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)

Katarina OBLAK BROWN
e-mail: katarina.oblak.brown@siol.net

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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*.

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 (*Čiča et al.*, 1998; *Rlavčec*, 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 (Aničič & Juršič, 1984, 1985; Buser, 1977, 1979) where six sections were examined for foraminiferal content: Trobni dol, Sveta Ana, Javoršica, Drensko rebro, Plošov breg and Imenška 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 Lagenidae 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...
from families Pappinidae and Uvigerinidae have been determined (OBLAK, 2006).

**Systematic**

Classis Foraminiferea 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 (ELLI & 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 - RIJANEK, 217, Tab. 2, Fig. 11  
1986 *Uvigerina venusta liesingensis* Toula - CICHA et al., 170, Pl. 18, Figs. 4, 6, 8  
1998 *Pappina neudorfensis* (Toula) - CICHA 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, Dr6, Dr9, Dr16-Dr19).

Occurrence: In the Central Paratethys, the species appears in the Upper Badenian (CICHA et al., 1998), although some authors set its first appearance in the Middle Badenian (PAPP & TURNOVSKY, 1953; PAPP & SCHMID, 1978; CICHA et al., 1986). In Croatia, (BAJRAKTAIĆ, 1979; PIKJIA et al., 1984) and in Poland (SZCZECH, 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 (RIJANEK, 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) - CICHA 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, Dr6, Dr9, Dr16-Dr18).
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Fig. 2. Stratigraphic columns of studied sections from the northern flank of the Planina syncline with marked sampling sites; Eggen.: Eggenburgian, Ottn.: Ottnangian, Karp.: Karpatian, Sarm.: Sarmatian, Serrav.: Serravallian. (Time scale modified after Lourens et al., 2004; Piller et al., 2004).

Sl. 2. Stratigráfski stolpci preučenih profilov severnega krila Planinske sinkline z označenimi vzorčnimi mesti; Eggen.: eggenburgij, Ottn.: ottnangij, Karp.: karpatij, Sarm.: sarmatij, Serrav.: serravalij (časovna razpredelnica prirejena po Lourens et al., 2004; Piller et al., 2004).
Occurrence: In the Central Paratethys, the species occurs through the whole Badenian (Cičha et al., 1998). In Slovenia, the species was reported only as *Uvigerina bonotiensis compressa* from the Lower and Middle Badenian (Rižavec, 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 it is best represented in waters shallower than 100 m (RöGl, 1976), and rare in waters shallower than 100 m (RöGl & SpieglEr, 2001). It occurs in suboxic sediments with high content of organic material (Spezzaferrj & Coric, 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 - Rižavec, 218, Tab. 2, Fig. 13.  
1985 *Uvigerina grilli* Schmid - Papp & Schmid, 74, Taf. 65, Fig. 6-10.  
1986 *Uvigerina aculeata* d’Orbigny - Cičha et al., 159, Pl. 14, Figs. 1, 4.  
1998 *Uvigerina aculeata* d’Orbigny - Cičha et al., 133, Pl. 50, Figs. 3-4.

Description: Outline of the test is lobate due to subshperical 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, Dr3, 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 (Cičha et al., 1998). In Slovenia, the species was determined in Lower and Middle Badenian (Rižavec, 1978).

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

1893 *Uvigerina aculeata* n.sp. Hosius, 50, 108, Taf. 2, Fig. 9 (Ellis & Messina, 1940).  
1895 *Uvigerina acuminata* nom.red. Hosius - Hosius, 10, 167 (Ellis & Messina, 1940).  
1963 *Uvigerina acuminata* Hosius - Papp, 250, Taf. 4, Fig. 11-15.  
1977 *Uvigerina acuminata* Hosius - Von Daniels & SpieglEr, 26, Taf. 3, Fig. 9-12.  
1986 *Uvigerina acuminata* Hosius - Cičha et al., 144, Pl. 7, Figs. 1-10.  
1986 *Uvigerina acuminata* Hosius - 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 (Cičha et al., 1998). In Austria, the species is reported from Ottnangian and Karpatian (Roetzell et al., 2006). In Slovenia, the species has been identified in Lower Badenian and Middle Badenian (Rižavec, 1976).

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

1955 *Uvigerina bellicostata* n.sp. Luczkowska, 118, Pl. 8, Figs. 10-13 (Cičha et al., 1998).  
1978 *Uvigerina costatoides* n.sp. Papp & Schmid, 283, Taf. 11, Fig. 5-8.  
1986 *Uvigerina bellicostata* Luczkowska - Cičha et al., 152, Pl. 11, Figs. 1-3, Pl. 12, Figs. 1, 5-6.  
1998 *Uvigerina bellicostata* Luczkowska - Cičha 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 (Cičha 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 (Pezeli, 2005;...
**U. costatooides**. 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 & SPEIGLER, 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 - CICHA et al., 147, Pl. 9, Figs. 1-2; 3-6.
1986 *Uvigerina semiornata brunnensis* Karrer - VON DANIELS, 102, Pl. 10, Figs. 1-5.
1998 *Uvigerina brunnensis* Karrer - CICHA 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 subequal. 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 (CICHA et al., 1998). In Austria, it is reported from Middle Badenian (PAPP & SCHMID, 1978) and in Romania from Upper Badenian (POPESCU, 1979).

**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 & SPEIGLER, 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 - CICHA 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 - CICHA 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 ends 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, Ig3, Ig10, Ig11, Ig14, Dr1, Dr9).

Occurrence: In the Central Paratethys, the species was reported from Lower Badenian (CICHA 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. pygmea* d’Orbigny - PAPP & TURNOVSKY, 127, Taf. V, Abb. B, Fig. 9-10.
1978 *Uvigerina cf. pygmea* d’Orbigny - PAPP & SCHMID, 281, Taf. 9, Fig. 13.
1978 *Uvigerina cf. pygmea* d’Orbigny - RIJAVEC, 218, Tab. 2, Fig. 12.
1986 *Uvigerina cf. U. pygmea* d’Orbigny - CICHA et al., 166, Pl. 16, Fig. 5.
1998 *Uvigerina cf. pygmea* d’Orbigny - CICHA 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 (CICHA et al., 1998), according to PAPP & SCHMID (1978) in Late Middle Badenian only. It is most frequent in Middle Badenian (CICHA 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 & Turnovský**, 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 - **Rögler & 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 Karpbian 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 Karpian (*Cicha et al.*, 1986), and frequent in Late Lower Badenian (*Papp & Turnovsky*, 1953). In Austria, it is reported from Early Lower Badenian (*Rögler & 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 & Speziger**, 20, Taf. 1, Fig. 1-10.

1978 *Uvigerina semiornata* d’Orbigny - **Papp & Schmid**, 281, Taf. 10, Fig. 4-7.

1985 *Uvigerina semiornata* d’Orbigny - **Rijavec**, 218, Tab. 2, Fig. 14.

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 Karpian 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 venusta* Franzenau - **Papp & Schmid**, 280, Taf. 9, Fig. 9-12.

1986 *Uvigerina venusta venusta* Franzenau - **Rijavec**, 217, Tab. 2, Fig. 9.

1986 *Uvigerina venusta venusta* Franzenau - **Ciacha et al.**, 168, Pl. 18, Figs. 1-3, 5, 7.


1998 *Uvigerina venusta venusta* Franzenau - **Cicha 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, Sa18, Sa17, 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).

Subfamilies 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) - Oblar, 298, 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 - Oblar, 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 Pupp & Turnovsky, U. pygmoideal Papp & Turnovsky, U. acuminate 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. brunensis Karrer first appear. Their first occurrence defines the beginning of the foraminiferal U. cf. pygmea Zone, which delimits the Early and Late Middle Badenian (Oblar, 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 Luczkowska. 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 & Schimid, 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,
although the Mediterranean Sea was connected to the Central Paratethys through the Trans-Tethyan trench corridor across Slovenia until the Upper Badenian (ROGL, 1999). Only the following four species are found to exist in both regions: *U. pygmooides* (BARBIERI & D’ONOFRIO, 1984: Middle Miocene of Italy), *U. semiornata* (SALAJ, 1992: Serravallian of Tunis), *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

Fig. 4. Stratigraphic ranges of species of genera Uvigerina, Pappina, Trifarina and Angulogerina in studied area. (Abbreviations explained at Fig. 2).

Sl. 4. Stratigrafski razponi vrst iz rodov Uvigerina, Pappina, Trifarina in Angulogerina na preučenem območju (kratice razložene pri sl. 2).
V namen te raziskave je bilo vzorčenih šest srednjiemeienskih profilov Planinske sinklinale v vhodni Sloveniji (sl. 1). Iz lapornih plast je bilo pobranih 159 vzorcev, in sicer v stratigrafskem razponu od spodnjebadenijskih do spodnjesarmatijskih plast (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 vzdož badenijskih plati kaze značilen biostratigrafski vzorec (sl. 3, 4). Večina razponov sovпадa z že poznanimi in trenutno najbolj referenciranim razponom za območje Centralne Paratetide (Cichia et al., 1988). Izjema je vrsta Pappina neudorfensis, ki se pravič pojavi že v mlajšem srednjem badeniju in se nele v zgornjem badeniju, kot navaja omenjena pappinid teratura, kar nakazuje na širši razpon vrste.

V ekološkem pogledu imajo pappinide in uvigerinide podobne okoljske preference. Njihov vir temperatura, kar nakazuje na širši razpon vrste.


FILIPESCU, S. & GIBRACEA, R. 1997: Lower Badeanian sea-level drop on the Western border of the Transylvanian basin: Foraminiferal paleo-
Badenian Pappinidae and Uvigerinidae from the South-western margin of the Pannonian Basin (Eastern Slovenia)


PLATE 2 – TABLA 2

1a-b Uvigerina cf. pygmea d’Orbigny; a, b - J33
2a-b U. pygmeoides Papp & Turnovský; a - Ig6, b - Pb54
3a-b U. semioriana d’Orbigny; a, b - J32
4 U. venusta Franzenau; J32
5 Angulogerina angulosa (Williamson); Ig4
6a-b A. esuriensis Hornbrook; a - Sa10, b - Sa8 , 7 Trifarina bradyi Cushman; Ig4.

Scale bar (merilce) = 100 µm.


