident, but still moderate oxic conditions prevail. Comparison with the previous assemblage shows an increasing stress indicator, whereas the index of high primary production decreases. Furthermore the strong decrease of the species richness and diversity with slight increase of dominance is indicated. This points to the increase of stress conditions in this depositional environment probably associated with restricted environmental conditions due to gradual regression and upwardly increasing debris inflow from the carbonate platform.

The shallowing trend is very strong in the upper part of these deposits, where gradually ever more frequent intercalations of detritic limestone occur. Samples UG13, UG74 and UG76 comprise the typical shallow water *Asterigerinata-Cibicidoides* assemblage. Such trend is possibly related to the start of the sea-level lowering typical for the *Spirorutilus carinatus* Zone of the Middle Badenian. In Ugljevik the deposition is still in deeper water but in the environment of the outer shelf. Correspondingly, in the Vienna Basin during the Middle Badenian sea-level fall the pelitic successions show common deltaic sand intercalations (Rögl et al. 2008).

Wielician transgression (TST2)

The *Bulimina-Valvulineria* assemblage dominates this interval. The most common species are *Bulimina subulata*, *Bulimina elongata*, *Valvulineria complanata* and *Bolivina dilatata*. Increased depositional depth (≈240 m) and continuous low oxic conditions are implied by that assemblage. It comprises the highest values of stress and high primary production indicators. Significant increase of domination and decrease of benthic assemblage diversity indicate strongly increased stress conditions followed by the change of quality and/or quantity of food. The low oxygen level and evident lamination in the upper part of the section point to the increased organic matter content. *B. elongata* appears commonly offshore, in front of stream outlets where the high content of organic matter reflects the increased nutrient input (Sgarella & Moncharmont Zei 1993; Spezzaferri & Ćorić 2001).

The composition of the benthic assemblage and increased content of transported shallow water species suggests the presence of a nearby stream outlet providing input of nutrients and debris material into the depositional environment. The freshwater influx resulting in stratification of the marine water would go along with the increased sediment lamination within the interval. Yet, the siliciclastic debris-flow is completely missing in the interval showing in contrast abundant and continuous fine-grained material input (distal tempestites) from the carbonate platform, apparently responsible for transported microfossil remains. The presence of stratification can be indeed explained by other mechanisms such are basinal restriction and/or rapid sea level increase, evident for the initial part of this interval.

A plausible alternative mechanism is put forward by the presence of diatomites. Hence for the lithologically very similar clay-diatomite succession along the steep escarpment of the Bohemian Massif in the North Alpine Foreland Basin local upwelling conditions have been inferred based on geochemical and micropaleontological multiproxy evidence (Grunert et al. 2010). Considering the inferred depth, the vicinity of the coast-line suggested by the calcareous nannoplankton compositions and paleogeographical setting, the presence of a steep escarpment is also a reliable setting interpretation for the studied section. The presumed upward transport of the cold nutrient-rich bottom-water responsible for benthic foraminifera compositions and diatomite blooms should be proved by additional proxy measurements.

In the Ugljevik section an apparent upsection trend is present toward the decrease of oxygen content at the sea bottom and benthic assemblage diversity, and increased trend for stress indicators and domination. The recorded primary production indicators values (<18 %) imply strongly decreased primary production during the Badenian and especially during the Early Badenian. Thus the order and composition of assemblages must have resulted from deepening of the basin associated with marine transgression, followed by subsequent sea-level oscillation phase, shallowing and finally the input of organic matter and nutrients into the depositional system.

Comparison with other localities

Deposits of the Upper Lagenidae Zone in the region of Ugljevik can be compared with the synchronous deposits of Badenian stratotype at Baden-Sooss in the Vienna Basin (E Austria) (Hohenegger & Wagreich 2012). Wagreich et al. (2008) interpreted the latter deposits as originating from a quiet offshore depositional environment at depths below the fair weather wave base. The enhanced bioturbation points typically to oxic bottom conditions. They were only occasionally interrupted as indicated by a few intervals of primary lamination bounded to disoxic conditions. Going upward, a slight increase of sand intercalations occurs pointing to a shallowing trend or enhanced sand transport. Beyond that, we find a conglomerate debris flow bed interpreted as a submarine mass flow. The cyclic sedimentation results mainly from differences in strength of the siliciclastic input. Organic matter is likely of terrigenous origin.

We infer a similar depositional environment for the lower part of the Ugljevik section. After initial transgression, the

more or less stable deep water environment established with an approximate depth of 200 m. Only minor oscillations of depositional depth and input of organic matter from the land were present. The shallowing is evident within the transitional deposits of the Upper Lagenidae to *Spirorutilus* Zone, accompanied by gradually ever more intensive intercalation of calcarenite before the carbonate platform depositional environment established at about 30 to 50 m sea depth. In the Vienna Basin that phase is represented by marginal environments of the Badenian Leitha limestone (Strauss et al. 2006).

The results of benthic assemblage analysis correlate well with environmental change at the regional level of the Central Paratethys for the investigated time interval. Hence we recorded during Early Badenian the anti-estuarine circulation pattern present without or with weak pronounced stratification of the water column. A well ventilated sea bottom results in high diversity of benthic foraminifera assemblages (Báldi 2006; Kováč et al. 2007). In contrast, during the Middle Badenian, stress conditions developed at the sea bottom associated with increase of food quantity and decrease of the oxygen content (Báldi 2006; Holcová & Zágoršek 2008; Kováčová et al. 2009).

The precise age inference for marine transgression in the region of Ugljevik provides evidence on the late Early Badenian initial transgression on the southern margin of the Pannonian Basin. We consider this event synchronous with the initial marine flooding of the Tuzla Basin according to new biostratigraphic results by Vrabac et al. (2011) and the close lateral distance to our investigation area (≈ 25 km SW). Hence the later authors not only confirmed the marine origin of the massive salt-bearing deposits in that basin (see Čičić & Jovanović 1987 for opposite opinion), but also provided evidence on the Badenian age for the underlying marine series. The salt deposition subsequent to initial flooding (TST) can be related to HST–LST phase triggering the basin restriction. The Ugljevik section demonstrates the presence of such a phase culminating in the Middle Badenian with the establishment of long-lasting carbonate-platform shallow-water conditions.

The Badenian (Wielician) Salinity Crisis (BSC) represents one of the major paleoenvironmental events in the Central Paratethys (Harzhauser & Piller 2007). Particularly in the Carpathian Foredeep vast evaporite deposits (Bąbel 2004, 2005) developed as a result of a major regional sea-level fall in the Middle Badenian (Kováč et al. 2007). The intercalated marls in the evaporites bear a conspicuously similar benthic foraminiferal assemblage (Bukowski et al. 2010) to our *Bulimina-Valvulineria* cluster in the uppermost part of the section Prokoš/Bogutovo Selo. De Leeuw et al. (2010, 2012b) recently confirmed the causal relationship of the BSC onset and the glacial event Mi-3b, resulting in significant drop in global sea level (≈ 40–50 m), astronomically dated to 13.82 Ma (Abels et al. 2005). The data from benthic foraminifera inferred an even stronger sea-level drop in the studied region that could, however, be a methodological artefact as discussed previously in the text. Furthermore, the abundant hermatypic corals during the LST deposition are a conspicuous phenomenon correlating not only with the latter short-term glacial event, but also with the long-term global cooling trend of the Middle Miocene Climate Transition (Holbourn et al. 2007; Mourik et al. 2011).

The stratigraphic position of the sequence boundary (LST2 base) in the studied section defined ≈ 35 m below the NN5/6 boundary, correlates well with its position in the Mediterranean sections (Hilgen et al. 2009). There, the 3rd order sequence boundary Ser1 coinciding with the Serravallian lower boundary precedes the later event by ≈ 170 kyr. Furthermore, the late start of the HST coinciding there with the NN6 onset also seems to correlate with the Ugljevik record. Hence, future sequence stratigraphic studies both from the Mediterranean and from the Central Paratethys should investigate in more detail their apparent causality.

Conclusions

The marine transgression in the late Moravian Upper Lagenidae Zone (late nannoplankton Zone NN5) starts with the moderately diverse *Asterigerinata-Cibicidoides* assemblage that lived in the highly oxic environment of the inner shelf. Ongoing transgression is indicated by the gradual increase in contributions of planktonic foraminifera, deep infaunal and opportunistic species of benthic foraminifera and decrease in oxygen content at the sea bottom. Very soon, the stable, moderately oxic conditions of the outer shelf became established, characterized by the species rich *Cibicidoides–Valvulineria* and *Valvulineria-Lenticulina* assemblages, without enhanced dominances. Upsection small scale oscillations of oxygen and/or nutrient content and quality are reflected by alternation of *Valvulineria-Globocassidulina* and *Valvulineria* assemblages. Such assemblage composition points to temporary input of organic matter in that region presumably by active rivers and streams.

The *Valvulineria-Globocassidulina* assemblage interval shows slight decrease of oxygen content at the sea bottom, and strong decrease of the diversity with increase of domination and environmental stress indicators. Such increased stress conditions coincide with the long-term regressive conditions of the HST and gradual upward shallowing. Hence the *Asterigerinata-Cibicidoides* assemblage below and above the massive carbonate body point to a sea-level difference of up to 200 m between the carbonate platform conditions in the middle part of the section and the maximal recorded depositional depths below and beyond that interval.

In the upper part of the section, lamination and almost continuous low oxic conditions occur pointing to enhanced input of the organic matter into the sea bottom. Beyond that the striking increase of dominance and the decrease of benthic community species richness point to alternating environmental conditions. Indicators of such conditions — the *Bulimina-Valvulineria* assemblage — characterize that interval. The composition of benthic assemblage together with increased content of transported, shallow water species could point to input from the land by the river inflow resulting in a stratified water column. The absent siliciclastic input in the section makes this scenario improbable putting forward the alternative mechanisms such are rapid transgression, restrictive basin conditions, or local upwelling conditions, although these were never previously suggested for the southern Central Paratethys domain.

The strongest influences on the composition and distribution of benthic foraminifera assemblages were the deepening of the depositional settings as a result of the initial Badenian transgression, followed by the oscillations of depositional depth and temporary input of terrigenous matter triggering the decrease of oxygen content at the sea bottom. During the Early Badenian the bottom water was well ventilated, whereas in the Middle Badenian, stress and low oxic conditions prevailed except during the interval of sea-level fall and the carbonate production event.

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UG-	Height (m)	SUM	Spirorutilus carinatus (D'ORBIGNY)	Martinotiella communis (D'ORBIGNY)	Semivulvulina pectinata (REUSS)	Textularia sp.	Sigmoilinita tenuis (CZJZEK)	Quinqueloculina buchiana	Quinqueloculina sp.	Grigelis pyrula D'ORBIGNY	Pseudonodosaria brevis D'ORBIGNY	Laevidentalina boueana D'ORBIGNY	Laevidentalina elegans D'ORBIGNY	Frondicularia sp.	Amphimorphina haueriana NEUGEBOREN	Plectofrondicularia digitalis (NEUGEBOREN)	Lenticulina calcar (LINNÉ)	Lenticulina inornata (D'ORBIGNY)	Lenticulina vortex (FICHTEL & MOLL)	Lenticulina sp.	Amphycoryna badenensis (D'ORBIGNY)	Saracenaria arcuata (D'ORBIGNY)	Marginulina hirsuta (D'ORBIGNY)	Vaginulinopsis pedum D'ORBIGNY	Vaginulina legumen (LINNÉ)	Hyalinonetrion clavatum D'ORBIGNY	Oolina sp.	Lagena striata (D'ORBIGNY)	Lagena sp.	Favulina hexagona (WILLIAMSON)	Glandulina ovula D'ORBIGNY	Fissurina sp.	Ceratocancris haueri (D'ORBIGNY)	Hoeglundina elegans (D'ORBIGNY)	Bolivina antiqua D'ORBIGNY	Bolivina dilatata REUSS	Bolivina hebes (MACFADYEN)	Bolivina plicatella (CUSHMAN)	Bolivina pokornyi CICHA & ZAPLETALOVA	Bolivina viennensis (MARKS)	Cassidulina laevigata D'ORBIGNY	Globocassidulina oblonga (REUSS)	Ehrenbergina serrata REUSS	Bulimina buchiana D'ORBIGNY	Bulimina elongata D'ORBIGNY	Bulimina gutsulica LIVENTAL	Bulimina subulata (CUSHMAN & PARKER)
100	63.43	283.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	2.5	12.4	0.0	0.0	0.0	0.0	12.0	1.1	0.0	0.0	5.7	0.0	21.2
90	56.04	281.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	8.5	0.0	3.9	1.1	0.0	5.0	1.1	0.0	0.0	8.5	3.2	9.6
86	50.74	304.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	1.3	3.9	0.0	4.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	2.0	9.8	0.0	0.0	1.3	0.0	6.2	3.0	0.0	0.0	18.0	0.0	13.1
84	48.24	294.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.8	0.0	0.3	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	2.4	7.5	0.0	1.7	0.0	0.0	11.2	2.7	0.0	0.0	18.7	0.0	8.8
82	46.69	279.50	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	3.2	0.0	1.1	0.0	0.9	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.4	5.4	7.2	0.0	1.8	0.0	0.0	10.0	4.3	0.0	0.0	7.5	0.0	7.2
79	45.00	277.00	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.7	0.0	0.0	1.1	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.0	1.8	0.0	0.0	1.8	0.0	0.0	2.2	2.9	0.0	0.0	3.2	2.9	11.9
78	44.10	303.00	0.0	0.0	0.7	0.0	0.3	0.0	0.0	0.0	1.2	0.0	0.0	0.0	1.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.0	5.0	0.0	0.7	0.0	0.0	1.0	0.0	0.0	0.0	14.2	0.0	29.0
77	42.90	279.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	1.4	9.3	0.0	3.2	0.0	0.0	3.6	1.1	0.0	0.0	6.1	1.4	8.9
76	42.40	286.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	5.2	0.0	0.0	0.7	0.0	0.0	2.1	5.6	0.0	0.0	1.0	0.0	2.1
74	27.43	298.00	1.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	8.7	0.0	0.0	0.7	0.0	0.0	2.7	0.7	0.0	0.0	1.0	0.7	0.7
19	27.08	277.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1.1	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	4.3	5.4	0.0	0.0	1.8	0.0	0.0	2.9	5.8	0.0	1.4	3.2	6.5	13.4
16	25.73	273.50	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7	5.9	0.0	0.0	3.3	0.0	0.0	2.6	7.7	0.0	0.0	6.2	0.0	9.1
72	25.63	298.00	2.0	0.1	0.7	0.0	0.7	0.0	0.0	0.0	4.4	2.4	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	2.7	0.0	5.7	4.7	0.0	1.7	0.0	0.0	1.3	7.7	0.0	1.0	2.3	0.0	6.0
15	25.43	289.00	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	6.6	8.0	0.0	1.4	0.0	0.0	4.8	11.1	0.0	1.0	1.4	0.0	8.0
13	24.37	302.00	0.0	1.2	2.6	0.0	0.0	0.0	2.3	0.0	0.0	0.7	0.0	0.7	0.0	0.2	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	1.3	3.0	7.0	2.6	0.0	0.3	0.0	0.0	3.6	3.3	0.0	0.7	1.3	0.0	3.3
12	24.08	295.00	1.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	2.0	0.0	0.3	0.0	0.0	1.4	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.8	8.1	3.1	0.0	0.7	0.0	0.0	12.9	7.1	0.0	0.7	1.7	0.0	7.1
10	23.09	289.00	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4	5.2	1.4	0.0	0.7	0.0	0.0	12.1	7.3	0.0	0.0	3.1	0.0	8.7
7	21.42	292.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	8.6	15.4	0.0	0.0	1.7	0.0	0.0	4.5	9.2	0.0	0.0	0.0	0.0	4.1
6	20.74	304.25	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.5	0.0	0.0	1.0	0.0	3.7	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	6.6	10.5	0.0	2.6	0.0	0.0	4.3	16.1	0.0	0.3	3.9	0.0	4.1
5	19.83	293.00	2.7	0.0	1.0	0.0	1.7	0.0	1.0	0.7	0.0	0.0	0.7	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	2.4	6.5	2.7	2.4	0.0	0.0	0.0	0.0	12.3	9.2	0.0	0.0	1.0	0.0	4.4
4	19.18	282.00	0.0	3.4	3.2	0.0	2.1	0.0	0.0	0.0	1.1	0.0	1.8	0.0	0.3	1.1	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	3.2	3.9	8.2	2.1	0.0	0.0	0.0	10.6	4.3	0.0	0.0	1.1	0.0	1.1
3	18.53	292.00	0.0	0.0	3.1	0.0	2.7	0.0	0.0	0.5	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	2.7	6.8	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	3.8	4.8	3.8	3.1	0.0	3.1	0.0	0.0	5.1	4.8	0.0	1.4	2.7	0.0	8.2
149	17.93	269.00	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	11.5	0.0	0.0	1.5	0.0	0.0	2.2	0.7	0.0	1.9	1.5	0.0	5.6
1	17.23	294.50	0.0	0.2	2.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.8	9.2	1.4	9.2	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	4.1	0.7	0.0	1.5	0.0	0.0	8.8	3.1	0.0	4.1	3.1	0.0	9.5
148	17.18	284.75	0.0	2.6	2.1	0.0	0.7	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	2.1	4.9	1.4	0.0	0.0	0.4	2.1	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	3.2	6.0	2.1	6.3	3.5	1.4	0.0	3.9	2.1	0.0	1.8	1.1	0.0	8.4
147	16.43	272.75	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.0	1.5	0.0	3.5	0.4	2.2	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.7	1.8	9.9	5.1	0.0	1.1	0.0	8.4	2.2	0.0	1.1	1.8	0.0	5.2
146	16.14	306.00	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	1.3	0.0	1.6	0.0	0.2	0.0	3.6	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	2.9	0.0	6.9	0.3	6.5	0.0	0.0	0.0	2.3	2.0	0.0	0.9	3.4	0.0	6.2
145	15.74	319.50	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.6	0.0	1.9	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	3.1	1.6	4.7	2.5	2.8	1.6	1.3	0.0	6.9	3.4	0.0	1.6	2.2	0.0	5.3
144	14.64	301.00	1.5	1.0	0.7	0.0	1.0	0.0	1.3	1.8	1.7	0.0	1.0	0.0	5.1	1.7	1.0	7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	3.1	0.0	4.7	1.0	2.3	4.3	3.0	2.3	0.0	3.4	0.0	1.6	2.2	0.0	4.3
143	14.24	278.00	0.0	0.4	0.0	0.0	1.8	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.4	0.7	9.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	10.1	2.2	1.1	7.2	0.0	0.0	0.0	9.4	5.0	0.0	0.4	1.1	0.0	6.8
142	12.74	280.75	2.5	1.1	0.0	0.0	1.1	0.0	0.0	0.0	2.8	0.0	3.7	0.0	0.0	1.6	2.1	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.4	0.0	0.0	2.1	0.7	7.8	4.3	8.2	1.4	4.6	3.2	4.3	3.6	0.0	0.7	0.7	0.0	1.1
141	12.04	297.50	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.3	0.0	1.0	6.7	2.4	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	2.0	7.7	1.3	3.0	7.4	3.4	5.7	5.4	0.0	0.7	1.0	0.0	1.1
140	11.74	285.25	0.0	0.7	0.0	0.4	0.7	0.0	0.0	0.0	3.9	0.0	1.1	0.0	0.7	7.9	0.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	3.9	3.2	3.5	4.2	1.1	3.5	3.2	0.0	1.8	3.5	0.0	1.1
139	11.44	310.00	1.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.3	0.0	1.3	1.6	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	4.8	3.5	0.0	5.5	2.3	5.5	7.7	0.0	1.3	0.0	0.0	1.1
138	10.94	292.75	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.7	0.0	0.3	0.0	0.1	0.0	6.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	4.4	5.1	4.1	3.1	5.5	1.7	4.1	2.7	0.0	4.1	0.0	2.4	0.0	0.0	6.8
137	9.84	301.50	0.7	0.0	0.0	0.0	2.7	0.0	0.0	0.0	1.3	0.0	0.2	0.0	1.7	1.3	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	6.6	7.3	2.0	0.0	5.3	3.3	8.0	7.0	0.0	1.3	0.0	5.0	0.0	0.0	6.8
136	8.84	281.00	0.2	1.1	0.7	0.0	1.8	0.0	0.0	0.0	1.2	0.0	0.4	0.0	1.1	1.8	10.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	6.6	5.7	11.0	0.7	3.2	0.7	4.0	0.7	2.8	1.1	0.0	1.1	3.9	0.0	7.5
135	7.94	270.50	1.1	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.7	0.0	0.6	0.0	0.0	1.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	5.5	8.5	0.0	5.9	1.5	0.0	0.0	5.2	0.0	0.0	1.8	1.1	0.0	1.1
134	6.99	287.50	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.3	0.0	0.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	4.5	8.0	4.5	3.8	0.7	0.0	2.4	14.6	8.7	0.0	0.0	1.4	4.2	0.0	4.2
133	6.49	292.00	1.4	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	4.8	4.5	0.7	0.7	1.4	3.1	8.9	6.5	0.3	0.3	0.0	0.0	6.5	0.0	6.2
132	4.39	306.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	6.2	5.6	1.6	0.0	4.9	5.9	2.9	0.0	2.0	0.0	0.0	6.5	0.0	6.2
131	1.49	305.50	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.9	0.0	0.5	0.0	0.0	0.0	0.0	2.6	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	3.9	8.5	6.2	1.6	0.0	4.9	4.3	2.3	0.0	2.3	4.6	0.0	6.2
130	0.74	288.25	0.0	0.0	0.3	0.0	3.5	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	1.0	1.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	4.2	10.4	2.1	0.0	1.7	0.7	3.1	0.0	0.0	0.0	2.4	1.0	3.1
129	0.19	284.00	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	1.8	5.3	1.4	0.0	0.0	0.0	4.9	0.7	0.0	3.1	0.0	0.0	3.9

UG-	Height (m)	Praeglobobulimina pyrula (D'ORBIGNY)	Pappina parkeri (KARRER)	Uvigerina aculeata (D'ORBIGNY)	Uvigerina grilli PAPP & SCHMID	Uvigerina macrocarinata PAPP & TURNOVSKY	Uvigerina pygmoides PAPP & TURNOVSKY	Uvigerina semiornata D'ORBIGNY	Uvigerina venusta FRANZENAU	Angulogerina angulosa (WILLIAMSON)	Trifarina brady (CUSHMAN)	Coryphostoma digitalis (D'ORBIGNY)	Reusella spinulosa (REUSS)	Fursenkoina acuta (D'ORBIGNY)	Sigmavirgulina tortuosa (BRADY)	Orthomorphina sp.	Neugeborina longiscata (D'ORBIGNY)	Siphonodosaria consobrina (D'ORBIGNY)	Stilostomella adolphina (D'ORBIGNY)	Valvulineria complanata (D'ORBIGNY)	Rosalina obtusa D'ORBIGNY	Eponides repandus (FICHTEL & MOLL)	Sphaeroidina bulloides D'ORBIGNY	Siphonina reticulata (CZJZEK)	Cibicidoides ungerianus (D'ORBIGNY)	Cibicidoides sp.	Hanzawaia boueana (D'ORBIGNY)	Lobatula lobatula (WALKER & JACOB)	Asterigerinata planorbis (D'ORBIGNY)	Amphistegina mammilla (FICHTEL & MOLL)	Nonionella turgida (WILLIAMSON)	Nonion commune (D'ORBIGNY)	Melonis pompilioides (FICHTEL & MOLL)	Pullenia bulloides (D'ORBIGNY)	Chilostomella ovoidea REUSS	Oridorsalis umbonatus (REUSS)	Heterolepa dutemplei D'ORBIGNY	Hansenisca soldanii D'ORBIGNY	Ammonia beccarii (LINNÉ)	Pararotalia sp.	Elphidium fichtellianum (D'ORBIGNY)	Elphidium rugosum (D'ORBIGNY)
100	63.43	9.9	0.0	0.0	0.0	0.0	0.0	0.7	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.1	0.0	0.0	0.0	0.0	4.2	1.1	0.0	1.1	1.1	0.0	0.0	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
90	56.04	8.2	0.0	0.0	0.7	0.0	0.0	0.4	6.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	17.0	0.0	0.0	0.0	0.0	5.0	0.7	0.0	0.0	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6
86	50.74	1.3	0.0	0.0	0.0	0.0	0.0	1.0	8.2	0.0	0.0	0.0	0.0	2.6	0.0	0.0	8.5	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.7	0.3	0.0	0.0	2.0	0.0	0.0	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
84	48.24	1.0	8.5	0.0	0.0	0.0	0.0	0.7	3.1	0.0	1.4	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0	0.0	0.0	1.4	0.7	0.0	0.7	12.2	0.0	0.0	3.4	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.7
82	46.69	0.0	9.7	0.0	0.0	0.0	0.0	1.8	7.5	0.0	1.1	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	10.4	0.0	0.0	0.0	0.0	1.8	0.7	0.0	1.8	7.5	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.4
79	45.00	1.4	0.7	0.0	0.0	0.0	0.4	0.7	1.4	0.0	1.1	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	31.0	0.0	0.0	0.0	0.0	9.4	1.8	2.2	1.1	3.2	4.3	0.0	1.4	0.7	1.1	0.0	0.0	2.5	0.0	0.0	0.0	1.1	0.0
78	44.10	6.3	3.3	0.0	0.0	0.0	1.0	4.6	5.6	0.0	0.0	0.0	0.0	1.7	0.7	0.0	0.0	0.0	0.0	16.5	0.0	0.0	0.0	0.0	1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
77	42.90	0.0	0.0	0.0	2.9	0.0	0.7	2.9	3.2	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	33.6	0.0	0.0	0.0	0.0	3.9	0.7	1.8	0.4	6.4	0.0	0.0	1.4	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
76	42.40	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.3	1.7	2.6	2.4	0.0	0.0	0.0	0.0	4.5	2.8	0.0	0.0	0.0	10.5	2.8	0.0	4.5	22.3	7.3	0.0	2.8	3.8	0.7	0.0	0.0	4.9	0.0	0.0	0.7	0.0	3.5
74	27.43	0.0	0.3	0.0	0.0	0.0	0.3	0.0	1.7	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	9.1	2.0	0.0	0.0	0.0	20.1	2.7	4.7	2.7	17.4	10.1	0.0	1.0	0.3	0.0	0.0	0.0	5.4	1.0	0.0	0.0	0.3	1.7
19	27.08	1.4	2.9	0.0	0.0	0.4	0.0	0.0	0.4	1.1	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.6	0.0	0.0	0.0	0.0	7.9	3.2	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	4.3	0.0	0.0	0.0	1.4
16	25.73	0.0	3.7	0.0	0.0	2.9	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	8.4	0.0	3.3	0.0	0.0	2.9	0.7	1.5	1.1	4.8	0.0	0.0	0.0	2.2	0.0	0.0	0.0	4.4	5.5	0.0	0.0	0.0	0.7
72	25.63	0.0	0.7	0.0	0.0	1.3	0.0	0.0	8.7	0.0	3.4	0.0	0.0	0.0	0.0	0.0	3.2	0.0	5.5	9.4	0.0	0.0	0.0	2.0	4.7	1.3	0.7	0.7	0.3	0.0	0.0	0.0	1.0	0.0	0.0	0.0	5.0	5.7	0.0	0.0	0.0	0.0
15	25.43	1.4	0.7	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	17.0	0.0	0.0	0.0	0.0	4.8	1.4	2.8	1.0	5.9	0.0	0.0	1.7	0.0	0.0	0.0	0.0	2.8	8.3	0.0	0.0	0.0	0.0
13	24.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	2.3	0.0	0.0	0.0	0.0	0.0	3.7	0.2	0.0	5.3	0.0	0.0	1.3	0.0	8.9	2.3	0.7	4.6	10.6	2.3	1.0	0.0	2.3	1.3	0.0	0.0	7.3	3.3	0.0	0.0	0.0	3.3
12	24.08	0.3	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6	0.0	0.0	0.0	0.0	9.8	2.4	1.4	1.0	3.7	0.0	0.0	1.7	1.4	1.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
10	23.09	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.7	0.0	0.0	1.7	0.7	0.0	14.9	0.0	0.0	0.0	0.0	6.6	2.4	0.0	0.0	1.4	0.0	0.0	5.2	0.0	0.7	0.0	0.0	4.5	2.1	0.0	0.0	0.0	0.0
7	21.42	0.0	0.0	0.0	1.0	2.1	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	25.7	0.0	0.0	0.0	0.0	4.8	2.1	0.7	0.0	1.7	0.0	0.0	1.0	0.0	2.1	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0
6	20.74	1.3	7.2	0.0	0.0	0.0	0.0	0.0	1.0	0.7	0.0	0.0	6.6	0.0	0.0	0.0	0.0	0.0	0.0	7.9	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	0.0	0.0	0.0
5	19.83	2.7	0.0	1.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	17.4	0.0	0.0	0.0	0.0	5.1	2.0	0.0	0.0	1.0	0.0	0.0	0.3	7.2	0.0	1.4	0.0	0.0	2.4	4.8	0.0	0.0	0.0
4	19.18	1.8	0.0	0.0	0.0	0.7	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	2.5	0.7	7.4	0.0	0.0	0.0	2.1	9.6	2.8	0.0	0.0	0.4	0.0	0.7	1.1	0.0	0.0	0.0	5.3	7.8	0.0	0.0	0.0	0.0	0.0
3	18.53	2.4	0.0	0.0	0.0	1.0	0.0	0.3	0.0	1.4	1.7	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	8.9	0.0	0.0	0.0	0.0	7.2	2.7	0.0	0.0	1.0	1.4	0.0	2.4	0.0	0.0	1.0	3.4	4.8	0.0	0.0	0.0	0.0	0.0
149	17.93	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.3	0.0	0.0	0.0	0.0	9.7	2.6	0.0	0.0	0.0	0.0	0.0	5.9	0.0	1.9	0.0	0.0	5.9	3.7	0.0	0.0	0.0	0.0
1	17.23	0.0	0.0	0.0	0.0	2.7	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.3	0.0	7.8	0.0	0.0	0.0	0.0	5.4	1.4	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	6.5	5.4	0.0	0.0	0.0	0.0
148	17.18	4.6	0.4	0.0	0.7	5.3	0.0	4.6	0.0	1.8	0.7	0.0	0.7	0.0	0.0	0.0	0.4	0.0	0.4	3.9	0.0	0.4	1.1	0.0	4.9	1.1	0.0	0.0	0.4	0.0	0.0	0.0	0.4	0.7	0.0	0.0	6.7	1.8	0.0	0.0	0.0	0.0
147	16.43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.0	20.2	0.0	0.0	0.0	0.0	5.5	2.6	0.0	0.0	0.7	3.4	0.0	0.0	1.5	0.0	1.1	0.0	3.7	5.1	0.0	0.0	0.0	0.0
146	16.14	1.6	0.7	0.0	3.3	4.2	1.0	3.6	0.0	1.6	0.0	0.0	0.7	0.0	0.0	0.0	1.8	0.8	0.0	3.9	0.0	0.0	0.0	0.0	7.5	2.3	0.0	0.3	1.3	0.0	0.0	3.6	0.0	2.3	0.0	0.0	6.5	2.9	0.0	0.0	0.0	0.0
145	15.74	0.9	0.0	1.3	0.0	2.5	0.0	5.0	0.0	5.0	2.5	0.0	0.0	1.3	0.0	0.0	0.6	0.2	0.3	19.4	0.0	0.0	0.0	0.0	4.7	1.6	0.0	0.0	0.0	0.0	0.0	3.6	1.6	0.9	0.0	0.0	5.0	3.1	0.0	0.0	0.0	0.0
144	14.64	0.3	1.0	0.0	0.0	1.7	0.3	3.7	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.3	1.0	14.3	0.0	0.0	0.0	0.0	8.6	0.7	0.3	1.7	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	5.0	3.7	0.0	0.0	0.0	0.0
143	14.24	1.1	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.4	2.2	0.0	19.1	0.0	0.0	0.4	0.0	4.3	1.1	0.0	0.0	0.0	0.0	0.0	1.1	0.4	0.7	0.4	0.0	1.9	1.3	0.0	0.0	0.0	0.0
142	12.74	0.0	0.4	0.0	0.0	0.4	0.0	0.0	0.0	1.4	0.0	0.0	0.4	0.0	0.0	0.0	2.8	0.0	0.2	7.8	0.0	0.0	0.0	0.0	4.6	3.6	0.0	0.0	0.0	0.0	0.0	0.7	1.8	0.0	0.0	0.0	6.4	3.9	0.0	0.0	0.0	0.0
141	12.04	0.0	1.7	0.0	2.7	0.0	0.0	0.7	0.0	5.7	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.7	0.3	23.9	0.0	0.0	0.0	0.0	3.4	0.7	0.0	0.0	0.0	0.0	0.0	1.0	1.7	0.0	0.0	0.0	1.0	1.7	0.0	0.0	0.0	0.0
140	11.74	1.1	0.0	0.0	0.0	1.4	0.0	7.4	0.0	3.2	1.4	0.0	0.0	1.4	0.0	0.0	3.2	4.7	3.4	8.8	0.0	0.0	0.0	0.0	4.6	0.7	0.0	0.0	0.4	0.0	0.0	1.1	0.0	0.0	0.0	0.4	1.4	5.3	0.0	0.0	0.0	0.0
139	11.44	0.0	0.0	0.6	0.0	0.3	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.6	0.0	0.0	0.0	0.0	6.8	1.9	0.0	0.0	0.0	0.0	0.0	1.3	2.6	1.0	0.0	0.0	6.5	4.8	0.0	0.0	0.0	0.0
138	10.94	1.4	1.7	0.0	0.0	0.3	0.0	1.4	0.0	1.7	0.0	0.0	0.0	2.7	0.0	0.0	0.6	1.7	0.2	9.2	0.0	0.0	0.0	0.0	7.5	2.7	0.0	1.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	4.1	6.1	0.0	0.0	0.0	0.0
137	9.84	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	3.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	1.0	0.0	0.0	0.0	1.3	0.0	0.0	0.3	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.3	9.3	0.0	0.0	0.0	0.0	0.7
136	8.84	1.1	0.0	0.4	0.0	0.0	0.4	3.9	0.0	1.4	0.7	0.0	0.0	0.0	0.0	0.0	0.9	2.0	0.0	6.0	0.0	0.0	0.0	0.0	7.1	0.7	0.0	0.0	0.4	0.0	0.0	0.4	1.4	0.0	0.0	0.0	3.9	3.2	0.0	0.0	0.0	0.7
135	7.94	5.5	0.0	0.0	0.0	0.0	0.0	1.1	0.0	4.1	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	9.2	0.0	0.0	0.0	0.0	7.8	1.5	0.0	0.7	1.8	0.0	0.0	4.8	4.4	3.7	0.0	0.0	4.1	4.8	0.0	0.0	0.0	0.0
134	6.99	0.3	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	11.1	2.1	0.0	0.0	0.0	4.2	0.0	2.1	1.7	1.4	0.0	0.0	7.3	2.8	0.0	0.0	0.0	0.3
133	6.49	0.0	0.0	0.3	0.0	0.7	1.2	2.1	0.0	1.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0	2.7	5.8	0.7	0.0	0.7	3.4	0.0	0.0	0.0	6.2	2.7	0.0	0.0	0.0	6.5	4.1	0.0	0.0	0.0	1.0
132	4.39	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.2	9.2	1.6	0.0	3.3	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	4.2	2.0	0.0	0.0	0.0	6.2	3.9	0.0	0.0	0.0	0.7
131	1.49	0.0	0.7	0.0	0.0	0.0	0.0	3.6	0.0	2.9	1.0	0.0	0.0	1.6	0.0	0.0	1.2	0.3	0.0	4.3	2.0	0.0	3.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	1.0	2.6	0.0	0.0	2.9	2.3	0.0	0.0	0.0	1.6
130	0.74	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	5.2	0.0	2.8	1.0	0.0	0.0	0.0	0.3	0.0	0.0	1.4	0.0	0.0	0.0	0.0	11.4	2.8	0.0	6.2	3.8	0.0	0.0	9.0	0.0	6.6	0.0	0.0	1.4	1.4	4.5	0.0	0.0	3.1
129	0.19	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	16.2	4.2	0.0	6.0	5.3	7.7	0.0	0.0	12.3	0.0	2.5	0.0	6.0	0.0	12.3	0.0	0.0	6.7