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Short communication

An updated generic status of *Ammogloborotalia* aff. *subvesicularis* (Hanzlíková) from the Middle Eocene deposits of the Fore-Magura Unit (Polish Outer Carpathians)

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Abstract: The Middle Eocene microfauna of the Fore-Magura Unit contains rich foraminiferal assemblages with numerous trochospiral, agglutinated species originally described as *Trochammina subvesicularis* Hanzlíková. The paper provides a reconsideration of this taxon due to its inconclusive generic status. A new insight into the systematics of trochamminid species is also discussed. A total of 25 samples from Middle Eocene slope marl deposits of the Fore-Magura Unit (from the western part of the Polish Outer Carpathians) were taken for examination. Based on the analysis of 183 specimens recovered from deep-sea mixed foraminiferal assemblages the species is assigned to the genus *Ammogloborotalia* (Zheng & Fu). The Eocene specimens, named under different generic names and in open nomenclature, similar to the description of *Trochammina subvesicularis* Hanzlíková, should be referred to the taxonomic name *Ammogloborotalia* aff. *subvesicularis*. Similar to modern species of *Ammogloborotalia* (Zheng & Fu), their Middle Eocene representatives imply a bathyal water depth and good connection of the flysch-type Fore-Magura zone basin with the World Ocean.

Keywords: agglutinated foraminifera, taxonomy, Eocene, Polish Outer Carpathians, Fore-Magura Unit

Introduction

The most commonly occurring microfossils in the flysch-type sediments that form the Outer Carpathians are agglutinated benthic foraminifera, which are often the only component of the assemblages (e.g., Kaminski & Gradstein 2005). They usually represent deep water agglutinated foraminifera (DWAF) or so-called flysch-type assemblages (Gradstein & Berggren 1981; Kaminski & Gradstein 2005). The trochamminaceans are one of the commonly reported groups of the flysch-type assemblages. They are representatives of both, extinct and recent foraminiferal taxa. In the Outer Carpathians, this group has been the subject of taxonomic identification for years (e.g., Geroch 1966; Olszewska 1984; Bubík 1995; Malata 2017; Waśkowska 2015b). Previously, most of the species were assigned to one genus – *Trochammina* (Parker & Jones). Based on further detailed investigations on morphology, such the type of aperture, character of sutures and shape of the dorsal side, more genera of trochamminids were described, e.g., *Ammoanita* (Seiglie & Baker), *Ammogloborotalia* (Zheng & Fu) and *Insculptarenula* (Loeblich & Tappan). During the biostratigraphic analysis of the samples from the Fore-Magura Unit (F-MU), 183 specimens of one species were considered as a new or rarely reported taxon. It turns out that this species was previously identified as *Trochammina subvesicularis* Hanzlíková (Homola & Hanzlíková 1955), *Insculptarenula* aff. *subvesicularis* (e.g., Gradstein & Kaminski 1997) or *Ammogloborotalia* aff. *subvesicularis* (e.g., Waśkowska 2015a). However, none of the mentioned genera is described in commonly used atlases of the Paleogene foraminifera such as Olszewska et al. (1996) and Kaminski & Gradstein (2005).

The specimens recovered from the Middle Eocene deep-sea mixed foraminiferal assemblages (slope marl and flysch type) of the F-MU, presented in this work, are identified as *Ammogloborotalia* aff. *subvesicularis* (Hanzlíková). In connection with unclear identification of species *Ammogloborotalia* aff. *subvesicularis* the discussion on its taxonomic status is given here.

Geological setting

The F-MU is a narrow, discontinuous belt of strongly tectonized sediments at the front of the Magura Nappe in the western part of the Polish Outer Carpathians (Burtan & Sokołowski 1956; Żelaźniewicz et al. 2011; Baliniak & Malata 2017). The F-MU belongs to the Foremagura group of units traced in separated outcrops or tectonic windows between the Magura and Silesian Nappes (e.g., Żelaźniewicz et al. 2011; Golonka et al. 2019). Sedimentation of the F-MU took place during the Late Cretaceous–Late Eocene stage of the Outer Carpathian Basin evolution while good connection with the World Ocean was present. In that time, the uplifted Silesian

Ridge separated the Magura and Silesian basins. The sedimentation area of the F-MU was located in the middle part of the Carpathian basins most probably on the southern slope elevation of the Silesian Ridge and favoured condensed hemipelagic sedimentation with the sporadic influence of turbiditic deposition (Golonka et al. 2005; Oszczypko & Oszczypko-Clowes 2009; Żelaźniewicz et al. 2011; Cieszkowski et al. 2012; Golonka et al. 2019). The lithostratigraphy of the F-MU is informal, fragmentarily preserved and covers, in general, the late Cretaceous (Turonian)–Oligocene time span (northern zone according to Burtan & Sokołowski 1956). A characteristic feature of the F-MU is the hemipelagic nature of the Paleocene–Eocene deposits. They are represented by marls interfingering with non-calcareous red and green shales. The hemipelagic sedimentation took place at bathyal water depth, on relatively small areas of the entire basin. These condensed and ductile sediments of a small thickness were displaced and tectonically reduced during the Early–Middle Miocene folding and thrusting movements (e.g., Burtan & Sokołowski 1956; Żelaźniewicz et al. 2011; Cieszkowski et al. 2012). Their present-day exposures are rare and structurally complicated. In the area of the western Outer Carpathians, the studied part of the F-MU (known also as the Fore Magura Thrust Sheet) can be traced south-west of Żywiec, west of the Soła River, in the belt from Juraszki, through Cisiec, Kamesznica to Koniaków villages in the west (Fig. 1). It continues onto the area of the Czech Republic in the northern part of Moravia (Hanzlíková et al. 1962; Švábenická et al. 2007). The studied sections (A and B) are located in the Polish part of the F-MU, south of Koniaków (Fig. 1).

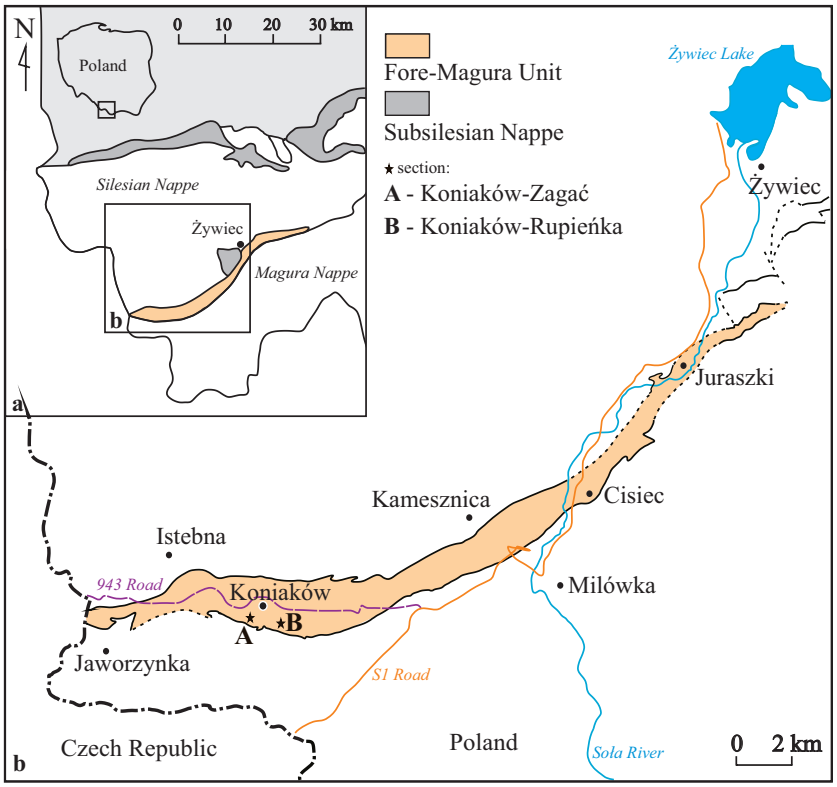

Fig. 1. Location of studied sections in the western part of the Polish Outer Carpathians (after Baliniak 2018).

Material and methods

A total of 25 samples were examined for the purpose of this study, 3 samples of the Koniaków–Zagać section (A) and 22 samples of the Koniaków–Rupieńka section (B). Altogether, 183 specimens of *Ammogloborotalia* aff. *subvesicularis* (Hanzlíková) were identified. The number of specimens varies from a single one up to 36 per sample, 10 specimens on average (Table 1). The samples were collected and treated using the standard micropaleontological procedure. Each sample (200 g) was soaked in a saturated solution of sodium sulphate, repeatedly heated and frozen up to a sufficient fragmentation for extraction of foraminiferal tests. After the disintegration of a rock sample, the clayey material was removed by washing on the sequence of sieves with the smallest mesh size 63 μm. Then, dried material was hand-picked up to around 300 specimens from each sample. Due to the lack of specimens in the smallest fraction (63–125 μm), the >125 μm fraction was examined.

Scanning microscope Hitachi S-4700 and Canon digital camera mounted on a Nikon SMZ1000 stereomicroscope were used for photographic documentation of the specimens.

Taxonomy

Classification of Loeblich & Tappan (1988) is used for generic division, while higher-order systematics is based on Kaminski (2014).

Class Foraminifera d'Orbigny 1826
Subclass Globothalamana Pawłowski, Holzmann & Tyszka 2013
Order Lituolida Lankester 1885
Suborder Trochamminina Saidova 1981
Superfamily Trochamminoidea Schwager 1877
Family Trochamminidae Schwager 1877
Subfamily Trochammininae Schwager 1877
Ammogloborotalia aff. *subvesicularis* (Hanzlíková, 1955)
Fig. 2.1–24

Table 1: Examined samples with their general lithology, total amount of foraminifera and percentage of agglutinated, calcareous benthic, planktonic specimens and *Ammogloborotalia* aff. *subvesicularis*. Lithology: I – grey and green thick-bedded marls; II – green soft marls; III – green and red thick-bedded marls; IV – red and brown thick-bedded marls; V – red and brown medium-bedded marls; VI – green and red soft marls; VII – red soft marls; VIII – red medium-bedded marls; IX – red thick-bedded marls.

section	samples	lithology	total no. of foraminifera	agglutinated (%)	calcareous benthic (%)	planktonic (%)	*Ammogloborotalia* aff. *subvesicularis*	
							no.	%
A	K-Z 11	I	312	28	10	62	2	0.6
	K-Z 12		242	21	6	73	36	14.9
	K-Z 13		243	28	6	66	24	9.9
B	K-R 14	II	276	98	2	0	1	0.4
	K-R 15	III	422	82	9	8	3	0.7
	K-R 18	IV	266	94	6	0	7	2.6
	K-R 19		275	84	11	5	7	2.5
	K-R 20		313	50	33	17	5	1.6
	K-R 21		429	62	22	15	9	2.1
	K-R 22		344	72	13	16	5	1,5
	K-R 23		355	53	26	21	4	1,1
	K-R 24		288	65	14	21	7	2.4
	K-R 25		285	79	13	8	5	1.8
	K-R 26		459	34	18	48	6	1.3
	K-R 27		356	83	12	5	9	2.5
	K-R 28	V	215	88	9	2	9	4.2
	K-R 29		709	52	28	20	19	2.7
	K-R 30	VI	337	73	9	18	9	2.7
	K-R 31	VII	372	43	11	46	3	0.8
	K-R 32		464	33	10	57	3	0.6
	K-R 33		522	31	21	48	2	0.4
	K-R 34	VIII	440	15	4	82	3	0.7
	K-R 35		552	5	2	93	2	0.3
	K-R 37		631	6	4	90	1	0.2
	K-R 38	IX	420	21	21	58	2	0.5
							183	

non *Trochammina subvesicularis* Hanzlíková: Homola & Hanzlíková 1955, p. 402, pl. 7, figs. 1–3
Trochammina subvesicularis Hanzlíková: Gradstein & Berggren 1981, p. 258, pl. 9, figs. 7,8
Trochammina (Insculptarenula) subvesicularis Hanzlíková: Charnock & Jones 1990, pl. 10, figs. 10–12; pl. 22, fig. 3
Trochammina cf. *subvesicularis* Hanzlíková: Gradstein et al. 1994, pl. 1, fig. 5
Insculptarenula aff. *subvesicularis* (Hanzlíková): Gradstein & Kaminski 1997, p. 224, fig. 8
Ammogloborotalia aff. *subvesicularis* (Hanzlíková): Waśkowska 2015a, p. 336, fig. 12, O–P
Insculptarenula aff. *subvesicularis* (Hanzlíková): Waśkowska 2015b, p. 289, fig. 13, J–K

Material: 183 specimens

Description: Test free, trochospiral with two to three whorls. The spiral side is slightly convex, rarely flat. The umbilical side is convex. Each whorl consists of 4⅓–5 chambers. On the umbilical side, chambers are somewhat triangular with distinct, depressed sutures. Chambers increase gradually in size as added and exhibit some irregularity in the shape. Periphery from rounded to more or less sub-acute. On the spiral side, chambers are irregular, elongated in coiling direction, clearly visible in the last whorl; chambers of the previous whorl are barely seen because of the coarse grains that "blur" the sutures.

Elongate, arch-like aperture from the umbilicus area to the max. ⅔ length of the base of the last chamber. The edge of the chamber above the aperture seems to create a lip (?) structure in some specimens. Wall medium to coarsely agglutinated. Average size: 0.35 mm height; 0.30 mm in diameter.

Remarks: This species differs from *Ammogloborotalia quinqueloba* (Geroch) (in Geroch 1959) in its more coarsely agglutinated wall, less elevated umbilical side, more irregularity in chamber shape on the umbilical side and Paleocene–Eocene range of the species.

Foraminiferal record and biostratigraphical age

The examined samples represent mixed assemblages of agglutinated, calcareous benthic and planktonic foraminifera. Agglutinated foraminifera are dominant component in 13 samples (K-R: 14–25, 27, 28, 30); planktonic foraminifera in 7 samples (K-Z: 11–13; K-R: 34–38). In 5 samples the number of both agglutinated and planktonic exceed 100 specimens (K-R: 26, 29, 30–33). The studied samples represent DWAF foraminiferal assemblages of two biofacies: slope marl and flysch type, generally developed above local carbonate compensation depth (CCD) (Kuhnt & Kaminski 1989, 1990; Kuhnt et al. 1989; Kaminski & Gradstein 2005). They are

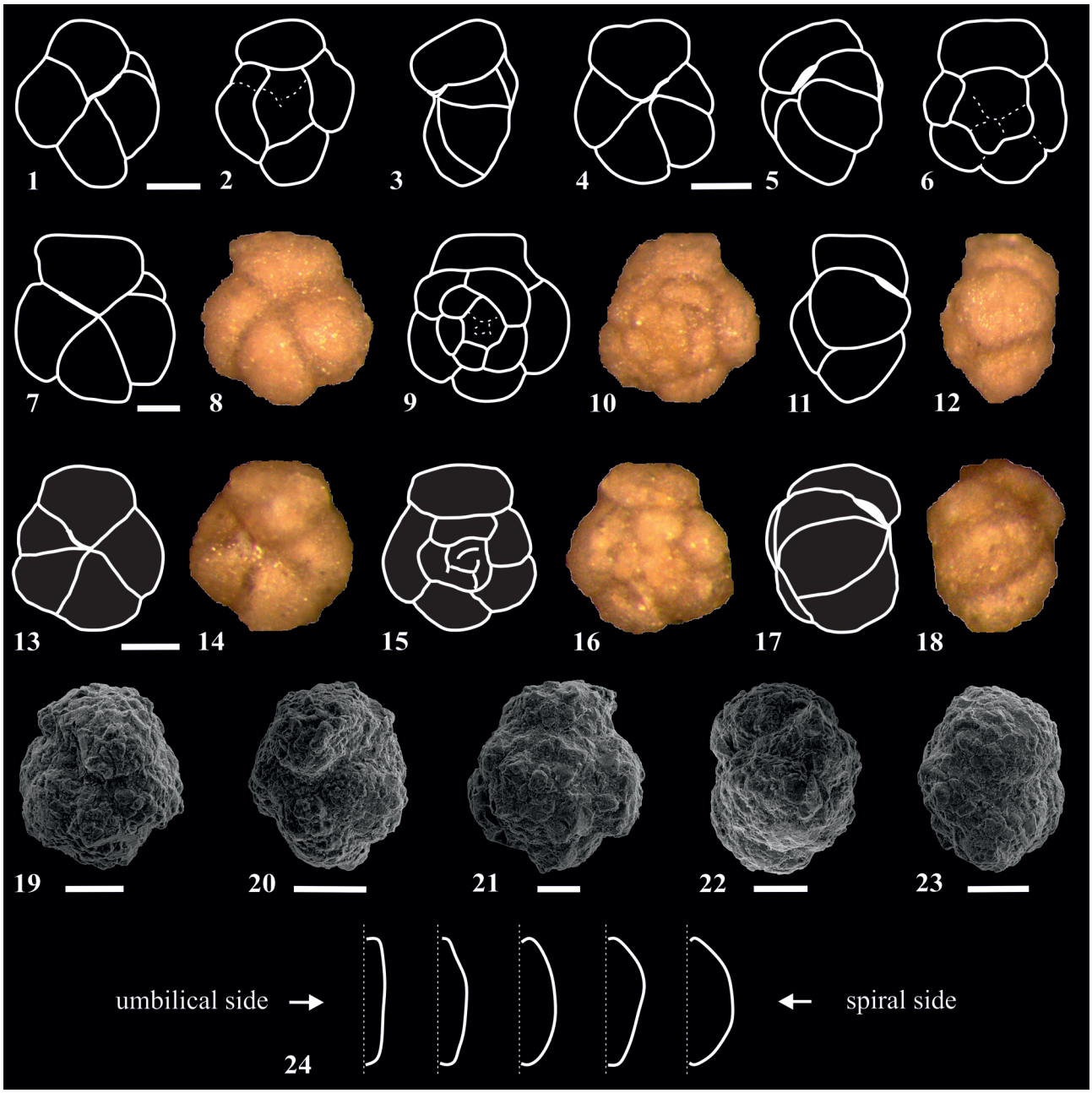

Fig. 2. *Ammogloborotalia* aff. *subvesicularis* (Hanzlíková). Scale bars = 100 µm. **1–3:** Sketch of a specimen from s. K-R 34/19; 1 — umbilical view; 2 — spiral view; 3 — peripheral view; **4–6:** Sketch of a specimen from s. K-Z 11/19; 4 — umbilical view; 5 — peripheral view; 6 — spiral view; **7–12:** specimen from s. K-R 21/19; 7, 8 — umbilical view; 9, 10 — spiral view; 11, 12 — peripheral view; **13–18:** specimen from s. K-R 15/19; 13, 14 — umbilical view; 15, 16 — spiral view; 17, 18 — peripheral view; **19–23:** SEM images of isolated specimens; 19 — umbilical view from s. K-Z 13/19; 20 — umbilical view from s. K-Z 13/19; 21 — spiral view from s. K-R 21/19; 22 — peripheral view on the aperture area from s. K-R 21/19; 23 — peripheral view on the aperture area from s. K-R 26/10; **24** — variability in convex spiral side of studied specimens.

represented by cosmopolitan and long-ranged agglutinated forms, such as *Rhabdammina* div sp., *Ammodiscus* div. sp., *Glomospira* div. sp., *Reophax* div sp., *Haplophragmoides* div sp. or *Spiroplectammina* div sp. Additionally, slope marl biofacies are characterized by greater proportion of planktonic foraminifera and presence of agglutinated species with calcareous cement, e.g., *Vulvulina eocaena*, *Plectina elongata*, *Eggerella propinqua*, *Clavulinoides* div sp. (Baliniak 2018).

Identified planktonic foraminifera species, such as *Subbotina corpulenta, Subbotina senni*, *Acarinina bullbrooki*, *Turborotalia frontosa* and their co-occurrence indicate Middle Eocene age of the assemblages, not younger than E11 zone (Berggren & Pearson 2005). According to *Ammodiscus*

Table 2: Characteristic features of *Trochammina, Ammoanita*, *Ammogloborotalia* and *Insculptarenula* genera. Based on Loeblich & Tappan (1988) and Zheng & Fu (2001).

	Trochammina	***Ammoanita***	***Ammogloborotalia***	***Insculptarenula***
Family	Trochamminidae	Trochamminidae	Trochamminidae	Adercotrymidae
aperture	umbilical-extraumbilical arch with a narrow bordering lip	umbilical-extraumbilical	arched slitlike, near the umbilical end	elongate extraumbilical slit
agglutinated wall	finely agglutinated	finely agglutinated	coarsely agglutinated	finely agglutinated
shape of the spiral side	flat to slightly convex, chambers increasing gradually	convex to highly convex, chambers increasing gradually	flat to slightly convex, chambers increasing gradually	flat to concave, chambers increasing rapidly
sutures	depressed, radial	depressed, slightly arched	depressed, radial	raised, strongly arched

(*Dolgenia*) *latus* and rare *Reticulophragmium amplectens,* the agglutinated index taxa of the zonation by Geroch & Nowak 1984, the age of studied samples is Middle to upper Middle Eocene.

Disscusions

The authors in different publications have changed the genus assignment and an age determination of the species *Trochammina subvesicularis* described originally by Hanzlíková (in: Homola & Hanzlíková 1955). The specimens of similar morphology have been included in *Trochammina (Insculptarenula) subvesicularis* by Charnock & Jones (1990). These authors pointed out the difference from *Trochammina* (*Insculptarenula*) *quinqueloba* Geroch in less elevated umbilical chambers and the similarity in morphology to planktonic *Morozovella conicotruncata* (Subbotina). Gradstein et al. (1994) presented specimens comparable with those from Charnock & Jones (1990) under the taxonomic name *Trochammina* cf. *subvesicularis*. Gradstein & Kaminski (1997) attributed *T. subvesicularis* (from Homola & Hanzlíková 1955) to *Insculptarenula subvesicularis* for the Cretaceous specimens that in their opinion show similarity to *Trochammina quinqueloba* Geroch. The specimens that occurred in the Paleogene sediments of the North Sea, Gradstein & Kaminski (1997) classified in open nomenclature as *Insculptarenula* aff. *Subvesicularis* and pointed out its differences from *Insculptarenula subvesicularis* in its less convex umbilical side with protruded last chamber. In their article, the authors suggest that references and specimens illustrated in Gradstein et al. (1994) should be re-assigned to *Ammoanita ingerlisae* (Gradstein & Kaminski). However, in the synonymic part of the paper Gradstein & Kaminski (1997), the specimens of *Trochammina* (*Insculptarenula subvesicularis* from Charnock & Jones (1990; pl. 10, figs. 10–12) were assigned to both: *Ammoanita ingerlisae* and *Insculptarenula* aff. *subvesicularis*, which proves the difficulties in species determination.

Bubík & Kaminski (1997) pointed out that *Trochammina quinqueloba* Geroch and *Trochammina subvesicularis* sensu Hanzlíková should be regarded as synonymous. *Trochammina subvesicularis* displays a similarity in the morphology of the test with the species *Trochammina quinqueloba* described and defined as Early Cretaceous in age (Geroch 1959). The main difference between these two taxa was their different stratigraphic range. Nevertheless, the type slide of *Trochammina subvesiculris* contained Albian–Cenomanian assemblage with *Plectorecurvoides alternans*, *P. irregularis*, *Thalmannammina neocomiensis*, *Gaudryina oblonga*, *Bulbobaculites problematicus*. Sporadic *Acarinina spinuloinflata* and *Turborotalia frontosa* are considered borehole cavings. Bubík & Kaminski (1997) mentioned that similar specimens with less convex umbilical side (and up to 5½ chambers in the last whorl), belonging to the Paleocene assemblages, should be regarded as a different species.

When comparing the descriptions of four genera: *Ammogloborotalia*, *Ammoanita*, *Insculptarenula* and *Trochammina* the characteristic features of the studied specimens from F-MU respond the most to the genus *Ammogloborotalia* (Table 2). Zheng & Fu (2001) described modern genus of trochamminaceans – *Ammogloborotalia.* Additionally, the type species *Ammogloborotalia stellaris* was recovered from bathyal water depth station (2100 m; Zheng & Fu 2001) which corresponds with palaeobathymetry of Fore-Magura sedimentation area. Kaminski et al. (2007) re-examined four species of trochamminids from the Cretaceous deposits and relocate them to the genus *Ammogloborotalia*, including also species: *A. abrupta*, *A. globorotaliaeformis*, *Ammogloborotalia* sp. 1, as well as *Trochammina quinqueloba* Geroch. Thus, the genus *Ammogloborotalia* is beginning to be considered as a proper genus for several fossil species of trochamminaceans. Nevertheless, the problem with the taxonomic identification of *Ammogloborotalia* aff. *subvesicularis* remains debatable. For example, Waśkowska recognized this species in the Eocene sediments of the Silesian Nappe in the Polish Outer Carpathians and named it *Insculptarenula* aff. *subvesicularis* (Waśkowska 2014, 2015b) while, in another work, she called it *Ammogloborotalia* aff. *subvesicularis* (Waśkowska 2015a), which confirms the problem with the taxonomic affiliation of this species.

Conclusions

Based on the material from the F-MU, I have come to the conclusion that the Paleogene specimens of agglutinated foraminifera can be assigned to species just in open nomenclature (aff.) *subvesicularis*.

Examination of 183 specimens and comparison with data from the literature allows us to assign the species to the genus *Ammogloborotalia*.

Ammogloborotalia aff. *subvesicularis* is described for the first time from the Fore-Magura Unit. It is a component of abundant and diverse mixed DWAF assemblages mainly developed above the local CCD. Specimens are well documented from Outer Carpathian and North Sea sediments which may indicate a good connection of the Fore-Magura zone and Outer Carpathian realm with the World Ocean during Middle Eocene time.

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