THE PALEONTOLOGICAL HERITAGE FROM THE UPPER CRETACEOUS CAUGAGIA SITE – NORTHERN DOBROGEA (TULCEA COUNTY, ROMANIA)

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Abstract. The Caugagia site is particularly noteworthy for its distinctive geological structures and fossils (the type locality for the Caugagia Member), establishing it as a key area for paleontological investigations in the Dobrogea region. This paper aims to synthesize the current knowledge about the Caugagia site and emphasize its importance.

Keywords: Inoceramids, Coniacian, Turonian, type locality, natural heritage.

Rezumat. Patrimoniul paleontologic din situl Cretacic superior Caugagia – Dobrogea de Nord (Județul Tulcea, România). Situl Caugagia este remarcabil pentru structurile sale geologice distincte și pentru fosilele din succesiunile sale, stabilindu-l ca o zonă cheie pentru investigațiile paleontologice din regiunea Dobrogea. Prezenta lucrare își propune să sintetizeze cunoștințele actuale despre situl Caugagia și să se pronunțe asupra importanței acestuia.

Cuvinte cheie: Inocerami, Coniacian, Turonian, localitate tip, patrimoniu natural.

INTRODUCTION

Caugagia is a village within the Baia locality, located in the Tulcea County, which forms part of the Northern Dobrogea region in South-East Romania. The Bal Bair Hill in its vicinity can be considered a site in its entirety due to the abundance of the fossil sites. The Peceneaga-Camena Fault, a major geological discontinuity that acts as a significant boundary, separating the relatively stable Moesian Platform from the more dynamic North Dobrogea Orogen, plays an important structural role in the region (SĂNDULESCU, 1984; SAVU, 2012).

PETERS (1867) made the first observations on the Upper Cretaceous deposits of the Babadag Basin and TOULA (1893) identified inoceramids in the marls here. ANASTASIU (1898) is credited with the first list of fossils from Caugagia. In 1906, MACOVEI published the presence of a characteristic Senonian species, *Pachydiscus* cf. *levyi* in the Babadag Basin. Based on the fossil fauna, SIMIONESCU (1914) divided the Upper Cretaceous deposits into two series: the Iancila Series (Cenomanian) and the Dolojman Series (Turonian-Senonian). MACOVEI (1934) described the fauna of the Dolojman series, citing several species of ammonites, echinoids and inoceramids found at Caugagia; these species allowed him to assign a Coniacian age to the deposits. In his synthesis on the Upper Cretaceous, of the Babadag Basin, ATANASIU (1940) considers that the deposits here are developed in typical Gosau facies (Fig. 1).

Figure 1. Image of the Bal Bair Hill, showing the paleontological site tested in our 2024-2025 campaigns (on the right) and other fossil sites included on the 1:50,000 geological map (MUREȘAN et al., 2018).

Among the Romanian geologists who visited the site and collected fossils, VALER POPOVICI-HAȚEG, ȘTEFAN CANTUNIARI and SAVA ATHANASIU should be mentioned.

Systematic studies of the Cretaceous formations in the Babadag Basin belong to researchers OREST and ELENA MIRĂUȚĂ (1964), LADISLAU SZÁSZ and JANA ION (1981, 1985, 1988, 1994, 1999).

After 2000, two studies were also carried out in the Bal Bair hill area: one on the echinoid fauna (GALLEMI et al., 2011) and the second, more extensive one under the coordination of Professor EUGEN GRĂDINARU. A team of foreign specialists, aimed at revising the biostratigraphic data for the Cretaceous of the Babadag Basin, based on a new detailed mapping in the Visterna, Baia and Caugagia sites/quarries (LODOWSKI & al., 2019).

MATERIALS AND METHODS

The research started with an extensive documentation on pre-existing information in the literature/on the internet and in the inventory catalogues of the National Geological Museum and reports from the National Geological Archive (of the Geological Institute of Romania). On this occasion, the paleontological collections of previous authors hosted in the museum were checked. Samples from the Caugagia site were selected and photographed.

New fossil material was collected in a series of field trips in the summer of 2025. The new paleontological material is still being prepared to be studied; part of this material was prepared (mechanical method), photographed and briefly analyzed. For the determination of species, we use the method of comparison with similar specimens known in the scientific literature (mentioned in synonymy); we compared specimen's morphology and morphometric parameters.

GEOLOGICAL FRAMEWORK

The Caugagia site, located to the northwest of the village of Baia, represents a significant area within the Babadag Basin (Fig. 2). This site is particularly important as it serves as the *type locality* for the Caugagia Member of the Dolojman Formation; the Coniacian succession in the Caugagia-Baia region of North Dobrogea is identified as a possible hypostratotype (ION & SZÁSZ, 1994). The geological succession in the Caugagia-Baia area includes rocks that have been dated to the Late Cretaceous age (Turonian-Coniacian). Notably, the Caugagia Member is characterized by its more clastic composition compared to other members of the Dolojman Formation, suggesting that there was a relatively higher input of sediments derived from land (terrigenous sediments) during the time it was being deposited (LODOWSKI et al. 2019, GALLEMÍ et al. 2011).

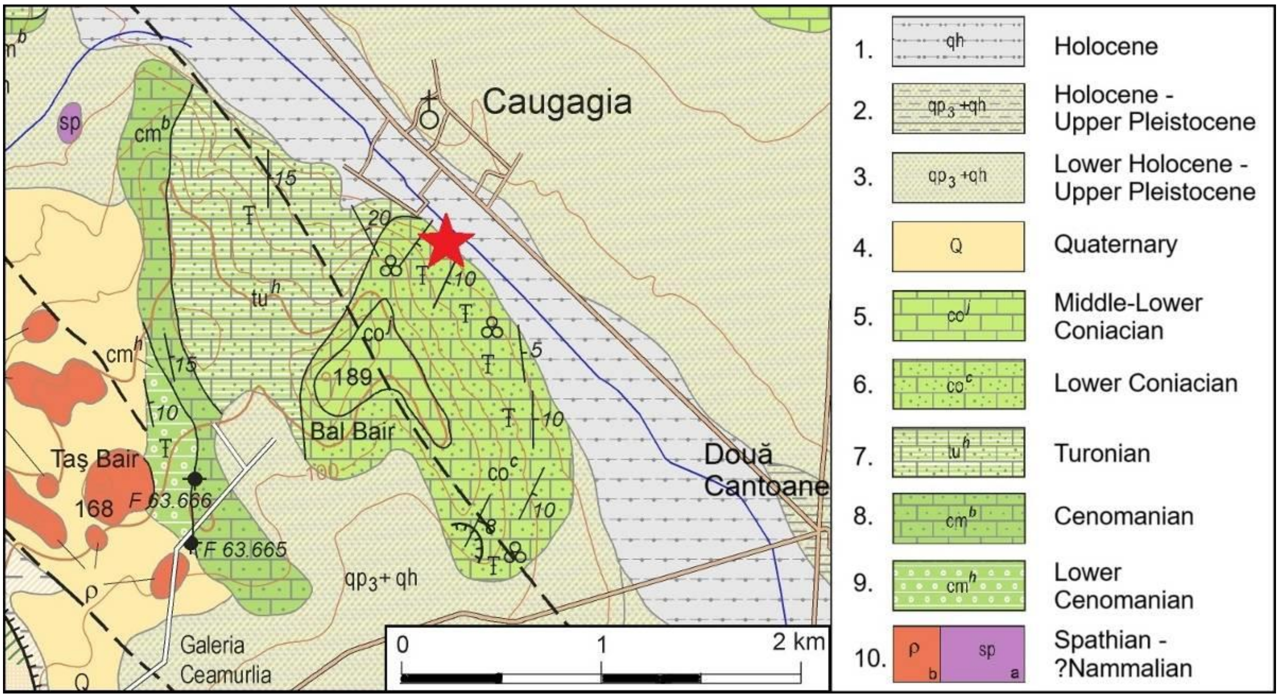

Figure 2. The Caugagia outcrop of the Dolojman Formation, occurrence on the geological map sc. 1:50.000 (MUREȘAN et al., 2018). Legend: Quaternary deposits – 1, Alluvial deposits; 2, Colluvial loessoid deposits (siltic clays); 3, Colluvial loesoid deposits (silts, clay silts); 4, Eluvial deposits (clays, silts). Upper Cretaceous deposits – Dolojman Formation 5, Jurilovca Member; 6, Caugagia Member; 7, Harada Member – Iancila Formation; 8, Babadag Member; 9, Hamangia Member; 10, Camena Formation: a) Conglomerates with a matrix of red sandstones; b) graded, decimetric sequences of green and red sandstones, siltstones and pelites with thin intercalations of oolitic limestone with microgasteropods.

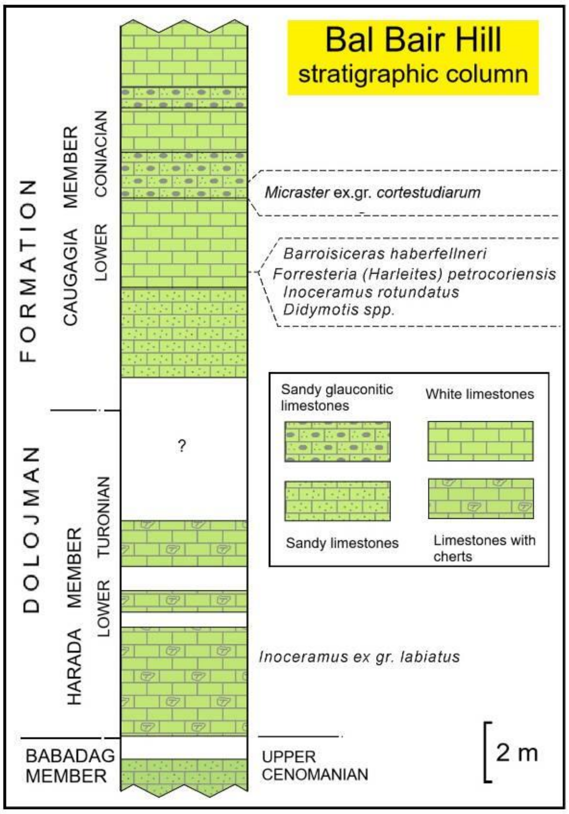

Figure 3. Stratigraphic column in Bal Bair Hill (after SZASZ & ION, 1988).

East of the Camena Formation, which is exposed in the Taş Bair Hill, the Late Cretaceous succesion starts with the Iancila Formation deposits and the Hamangia Member (uncemented polygenic gravels; conglomeratic limestone and conquina with glauconite (9) followed by the Babadag Member (yellowish limestone and calcareous sandstones, poorly fossiliferous, with rare cherts (8), which also occur in the northern part of the Bal Bair Hill (Fig. 3). The Dolojman Formation starts in the northern half of the Bal Bair Hill, with the Turonian deposits of Harada Member (sandy, yellowish, pinkish limestone: sometimes interlayered with white or greenish limestone); more frequent cherts (7); these deposits with cherts are also exposed in the northern extremity of the site. They are overlain by yellowish sandy limestone with decimetric intercalations of greenish-white limestone (6) of the Caugagia Member, rich in fossils (inoceramids, ammonites, echinoids, bivalves, and other). These deposits contain very rare cherts (spongoliths) and make up the entire southern slope of the hill. In the hilltop area, the deposits (limestone, clayey limestone and yellowish chalky marls, well stratified; sandy limestone (5) of the Jurilovca Member were also highlighted (SZASZ & ION, 1988).

SITE DESCRIPTION

The site is a natural exposure of calcareous deposits on the steep slope of the Caugagia (Bal Bair Hill), about 10 meters above the roadside, over a grassy slope. The outcrop is about 150 meters long and about 25 meters high. It is marked by areas of trees (shrubs), soil or scrub up to the boundary with the forest above. As can be seen in the images in Figures 1 and 4, the main outcrop located right next to the village (the northernmost) is on the border with the forest.

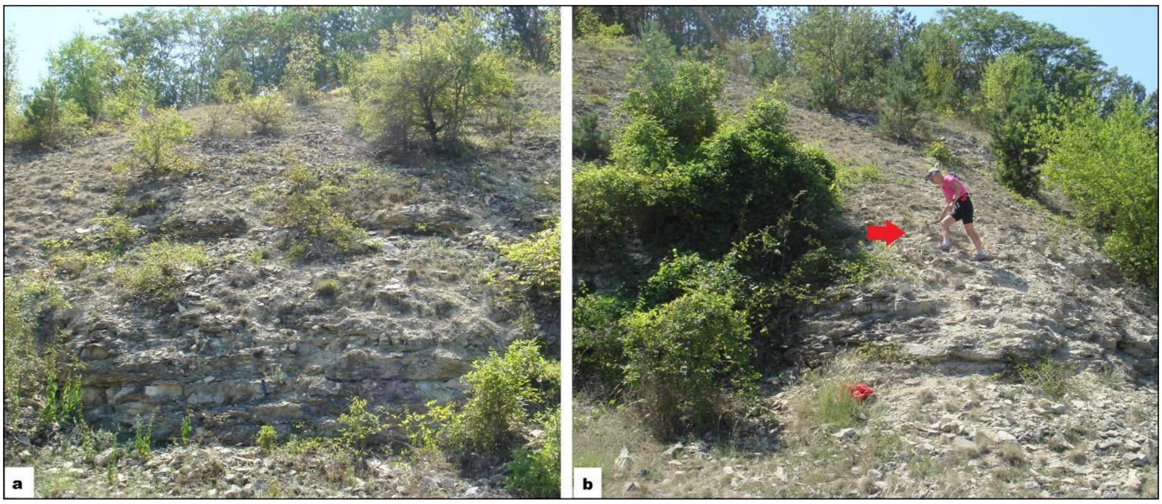

Figure 4. The outcropping limestone of Caugagia Member (Coniacian); level with *Micraster* cf. *brevis* and *Gaudryceras* found indicated by the red arrow.

From this point to the southwest, there are several small slope outcrops in the grassy hillside. 100 years ago, when there was no forest on the hills, these deposits were probably better exposed. Several researchers have studied them in the past, which is why they are shown on the geological map. At a higher level on the same slope, towards the crest of the hill, close to its southern extremity, there is a quarry exposing two to three layers of rocks over an area of approximately one hectare (Fig. 5a). On these surfaces, various fossils can be observed, some sectioned (like sea urchins - Fig. 5b). Deposits exposed in in the quarry were recently studied by a team of paleontologists led by Professor Eugen Grădinaru from the University of Bucharest (details in LODOWSKI & al, 2019). Our team made also some brief observations in this outcrop.

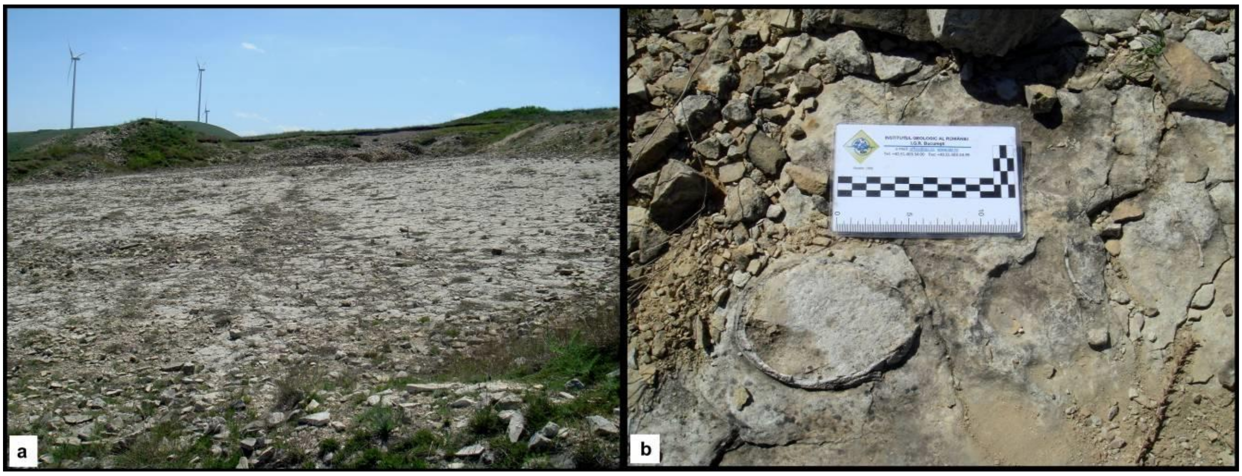

Figure 5. a) Bed surface of limestone (Caugagia Member - Coniacian) in the Caugagia quarry from the southern extremity of the Bal Bair Hill; b) detail with some sectioned echinoids (?*Echinocorys*) on the bed surface.

FOSSIL ASSEMBLAGE

The fossil fauna, so far consisting exclusively of invertebrates, is distributed in many levels and only few of them show agglomeration of remains (as inoceramids for example). After studying all the available published materials and reports, we proceeded to the direct analysis of the paleontological collections from the Caugagia site hosted in the repository of the National Geological Museum- NGM.

Figure 6. Specimens from V. Anastasiu Collection: a) *Nautilus elegans* d'Orbigny; b) *Serpula* sp.; c) Solitary coral.

In Victor Anastasiu's Collection, we have identified specimens of solitary corals, nautiloids (*Nautilus elegans* d'Orbigny), tubeworms (Fig. 6) and inoceramids. In V. Popovici-Hatzeg's Collection, *Hemiptychoceras subgaultinum* Breistroffer, 1940 is preserved, a controversed species, which is specific for the Albian. The Gheorghe Macovei Collection includes specimens of inoceramids, echinoids and ammonites (Fig. 8a-c), with pieces that impress by size, as illustrated here („*Inoceramus schloembachi* Bohm" = *Cremnoceramus crassus* (Petrascheck, 1903) – Fig. 7). The Sava Athanasiu's Collection contains six small specimens of *Cyclolites* sp. (Fig. 8d). Ștefan Cantuniari collected some pieces identified by V. Anastasiu (*Micraster* sp., *Inoceramus cripsii* Mantell and *Lytoceras* sp.). In the Collection of Elena and Orest Mirăuță there are many species of *Inoceramus* (Fig. 8f) and few important ammonites: *Barroissiceras haberfelneri* Hauer (Fig. 8e), *Neancyloceras sertum* Muller & Woll. The richest collection belongs to Ladislau Szász, but divided into two repositories, in the NGM and in the Laboratory of Paleontology of the University of Bucharest (especially his collection of inoceramids). In the NGM it contains bivalves, ammonites and echinoids as illustrated in Plate 1.

Figure 7. *Cremnoceramus crassus* (PETRASCHECK, 1903) - Macovei

As expected, in addition to the pieces presented in the various scientific papers of previous authors, we found other unpublished pieces in the drawers of the repository.

Table 1.

Inoceramids (MACOVEI, 1934; MIRĂUŢĂ & MIRĂUŢĂ, 1964; SZÁSZ, 1985, 1988; TRÖGER, 2009; WILMSEN et al., 2014)	
I. schloenbachi Böhm, 1912	*Cremnoceramus crassus crassus* (Petrascheck, 1903)
I. incertus Jimbo, 1894	*Mytiloides incertus* (Jimbo, 1894)
I. inaequivalvis Schluter, 1877	*Inoceramus inaequivalvis* Schluter
I. inconstans inconstans Woods, 1912	*Cremnoceramus inconstans* (Woods, 1912)
I. striatoconcentricus szadetzkyi (Simionescu, 1899)	*Mytiloides striatoconcentricus szadetzkyi* (Simionescu, 1899)
I. ex.gr. *glatziae* Flegel,1905	in revision(Walaszczyk & Grădinaru)
I. crassus anderti Szász, 1985	*Cremnoceramus crassus crassus* (Petrascheck, 1903)
I. lusatiae Andert, 1911	*Inoceramus lusatiae* Andert, 1911
I. brogniartiformis Szász, 1985	in revision (Walaszczyk & Grădinaru)
I. danubiensis Szász, 1988	in revision (Walaszczyk & Grădinaru)
I. paradeformis Szász, 1985	*Tethyoceramus paradeformis* (Szász, 1985)
I. woodsi Fiege, 1930	in revision (Walaszczyk & Grădinaru)
I. waltersdorfensis waltersdorfensis Andert, 1911	*Cremnoceramus waltersdorfensis waltersdorfensis* (Andert, 1911)
I. incurvatissimus Tröger, 1974	in revision (Walaszczyk & Grădinaru)
I. fiegei fiegei Tröger, 1967	*I. fiegei fiegei* Tröger, 1967
I. lamarcki lamarcki Parkinson, 1819	in revision (Walaszczyk & Grădinaru)
I. rotundatus Fiege, 1930	*Cremnoceramus rotundatus* (Fiege, 1930)
I. pseudoinconstans Szasz, 1985	*Cremnoceramus pseudoinconstans* (Szasz, 1985)
I. babadagensis Szasz, 1985	*Cremnoceramus babadagensis* (Szasz, 1985)
I. erectus Meek, 1877	in revision (Walaszczyk & Grădinaru)
I. aff. *Naumanni* Yokoyama, 1890	*Sphenoceramus naumanni* (Yokoyama, 1890)
I. costellatus Woods,1912	*Inoceramus costellatus* Woods, 1912
I. stillei Heinz, 1928	*Mytiloides scupini* (Heinz, 1930)
I. wandereri Andert, 1911	*Tethyoceramus wandereri* (Andert, 1911)
I. striatus (Mantell, 1822)	*Gnesioceramus crippsi* (Mantell, 1822)
I. sublabiatus Muller, 1888	*Cremnoceramus waltersdorfensis waltersdorfensis* (Andert, 1911)
I. crippsi Mantell, 1822	*Inoceramus crippsi* Mantell, 1822
Ammonites (MACOVEI, 1934; O. & E. MIRĂUŢĂ, 1964; SZASZ, 1981, 1988)	
Hemiptychoceras subgaultinum Breistroffer, 1940	*Hemiptychoceras subgaultinum* Breistroffer, 1940
Pachydiscus brandti Redten, 1873	*Pseudokosmaticeras brandti* Redtenbacher, 1873
Harleites bentori Parnes, 1964	in revision
Barroisiceras haberfellneri Hauer, 1866	*Barroisiceras haberfellneri* Hauer, 1866
Lytoceras (*Gaudryceras*) *mite* Hauer, 1866	*Gaudryceras mite* (Hauer, 1866)
Pachydiscus cf. *levyi* Grossouvre, 1894	*Eupachydiscus* cf. *levyi* (Grossouvre, 1894)
Crioceras serta (Muller&Wollemann, 1906)	in revision (*Glyptoxoceras* sp.)
Neocrioceras (Schlueterella) kossmati (Simionescu, 1899)	---
Scaphites ex.gr. *compressus* (d'Orbigny, 1842)	---
Austiniceras cf. *mobergi* (de Grossouvre, 1894)	*Mesopuzosia* cf. *mobergi* (de Grossouvre, 1894)
Damesites aff. *Sugata* (Forbes, 1846)	*Damesites* aff. *Sugata* (Forbes, 1846)
Nowakites macoveii Szasz, 1981	*Tongoboryceras canali* (de Grossouvre, 1984)
Yabeiceras sp. aff. *Yabeiceras orientale* (Tokunga et Shimizu, 1926)	---
Harleites bentori Parnes, 1964	*Harleites bentori* Parnes, 1964 (=*Barroisicearas)*
Harleites harlei (de Grossuvre,1894)	---
Gaudryceras denseplicatum Jimbo, 1894	*Gaudryceras denseplicatum* (Jimbo,1894)
Forresteria (*Harleites*) *petrocoriensis* (Coquand, 1859)	*Forresteria* (*Harleites*) *petrocoriensis* (Coquand, 1859)
Gaudryceras aff. *Varagurense* Kossmat, 1895	*Gaudryceras varagurense* Kossmat, 1895
Harleites harlei (de Grossouvre, 1894)	*Barroisiceras harlei* (de Grossouvre, 1894)
Neocrioceras (Schlueterella) kossmati Simionescu, 1899	---
Echinoids (SZASZ, 1988 ; GALLEMI et al., 2011)	
Micraster cortestudiarum (Goldfuss,1829)	*Micraster cortestudiarum* (Goldfuss,1829)
?Echinocorys bayani	---
Rispolia subtrigonata Catullo, 1827	*Rispolia subtrigonata* Catullo, 1827
Other (ANASTASIU, 1898 ; Athanasiu ; MACOVEI, 1934 ; SZASZ, 1988)	
Nautilus elegans Sowerby, 1816	*Cymatoceras elegans* (Sowerby, 1816)
Exogyra columba Lamarck, 1819	*Exogyra columba* Goldfuss, 1833
Janira aequicosta Lamarck, 1819	*Neithea aequicostata* (Lamarck, 1819)
Didymotis variabilis Gerhardt, 1897	*Didymotis variabilis* Gerhardt, 1897
Serpula sp.	---
Cyclolites sp.	---

The specific assemblage resulting from all the authors is presented in Table 1. Few specifications worth mentioning about the stage of researches and species names are included in this table. Part of the species were already revised, but only for the scientific names and not for new redeterminations by newest palaeontological standards, and other are still in work for redetermination, as is the case of the inoceramids from the Szász Collection stored in the Laboratory of Palaeontology of the University of Bucharest (see in LODOWSKI & al., 2019).

Figure 8. a) *Pseudokosmaticeras brandti* Redtenbacher; b) *Inoceramus crippsi* Mantell;
c) *Harleites harlei* (Grossouvre) – a, b, c - Macovei Coll.; d) *Cyclolites* sp.- Sava Athanasiu Coll.;
e) *Barroisiceras haberfellneri* Hauer; f) *Inoceramus striatus* (Mantell) – e and f - Orest & Elena Mirăuţă Coll.

Integrated detailed biostratigraphy (macro- and micro-fossils) for the Caugagia Member was carried out based on systematic sampling by Ladislau Szász and Jana Ion in the eighties and published in 1988, followed by new interpretations of Ion & Szász (1994) and Ion & al. (1999). The highlighted microfauna associations contain the index taxa *Marginotruncana tarfaiensis*, *M. renzi*, *M. pseudolinneiana*, *Whiteinella paradubia* and *Dicarinella concavata*, specific to the biozones of the Lower Coniacian.

During our recent field observations, several new macrofossils were extracted and are still being prepared for identification. The species found and presented in Table 2 resulted from preliminary identifications.

Table 2.

Species	Synonymy
Gaudryceras cf. *mite* (HAUER, 1866) (Pl. 2, Fig. 2) Lower Coniacian / Cremnoceramus deformis deformis Zone	HOFFMANN, 2010 - p. 94, Fig. 35 B, D; KENNEDI & al., 1995 – p. 390, Pl. 1/20, 21; KENNEDY & SUMMESBERGER, 1979 – p. 74, text-Fig. 1, Pl. 1/1, Pl. 2/1, 2; (?)WIESE, 2000 – p. 128, Pl. 1/1.
Micraster (*Gibbaster*) cf. *brevis* DESOR, 1847 (Pl. 2, Fig. 3) Lower Coniacian / Cremnoceramus deformis deformis Zone	OLSZEWSKA-NEJBERT, 2007 – p. 59, pl. 30/ 4; pl. 31/ 1-3. SCHLÜTER, 2016 - p. 1-26, fig. 1 A-D.
Echinocorys sp. cf. *E.* ex.gr. *scutata* LESKE, 1778, “*vulgaris*” morfotype (Pl. 2, Fig. 4) Lower Coniacian	OLSZEWSKA-NEJBERT, 2007–p. 17, Pl. 9/3, Pl. 10/3, pl. 11/1-3. SMISER, 1935 – p. 10, Pl. 2/1 a-d. RAZMI & al., 2013 – p. 254, Pl. 8-9.
Sciponoceras sp. cf. *S. bohemicum bohemicum* (FRITSCH, 1872) (fragment of 23mm length and 13x10mm whorl section) Lower Coniacian	KENNEDY & SUMMESBERGER, 2024 – p. 24, text-Fig. 14, Pl. 10/1-23; WILMSEN & NAGM, 2014 – p. 233, Fig. 13k; KENNEDY & WALASZCZYK, 2023 – p. 649, text-Figs 10, 11A.
Spondylus sp. cf. *S. santonensis* D’ORBIGNY, 1847 (Pl. 2, Fig. 1) ? Late Cretaceous	DHONDT, 1985 – p. 44, Figs. 1 b-c.

Paleoenvironmental assessment. The occurrence and preservation of inoceramids from the Caugagia site is characterized by their presence in situ (=occurrence in life position) to allochthonous shell fragments. Inoceramids (an extinct group of pteriomorphian bivalves) who preferentially inhabited a well-oxygenated nearshore seafloor are distributed in various depositional environments and have been regarded as a recliner (lean back at different angles) in offshore carbonate muddy and clastic (oolithic) substrate. The presence of vertically embedded large articulated individuals suggests that they were also well adapted, with an upright life position, in low-to-high-energy shallow environments characterized by high carbonate sediment supply.

The glauconite-bearing sandy (peloidal) bioclastic limestone are deposited in shallow to moderately-deep marine environments, potentially indicating a period of slow sedimentation and/or marine transgression-related periods with fluctuating sea levels and reducing (suboxic) conditions on the seafloor. The rare presence of echinoids in the sandy bioclastic limestone support the general deepening of the depositional environment followed by shallowing upward tendencies.

Marine organisms inhabiting soft-bottom sediment are particularly susceptible to rapid sedimentation. Numerous closed bivalve shells were loosely packed in well-sorted medium-grained to coarse-grained carbonate sandstone related to a rapid sedimentation event. The marine soft-bottom sediments above the storm wave base are susceptible to physical processes (e.g. current, wave) and if sedimentation rate exceeded an organism's ability to escape, the individual would be buried alive in the sediment, thus may prevent the mollusk shells from gaping open at the hinge, providing evidence for rapid (anastrophic) burial. The bivalve shells show little or no alternation, abrasion or encrustation.

Numerous shelled pelagic cephalopods (Ammonoids and Nautiloids) are preserved at the Caugagia site and are remarkable for their taxonomic richness, given the diversity-dependent mechanisms that show the spatial heterogeneity of the offshore environments. The unusual presence of straight-shelled ammonoids, baculitids and scaphitids that inhabited near-bottom marine environments, often in shallow water, suggest they did not drift postmortem and likely lived at the study site.

Calcareous tubeworms of Polychaete serpulids, solitary corals (mushroom zooxanthellate corals - Scleractinia: Fungiidae) and sponges are rock-forming, and reef-building in sandy limestone and shelly limestone, indicating a semi-restricted to open shallow marine environment with medium to low water energy.

CONCLUSIONS

The Caugagia site holds considerable biostratigraphic significance, making substantial contributions to the dating and correlation of the Upper Cretaceous rock layers both within the Dobrogea region and potentially across a broader European context. Its recognition as a possible hypostratotype for the Coniacian stage underscores its value as a reference point for the international geological community. Moreover, the geological and paleontological evidence recovered from Caugagia provides crucial insights into the paleoenvironmental conditions that characterized the Babadag Basin during the Turonian and Coniacian ages, indicating a shallow-water, near-shore marine setting. The observed similarities between the fossil assemblages at Caugagia and those found in Western Europe highlight the biogeographical affinities that existed during the Late Cretaceous, contributing to a more complete understanding of ancient marine ecosystems and their global distribution.

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Plate 1

Plate 1. Fossild from Szász Coll. 1. *Pseudokossmaticeras* sp. (Inv. 14.858); 2. *Didymotis* sp. (Inv. 17.136); 3. *Nowakites macoveii* Szasz (Inv. 14.860 – Paratype); 4. *Scaphites* ex.gr. *compressus* d’Orbigny (Inv. 14.855); 5. *Neocrioceras kossmati* (Simionescu)(Inv. 14.854); 6. *Yabeiceras* sp. aff. *Y. orientalie* Tokunaga & Shmizu (Inv. 14.864).

Plate 2

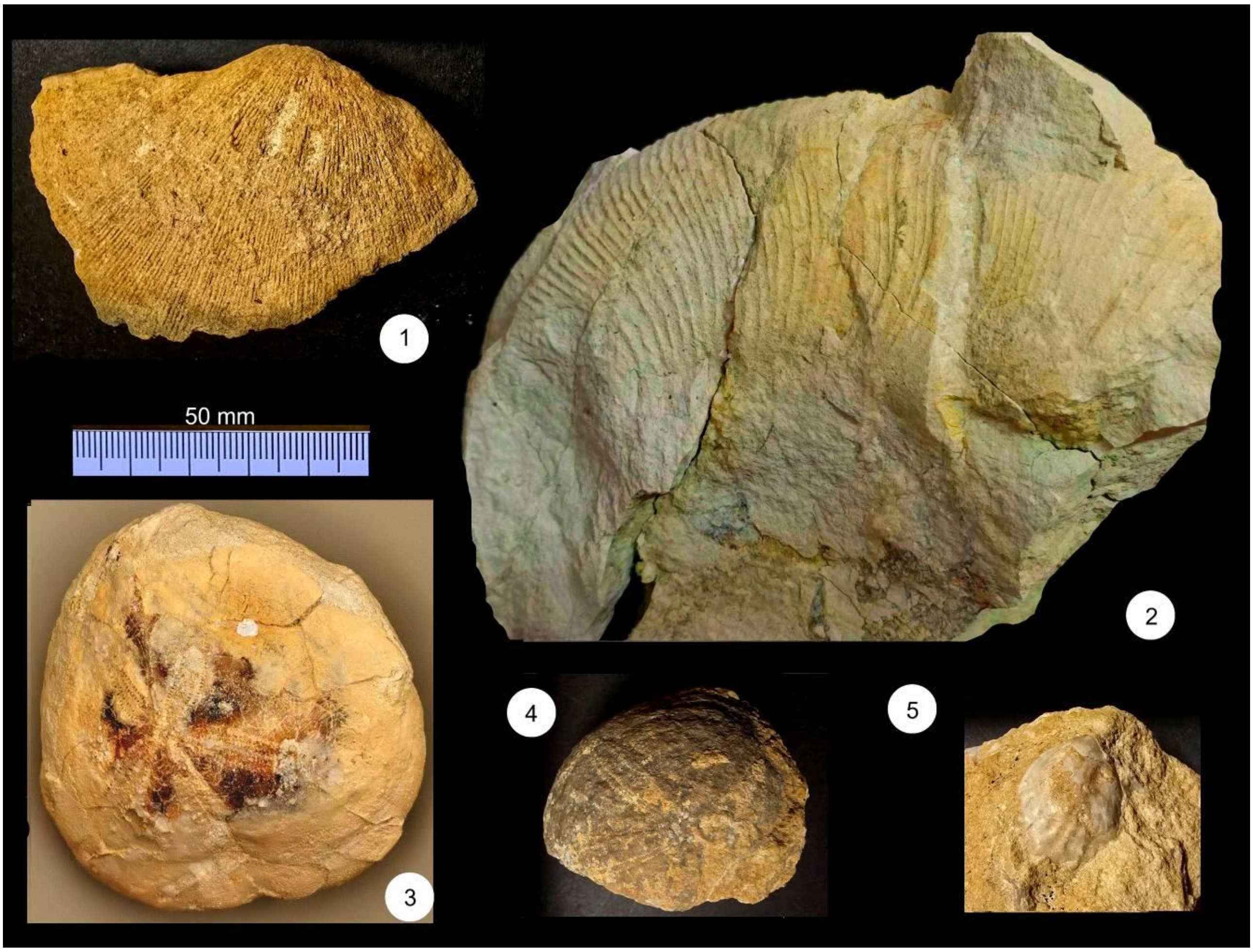

Plate 2. 1. New finds from the Caugagia site (Dolojman Formation – Caugagia Member, Lower Coniacian). *Spondylus* cf. *santonensis* d'Orbigny; 2. *Gaudryceras* cf. *mite* Hauer; 3. *Micraster* cf. *brevis* Desor; 4. *Echinocorys* sp.; 5. Ostreidae.

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