Геолошки анали Балканскога полуострва Annales Géologiques de la Péninsule Balkanique	68	61–71	Београд, децембар 2007 Belgrade, December 2007

DOI: 10.2298GABP/0701061B

Cassiopid gastropods from the Cretaceous of western Serbia

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Abstract. Three species of Cassiopidae (Cerithioidea, Gastropoda) are described from outcrops in the vicinity of the villages Rastište and Mokra Gora in western Serbia. They occur in marly limestones of near shore shallow water deposits. Earlier micropaleontological investigations have indicated an Albian–Cenomanian age. The species encountered are related to those present in deposits of the European margin of the Tethys and closest relationships exist to those of the Armenian and Transcaucasian region. Our species can be placed in the genera *Cassiope*, *Paraglauconia* and *Bicarinella*. A new species *Cassiope kotromanensis* is erected. Assumptions about post-mortem shell transport and size sorting of gastropod shells were examined through statistical analysis.

Key words: Gastropoda, Cassiopidae, Cretaceous, Albian, Cenomanian, statistical analysis, western Serbia.

Апстракт. У раду су описане три врсте касиопида (Cerithioidea, Gastropoda) које потичу са изданака у околини села Растиште и Мокра Гора у западној Србији. Примерци су нађени у лапоровитим кречњацима насталим у плиткој води, близу обале. Ранија микропалеонтолошка истраживања указала су на алб-ценоманску старост ових стена. Врсте које су описане показују велику сличност са примерцима откривеним у Јерменији и Закавказју. Оне припадају родовима *Cassiope*, *Paraglauconia* и *Bicarinella*. Описана је нова врста *Cassiope kotromanensis*. Претпоставке о постморталном транспорту љуштура испитане су статистичком анализом.

Кључне речи: Gastropoda, Cassiopidae, креда, алб, ценоман, статистичка анализа, западна Србија.

Introduction

Albian to Campanian sediments, resulting from a wide ranging transgression, are commonly encountered in western Serbia. Some of the outcrops are located between the Beli Rzav and Crni Rzav Rivers, with an extent of about 40 km in a NN–SSE direction. These deposits contain many fossils and were previously considered to be of Senonian age (Žujović 1893; Živković 1908; Ampferer 1928; Milovanović 1933). More Recent work on their microfauna point to an Albian–Cenomanian age (Pejović & Radoičić 1971). The fossil assemblages are dominated by cassiopid gastropods, less frequent are bivalves, ostracods, dasycladaceans and foraminifers. The aim of the present study was to describe more closely the cassiopid gastropods, and to discuss their systematic and biogeographic relationships.

Geological setting

The lithology is represented by terrigenous clastites in the base, covered by bioclastic limestone. A local stratigraphic column was observed at the right bank of the Beli Rzav River at the hamlet Uroševići (coordinates N 43°45'50", E 19°28'30"). Three separate members of the stratigraphic column could be distinguished:

1. The lowermost member consists of dark gray oolitic sandstone and conglomerate with intercalated thin beds of micritic limestone. The coarse sandstone holds particles of different size including fragments of serpentine, glauconite and infrequent quartz. The components are poorly sorted and weakly rounded. Larger particles predominate over smaller ones. Conglomerate pebbles originated from laterites and the peridotitic bedrock of the former islands. This composition of the

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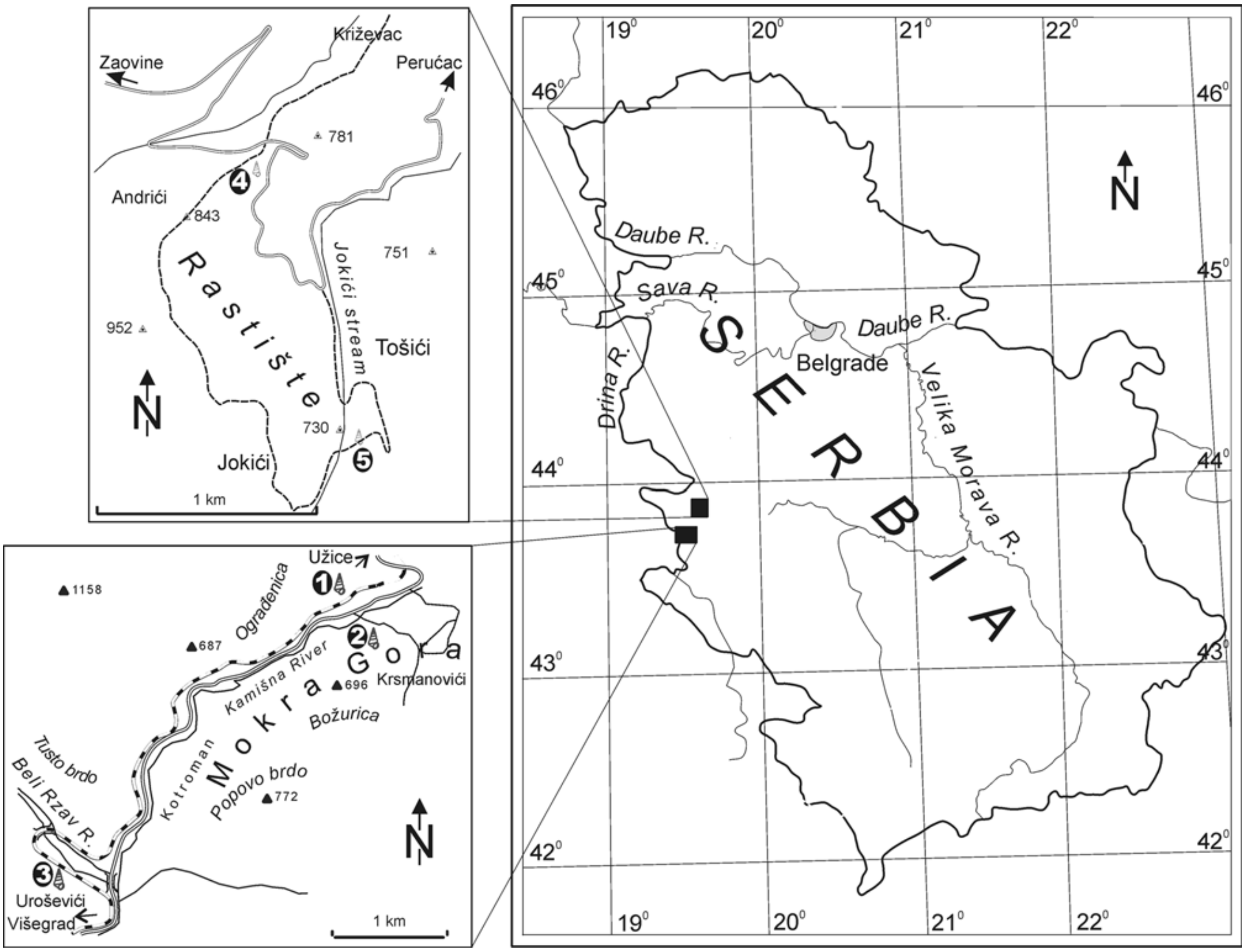

Fig. 1. Topographic map with fossiliferous localities.

beds presents evidence for a deposition in an environment of agitated shallow water, close to a seashore, with strong wave action. Rapid deposition of terrigenious material corresponds with about facial belts 8 and 9 of the classification adopted by WILSON (1975). The total thickness of the lowermost member is about 7 m.

At the beginning of marine flooding of the area, the surface was rugged and the surrounding area mountainous. Due to the composition of the soil formed on peridotites in an arid climate, plant cover on land was thin. Eroded material, therefore, was washed into the area of deposition rapidly and came from nearby. The almost complete absence of fossils in these beds indicates a stressed environment for marine organisms. The presence of oolites point to the presence of strong oscillating currents in shallow water. Intercalated fine beds were deposited in more protected lagoons.

2. The middle member of the stratigraphic column is composed of bioclastic limestones with a fine grained matrix, nodular bedding planes, and thin layers of interbedded marls. Thin sections revealed the composition of a shell coquina with a micro-crystalline calcitic matrix and evenly distributed clay material. Beside minute shell particles of mollusks, fecal pellets and algae are abundant. PEJOVIĆ & RADOIČIĆ (1971) mentioned *Bacinella sterni* RADOIČIĆ, *Nezzazatinella* cf. *picardi* (HENSON) and *Salpingoporella urladanasi* CONRAD, RADOIČIĆ & REY, from the lower part of this member and scarce assemblage with *Nezzazatinella* cf. *picardi* and *Hemicyclamina sigali* (MYNC) from the upper part. In thin-bedded micrites, numerous microscopic mud cracks and birdseye structures are present. These voids are sporadically filled by silico-clastic silt. The sediments were deposited under shallow water conditions, with frequent exposure above sea level. The influx of material from the land was less if compared with the beds of the lower member. The thickness of the middle member is nearly 28 m.

3. The upper member in this stratigraphic column is composed of bioclastic micritic limestone with interbedded thin marl. In thin section fecal pellets, bioturbation, debris of organic material, mollusc shells, and some oogonia and stem fragments of charophytes are noted. The lower part of the member consists predominantly of algal marly limestone with a lot of pyrite and organic material. Here small codiacean pebbles and grains and some *Hemicyclammina sigali* are present.

Higher up in the column the sediments are predominantly marly and contain abundant hematite and limonite particles as well as numerous dasycladaceans, codiacean grains, a few miliolinid foraminifera, shells of small gastropods, sponge spicules, spines of echinoderms and other biogenes. The sediment suggests deposition in warm shallow water, with varying salinity, and without significant water circulation. Frequent charophyte and ostracode debris indicate the temporary influence of brackish water. According to the enumerated characteristics, the sediments were formed on an open or restricted platform, behind an organic reef, about facies belts 7 and 8 of the classification of WILSON (1975). Some charecteristics indicate the environment of slightly deeper lagoons, intermittently connected with the open sea. The thickness of the upper member of the stratigraphic column is about 14 m.

The tectonic characteristics of the Cretaceous deposits are such that the beds form a syncline with Turonian deposits at the axial part, while outcrops of Albian–Cenomanian sediment are wide-spread at the margins of this structure. The syncline became fractured by numerous subsequent faults, forming several vertically displaced blocks.

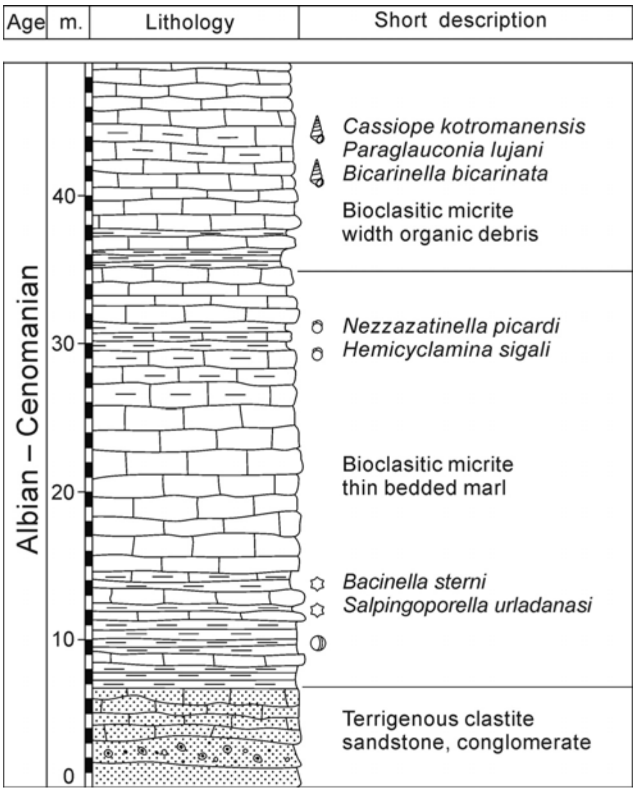

Fig. 2. Local stratigraphic column at Uroševići.

Material and methods

The majority of the material (84 specimens in total) described below was hand-picked from the bioclastic micritic limestone with interbedded thin marl (upper member of the stratigraphic column). The gastropod assemblage contains *Cassiope kotromanensis, Bicarinella bicarinata* and *Paraglauconia lujani*. Gastropods were collected from outcrops of marly limestone in the vicinity of Mokra Gora, Kotroman and Rastište villages. Fossil bearing localities were numbered 1 to 5 and are indicated at Fig. 1.

The collection is housed at the Faculty of Mining and Geology in Belgrade (registration numbers NB/67/11 to NB/162/97).

Principal components analysis was conducted to examine the possibility of post-mortem shell transport and size sorting within the gastropd assemblage.

Some of the taxa concerned here were introduced and studied by the Armenian paleontologist Vardges Akopyan. In his publications his name was spelled Hacobjan, but is frequently cited as Akopyan. His publications were originally written in Russian, and according to transliteration rules his name would have to be spelled Akopyan, even though it is Armenian. To avoid confusion, we use here the transliteration Akopyan.

Systematic paleontology

Family Cassiopidae BEURLEN, 1964
(= Cassiopidae KOLLMANN, 1979;
Glauconiidae PCHELINTSEV, 1953)

The family is based on the genus *Cassiope* COQUAND, 1865. which is conical in shape, with wavy spiral ribs and a rounded aperture. The base is angular and the umbilicus open. According to CLEEVELY & MORRIS (1988), the wide conical shell has flattened whorls that are ornamented by spiral ribs that may bear tubercles. The outer lip of the aperture is curved so that there is a posterior lobe. The protoconch morphology has been discussed by KOWALKE & BANDEL (1996, pl. 5, figs. 5, 6) based on *Cassiope kefersteinii* (MÜNSTER in GOLDFUSS, 1844) from the Late Cretaceous of the Gosau (Northern Alps). That protoconch consists of 3 whorls with the embryonic shell about 0.12 mm wide. The ornament of the larval whorls consists of two spiral ribs and a row of tubercles below the suture (BANDEL 1993). The operculum found in the aperture of a half grown individual shows multispiral composition similar to that found in modern Potamididae. It is quite possible that this modern group of coastal Cerithioidea represents the closest relatives to the Cretaceous Cassiopidae, which obviously also lived near shore and was influenced by fresh water run off.

Genus ***Cassiope*** COQUAND, 1865

Type species. *Cassiope kefersteini* MÜNSTER in GOLDFUSS, 1844, Gosau Group, Coniacian–Campanian, Austria.

Diagnosis. The shell is conical with flattened whorls angled at the base. The ornament consists of spiral threads and rows of nodes. The growth line pattern is sinuous with a shallow bay below the suture. The base is flattened to weakly convex and may have a small slit-like umbilicus. The aperture is simple and of elongated oval shape (WENZ 1938; CLEEVELY & MORRIS 1988). The protoconch consists of three rounded whorls forming a conical shell, ornamented by two spiral ribs in its larval shell portion (BANDEL 1993, pl. 4, fig. 6; KOWALKE & BANDEL 1996). The genotype has an up to 40 mm high shell that consists of about ten whorls with a regular increase in size. Ornament consists of spiral ribs, sometimes increasing in number at latest whorls. In addition to the main spiral ribs, there may be fine spiral threads.

Cassiope kotromanensis sp. nov.
Fig. 3A–E.

? 1949 *Glauconia coquandi* (D'ORB.) – PETKOVIĆ & PAŠIĆ: 141, pl. 1, fig. 1.
? 1952 *Glauconia coquandi* (D'ORB.) var. *velesana* n. var. – ĆIRIĆ: 256, pl. 4. fig. 2, non figs. 3–5.
non 1952 *Glauconia coquandi* (D'ORB.) – ĆIRIĆ: 253, pl. 2, figs. 1–3, 5, 6.
1968 *Cerithium exiguum* ZEKELI – BRKOVIĆ: 127, pl. 1, fig. 1.
1968 *Cerithium distinctum* ZEKELI – BRKOVIĆ: 127, pl. 1, fig. 2.

Holotype: NB/67/23, Plate 1, Figs. 1, 2.
Paratypes: NB/67/11…NB/162/97.
Derivation of the name: After nearby locality Kotroman.
Type locality: Uroševići Hamlet, Beli Rzav River.
Type horizon: Cenomanian bioclastic micritic limestones (upper part of the local stratigraphic column in Fig. 2).

Material. 47 specimens from outcrops at Kamišna, the banks of the Beli Rzav River and Andrići Hamlet, localities 3, 4 and 5 in Fig. 1.

Diagnosis. A small cassiopid, variably ornamented with 3–4 tuberculated spiral ribs. The sinus in the opisthocyrt growth lines occurs at the middle part of the whorls, while a shallow sinus occurs at the base.

Description. The conical shell consists of about five whorls with flat sides and is up to 35 mm high, with an apical angle of 25–31°. Sutures are V-shaped and narrow, and inclined at about 16°. The juvenile whorls also have this characteristic suture. The whorls are sculptured by three wide, equally spaced spiral cords, which bear 18–20 up to 2 mm wide tubercles on each whorl. The spiral ribs are clearly separated and slightly wider than the space between them. In some specimens, a narrow tuberculated spiral thread positioned between the central and the abapical spiral cords appears. This thread is slightly narrower than the other cords, or it can be a fine, pustulae bearing spiral thread of second order.

The growth lines reflect the broad and shallow sinus of the outer lip. The corner to the base is sharp, the base is convex, has a narrow umbilical slit and bears three or four spiral lines with small tubercles. Besides the main sinus, there is a delicate shallow sinus of secondary order at the basal surface. Longitudinal sections indicate the whorl height as large as the whorl width.

Remarks. The significance of the patterns of the growth line in species determination of *Cassiope* had been emphasized by KOLLMANN (1979) and CLEEVELY & MORRIS (1988). One of the characteristic features of the shell of *Cassiope kotromanensis* is the presence of the collabral sinus reflecting the shape of the outer lip, and a second sinus present on the basal surface. Our specimens have an average height of about 23 mm, and, therefore, measure only about half the size of other species of the Cassiopidae. They also have a slightly smaller spiral angle than *Glauconia coquandiana* (D'ORBIGNY) described by AKOPYAN (1976). PETKOVIĆ & PAŠIĆ (1949) described four subspecies of *Glauconia coquandiana*, ornamented by small pustules on some of the spiral cords. Only one of their specimens (PETKOVIĆ & PAŠIĆ 1949, pl. 1, fig. 1) shows some characteristics of *Cassiope kotromanensis* and is tentatively included in the synonymy. Also ĆIRIĆ (1952) described numerous types as different subspecies of *Glauconia coquandiana*. The original specimens are not available, while according to the author's description only *Glauconia coquandiana* var. *velesana* bears tuberculated spiral cords, resembling *Cassiope kotromanensis*. ĆIRIĆ (1952) mentioned a wider apical angle, 34–40°, when compared with *Cassiope kotromanensis,* and the specimen is hesitantly included in the synonymy. Specimens from other nearby localities identified as *Cerithium exiguum* ZEKELI and *Cerithium distinctum* ZEKELI by BRKOVIĆ (1968) also belong to *Cassiope kotromanensis*. The characteristic shape of the growth lines reflecting the sinus of the median and basal part of the outer lip of the aperture was not noted by these authors.

Occurrence. Albian–Cenomanian beds in the vicinity of Kotroman, Uroševići, Kamišna and Beli Rzav River banks, western Serbia.

Genus *Paraglauconia* STEINMANN, 1929

Type species. *Paraglauconia carbonaria* (ROEMER, 1836), Wealden (Early Cretaceous), Germany.

Diagnosis (following AKOPYAN, 1976). According to it, the shell is of conical shape with concave whorls. Ornament consists of two rows of nodes positioned at the apical corner and the edge to the base of whorls. Spiral rows of secondary order may occur. The growth lines bear a wide sinus which reflects a wide lobe at the middle of the outer lip of the aperture.

CLEEVELY & MORRIS (1988) noted in *Paraglauconia tricarinata* (SOWERBY in FITTON, 1836) a protoconch which is in essential features like that of *Cassiope*

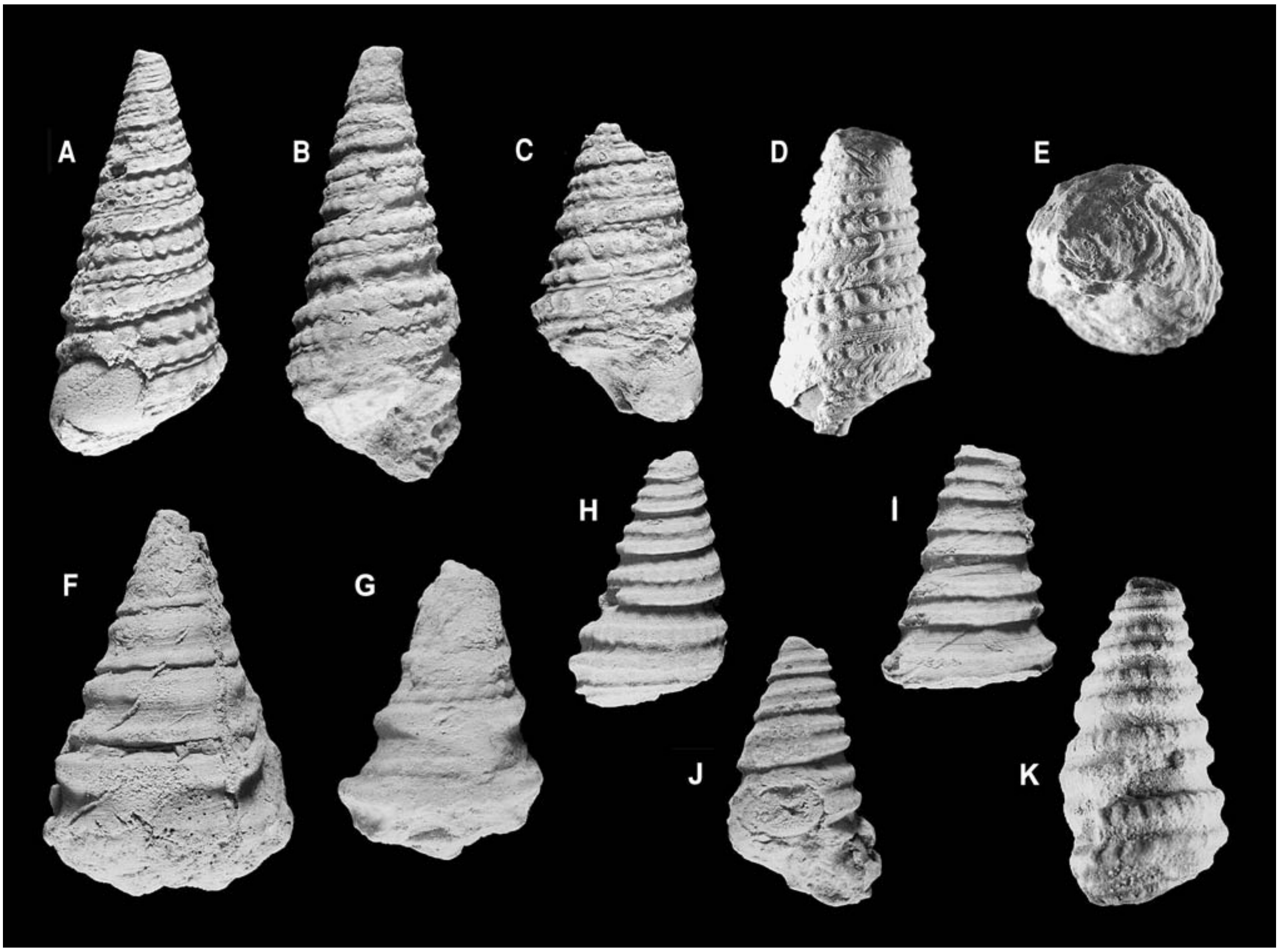

Fig. 3. **A–E**. *Cassiope kotromanensis* sp. nov. **A**, **B**. NB/67/23, lateral and apertural view, ×1.5; **C**, NB/67/28, apertural view, ×1.5; **D**, NB/67/30, lateral view, ×2; **E**, NB/67/23, basal view, ×2; **F**, **G**, *Paraglauconia lujani* (DE VERNEUIL & COLOMB, 1853). **F**, NB/D8/7, lateral view, ×1.5; **G**, NB/D9/2, lateral view, ×1.5; **H–K**, *Bicarinella bicarinata* (PCHELINTSEV, 1953). ×1.5, **H**, NB/94/89, lateral view, ×1.5; **J**, NB/94/89, apertural view, ×1.5; **I**, NB/67/21, lateral view, ×1.5; **K**, NB/94/90, lateral view, ×1.5.

kefersteini, having two spiral keels on its larval shell portion. They noted that the base of the teleoconch is convex and may bear spiral lines. The aperture have an oval shape.

Paraglauconia lujani
(DE VERNEUIL & COLOMB, 1853)
Fig. 3F, G.

1853 *Cerithium Lujani* DE VERNEUIL & COLOMB: pl. 3, fig. 17.
? 1865 *Cassiope verneuilli* COQUAND: pl. 4, figs. 1, 2.
1865 *Cassiope Lujani* var. *crassa* COQUAND: 61, pl. 4, figs. 1, 2.
1865 *Cassiope Lujani* var. *laevigata* COQUAND: 61, pl. 4, figs. 3, 4.
1865 *Cassiope Lujani* var *nodosa* COQUAND: 62, pl. 4, fig. 5.
1868 *Vicarya lujani* (DE VERNEUIL & COLOMB) – DE VERNEUIL & LORIERE: 5-7, pl. 1, fig. 3.
1868 *Vicarya strombiformis* SCHLOTHEIM DE VERNEUIL & LORIERE: pl. 7, pl. 1, fig. 4.
1899 *Glauconia* cf. *lujani* (DE VERNEUIL) – PERON: 95-96, pl. 1. fig. 10.
1909 *Glauconia Lujani* (DE VERN.) – COSSMANN: 168, pl. 4, figs. 11–12.
1932 *Glauconia Lujani* VERN. – PETKOVIĆ & BOJIĆ: 13.
1952 *Glauconia coquandi* D'ORB. var. excavata REP. – ĆIRIĆ: 255, pl. 2, fig. 9.
1976 *Paraglauconia lujani* (VERNEUIL) – AKOPYAN: 138.
1982 *Paraglauconia lujani* (VERNEUIL) – KOLLMANN: 337, pl. 1, figs. 7–9.
1984 *Paraglauconia lujani* (DE VERNEUIL & COLOMB) – CLEEVELY *et al*.: 98, fig. 2, (non figs. 11–14).
1984 *Cassiope dorsetensis* MENNESSIER: 78, pl. 27, figs. 10, 11.
1984 *Cassiope luxani* (DE VERNEUIL) emend. VILANOVA – MENNESSIER: 78, pl. 26, figs. 18–27; pl. 27, fig. 6.
1984 *Cassiope luxani* (DE VERNEUIL) nodosa COQUAND – MENNESSIER: 78, pl. 26, figs. 27 a–b.
1984 *Cassiope luxani* (DE VERNEUIL) crassa COQUAND – MENNESSIER: 78, pl. 27, figs. 4–5.
1988 *Paraglauconia lujani* (DE VERNEUIL & COLOMB) – CLEEVELY & MORRIS: 265, text-fig. 14.

Material. 29 specimens from the hamlets Andrići and Rastište, localities 3, 4, 5 in Fig. 1.

Description. The shell is conical, up to 40 mm high, consists of four to six slightly concave whorls with grooved sutures, and has an apical angle of 26°. The sculpture consists of two main spiral ribs, which bear broad tubercles and are positioned next to the suture, one above it, the other below it. Some specimens have in addition two or three spiral lines in the centre of the whorl, while others have numerous very fine and delicate spiral lines all over the outer surface of the whorls. The growth lines are opisthocyrt, very fine, and the tangental point of their sinus is situated between the middle of the whorl and its upper third. The base carries one spiral rib and numerous fine narrow spiral lines. In longitudinal section, the inner cavities have an oval outline with a height/width ratio of 0.88.

Remarks. *Cassiope verneuilli* COQUAND (1865) has a more prominent apical spiral rib and is included in the synonymy, but with doubts. *Paraglauconia lujani* resembles in shape and orientation *Cassiope branneri* (HILL, 1893) from the Aptian to Early Cenomanian Comanche Formation in North America (STANTON, 1947), but is more stout and has a wider apical angle. *Paraglauconia lujani* was described but not figured by PETKOVIĆ & BOJIĆ (1932) from Aptian beds of eastern Serbia, and also *Glauconia coquandi* D'ORB. var. *excavata* described by ĆIRIĆ (1952) from Turonian deposits in central Macedonia appears to belong to this species.

Occurrence. Albian–Cenomanian beds in the vicinity of Andrići and Rastište hamlets.

Genus *Bicarinella* AKOPYAN, 1976

Type species. *Pseudomesalia bicarinata* PCHELINTSEV, 1953, Late Cenomanian, Armenia.

Diagnosis (according to AKOPYAN, 1976). The shell is conical with a high spire. Whorls are slightly convex, with two major keels. They frequently bear tubercles and give the whorls an angular shape. The suture is well expressed. Ornament may also consist of additional weak spiral threads. The area between the keels in the central part of the whorls is flattened. The base is convex with a narrow umbilicus. The aperture is rounded and has a wide and deep sinus at its outer lip.

Bicarinella bicarinata (PCHELINTSEV, 1953)
Fig. 3H–K.

? 1938 *Paraglauconia mediocarinata* MIKINČIĆ: 155, pl. 1, figs. 3–4.
1953 *Pseudomesalia bicarinata* PCHELINTSEV: 99, pl. 11, figs. 3–4, (non figs. 1, 2, 5, 6), pl. 12, figs. 1–5.
1974 *Pseudomesalia bicarinata* PCHELINTSEV – AKOPYAN: 234, pl. 119, figs. 2–3.
1976 *Bicarinella bicarinata* (PCHELINTSEV) – AKOPYAN: 165.
1976 *Bicarinella bicarinata bicarinata* AKOPYAN: 166, pl. 38, figs. 1–3.
1976 *Bicarinella bicarinata ornata* AKOPYAN: 167, pl. 38, figs. 5–6.
1981 *Pseudomesalia bicarinata* PCHELINTSEV – TSANKOV: 58, pl. 13, figs. 14–17.
1984 *Pseudomesalia (Bicarinella) bicarinata* PCHELINTSEV – MENNESSIER: 54, pl. 14, figs. 17–21, 35.

Material. 18 specimens from the right bank of the Beli Rzav River, and from the Kremići Stream, localities 1, 2, 3 and 5 in Fig. 1.

Description. The conical shell is up to 30 mm high and has an apical angle of 26–30°. Its whorls have flattened sides and distinct sutures. Ornament consists of two prominent spiral ribs the upper of which lies at the cetre, the second at the basal edge of the whorls. The spiral cords bear tubercles that are small on early whorls and increase in size towards the last whorl. Two or three secondary spiral threads appear between the main cords in some individuals. Growth lines are opisthocyrt and bear a shallow, widely V-shaped sinus with the tangental point between the central and the abapical third of the whorl, the point of inflexion is at the main spiral rib. Growth lines have a secondary shallow sinus near the base of the whorls. The base is convex, has a narrow umbilicus and bears two prominent spiral ribs and a few spiral threads.

Remarks. Our specimens are only about half the size of those individuals that have been described from other localities and listed in the synonymy. *Bicarinella bicarinata* resembles *Cassiope burnsi* from the Aptian to Early Cenomanian Comanche formation, Texas, described by STANTON (1947). *Cassiope burnsi* bears ornament with a less nodose character of the spiral cords. From Aptian beds in central Serbia, MIKINČIĆ (1938) described the species *Paraglauconia mediocarinata*, which closely resembles *B. bicarinata* in size and shape. It differs by having a delicate second sinus at the base of the shell and by the absence of an umbilicus. This species is only tentatively included in the synonymy. If future research shows that the two species are conspecific, *B. mediocarinata* would have priority over *B. bicarinata*.

Occurrence. Albian–Cenomanian at Mokra Gora and Uroševići.

Discussion of the small size of the specimens

During the investigation, it became evident that the studied shells are quite small, even with same amount of whorls, much smaller than specimens cited in the synonymy. There are three possible explanations for the small size of cassiopids from the examined outcrops.

One of the possibilities is that Cassiopidae from the central part of the Tethys, during Albian and Cenomanian time did not attain the same large dimensions of the individuals which form the typical Late Cretaceous members of this family. This assumption may be supported by the fact that the here reported individuals come from beds which are older than the beds where the cited species were found. Consequently species regarded as synonyms of *Cassiope kotromanensis* were mentioned in localities of Turonian age, while here it is found in Albian–Cenomanian beds. As some other cassiopids known from older rocks have no miniature dimensions, for example, *Paraglauconia lujani* according to COQUAND (1865), FRITSCHE (1924), CLEEVELY & MORRIS (1988), this reason seems less probable (although it should not be absolutely rejected).

A second possibility for the small size of the discussed individuals may be seen in the influence of environmental factors. Living conditions in the coastal lagoons along the Tethys terranes now representing central Serbia could have been sub-optimal. They could have inhibited the proper growth of the snails. This assumption is difficult to confirm, since unfavorable factors of the environment which could have inhibited growth are not easily detected from rock facies. Also the preservation of the shells is not sufficient to compare individuals by counting their number of shell whorls. This could provide a clearer picture of the possible reasons for the smallness of the individuals. Difficulties during growth of the individuals may have come from the periodical influence of fresh water, supported by presence of charophyte stems in the deposits.

A third hypothesis explaining the small shell dimensions may come from post-mortem shell transport and size sorting. The occurrence of shell sorting during transport on the sea-bed has been described in numerous cases (BOUCOT 1953; CADÉE 1982, 1988, 1989). Water currents may have transported and sorted dead shells. During the transport, according to size and weight, sorting is performed, affecting the size frequency distribution of the reworked shells. The resulting death assemblage may have concentrated predominantly small shells. A modern case of such a secondary shell sorting in the tropical environment of the Philippines has been described by BANDEL (1991). This third explanation could be checked by several statistical methods.

Statistical analysis

Assumptions about small size of the gastropods were checked through statistical analysis. Firstly all the specimens were measured and the size distribution was calculated, just to confirm the assumptions concerning the small size of the individuals. Subsequently statistical analysis was performed through two steps. The first included a comparison of the shell dimensions, to confirm the presence of any significant differences between shells of several species originating from the same outcrops. The second included a similar investigation conducted over the same species originating from different localities. For each specimen, appropriate dimensions were measured and parameters calculated, while principal component analysis was used for the further statistical investigations. Considering dimensions such as general shell height, width, height of last whorl, principal components were calculated, mutually correlated (to designate the most contrasted dimensions of the entered data). Principal components were sorted by the magnitude of variability, so that the first one has the highest variability, while the last one has the lowest variability.

Size distribution in the fauna

For each specimen, the following dimensions were measured: height of the shell (H), height of the last whorl (h), shell width (W), angle of spire (?). Some parameters were indirectly calculated: height per width ratio for the whole shell (W/H), and the same ratio for the last whorl (W/h). Furthermore, sample mean and standard deviation for each parameter were calculated. The results are shown in Table 1.

The observation that the shells are notably smaller than those of the specimens cited in the synonymy was confirmed by the values presented in Table 1. In some species, the shells are nearly only half as large as the corresponding specimens from other localities.

Relationship of different species from the same outcrops

The first investigation was performed on the specimens collected at outcrops near the hamlet Uroševići (locality 3, Fig. 1), regarding specimens of the species *Cassiope kotromanensis* and *Bicarinella bicarinata*.

Considering the data (Table 1), it is evident that *Bicarinella bicarinata* has a mean height of 22 mm, while specimens described in the literature reach up to 50 mm (AKOPYAN 1976) or even 75 mm (MENNESSIER 1984). Furthermore, *Cassiope kotromanensis* has half of the typical height of Cassiopidae (ZEKELI 1852; AKOPYAN 1976). As both species are quite small and have about equal dimensions, we assume that the shells endured moderate transport, and consequently adequate sorting due to dimension, before they finally became deposited and fossilized.

To check this assumption, the first principal components of all specimens were compared and tested. Small differences between the components for both groups was confirmed with a simple t-test 1.17, which is significantly less than 2.14, a critical value for the related number degrees of freedom.

The assemblage that had been collected in the western part of the Rastište Village (locality 5 in Fig. 1) was considered in the same manner. Here the abundant association of *Paraglauconia lujani* and *Cassiope kotromanensis* is characterized by shells which are significantly smaller than those from other localities noted in the

Table 1. Average values of the shell dimension (in mm) for the collected sample. Legend: H, height of the shell; h, height of the last whorl; W, width of the shell; α, spire angle (in degrees); W/H, width/height ratio for the whole shell; W/h, same ratio for the last whorl. The numbers in brackets represent the standard deviation for the collected sample.

Species	H	h	W	α	W/H	W/h
Cassiope kotromanensis	25.30 (6.64)	8.49 (2.25)	13.71 (3.41)	31.39 (3.89)	0.55 (0.07)	0.34 (0.05)
Paraglauconia lujani	27.65 (6.50)	9.90 (3.28)	16.70 (3.77)	32.55 (4.20)	0.62 (0.18)	0.36 (0.09)
Bicarinella bicarinata	22.39 (6.43)	8.49 (2.92)	13.22 (3.12)	29.11 (5.21)	0.60 (0.10)	0.39 (0.15)

other parts of the Tethys Ocean. As in the previous associations, *Paraglauconia lujani* is 27 mm high versus 65 mm (specimen pictured in MENNESSIER 1984), while *Cassiope kotromanensis* reaches 25 mm versus 50 mm of most Cassiopids (AKOPYAN 1976). For the two species present here, principal components were calculated and checked with the t-test. The result 1.66 is less than 2.05, the critical value for 27 degrees of freedom.

As in the previous example, there are no significant differences between shell size for the different groups. It is thus assumed that the shells from this outcrop are part of a moderately transported fossil death assemblage.

Relationship of the same species from different outcrops

The survey was conducted with shells belonging to the same species, but which were collected at isolated outcrops. The analysis was carried out for different samples: *Cassiope kotromanensis* collected at the Rastište Village (localities 4 and 5, Fig. 1); a sample of *Bicarinella bicarinata* collected at the left bank of the Kamišna River (locality 2, Fig. 1), was compared with samples collected at the localities Uroševići (locality 3, Fig. 1) and Jokići (locality 5, Fig. 1). For each pair of samples t-tests of the principal components were performed. The results are shown in Table 2. The first column represents localities for which the t-test was calculated, the second column represents the degrees of fredom, the third column shows the calculated value of t-tests, while the last column shows the critical value for the appropriate degrees of freedom.

As becomes evident, *Cassiope kotromanensis* shows notable size differences between the assemblages collected at outcrops 4 and 5. The second listed species *Bicarinella bicarinata* shows significant differences for the shells originating from localities 2 and 3, as well as for the shells from localities 2 and 5. The other samples show no significant differences.

This contrast is visible in the principal components plot. The diagram in Fig. 4 shows the parameters of

Table 2. Principal components t-test for the same species at separate localities.

Localities:	df	t stat	t critical
Cassiope kotromanensis loc. 4 vs loc. 5	34	3.282	2.030
Bicarinella bicarinata loc. 2 vs loc. 3	9	3.746	2.262
Bicarinella bicarinata loc. 2 vs loc. 5	9	2.539	2.262

Cassiope kotromanensis with larger specimen components (originating from the locality 5) predominant at the right side (black circles), and smaller ones (locality 4), at the left side of the diagram (white circles). The diagram in Fig. 5 shows the analysis of *Bicarinella bicarinata* collected at the localities 2 and 3. As in the previous diagram, the larger specimen components (locality 2) are grouped at the right side of the diagram, while the smaller ones (locality 3) are noted at the left side.

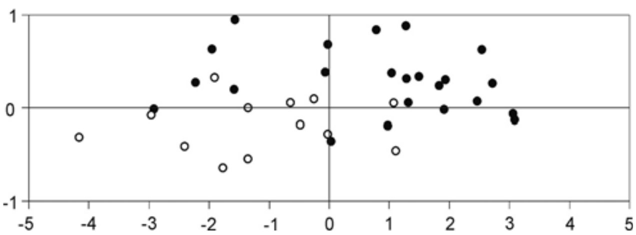

Fig. 4. Principal components diagram for *Cassiope kotromanensis*. Legend: black circles, specimens from locality 5; white circles, specimens from locality 4; horizontal line, 1st principal component; vertical line 2nd principal component.

The presented data confirm the conclusion that the studied gastropod assemblages are composed of shells

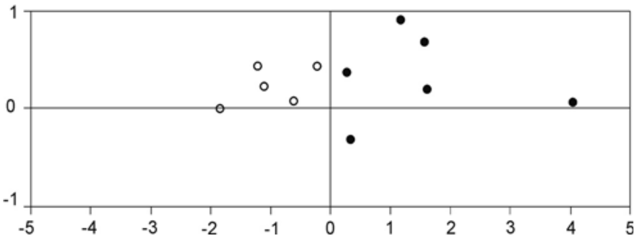

Fig. 5. Principal components diagram for *Bicarinella bicarinata*. Legend: black circles, specimens from locality 2; white circles, specimens from locality 3, horizontal line 1st principal component; vertical line 2nd principal component.

that had been transported before their fossilization. As there were no significantly damaged shells, it may be concluded that the transport was short, but prolonged enough to remove shells out of their original habitat and to perform sorting by size. The sedimentological analysis confirms this suggestion. Rock characteristics at the fossiliferous localities correspond to the facial belts 7 and 8 after the classification by WILSON (1975). The gastropod assemblages can be connected with intertidal flats, close to a shore line.

Conclusions

Three species of Cassiopidae (Cerithioidea, Gastropoda) are described from outcrops in western Serbia. Earlier microfossil investigations (PEJOVIĆ & RADOIČIĆ 1971) indicated an Albian–Cenomanian age. According to its character, this fauna resembles associations which have been noticed from other outcrops of Tethyan sediments of the Cretaceous. The greatest similarity was recognised with the Armenian and Transcaucasian regions.

The generally smaller size of the individuals encountered in the material of this study is explained by sorting due to transportation. But also environmental factors may have had an influence on the shell size. Evolutionary factors are considered unlikely to be of greater importance.

Acknowlegments

We wish to thank HEINZ KOLLMANN (Naturhistorisches Museum, Vienna) for his kind advices in analyzing the cassiopid assemblages. The co-operation of the following colleagues is gratefully recorded: the late DESANKA PEJOVIĆ, pointed out the fossiliferous localities, RAJKA RADOIČIĆ (Geological Survey of Serbia) covered micro-fossil identification, DIVNA JOVANOVIĆ (Geological Survey of Serbia) assisted in the analysis of the sediment characteristics, VESNA DIMITRIJEVIĆ and DRAGAN ANĐELKOVIĆ (Faculty of Mining and Geology, Belgrade) assisted in the preparation of this manuscript, while VLADAN RADULOVIĆ helped with the photographs, to all our special thanks. We are also indebted to colleagues who reviewed the paper SVEN NIELSEN (Institut für Geowissenschaften der Universität Kiel) and JOACHIM GRÜNDEL (Institut für Geologische Wissenschaften, the Freie Universität Berlin). K.B. and S.K. also express their thanks for the financial support of the DFG in project Ba675/21-2 for their visit to the outcrops in Serbia guided by Nenad Banjac. The work of N.B. was supported by the Ministry of Science of the Republic of Serbia (Project No. 146009), which is thankfully recorded.

References

AKOPYAN, V.T. (ed.), 1974. *Atlas of the Fossil Fauna of the Armenian SSR*. 424 pp. Akademiâ Nauk Armânskoj SSR (In Russian).

AKOPYAN, V.T. 1976. *Late Cretaceous Gastropods of the Armenian SSR*. 444 pp. Akademiâ Nauk Armânskoj SSR Erevan (In Russian).

AMPFERER, O. 1928. Zur Tektonik und Morphologie des Zlatibormassivs. *Denkschriften der Kaiserlichen Akademie der Wissenschaften,* 101: 363–367.

BANDEL, K. 1991. Character of the microgastropod fauna from a carbonate sand of Cebu (Philippines). *Mitteilungen des Geologisch-Paläontologischen Instituts der Universität Hamburg*, 71: 441–485.

BANDEL, K. 1993. Caenogastropoda during Mesozoic times. *Scripta Geologica, Special Issue*, 2: 7–56.

BEURLEN, K. 1964. As espécies dos Cassiopinae, nova subfamília dos Turritellidae, no Cretáceo do Brasil. *Arquivos de Geologia, Universitat do Recife*, 5: 1– 44.

BOUCOT, A.J. 1953. Life and death assemblages among fossils. *American Journal of Science*, 251 (1): 25–40.

BRKOVIĆ, G. 1968. Contribution to the knowledge of the Senonian fauna at the vicinity of Višegrad. *Geološki glasnik*, 12: 125–130 (In Serbian).

CADÉE, G.C. 1982. Low juvenile mortality in fossil brachiopods, some comments. *Interne Verslagen Nederlands Instituut voor Onderzoek de Zee*, (for 1982–1983), 1–29.

CADÉE, G.C. 1988. The use of size-frequency distribution in paleoecology. *Lethaia*, 21: 289–290.

CADÉE, G.C. 1989. Size-selective transport of shells by birds and its palaeoecological implications. *Palaeontology*, 32 (2): 429–437.

CLEEVELY, R.J., MORRIS, N.J. & BATE, G. 1984. An ecological consideration and comparison of the Punfield Marine Band (Lower Aptian) Mollusca. *Proceedings of the Dorset Natural History and Archaeological Society*, 105: 93–106.

CLEEVELY, R.J. & MORRIS, N.J. 1988. Taxonomy and ecology of Cretaceous Cassiopidae (Mesogastropoda). *Bulletin of the British Musseum* (*Natural History*), 44 (4): 233–291.

COQUAND, H. 1865. *Monographie de l'Étage Aptien de l'Espagne*. 221 pp. Mémoire de la Société d'Emulation de la Provence, Imprimeurs de la Société d'Émulation, Marseille.

COSSMANN, M. 1909. *Éssais de Paléoconchologie Comparée*. Part 8: 248 pp. Chez l'Auteur, Paris.

ĆIRIĆ B. 1952. Cretaceous fauna from the vicinity of Veles. *Glasnik Prirodnjačkog muzeja* (*Ser. A*), 2: 249–276 (In Serbian).

FITTON, W.H. 1836. Observations on some of the strata between the Chalk and the Oxford Oolite in the south-east of England. *Transactions of the Geological Society of London, Ser. 2,* 4: 103–378.

FRITZSCHE, C. 1924. Beiträge zur Geologie und Paläontologie von Südamerika. XXVII. Neue Kreidefaunen aus Südamerika (Chile, Bolivia, Peru, Columbia). *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, 50: 1–56.

GOLDFUSS, A. 1844. *Petrefacta Germaniae*. Part 3. 128 pp. Düsseldorf.

HACOBJAN, V.T. see AKOPYAN, V.T.

HILL, R.T. 1893. Paleontology of the Cretaceous formations of Texas; the invertebrate paleontology of the Trinity division. *Proceedings of the Biological Society of Washington*, 8: 9–40.

KOLLMANN, H.A. 1979. Gastropoden aus den Losensteiner Schichten der Umgebung von Losenstein (Oberösterreich) 3. Teil - Cerithiacea (Mesogastropoda). *Annalen des Naturhistorischen Museums in Wien*, 82: 11–51.

KOLLMANN, H.A. 1982. Cenomane Gastropodenfaunen aus der Ophiolith-Konglomeraten Bötiens (Griechenland). *Annales Géologiques des Pays Helléniques*, 31: 333–358.

KOWALKE, T. & BANDEL, K. 1996. Systematik und Paläoökologie der Küstenschnecken der nordalpinen Brandenberg-Gosau (Oberconiac/Untersanton) mit einem Vergleich zur Gastropodenfauna des Maastrichts des Trempbeckens (Südpyrenäen, Spanien). *Mitteilungen der Bayerischen Staatssammlung für Paläontologie und historische Geologie*, 36: 15–71.

MENNESSIER, G. 1984. Révision des Gastéropodes Appartenant á la Famille des Cassiopidae Kollmann (= Glauconiidae Pchelintsev). *Travaux du Département de Géologie de l'Université de Picardie*, 1: 1–190.

MIKINČIĆ, V. 1938. Contribution to the paleontology and stratigraphy of the Cretaceous at Šumadija. *Vesnik Geološkog instituta*, 7: 152–165 (In Serbian).

MILOVANOVIĆ, B. 1933. Contribution to the geology of western Serbia – Upper Cretaceous of the Mokra Gora basin. *Geološki anali Balkanskoga poluostrva*, 11 (2): 132–160 (In Serbian).

D'ORBIGNY, A. 1843. *Paléontologie Francaise. Terrains Crétacés*. 2. Gastéropodes. 456 pp. Victor Mason edit, Paris.

PCHELINTSEV, F.V. 1953. *Gastropod Fauna of the Upper Cretaceous Deposits of Transcaucasus and Middle Asia*. 391 pp. Akademiâ Nauk SSSR, Moskva–Leningrad (In Russian).

PETKOVIĆ, K. & BOJIĆ, D. 1932. Aptian of eastern Serbia. *Geološki anali Balkanskoga poluostrva*, 11 (1): 10–19 (In Serbian).

PETKOVIĆ, K. & PAŠIĆ, M. 1949. About the paleontological and stratigraphical characteristics of Glauconids from the footwall of the "V" layer at Kukuljaš – Rtanj mine (eastern Serbia). *Geološki anali Balkanskoga poluostrva*, 17: 140–147 (In Serbian).

PEJOVIĆ, D. & RADOIČIĆ, R. 1971. Ueber die Stratigraphie der Kreideserie der Mokra Gora. *Bulletin Scientifique du Conseil des Academies des Sciences et des arts de la RSF de Yugoslavie, Section A*, 16 (7–8): p. 138.

PERON, A. 1899. Études paléontologiques sur les terrains du Département de l'Yonne. Céphalopodes et gastéropodes de l'étage Neocomien. *Bulletin de la Societé des Sciences historie naturelle Yonne*, 53 (3): 67–219.

ROEMER, F.A. 1836. *Die Versteinerungen des norddeutschen Oolithen-Gebirges*. iv + 218 pp. Verlag der Hahn'schen Hofbuchhandlung, Hannover.

STANTON, T.W. 1947. Studies of some Comanche Pelecypods and Gastropods. *U.S. Geological Survey Professional Papers*, 211: 1–256.

STEINMANN, G. 1929. *Geologie von Peru*. 448 pp., Carl Winters Universitätsbuchhandlung, Heidelberg.

TSANKOV, V. (ed.), 1981. *Les fossiles de Bulgarie V – Crétacé supérieur*. 233 pp. Academie Bulgarie des Sciences, Sofia.

VERNEUIL, E. DE & COLLOMB, E. 1853. Coup d'oeil sur la constitution géologique de quelques provinces de l'Éspagne. *Bulletin de la Société Géologique de France*, 10: 61–147.

VERNEUIL, E. DE & LORIERE G. DE 1868. *Descriptions des fossiles du Néocomien superieur de Utrillas et ses environs* (*Province de Teruel*). 30 pp. Monnoyer, Le Mans.

WENZ, W. 1938–1944. *Handbuch der Paläozoologie*. Gastropoda, Part 6, 1639 pp. Verlag Gebrüder Bornträger, Berlin.

WILSON, J. L. 1975. *Carbonate Facies in Geologic History*. 471 pp., Springer Verlag, Berlin Heidelberg New York.

ZEKELI, F. 1852. Die Gasteropoden der Gosaugebilde. *Abhandlungen der Kaiserlich-Königlichen Geologischen Reichsanstalt* (*Wien*), 1: 1–124.

ŽIVKOVIĆ, M. 1908. Geology in the vicinity of Užice. *Izveštaj Užičke gimanzije za 1907–8 školsku godinu,* 1–24 (In Serbian).

ŽUJOVIĆ, J. 1893. *Geology of Serbia*. Part 1. 334 pp. Srpska Kraljevska akademija, Beograd (In Serbian).

Резиме

Касиопидни гастроподи креде западне Србије

Описане су три врсте гастропода откривене у кредним седиментима западне Србије. Албско-ценомански седименти таложени су током трансгресије која је средином креде обухватила широки простор. Ове творевине налазе се између река Бели и Црни Рзав, пружајући се око 40 km у правцу северсеверозапад–југјугоисток. Оне садрже фосиле за које се сматрало да су сенонске старости (ЖУЈОВИЋ 1893; ЖИВКОВИЋ 1908; AMPFERER 1928; МИЛОВАНОВИЋ 1933). Новији радови, засновани на анализи асоцијација микрофауне указали су на стратиграфску припадност алб-ценоману (PEJOVIĆ & RADOIČIĆ

1971). У фосилним заједницама доминирају касиопидни гастроподи, а поред њих јављају се бивалвије, остракоди, дазикладацее и фораминифери. Циљ овог рада је да се опишу неке врсте гастропода и размотре њихови систематски и бигеографски односи.

Могуће је издвојити три члана локалног стратиграфског стуба. Најнижи члан чине тамносиви оолитски пешчари, слабо сортирани и слабо заобљени. Таложени су близу обале у средини високе енергије. Одговарају фацијалним појасевима 8 и 9, WILSON (1975). Средњи члан чине биокластични кречњаци. Садрже ретке фрагменте макрофауне, фекални пелет, и алге: *Bacinella sterni* RADOIČIĆ, *Nezzazatinella* cf. *picardi* (HENSON) и *Salpingoporella urladanasi* CONRAD, RADOIČIĆ & REY. У вишим деловима јављају се *Nezzazatinella* cf. *picardi* и *Hemicyclamiina sigali* (MYNC). На препаратима се уочавају бројне пукотине и фенестриране структуре испуњене финозрним материјалом. У поређењу са претходним чланом, принос материјала са копна био је мањи. Највиши члан представљен је биокластичним кречњацима који се смењују са танкослојевитим лапорцима. Садрже фрагменте љуштура мекушаца, зрна кодиацеа, оогоније харофита и алге *Hemicyclammina sigali.* У вишим деловима овог члана честе су љуштуре гастропода, спикуле сунђера и бодље ехинодермата. Седименти су депоновани у плиткој води, промењљивог салинитета, са честим приносом слатке воде са копна, иза спрудног гребена, а одговарају фацијалним појасевима 7 и 8 према WILSON-у (1975).

Гастроподи описани у раду откривни су у биокластичним кречњацима највишег члана стратиграфског стуба. Фосилоносни локалитети се налазе у Котроману, Мокрој Гори и Растишту и обележени су бројевима 1 до 5 на сл. 1. Описана је нова врста гастропода *Cassiope kotromanensis,* и врсте *Bicarinella bicarinata* и *Paraglauconia lujani* које су одраније познате на нашим локалитетима. У домаћој литератури већ су описане врсте са неким одликама примерака *Cassiope kotromanensis*, али су приписане роду *Cerithium* или роду *Glauconia.* Мора се нагласити да је нова врста врло слична појединим варијететима примерака *Glauconia coquandi* које је описао ЋИРИЋ (1952), али има различит угао завојнице, а оригинални примерци ЋИРИЋА (1952) нису били доступни за детаљнија истраживања. Родови *Paraglauconia* и *Bicarinella* такође су откривени на нашим просторима, али су описани под различитим називима и потичу са других локалитета.

Током истраживања констатовано је да су прикупљени гастроподи знатно мањи од примерака који потичу са других локалитета, ван Србије. Предпостављена су три могућа узрока ове појаве. Први је да гастроподи током алба и ценомана још увек нису достигли димензије одговарајућих припадника исте фамилије у другим, севернијим локалитетима горње креде Тетиса. Други могући узрок је да примерци нису могли да достигну одговарајућу величину услед дејства неповољних фактора средине, честим приносом слатке воде и сл. Трећи могући узрок је класификација и сортирање током транспорта љуштура обављеног после смрти организама, а пре фосилизације. На основу тога је успостављена хипотеза која је проверена статистичким методама. Резултати истраживања су са одговарајућим степеном вероватноће указали да су љуштуре транспортоване пре коначне фосилизације па је ова хипотеза прихваћена као објашњење за ограничен раст индивидуа. Фактори развоја и еволуције организама, као и услови средине, нису у потпуности одбачени али се сматрају као мање вероватни за објашњење малог раста индивидуа.