

Badenian Pappinidae and Uvigerinidae from the South-western margin of the Pannonian Basin (Eastern Slovenia)

Badenijske pappinide in uvigerinide z jugozahodnega obrobja Panonskega bazena (vzhodna Slovenija)

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Abstract

This study identifies fourteen foraminiferal species of families Pappinidae and Uvigerinidae, found in Badenian sediments of Eastern Slovenia (six sections in the Planina syncline). Two of the species, *Uvigerina bellicostata* and *Angulogerina esuriensis* are identified in Slovenia for the first time. Determined species show characteristic Central Paratethyan biostratigraphic distribution throughout the studied sections, allowing the positioning of a Late Middle Badenian foraminiferal Zone named after the species *Uvigerina* cf. *pygmea*.

Izvleček

V študiji je predstavljenih štirinajst foraminifernih vrst iz družin pappinid in uvigerinid, določenih v badenijskih plasteh šestih profilov vzhodne Slovenije (Planinska sinklinala). Dve vrsti, *Uvigerina bellicostata* in *Angulogerina esuriensis*, sta na območju Slovenije določeni in opisani prvič. Predstavljene vrste kažejo značilno biostratigrafsko razporeditev vzdolž preučenih profilov. S prvim pojavom vrste *Uvigerina* cf. *pygmea* je definirana tudi istoimenska mlajša srednjabadenijska foraminiferna biocona.

Introduction

The foraminiferal families Pappinidae Haunold 1990 and Uvigerinidae Haeckel 1894 include morphological and ecological similar foraminifers. The growing strategy of both taxonomic groups is based on triserially arranged chambers, which can be present throughout the test (Uvigerinidae) or at least in the earlier stage (Pappinidae). Both families were grouped into a single family Uvigerinidae for almost a century. In 1990, the family Pappinidae was separated from the previous common family. Family Pappinidae is defined by an initial triserial growth followed by a final biserial stage.

In the Central Paratethys, the families Pappinidae and Uvigerinidae represent biostratigraphic index groups, used also for the setting of Miocene biozones (CÍCHA et al., 1998; RÍJAVEC, 1978: Lower Badenian *U. macrocarinata* and *U. grilli* Zones, Middle Badenian *U. venusta* and *U. cf. pygmea* Zones, and the Upper Badenian *U. liesingensis* Zone (= *Pappina neudorfensis* Zone). Similar distribution patterns to those in the Central Paratethys were observed in the sections of this study. This study was carried out in the Planina syncline

in Eastern Slovenia (ANIČIĆ & JURIŠA, 1984, 1985; BUSER, 1977, 1979) where six sections were examined for foraminiferal content: Trobni dol, Sveta Ana, Javoršica, Drensko rebro, Plohov breg in Imenska gorca (Fig. 1). The Middle Miocene strata of the investigated syncline start with Badenian conglomerate, overlain by calcarenite, marly calcarenite and uppermost by marl. The following Lower Sarmatian is represented by marl. The Badenian/Sarmatian boundary has been found to be continuous in previous research (OBLAK, 2007b, 2009); these results have not yet been included in the publication of geology of Slovenia (HORVAT, 2009). One hundred and fifty-nine samples were taken from marly calcarenite and marl; ranging from the Lower Badenian Lower and Upper Lagener Zones, Middle Badenian *Pseudotriplasia robusta* and *Uvigerina* cf. *pygmea* Zones, Upper Badenian *Bolivina dilatata* Zone up to the Lower Sarmatian *Anomalinoides dividens* Zone (Fig. 2).

Results

In all 159 studied Middle Miocene samples taken from six sections the following 14 species

Fig. 1. Location map of the study area (sampled sections from W-E: Td = Trobni dol, Sa = Sveta Ana, J = Javoršica, Dr = Drensko rebro, Pb = Plohov breg, Ig = Imenska gorca). (Map modified after ANIČIĆ et al., 2004).

Sl. 1. Lokacijska karta preučenega območja (vzorčeni profili od Z-V: Td = Trobni dol, Sa = Sveta Ana, J = Javoršica, Dr = Drensko rebro, Pb = Plohov breg, Ig = Imenska gorca) (karta prirejena po ANIČIĆ et al., 2004).



from families Pappinidae and Uvigerinidae have been determined (OBLAK, 2006).

Systematic

Classis Foraminifera Lee 1990
 Ordo Buliminida Fursenko 1958
 Superfamilia Buliminacea Jones 1875
 Familia Pappinidae Haunold 1990
 Genus Pappina Haunold 1990
***Pappina neudorfensis* (Toula 1900)**
 (Pl. 1, Figs. 1a-b)

- 1900 *Uvigerina neudorfensis* n.sp. TOULA, 12, text - Fig. 3
 1914 *Uvigerina liesingensis* - TOULA, 100(3), 10 (ELLIS & MESSINA, 1940)
 1953 *Uvigerina venusta liesingensis* Toula - PAPP & TURNOVSKY, 126, Pl. 5, Abb. B, Figs. 11-12.
 1963 *Uvigerina venusta liesingensis* Toula - PAPP, 250, Taf. 4, Fig. 21-25.
 1978 *Uvigerina liesingensis* Toula - PAPP & SCHMID, 281, Taf. 9, Fig. 14-17
 1978 *Uvigerina venusta liesingensis* Franzenau - RIJAVEC, 217, Tab. 2, Fig. 11
 1986 *Uvigerina venusta liesingensis* Toula - CÍCHA et al., 170, Pl. 18, Figs. 4, 6, 8
 1998 *Pappina neudorfensis* (Toula) - CÍCHA et al., 114, Pl. 49, Fig. 7

Description: Elongated test, initially triserial, becoming biserial in later stages. The initial biserial section consists of up to 5 chamber pairs. Sutures are depressed. Test margin is dentate. Surface is ornamented by numerous narrow but obviously elevated parallel costae which do not cross sutures. Perforation is coarse. Oval aperture is at the end of a short wide neck, it is provided with a tooth.

Age: Late Middle Badenian and Upper Badenian (18 samples: Td2, Td5-Td7, Sa9-Sa11, J30, J32, J33, Pb1, Pb47, Dr8, Dr9, Dr16-Dr19).

Occurrence: In the Central Paratethys, the species appears in the Upper Badenian (CÍCHA et al., 1998), although some authors set its first appearance in the Middle Badenian (PAPP & TURNOVSKY, 1953; PAPP & SCHMID, 1978; CÍCHA et al., 1986). In Croatia, (BAJRAKTAREVIĆ, 1979; PIKIJA et al., 1984) and in Poland (SZCZUCHA, 2000), it has been identified in the Upper Badenian. In Slovenian, the species has previously been described and illustrated from the Middle and Upper Badenian (RIJAVEC, 1978).

***Pappina parkeri* (Karrer 1877)** (Pl. 1, Figs. 2a-b)

- 1877 *Uvigerina parkeri* n.sp. KARRER, 385, Pl. 16b, Fig. 50.
 1963 *Uvigerina bononiensis compressa* (Cushman) - PAPP, 252, Taf. 5, Fig. 11-14.
 1998 *Pappina parkeri* (Karrer) - CÍCHA et al., 115, Pl. 49, Figs. 1-2, 8-9.

Description: Elongated somewhat flattened test consists of early triserial and later biserial stage. Biserial stage is approximately 2/3 of test length, consisting of up to seven chambers. Each new chamber is formed at the same level of the previous chamber but as it develops over the top previous chamber, resulting in the characteristic C shape of the chambers. Test is widest in the second third of its length. Surface ornamentation is by fine but distinct longitudinal costae which break at sutures. Sutures of the final chamber extend over a short neck developed at the top of the test. Round aperture is at the end of the neck and provided with a toothplate.

Age: Lower Badenian and Early Middle Badenian (51 samples: Sa3, J2, J3, J5, J7-J12, J14, J18, J22, J23, J28, Pb6, Pb8, Pb50/2, Pb51/1, Pb12-Pb14, Pb17-Pb19, Pb54, Ig1-Ig13, Ig15, Ig16, Dr2, Dr8, Dr9, Dr16-Dr18).

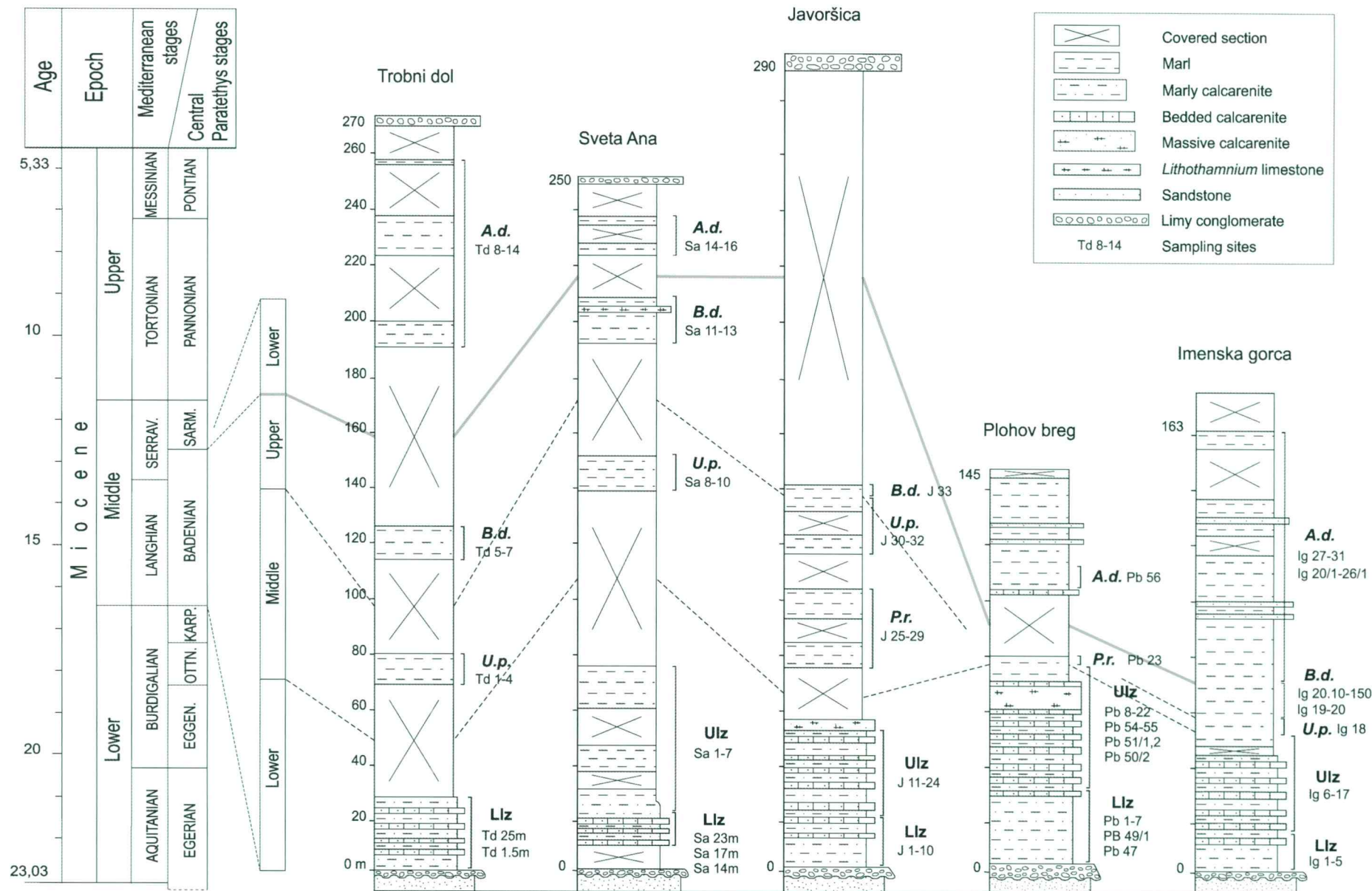


Fig. 2. Stratigraphic columns of studied sections from the northern flank of the Planina syncline with marked sampling sites; Eggen.: Eggenburgian, Otnn.: Otnangian, Karp.: Karpatian, Sarm.: Sarmatian, Serrav.: Serravallian. (Time scale modified after LOURENS et al., 2004; PILLER et al., 2004).

Sl. 2. Stratigrafski stolpci preučenih profilov severnega krila Planinske sinklinale z označenimi vzorčnimi mesti; Eggen.: eggenburgij, Otnn.: otnangij, Karp.: karpatij, Sarm.: sarmatij, Serrav.: serravalijski (časovna razpredelnica prirejena po LOURENS et al., 2004; PILLER et al., 2004).

Occurrence: In the Central Paratethys, the species occurs through the whole Badenian (CICHA et al., 1998). In Slovenia, the species was reported only as *Uvigerina bononiensis compressa* from the Lower and Middle Badenian (RIJAVEC, 1984; DOZET et al., 1998).

Familia Uvigerinidae Haeckel 1894
Subfamilia Uvigerininae Haeckel 1894
Genus *Uvigerina* d'Orbigny 1826

Description of the genus: Elongated test is built of a triserial arrangement of chambers. Surface is ornamented predominantly with vertical costae or thinner striae, rarely it is smooth or spinate. Sutures are oblique and depressed. At the terminal end of the test a more or less distinct neck is developed, giving the test an amphora like appearance. At the top of the neck, is situated a round aperture, which has a toothplate.

Ecology: Genus *Uvigerina* is predominantly infaunal and partially epifaunal. It is characteristic for cold marine environment of depths from 100 to more than 4500 m; for shelf and bathyal zone (MURRAY, 1991). It is well represented in waters of deep neritic and upper bathyal zone (WENGER, 1987), and rare in waters shallower than 100 m (RÖGL & SPEZZAFERRI, 2003). It occurs in suboxic sediments with high content of organic material (SPEZZAFERRI & ČORIĆ, 2001).

Uvigerina aculeata d'Orbigny 1846

- 1846 *Uvigerina aculeata* n.sp. D'ORBIGNY, 191, Tab. XI, Figs. 27-28.
1978 *Uvigerina aculeata aculeata* d'Orbigny - RIJAVEC, 218, Tab. 2, Fig. 13.
1985 *Uvigerina grilli* SCHMID - PAPP & SCHMID, 74, Taf. 65, Fig. 6-10.
1986 *Uvigerina aculeata aculeata* d'Orbigny - CICHA et al., 159, Pl. 14, Figs. 1, 4.
1998 *Uvigerina aculeata* d'Orbigny - CICHA et al., 133, Pl. 50, Figs. 3-4.

Description: Outline of the test is lobate due to subspherical chambers. Surface is ornamented by elongated spines; in the initial part of the test spines may join into shorter costae. Neck is well developed.

Age: Lower to Upper Badenian (19 samples: Sa1-Sa5, J25, J27, Pb54, Pb19-Pb23, Ig20, Dr1, Dr5, Dr12, Dr13, Dr15).

Occurrence: In the Central Paratethys, the species first appears in the Lower Badenian and continues to the early Upper Badenian; being most common in Middle Badenian (CICHA et al., 1998). In Slovenia, the species was determined in Lower and Middle Badenian (RIJAVEC, 1978).

Uvigerina acuminata Hosijs 1893 (Pl. 1, Figs. 3a-b)

- 1893 *Uvigerina aculeata* n.sp. HOSIJS, 50, 108, Taf. 2, Fig. 9 (ELLIS & MESSINA, 1940).
1895 *Uvigerina acuminata* nom.nov. Hosijs - HOSIJS, 10, 167 (ELLIS & MESSINA, 1940).
1963 *Uvigerina acuminata* Hosijs - PAPP, 250, Taf. 4, Fig. 11-15.
1977 *Uvigerina acuminata* Hosijs - VON DANIELS & SPIEGLER, 26, Taf. 3, Fig. 9-12.
1986 *Uvigerina acuminata* Hosijs - CICHA et al., 144, Pl. 7, Figs. 1-10.
1986 *Uvigerina acuminata* Hosijs - VON DANIELS, 92, Pl. 5, Figs. 1-8.

Description: Test is pointed in its initial part. It is widest at the middle. Surface is ornamented with costae which do not extend over sutures. Costae are broader, shaped into wide spines in their initial part, becoming thinner toward later part. Costae are absent from the upper half of the test. Neck is short and depressed at the base.

Age: Lower Badenian (13 samples: Sa1, J2, J7, J15, Pb9, Pb20/2, Pb13, Pb15, Pb17, Pb18, Ig2-Ig4, Ig6).

Occurrence: In the Central Paratethys, the species ranges from Ottnangian to Middle Badenian; it is most common in Karpatian and Lower Badenian (CICHA et al., 1998). In Austria, the species is reported from Ottnangian and Karpatian (ROETZEL et al., 2006). In Slovenia, the species has been identified in Lower Badenian and Middle Badenian (RIJAVEC, 1976).

Uvigerina bellicostata Łuczkowska 1955 (Pl. 1, Figs. 4a-b)

- 1955 *Uvigerina bellicostata* n.sp. ŁUCZKOWSKA, 118, Pl. 8, Figs. 10-13 (CICHA et al., 1998).
1978 *Uvigerina costatoides* n.sp. PAPP & SCHMID, 283, Taf. 11, Fig. 5-8.
1986 *Uvigerina bellicostata* Łuczkowska - CICHA et al., 152, Pl. 11, Figs. 1-3, Pl. 12, Figs. 1, 5-6.
1998 *Uvigerina bellicostata* Łuczkowska - CICHA et al., 133, Pl. 51, Figs. 9-10.

Description: Test is widest in the middle. Surface is ornamented with wide and flattened flaring costae which generally do not extend over sutures. Neck is depressed at the base. Aperture is bordered with a well developed lip.

Age: Upper Badenian (sample Ig20).

Occurrence: In the Central Paratethys, the species is known from Upper Badenian (CICHA et al., 1998). It is more common in Eastern part of the Central Paratethys, although it appears also in the Western part, e.g. Austria (PAPP & SCHMID, 1978; *U. costatoides*) and Croatia (PEZELJ, 2005;

U. costatoides). In Slovenia, the species has yet to be determined.

***Uvigerina brunnensis* Karrer 1877**
(Pl. 1, Figs. 5a-b)

- 1877 *Uvigerina brunnensis* n.sp. KARRER, 385, Taf. 16b, Fig. 49.
1953 *Uvigerina semiornata brunnensis* Karrer - PAPP & TURNOVSKY, 130, Taf. V, Abb. C, Fig. 8.
1977 *Uvigerina semiornata brunnensis* Karrer - VON DANIELS & SPIEGLER, 21, Taf. 2, Fig. 1-2.
1978 *Uvigerina brunnensis* Karrer - PAPP & SCHMID, 282, Taf. 10, Fig. 8-11.
1979 *Uvigerina brunnensis* Karrer - POPESCU, 35, Pl. XXI, Figs. 8-9.
1984 *Uvigerina brunnensis* Karrer - RIJAVEC, 84, Tab. 1, Fig. 6.
1986 *Uvigerina semiornata brunnensis* Karrer - CICHÁ et al., 147, Pl. 9, Figs. 1-2, 4, 6.
1986 *Uvigerina semiornata brunnensis* Karrer - VON DANIELS, 102, Pl. 10, Figs. 1-5.
1998 *Uvigerina brunnensis* Karrer - CICHÁ et al., 133, Pl. 53, Figs. 5-6.

Description: Test is characteristically elongated and narrow; with more or less parallel sides. Arrangement of chambers tends to change from triserial to biserial in later stage of the test. Chambers are numerous and subspherical. Initial part of the test is narrow and rounded. Surface is ornamented with weak costae which do not extend over the final chambers. Neck is well developed.

Age: Late Middle Badenian and Upper Badenian (8 samples: Pb1-Pb5, Pb47, Ig19, Dr17).

Occurrence: In the Central Paratethys, the species is known from Middle and Upper Badenian (CICHÁ et al., 1998). In Austria, it is reported from Middle Badenian (PAPP & SCHMID, 1978) and in Romania from Upper Badenian (POPESCU, 1979). In Slovenia, the species has previously been described and illustrated (RIJAVEC, 1984) or determined only (RIJAVEC, 1978) from the Middle Badenian.

***Uvigerina macrocarinata* Papp & Turnovsky 1953**
(Pl. 1, Figs. 6a-b)

- 1953 *Uvigerina macrocarinata* n.sp. PAPP & TURNOVSKY, 123, Taf. V, Abb. B, Fig. 1-3.
1963 *Uvigerina macrocarinata* Papp & Turnovsky - PAPP, 249, Taf. 4, Fig. 6-10.
1977 *Uvigerina macrocarinata* Papp & Turnovsky - VON DANIELS & SPIEGLER, 26, Taf. 4, Fig. 1-4.
1978 *Uvigerina macrocarinata* Papp & Turnovsky - PAPP & SCHMID, 280, Taf. 9, Fig. 1-4, Taf. 11, Fig. 2-4.
1978 *Uvigerina macrocarinata* Papp & Turnovsky - RIJAVEC, 216, Tab. 2, Fig. 7.
1986 *Uvigerina macrocarinata* Papp & Turnovsky - CICHÁ et al., 154, Pl. 11, Figs. 4-7.

- 1986 *Uvigerina macrocarinata* Papp & Turnovsky - VON DANIELS, 94, Pl. 6, Figs. 1-6.
1998 *Uvigerina macrocarinata* Papp & Turnovsky - CICHÁ et al., 134, Pl. 51, Figs. 3-4.
2003 *Uvigerina macrocarinata* Papp & Turnovsky - RÖGL & SPEZZAFERRI, Pl. 5, Figs. 22-23.

Description: Test is stout and rounded in its initial part. Main stage of the test is ornamented with distinct costae extending over sutures. Initial part of costae is formed into a blunt spine. Costae end at the base of the last chamber; consequently the surface of the last chamber is smooth. Neck is short and depressed at the base.

Age: Lower Badenian (21 samples: Sa17m, Sa23m, Sa4, Sa5, Sa7, Pb1-Pb5, Pb47, Pb49/1, Pb54, Pb19, Pb20, Ig3, Ig10, Ig11, Ig14, Dr1, Dr9).

Occurrence: In the Central Paratethys, the species was reported from Lower Badenian (CICHÁ et al., 1998), according to PAPP & SCHMID (1978) in Early Lower Badenian only. In Austria (RÖGL & SPEZZAFERRI, 2003) and in Romania (PAPP & SCHMID, 1978), it is reported from Early Lower Badenian. In Slovenia, the species was previously identified in Lower Badenian (RIJAVEC, 1978).

***Uvigerina cf. pygmea* d'Orbigny 1826**
(Pl. 2, Figs. 1a-b)

- 1826 *Uvigerina pygmea* n.sp. D'ORBIGNY, 269, Pl. 12, Figs. 8-9.
1953 *Uvigerina cf. pygmaea* d'Orbigny - PAPP & TURNOVSKY, 127, Taf. V, Abb. B, Fig. 9-10.
1978 *Uvigerina cf. pygmaea* d'Orbigny - PAPP & SCHMID, 281, Taf. 9, Fig. 13.
1978 *Uvigerina cf. pygmaea* d'Orbigny - RIJAVEC, 218, Tab. 2, Fig. 12.
1986 *Uvigerina cf. U. pygmaea* d'Orbigny - CICHÁ et al., 166, Pl. 16, Fig. 5.
1998 *Uvigerina cf. pygmea* d'Orbigny - CICHÁ et al., 134, Pl. 49, Fig. 10.

Description: Initial part of the test is pointed. Test is lobate in outline and it is widest in its middle part. Surface of the initial stage is covered with fine costae while the upper third of the test is ornamented with tinny pustules. Neck is long and slender.

Age: Late Middle Badenian and Upper Badenian (11 samples: Td1-Td4, J29, J33, Ig18-Ig20, Dr17, Dr19).

Occurrence: In the Central Paratethys, the species appears rarely in Middle and Upper Badenian (CICHÁ et al., 1998), according to PAPP & SCHMID (1978) in Late Middle Badenian only. It is most frequent in Middle Badenian (CICHÁ et al., 1986). In Slovenia, the species has previously been described and illustrated (RIJAVEC, 1984) or identified only (RIJAVEC, 1976, 1978) from the Middle Badenian.

***Uvigerina pygmoides* Papp & Turnovsky 1953**
(Pl. 2, Figs. 2a-b)

- 1953 *Uvigerina pygmoides* n.sp. PAPP & TURNOVSKY, 131, Taf. V, Abb. C, Fig. 4.
1978 *Uvigerina pygmoides* Papp & Turnovsky - PAPP & SCHMID, 282, Taf. 10, Fig. 1-3.
1978 *Uvigerina pygmoides* Papp & Turnovsky - RIJAVEC, 219, Tab. 2, Fig. 16.
1984 *Uvigerina pygmoides* Papp & Turnovsky - BARBIERI & D'ONOFRIO, 446, Pl. 2, Fig. 18.
1985 *Uvigerina pygmoides* Papp & Turnovsky - PAPP & SCHMID, 74, Taf. 65, Fig. 1-5.
1986 *Uvigerina pygmoides* Papp & Turnovsky - CICHA et al., 172, Pl. 19, Figs. 1-2, 4-5.
1998 *Uvigerina pygmoides* Papp & Turnovsky - CICHA et al., 134, Pl. 53, Figs. 10-12.
2003 *Uvigerina ? pygmoides* Papp & Turnovsky - RÖGL & SPEZZAFERRI, 51, Pl. 5, Fig. 28, Pl. 9, Fig. 11.

Description: Test is widest in the lowest third, and pointed towards the base. There are frequent costae developed on the surface, which continue up to the neck. Neck is very short and wide, and never depressed at its base.

Age: Lower Badenian (15 samples: Td1.5m, J3, Pb1, Pb6, Pb10, Pb54, Pb18, Pb20, Ig1, Ig2, Ig6, Ig12, Ig15, Dr12, Dr13).

Occurrence: In the Central Paratethys, the species appears from Karpatian to Middle Badenian (CICHA et al., 1998), according to PAPP & SCHMID (1978) in Late Early Badenian and Early Middle Badenian only. It is rare in Karpatian (CICHA et al., 1986), and frequent in Late Lower Badenian (PAPP & TURNOVSKY, 1953). In Austria, it is reported from Early Lower Badenian (RÖGL & SPEZZAFERRI, 2003) and in Romania, from Late Lower Badenian (FILIPESCU & GÎRBACEA, 1997). In Slovenia, the species was reported from Lower and Middle Badenian (RIJAVEC, 1978, 1984).

***Uvigerina semiornata* d'Orbigny 1846**
(Pl. 2, Figs. 3a-b)

- 1846 *Uvigerina semiornata* n.sp. D'ORBIGNY, 189-190, Tab. XI, Figs. 23-24.
1953 *Uvigerina semiornata semiornata* d'Orbigny - PAPP & TURNOVSKY, 128, Taf. V, Abb. C, Fig. 1, 3, 7.
1977 *Uvigerina semiornata semiornata* d'Orbigny - VON DANIELS & SPIEGLER, 20, Taf. 1, Fig. 1-10.
1978 *Uvigerina semiornata* d'Orbigny - PAPP & SCHMID, 281, Taf. 10, Fig. 4-7.
1978 *Uvigerina semiornata semiornata* d'Orbigny - RIJAVEC, 218, Tab. 2, Fig. 14.
1985 *Uvigerina semiornata* d'Orbigny - PAPP & SCHMID, 74, Taf. 64, Fig. 1-10.
1986 *Uvigerina semiornata semiornata* d'Orbigny - CICHA et al., 146, Pl. 8, Figs. 1-3, 5-7.

- 1986 *Uvigerina semiornata semiornata* d'Orbigny - VON DANIELS, 96, Pl. 7, Figs. 1-5, Pl. 8, Figs. 1-6.
1987 *Uvigerina semiornata* d'Orbigny - WENGER, 280, Taf. 9, Fig. 9-10.
1998 *Uvigerina semiornata* d'Orbigny - CICHA et al., 135, Pl. 53, Figs. 1-3.

Description: Initial part of the test is rounded. Test is widest in its upper half. Surface is covered with weak costae that might continue over sutures. The uppermost part of the last chamber or last few chambers is smooth. Neck is depressed at the base.

Age: Late Lower Badenian to Upper Badenian (29 samples: Td1, Td2, Td4, Sa8, Sa13, J27-J32, Pb3-Pb5, Pb49/1, Pb22, Pb23, Ig18, Ig19, Dr3-Dr6, Dr9, Dr10, Dr15, Dr17- Dr19).

Occurrence: In the Central Paratethys, the species is believed to occur from the Karpatian to earliest Upper Badenian; it is most common in Badenian (CICHA et al., 1998, PAPP & SCHMID, 1985: Late Lower Badenian). Contrary, in Bavaria it is reported already from Upper Egerian and Lower Ottnangian (WENGER, 1987). In Slovenia, the species is known from Lower and Middle Badenian (RIJAVEC, 1976, 1978, 1984).

***Uvigerina venusta* Franzenau 1894**
(Pl. 2, Fig. 4)

- 1894 *Uvigerina venusta* n.sp. FRANZENAU, 6, 284, pl. 6, fig. 60 (ELLIS & MESSINA, 1940)
1953 *Uvigerina venusta venusta* Franzenau - PAPP & TURNOVSKY, 125, Taf. V, Abb. B, Fig. 8, 13.
1963 *Uvigerina venusta venusta* Franzenau - PAPP, 250, Taf. 4, Fig. 16-20.
1978 *Uvigerina venusta* Franzenau - PAPP & SCHMID, 280, Taf. 9, Fig. 9-12.
1978 *Uvigerina venusta venusta* Franzenau - RIJAVEC, 217, Tab. 2, Fig. 9.
1986 *Uvigerina venusta venusta* Franzenau - CICHACHA et al., 168, Pl. 18, Figs. 1-3, 5, 7.
1993 *Uvigerina venusta* Franzenau - HAUNOLD, 180-191, Pl. 1, Figs. 7-8.
1998 *Uvigerina venusta* Franzenau - CICHACHA et al., 135, Pl. 52, Figs. 7-9.

Description: Base of test tapers to a point. The uppermost part of the test may show a biserial growth pattern; and consequently flattening of the test is seen in this stage of the test development. Surface is ornamented with thick parallel costae which end at sutures. Neck is short.

Age: Late Middle Badenian and Upper Badenian (25 samples: Td1, Td2, Td4-Td7, Sa8, Sa10-Sa12, J29-J33, Ig18, Ig19, Dr8- Dr11, Dr16-Dr19).

Occurrence: In the Central Paratethys, the species occurs in Middle and Upper Badenian (CICHA et al., 1998, PAPP & SCHMID, 1978, PAPP &

TURNOVSKY, 1953). In Croatia, it is reported from the Upper Badenian (BAJRAKTAREVIĆ, 1979). In Slovenia, the species was reported from Middle Badenian (RIJAVEC, 1976, 1978, 1984) and Upper Badenian (RIJAVEC, 1978; RIJAVEC & DOZET, 1996).

Subfamilia Angulogerininae Galloway 1933

Genus *Angulogerina* Cushman 1927

Angulogerina angulosa (Williamson 1858)

(Pl. 2, Figs. 5)

1858 *Uvigerina angulosa* n.sp. WILLIAMSON, 67, Pl. V, Fig. 140.

2007a *Angulogerina angulosa* (Williamson) - OBLAK, 296, Pl. 1, Figs. 1a-b.

Age: Lower to Upper Badenian (78 samples: Td25m, Sa1, Sa2-Sa8, Sa10, Sa13, J2-J12, J14, J19-J24, J27-J29, J31-J33, Pb1, Pb47, Pb6, Pb8-Pb10, Pb50/2, Pb51/1, Pb13-Pb20, Pb54, Pb23, Ig1-Ig7, Ig 9-Ig11, Ig14, Ig16, Ig19, Dr1-Dr3, Dr8-Dr10, Dr12, Dr15, Dr17, Dr18).

Angulogerina esuriensis Hornibrook 1961

(Pl. 2, Figs. 6a-b)

1961 *Angulogerina esuriensis* n.sp. HORNIBROOK, 69, Pl. 9, Figs. 154-155 (CICHA et al., 1998).

1998 *Angulogerina esuriensis* Hornibrook - CICHA et al., 80, Pl. 54, Figs. 1-2.

Description: Small narrow test is triserial at the beginning, tending toward the uniserial arrangement later. There are one to three loosely arranged chambers in the uniserial stage. Test is triangular in cross section. All three angles of the test are carinate and well developed. Ornamentation is reduced in comparison with the familiar species *A. angulosa*; costae are scarcer and limited mostly to the lower part of the test while the uppermost chambers are smooth. The aperture is at the top of a short neck and it is bordered by a lip. It carries a toothplate.

Age: Upper Middle Badenian (3 samples: Sa8-Sa10).

Occurrence: In the Central Paratethys, the species is reported from Lower and Middle Badenian (CICHA et al., 1998). In Slovenia, the species has yet to be determined.

Genus *Trifarina* Cushman 1923

Trifarina bradyi Cushman 1923

(Pl. 2, Fig. 7)

1923 *Trifarina bradyi* n.sp. CUSHMAN, 104(4), 99, Pl. 22, Figs. 3a-9b (ELLIS & MESSINA, 1940).

2007a *Trifarina bradyi* Cushman - OBLAK, 298, Pl. 1, Figs. 2a-b.

Age: Lower Badenian to Late Middle Badenian (68 samples: Sa5, Sa6, J1-J3, J5-J16, J18-J24, J26,

J28, J32, Pb6, Pb8-Pb19, Pb50/2, Pb51/1, Pb51/2, Pb54, Pb55, Pb21-Pb23, Ig1-Ig14, Ig16, Ig17, Dr2, Dr3, Dr10, Dr13).

Biostratigraphy

Biostratigraphical ranges of determined species and their presence in individual sections are represented in Fig. 3 and Fig. 4.

In the Early Lower Badenian sediments, the following species appear for the first time: *U. macrocarinata* Papp & Turnovsky, *U. pygmoides* Papp & Turnovsky, *U. acuminata* Hosius, which go extinct at the end of the Lower Badenian, as well as *P. parkeri* (Karrer) and *T. bradyi* Cushman, which continue to the Middle Badenian.

In the Middle Badenian the species *P. neudorfensis* (Toula), *U. cf. pygmea* d'Orbigny, *U. venusta* Franzenau and *U. brunnensis* Karrer first appear. Their first occurrence defines the beginning of the foraminiferal *U. cf. pygmea* Zone, which delimits the Early and Late Middle Badenian (OBLAK, 2006). In the Middle Badenian sediments the species *A. esuriensis* Hornibrook was also identified, although its appearance is not stratigraphically significant.

In the Upper Badenian, there is the first occurrence of *U. bellicostata* Łuczkowska. Its last occurrence along with all other surviving pappinids and uvigerinids occurs at the end of the Badenian.

Species *U. aculeata* d'Orbigny, *U. semiornata* d'Orbigny and *A. angulosa* (Williamson) range throughout the whole Badenian and are therefore of no biostratigraphic value.

Conclusions

The species *U. bellicostata* and *A. esuriensis* have been found for the first time in Slovenia. *U. bellicostata* represents especially interesting finding. The species is rarely documented in the Western part, but is more common in the Eastern part of the Central Paratethys. In this study, it is represented by numerous well developed tests (Imenska gorca section).

Distribution of studied foraminifera shows a characteristic stratigraphical pattern throughout Badenian sediments. Most of ranges found in this study fit to previously known and current most referenced stratigraphic ranges for the wider Central Paratethys area (CICHA et al., 1998). The exception is a species *P. neudorfensis*, which is not limited to the Upper Badenian only as suggested in the cited literature, but it appears for the first time already in the Late Middle Badenian. Its presence in Middle Badenian strata has already been reported in previous literature (PAPP & TURNOVSKY, 1953; PAPP & SCHMID, 1978; CICHA et al., 1986), which supports the statement about wider stratigraphic range of the species than is currently accepted.

Surprisingly, not many of the species determined in this study are reported from the same time zones in the adjacent Mediterranean region,

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			Biozones		Lower Lag. Zone						Upper Lag. Zone						<i>P. robusta</i>						<i>U. cf. pygmea</i>						<i>B. dilatata</i>						<i>A. dividers</i>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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Fig. 3. Species presence of genera *Pappina*, *Uvigerina*, *Angulogerina* and *Trifarina* in individual sections. Missing biozones of particular sections are marked as shaded columns. Sl. 3. Prisotnost vrst iz rodov *Pappina*, *Uvigerina*, *Angulogerina* and *Trifarina* v posameznih profilih. Biocone, ki v določenih profilih niso bile dokazane, so osenčene.

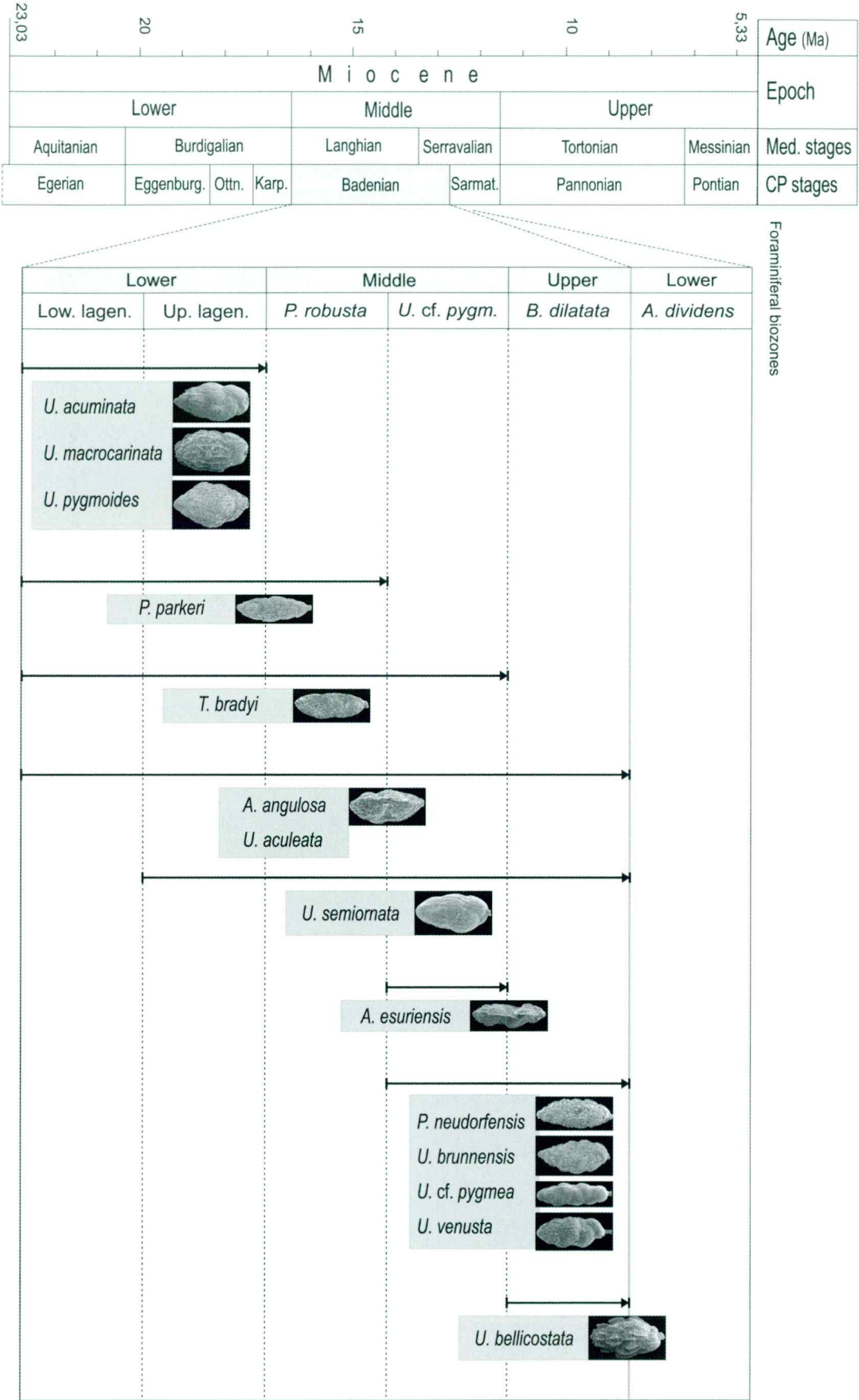
although the Mediterranean Sea was connected to the Central Paratethys through the Trans-Tethyan trench corridor across Slovenia until the Upper Badenian (RÖGL, 1999). Only the following four species are found to exist in both regions: *U. pygmoides* (BARBIERI & D'ONOFRIO, 1984: Middle Miocene of Italy), *U. semiornata* (SALAJ, 1992: Serravallian of Tunisia), *T. bradyi* (DONDI & BARBIERI, 1982: Miocene to Pleistocene from Italy) and *A. angulosa* (DONDI & BARBIERI, 1982: Oligocene to Pleistocene from Italy). One possible cause for this low comparativeness could be the use of different synonyms for the same species on both sides of the trench.

Ecologically, pappinids and uvigerinids show similar environmental preferences. Their acme throughout the Badenian, and eventual extinction at the end of the stage, coincides with environmental changes that were occurring at that time. Pappinids and uvigerinids which prefer euhaline deep-water environment could not tolerate the shallowing and freshening of the sea that occurs at the beginning of the Sarmatian period (coincidental with a 3rd order sequence Ser3 according to HOHENEGGER et al., 2008; after HAQ et al., 1988).

Badenijske pappinide in uvigerinide z jugozahodnega obrobja Panonskega bazena (vzhodna Slovenija)

Povzetek

Foraminiferni družini Pappinidae Haunold 1990 and Uvigerinidae Haekel 1894 vključujeta morfološko in ekološko zelo podobne luknjičarke. Pri obeh taksonomskih skupinah so hišice vsaj v začetnem stadiju (pappinide) ali tekom celotne rasti (uvigerinide) zgrajene iz triseriialno razvščenih kamric. Družini sta bili skoraj stoletje združeni v skupno družino uvigerinid. Oddvojitev pappinid od omenjene skupne družine leta 1990 je temeljila na spoznanju, da je biseriialnost, ki se pojavi le v končnem stadiju rasti pappinid, zadosten pogoj za osnove nove samostojne družine. Na območju Centralne Paratetide veljata družini pappinid in uvigerinid za pomembni bentoški stratigrafski indikatorski skupini, pogosto uporabljeni pri bioconaciji miocena (CICHA et al., 1998; RIJAVEC, 1978).



V namen te raziskave je bilo vzorčenih šest srednjemiocenskih profilov Planinske sinklinale v vzhodni Sloveniji (sl. 1). Iz lapornih plasti je bilo pobranih 159 vzorcev, in sicer v stratigrafskem razponu od spodnjebadenijskih do spodnje-sarmatijskih plasti (sl. 2). Določenih je štirinajst vrst iz družin pappinid in uvigerinid (glej Results: Systematic). Vrsti *Uvigerina bellicostata* in *Angulogerina esuriensis* doslej v Sloveniji še nista bili opisani. Zanimiva je najdba zlasti vrste *Uvigerina bellicostata*, ki velja za značilno predstavnico vzhodnega dela Centralne Paratetide.

Razporeditev določenih foraminifer vzdolž badenijskih plasti kaže značilen biostratigrafski vzorec (sl. 3, 4). Večina razponov sovpa z že poznanimi in trenutno najbolj referenčnimi razponi za območje Centralne Paratetide (CICHA et al., 1998). Izjema je vrsta *Pappina neudorfensis*, ki se prvič pojavi že v mlajšem srednjem badeniju in ne šele v zgornjem badeniju, kot navaja omenjena literatura, kar nakazuje na širši razpon vrste.

V ekološkem pogledu imajo pappinide in uvigerinide podobne okoljske preference. Njihov višek pojavljanja skozi celoten badenij in popolno izumrtje konec le-tega kaže na spremembo ekoloških parametrov v srednjem miocenu. Omenjene foraminifere kot značilne prebivalke evhalinega globljevodnega okolja namreč niso bile sposobne tolerirati oslajevanja in plitvenja morja, ki se je začelo s pričetkom sarmatija.

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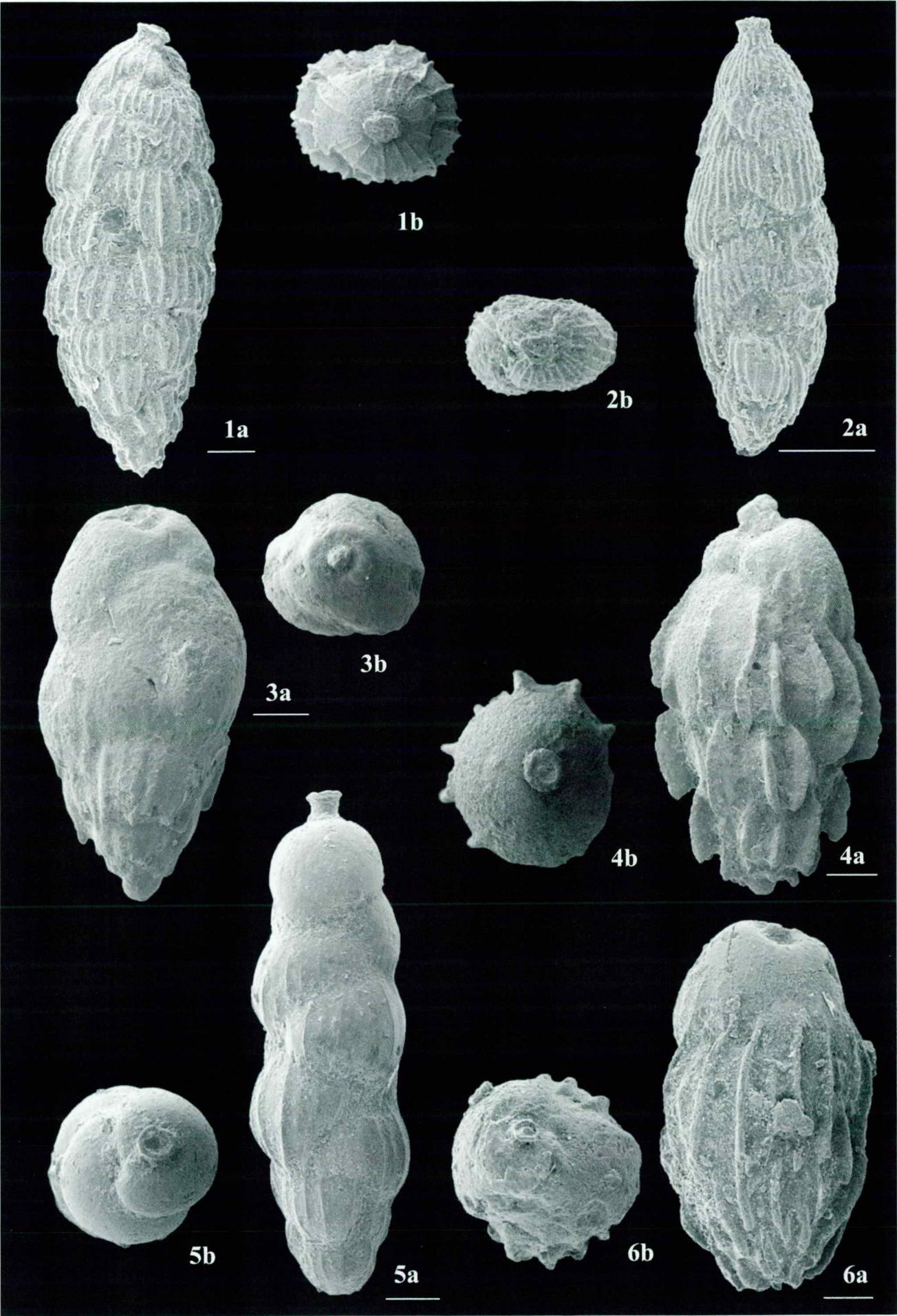
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PLATE 1 – TABLA 1

- 1a-b *Pappina neudorfensis* (Toula); a, b - J33
 2a-b *Pappina parkeri* (Karrer); a - J10, b - J8
 3a-b *U. vigerina acuminata* Hosijs; a, b - Ig4
 4a-b *U. bellicostata* Łuczowska; a, b - Ig20.10
 5a-b *U. brunnensis* Karrer; a, b - Ig19
 6a-b *U. macrocarinata* Papp & Turnovsky; a, b - Pb54

Scale bar (merilce) = 100 µm.

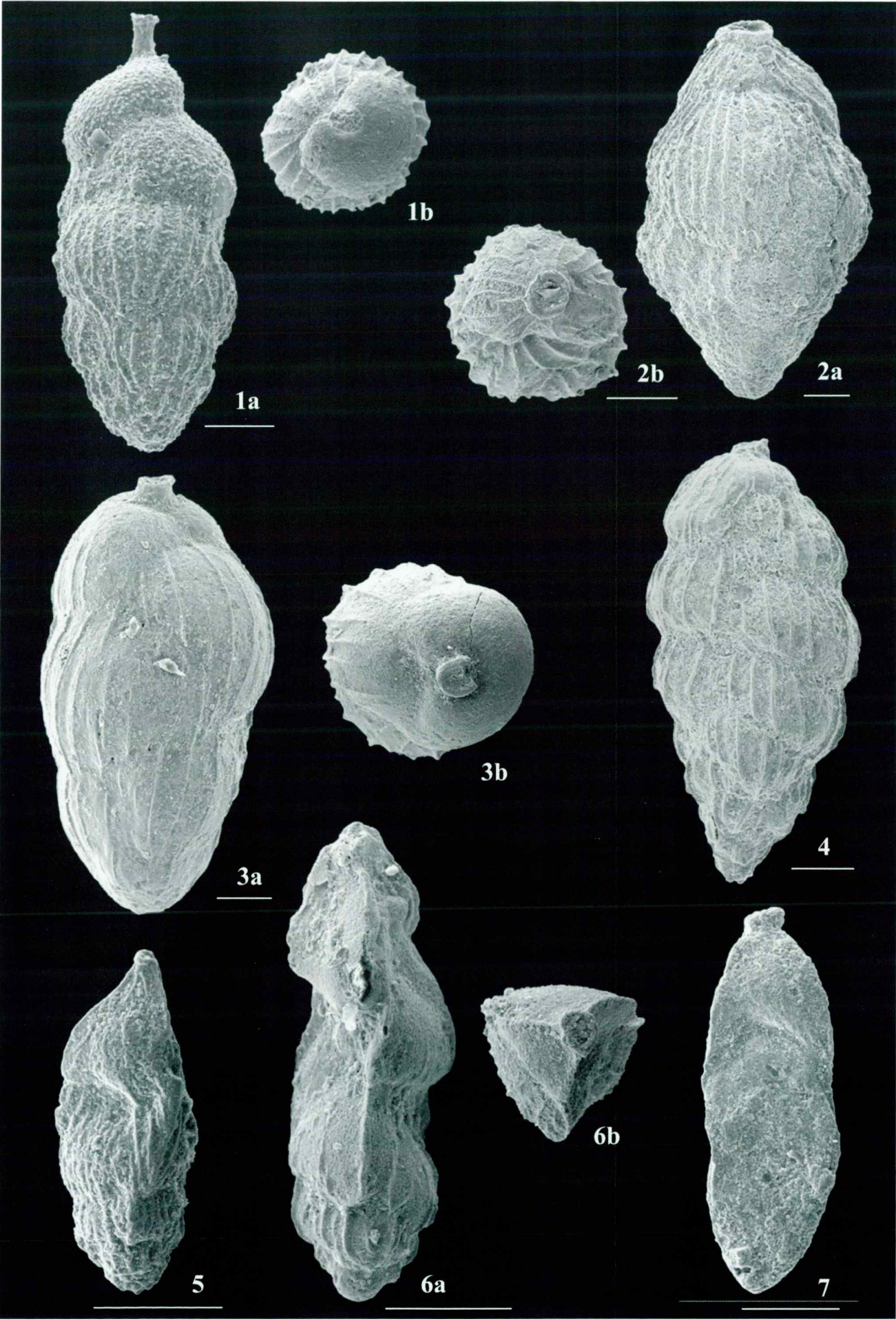


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PLATE 2 – TABLA 2

- 1a-b *Uvigerina* cf. *pygmea* d'Orbigny; a, b - J33
 2a-b *U. pygmoides* Papp & Turnovsky; a - Ig6, b - Pb54
 3a-b *U. semiornata* d'Orbigny; a, b - J32
 4 *U. venusta* Franzenau; J32
 5 *Angulogerina angulosa* (Williamson); Ig4
 6a-b *A. esuriensis* Hornibrook; a - Sa10, b - Sa8, 7 *Trifarina bradyi* Cushman; Ig4.

Scale bar (merilce) = 100 µm.



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