UPPERMOST ALBIAN - LOWER CENOMANIAN CALCAREOUS RED ALGAE FROM THE BABADAG BASIN (NORTHERN DOBROGEA, ROMANIA)

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Abstract. Calcareous red algae are organisms of great relevance in paleontological studies as they were important producers of calcium carbonate throughout geological time. This is also true for the Albian – Cenomanian time-interval, when shallow-water carbonate factories experienced a general decline in the northern Neo-Tethyan areas. In this paper, red algae taxa belonging to the uppermost Albian - lower Cenomanian carbonate succession of the Enisala Member (Iancila Formation, Babadag Basin) were documented and described, along with their associated microfacies. Based on the identified fossil taxa and the microfacies analyses, interpretations of the depositional environments have been made, suggesting an open-marine platform interior environment with normal salinity levels and reduced luminosity. The age of the carbonate succession is considered to be within the latest Albian - early Cenomanian interval, based on fossil evidence from the studied samples and research done by previous authors.

Keywords: Rhodophyta, carbonates, microfacies, Albian, Cenomanian, North Dobrogea.

INTRODUCTION

Calcareous red algae (CRA) have been an integral component of shallow-water carbonates since at least the Ordovician period and continue to be so to this very day (Wray, 1977 and Sarkar, 2025). The study of fossil red algae in Romania has previously been focused mainly on carbonate sequences from the Cenozoic, particularly from the Miocene (e.g., Bucur & Filipescu, 1994; Chelaru & Bucur, 2016; Chelaru et al., 2019; Chelaru, 2020). However, occurrences of fossil red algae in Romania were rarely mentioned from the upper Albian - Cenomanian post-tectonic sedimentary cover of the Carpathians areas and of the North Dobrogea Orogen. CRA have been described previously from the Lower Cretaceous of the Reşiţa-Moldova Nouă zone (Bucur, 1981; Bucur & Dragastan, 1986), Upper Cretaceous of the Rusca Montană Basin (Bucur & Strutinski, 1983) and border of the Apuseni Mountains (Bucur & Duşa, 1986; Bucur & Urian, 1989; Săsăran et al., 2018). Other occurrences of Cretaceous CRA in the Carpathian areas have been briefly mentioned by Codarcea & Pop (1963).

Cenomanian shallow-water carbonate deposits containing red algae are rarely exposed on the territory of Romania. Such carbonates are locally known from the post-tectonic sedimentary cover of the North Dobrogea Orogen, from the Babadag Basin, in the vicinity of the Enisala locality. The Cenomanian age of the Enisala carbonate succession was first mentioned by Pompeckj (1897) and Simionescu (1910, 1914). Further studies were accomplished throughout the 20th century by Macovei & Atanasiu (1934), Atanasiu (1940) and Mirăuţă & Mirăuţă (1964). Mutihac et al. (1972) proposed an Aptian-Albian age for the carbonate succession from Enisala, based on brachiopod, foraminifera and red algae fossils. This carbonate succession was attributed to the Vraconian (Upper Albian) by Grădinaru (2002) and Grădinaru et al. (2006), based on brachiopod taxa and a single ammonite specimen of the newly-described species *Lepthoplites enisalaensis* Grădinaru, 2002. The genus *Lepthoplites* was introduced by Spath (1925) and several species have been described from the Uppermost Albian deposits from Europe (England, France, Switzerland, Germany, Spain, Romania) and also from Western Kazakhstan (Grădinaru, 2002 and references there in). Bucur & Baltres (2002) reported the presence of Cenomanian successions bearing red algae, from two boreholes drilled near the Nicolae Bălcescu and Mihai Bravu localities in the north-eastern part of the Babadag Basin. Recent studies (Crăciun, 2023, 2025) performed in the same area have also mentioned the abundance of red algae from the same carbonate succession.

The aims of this paper are: (1) to present the taxonomy of red algae identified in the Cretaceous carbonate successions from the Enisala section; (2) to present for the first time the lithostratigraphic log and the associated microfacies of the studied succession; (3) to discuss the depositional environment and the paleoecology of the associated fossil assemblages of the Cretaceous carbonates from the Enisala section, based on microfacies analysis.

GEOLOGICAL SETTING AND STRATIGRAPHY

The studied red algae were recorded from one section located near the Enisala locality, right underneath the medieval settlement with the same name (GPS

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44°52'58"N 28°50'08"E) on the slope of Razelm Lake. The studied carbonate succession is part of the post-tectonic sedimentary cover of the North Dobrogea Orogen, accumulated in the Babadag Basin (Fig. 1a). The North Dobrogea Orogen is a Cimmerian fold-and-thrust belt with a Variscan basement, covered by Triassic to Jurassic sedimentary and volcanic successions. The Cimmerian structures are sealed by Cretaceous deposits accumulated in the post-tectonic Babadag Basin (Fig. 1b). The lithofacies typical for the basin are represented by mixed carbonate-siliciclastic deposits, but there are some differences in their structure depending on their corresponding geographical location, being thicker in the northern region of the basin and thinner in the south (Săndulescu, 1984). With a length of 60 km and a width of up to 20 km at its widest point, the Babadag Basin is packed with rocks of latest Albian to Santonian age. The thickness of the Cretaceous deposits in the Babadag Basin varies greatly, ranging from over 1600 m in its north-central part to as little as 266 m only 4,5 km southeast from the centre (Bucur & Baltres, 2002). Detailed biostratigraphy of Cretaceous deposits from the Babadag basin was performed by numerous previous researchers (Mirăuță & Mirăuță, 1964; Szász, 1985; Szász & Ion, 1988; Ion & Szász, 1994; Ion et al., 1997; Bucur & Baltres, 2002; Lodowski et al., 2019) based on their fossil content including ammonites, inoceramid bivalves, foraminifera, and nanoplankton.

The Cretaceous deposits from the Babadag Basin were divided by Simionescu (1914) into the Iancila Formation (Albian-Cenomanian) and the Dolojman Formation (Turonian-Coniancian). The Iancila Formation can reach a thickness of 400 m and is composed of calcareous sandstones and crinoidal calcarenites with few intercalations of calcareous conglomerates. Lithostratigraphic differences have led previous researchers to divide this formation into four members: Enisala, Hamangia, Babadag, and Golovița (Patrulius et al., 1974; Szász & Ion, 1988).

Near Enisala locality, the lower part of the Cretaceous succession (Albian-Cenomanian) from Babadag Basin is exposed (Fig. 1c). The Cretaceous section is 20 meters thick and consists of bioclastic limestones, locally rich in fossils (especially brachiopods and red algae) and represents the Enisala Member of the Iancila Formation (Simionescu, 1914) which unconformably overlie the Triassic deposits.

Bucur & Baltres (2002) reported the presence of Cenomanian deposits from the cores of two wells drilled on the north-eastern part of the Babadag Basin (Fig. 1c). One well (12/5) is located south to the Nicolae Bălcescu locality, at almost 20 kilometres north-west from the Enisala section, and crossed the Iancila Formation at approximate 400 meters thickness level. The second well (69.806) is located near to Turda locality, at 4,5 km south-eastward from the well 12/5 and penetrated the Iancila Formation at approximate 291 meters thickness (Bucur & Baltres, 2002). The age of the studied carbonates from these two wells was considered by Bucur & Baltres (2002) as Early Cenomanian based on foraminifers and CRA taxa. The Upper Cretaceous successions crossed by these wells unconformably overlie the Triassic deposits.

MATERIALS AND METHODS

A total of 50 rock-samples were collected from the Heraclea Fortress (Enisala Hill) section. From these, 40 rock samples were selected for thin sections (6x6 cm length and 3x3 cm width) and polished slabs that were further examined under petrographic and binocular microscopes. These thin sections are stored in the Laboratory of Paleontology of the University of Bucharest (LPB), Iuliana Lazăr collection. Another important collection that has been studied from the same section, is represented by more than 200 thin sections, made from samples collected by late Eugen Grădinaru and stored in the Department of Geology of the Babeş-Bolyai University (UBB), Ioan I. Bucur collection.

The classification of carbonate textures is based on the system established by Dunham (1962), with subsequent modifications introduced by Embry & Klovan (1971).

RESULTS

Description of the Enisala section

The Enisala section is located on the south-western slope of the Enisala Hill, bellow the archaeological site Heraclea Fortress (Fig. 2a). The section exposed the Triassic Wetterstein-type thick-bedded grey limestones that are unconformably overlaid by the lower part of the Iancila Formation (Enisala Member, cf. Patrulius, et al. 1974). The top of the Triassic limestones is strongly brecciated, affected by numerous fissures, fractures and cavities filled with late diagenetic cements and/or with pink limestones of the overlying unit (Fig. 2b). The overlying unit (the Enisala Member) is almost 20 meters thick. The base of this unit is represented by a sedimentary breccia (1,7 m thick) with angular clasts of Triassic limestones and carbonate matrix represented by a ferruginous bioclastic packstone with rare red algae (Fig. 3b). The next 1,5 meters are represented by pink and yellowish-grey crinoidal limestones (Fig. 3c), followed by approximate 7 meters of medium-bedded pink to yellow-grey bioclastic limestones very rich in calcareous red algae, echinoid debris and molluscan shell fragments (Fig. 3d, e). The macrofossils are represented mainly by ostreoid and inoceramid bivalves and by abundant rhynchonellid and terebratullid brachiopods. Encrusting organisms such as bryozoans and serpulids are common. Rare small colonial corals, gastropods and a few echinoid specimens were observed. The red algae are present all over the section, with numerous complete, well-preserved specimens. Benthic and planktonic foraminifera are

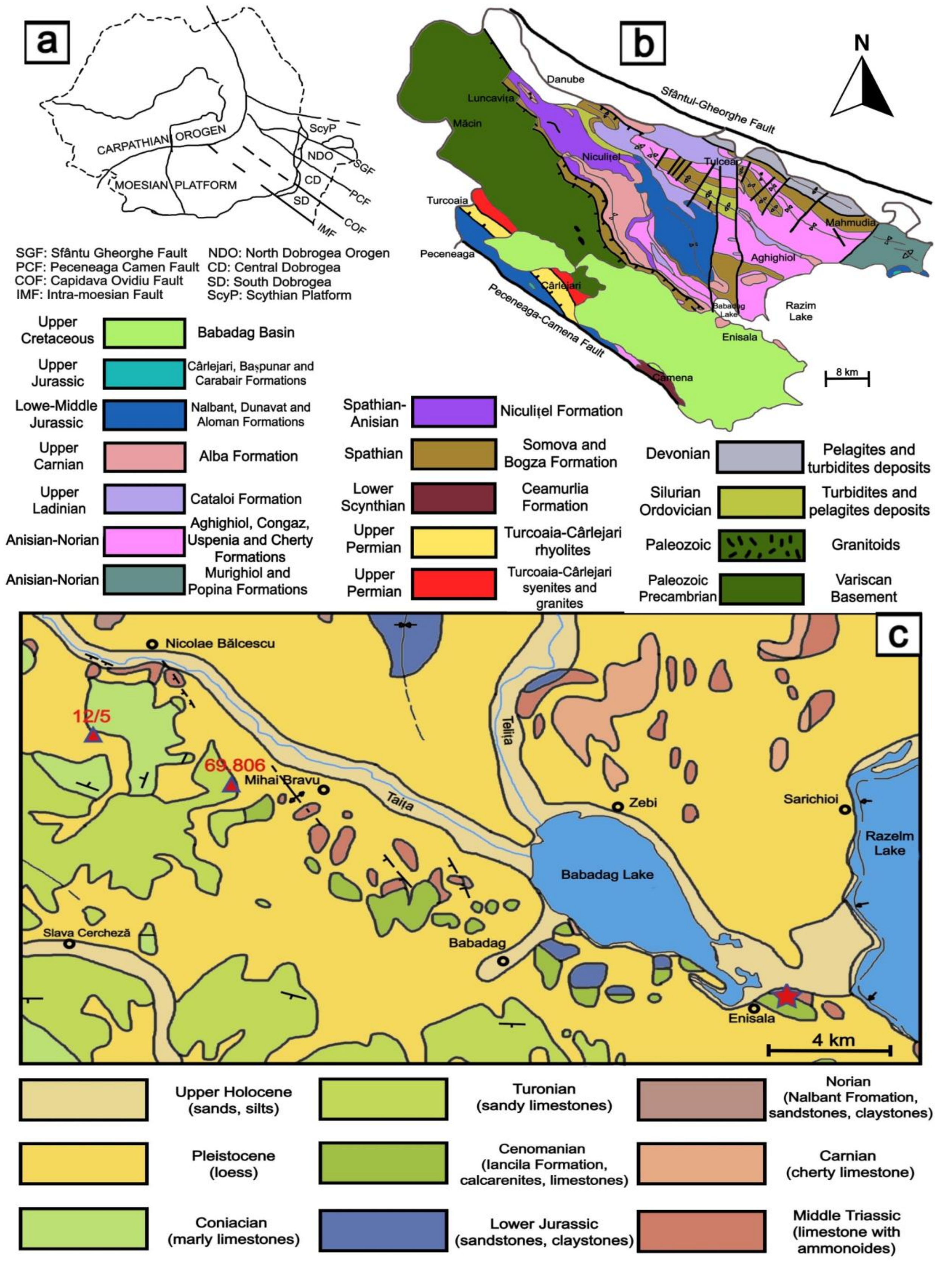

Figure 1. a. Simplified geotectonic map of Romania with location of the North Dobrogea Orogen (NDO); **b.** Tectonostratigraphic map of the North Dobrogea Orogen showing the main tectonic units and the distribution of Mesozoic deposits (modified from Seghedi, 2006); **c.** Geological map of the area (based on the geological map, 1:200000 of the Tulcea area, Mirăuţă et al., 1967) with the location of the Enisala section (Cenomanian deposits, red star) and the locations of the two wells (red triangles) that drilled the succession of the Cenomanian deposits in subsurface.

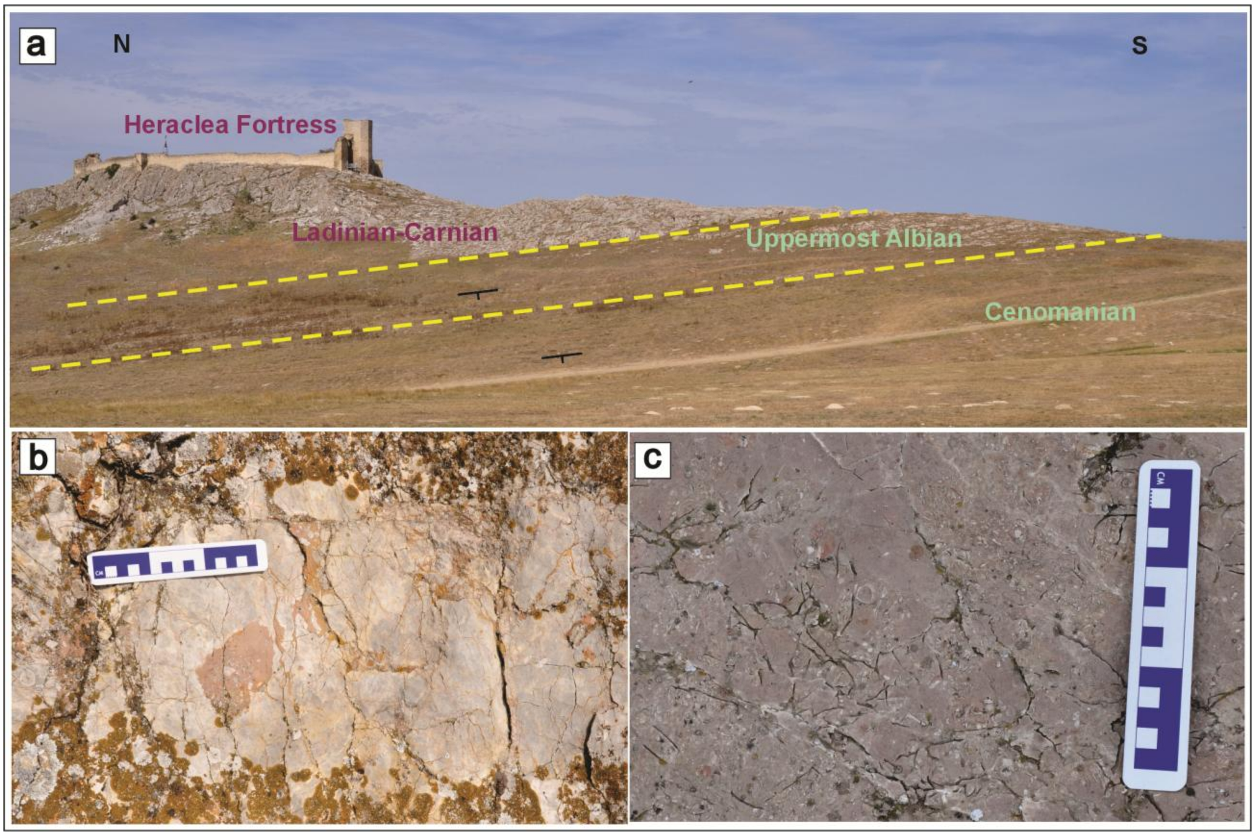

Figure 2. a. Outcrop view of the Enisala section: upper Triassic bedded limestones and the post-tectonic sedimentary cover represented by Uppermost Albian-Cenomanian carbonates; **b.** The top of the Triassic limestones is strongly brecciated, affected by numerous fissures, fractures and cavities filled with pink limestones of the overlying unit of Iancila Formation; **c.** Pink-yellow-grey bioclastic limestones very rich in red calcareous algae, echinoid debris and molluscan and brachiopods shell fragments (Enisala Member, Iancila Formation).

present in several beds. One ammonoid specimen of *Lepthoplites enisalaensis* (Grădinaru, 2002) was found in this succession. The last 8 to 10 meters of the succession are represented by bioclastic (mainly crinoidal) limestones with fragments of red algae (Fig. 3f, g).

Microfacies

Four microfacies types (MFT's) have been identified from the studied carbonates of the Enisala Hill section:

MFT1 - The base of the Cenomanian carbonate succession is represented by a *transgressive basal carbonate breccia* - containing centimetre-sized angular carbonate clasts from the Triassic underlying deposits. The ferruginous micritic matrix contains a high proportion of millimetric angular carbonate clasts (Fig. 4a, b);

MFT2 - *Bioclastic wackestone – packstone with fractures filled with sparitic calcite* (Fig. 4c-f): bioclasts are strongly bioeroded and recrystallized and consists of thick-shell bivalves, bryozoans and red algae (*Paraphylum primaevum* Lemoine*)*, rare holothurian sclerites, foraminifers; the matrix consists of ferruginous micrite and fine skeletal debris.

MFT3 - *Bioclastic wackestone–floatstone with whole fossils and well preserved epifauna* (Figs. 5-10): the facies is a poorly sorted skeletal floatstone; the micritic matrix is bioclastic wackestone with shell debris and small, angular quartz grains; the larger fossils are represented by brachiopods, oysters, inoceramids and rudists bivalves, corals, gastropods, bryozoans, red algae, rare dasycladalean algae, serpulid worm-tubes; crinoid ossicles are abundant and holothurian sclerites, echinoid spines are also present, along with benthic foraminiferas, including rare orbitolinid foraminifera, ostracods and calcispheres; bivalves and brachiopods shells are abundant, well preserved, with articulated shells; however, there are also abundant fragmentes of bivalves, corals and gastropods; the oysters shells preserve the prismatic outer layer and the foliated or vesicular layer (Fig. 10f, g); rare inoceramid shells exhibit the characteristic prismatic microstructure, with honeycomb pattern in plan view and the difference in prism size in the outer and inner shell layer (Fig. 10d); the brachiopod shells show specific endopunctation (Fig. 9e); bivalves and brachiopods shell fragments are strongly bored/bioeroded; bryozoans and red algae are common and very well preserved; the skeletal grains are not coated

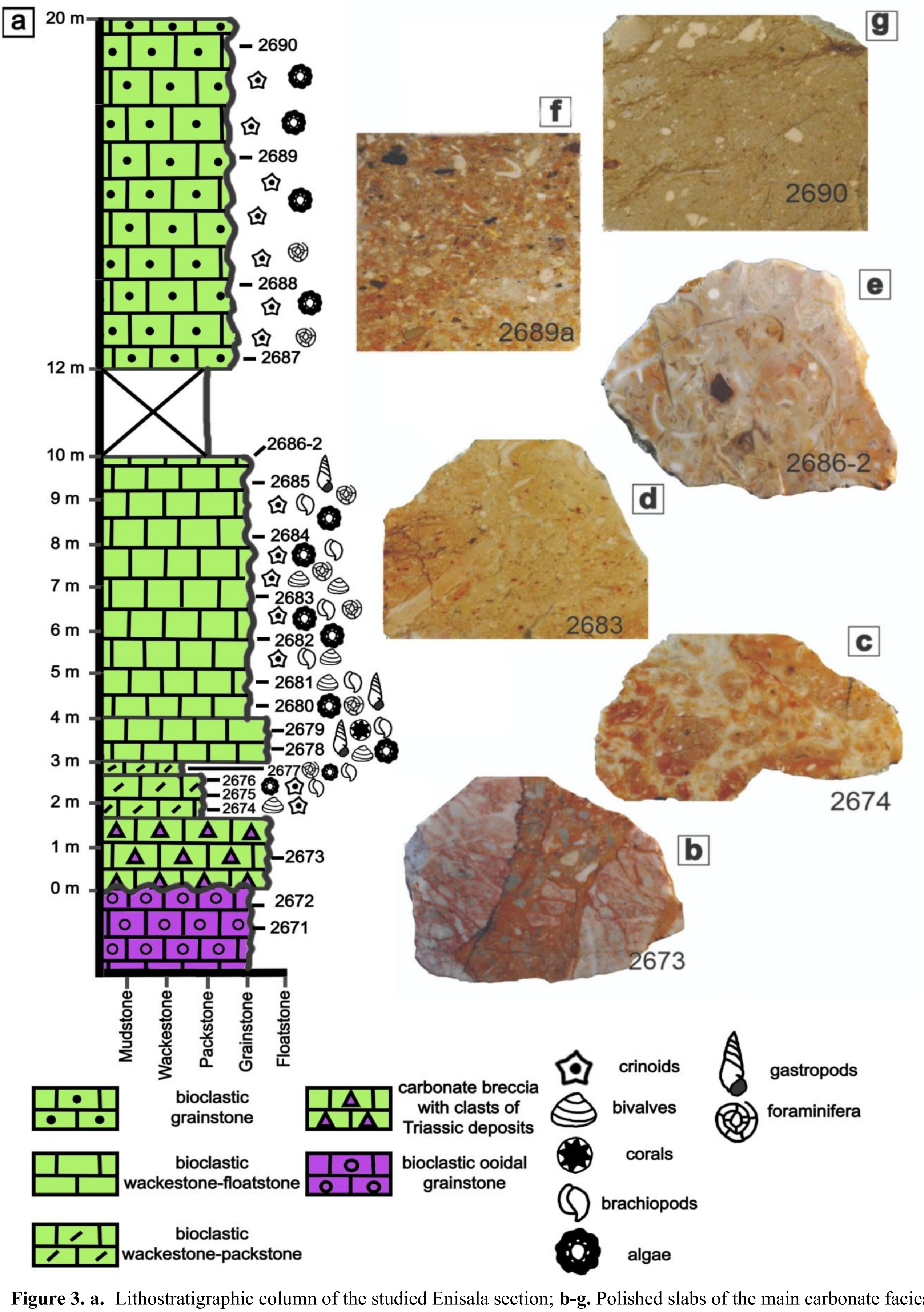

Figure 3. a. Lithostratigraphic column of the studied Enisala section; **b-g.** Polished slabs of the main carbonate facies.

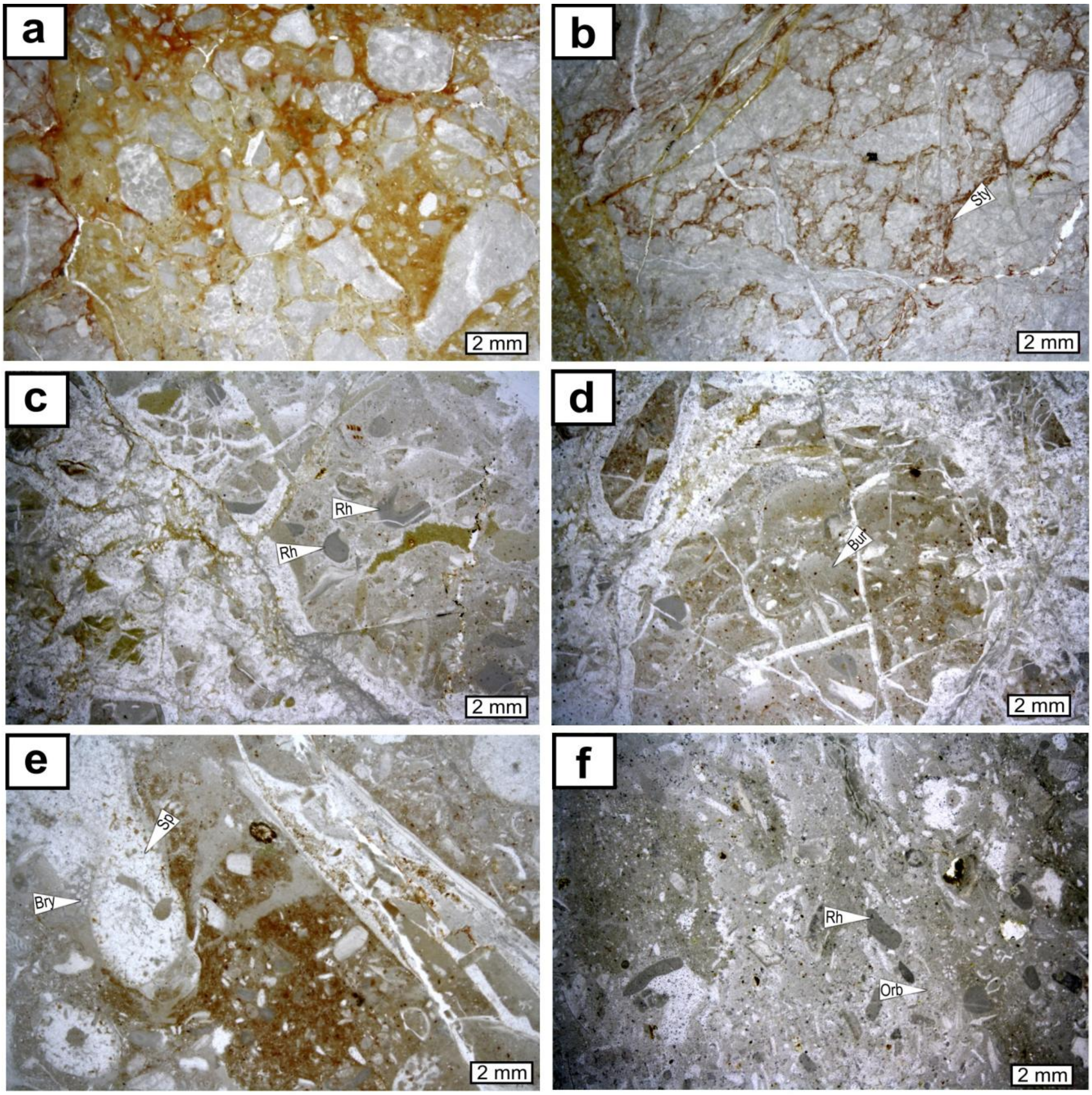

Figure 4. Microfacies identified in the studied section: **a-b.** MFT1 Transgressive basal carbonate breccia containing centimetre-sized angular carbonate clasts from the Triassic underlying deposits; **c-f.** MFT2 Bioclastic wackestone–packstone with fractures filled with sparitic calcite: red algae (Rh), bryozoans (Bry), orbitolinid foraminifera (Orb), calcified sponge (Sp), burrow (Bur), styolites (Sty). IDs of the LPB thin sections: a, b - 2673; c, d - 2674; e - 2675; f - 2676.

and non-skeletal grains (peloids, intraclasts, ooids) are absent.

MFT4 - *Grainstone-packstone with abundant red algae.* Red algae are common along with crinoids and bivalves bioclasts; the micritic matrix contain millimetric quartz grains and extraclasts (Fig. 11c, f).

Taxonomy of identified calcareous red algae

Several taxa of CRA were identified in the studied thin sections, which will be described systematically below. The suprageneric taxonomy follows Hrabovský et al., 2015. Most of the identified fossil CRA belong to two families, Sporolithaceae and Corallinaceae. The genus *Agardhiallopsis* is of uncertain order and family.

Division **RHODOPHYTA** Wettstein, 1901
Class **FLORIDEOPHYCEAE** Cronquist, 1960
Subclass **CORALLINOPHYCIDAE** Le Gall & Saunders, 2007
Order **SPOROLITHALES** Le Gall et al.,2009
Family **SPOROLITHACEAE** Verheij, 1993

Genus ***Sporolithon*** Heydrich, 1897

Sporolithon rude **(Lemoine) Ghosh and Maithy, 1996**
Fig. 12 a-f

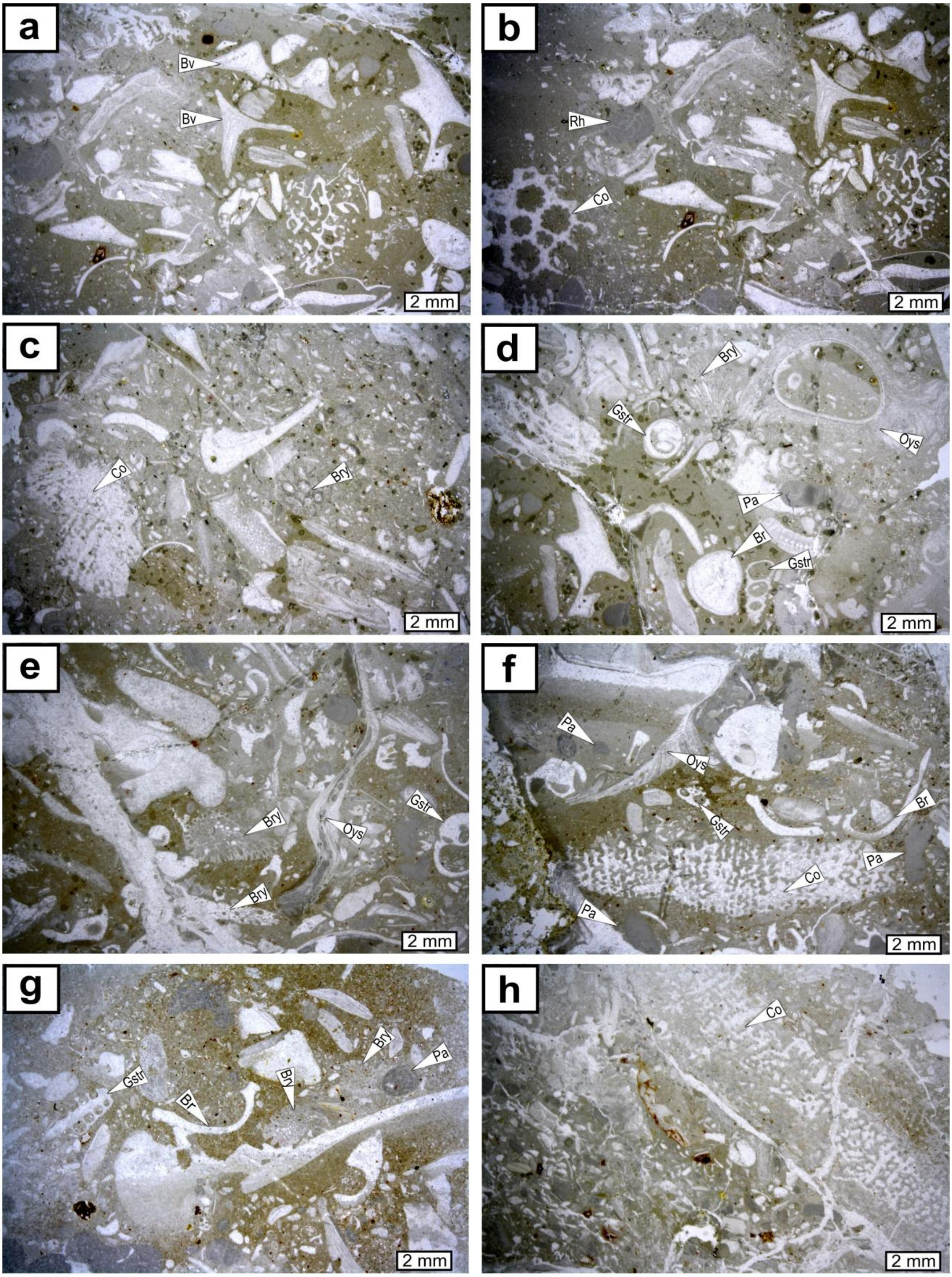

Figure 5. a-h. Microfacies identified in the studied section: MFT3 Bioclastic wackestone – floatstone with whole fossils and well preserved epifauna: bivalve shells (Bv), red algae (Rh), *Paraphylum* (Pa), colonial corals fragments (Co), gastropods (Gstr), oyster bivalves (Oys), brachiopod shells (Br), bryozoans (Bry). IDs of the LPB thin sections: a, b, c, d - 2678; e, f - 2679; g - 2680; h - 2683.

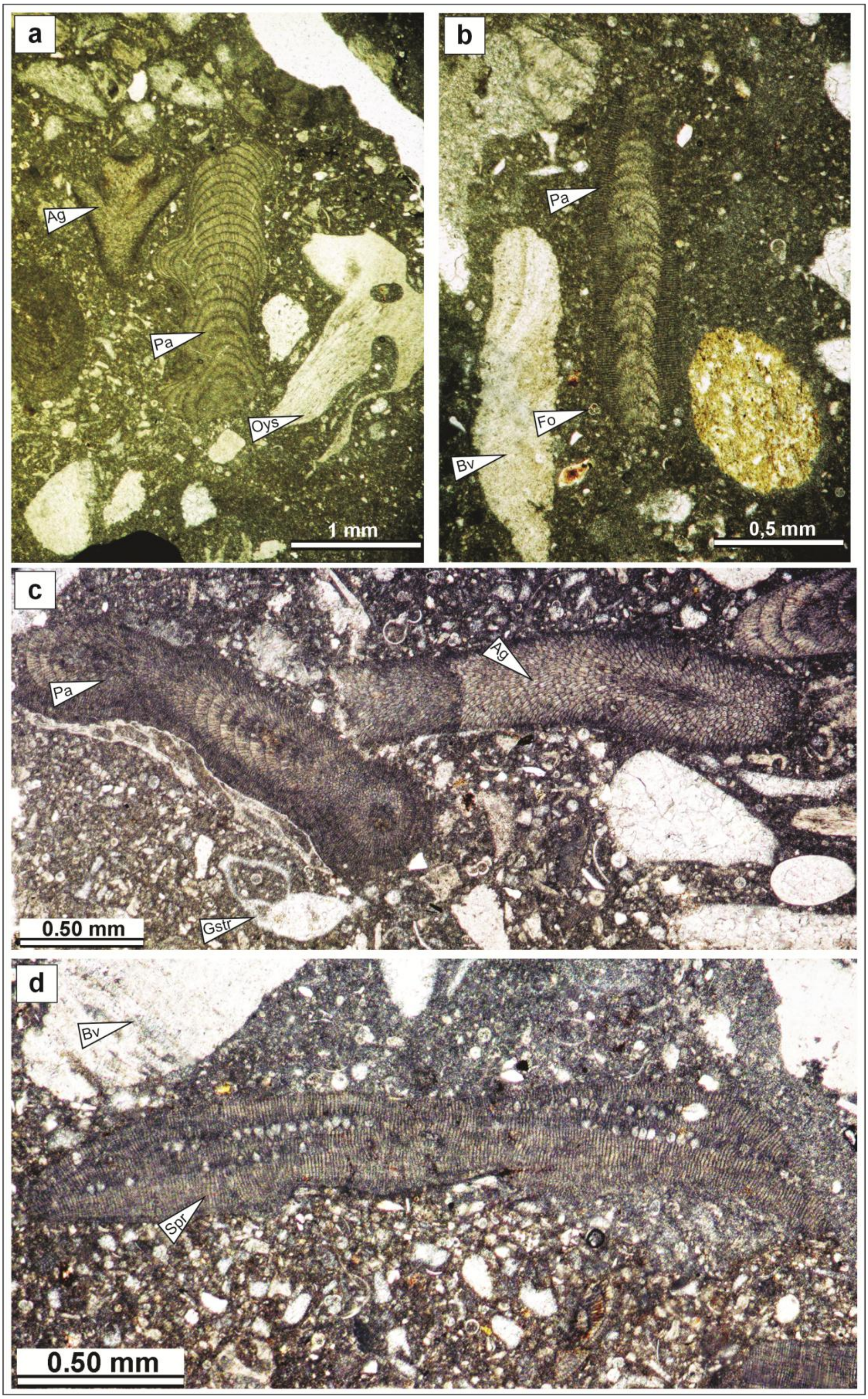

Figure 6. Microfacies identified in the studied section: **a-d** MFT3 Bioclastic wackestone–floatstone with whole fossils and well preserved epifauna: *Agardhiellopsis* (Ag), *Paraphylum* (Pa), *Sporolithon* (Spr), oyster bivalves (Oys), foraminifera (Fo), bivalve shells fragments (Bv). IDs of the UBB thin sections: a - 9; b - 18; c - 15; d - 28.

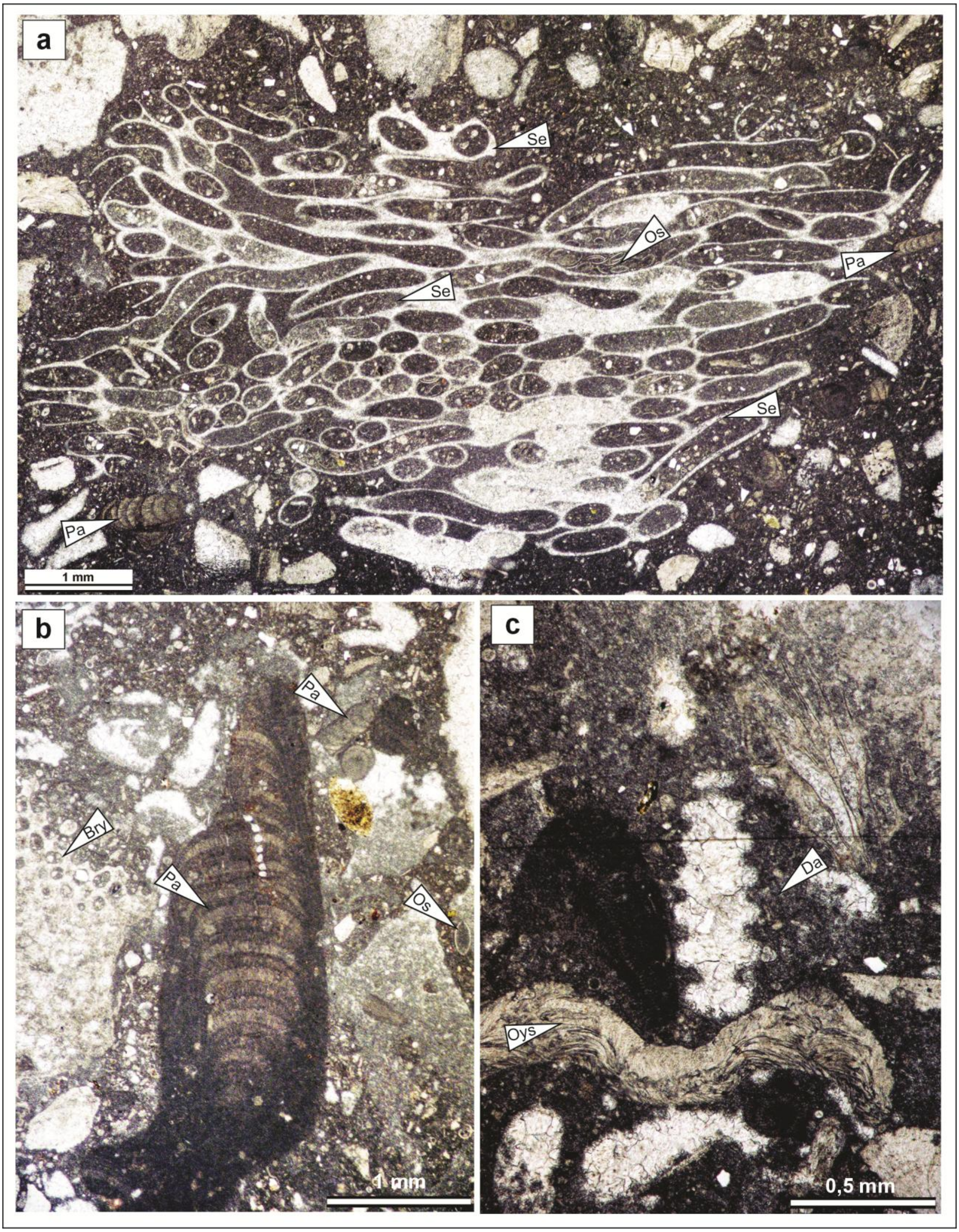

Figure 7. a-c. Microfacies identified in the studied section, MFT3 Bioclastic wackestone – floatstone with hole fossils and well preserved epifauna: **a,** serpulid worms (Se); **b**, *Paraphyllum* (Pa), bryozoans (Bry), ostracodes (Os); **c**, dasycladalean algae (?) (Da) and oyster fragments (Oys). IDs of the UBB thin sections: a - 77; b - 84; c - 91.

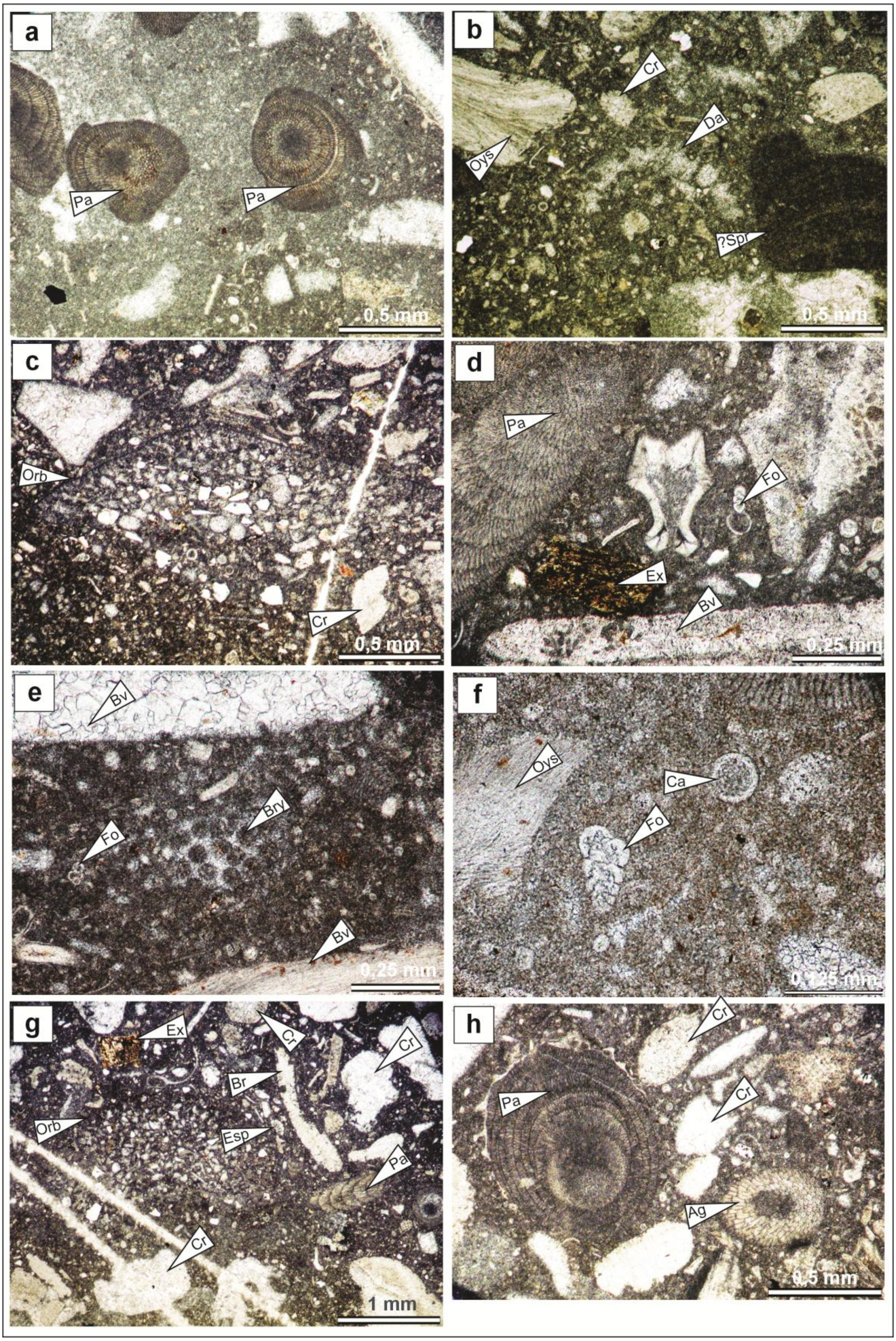

Figure 8. a-h. Microfacies identified in the studied section, MFT3 Bioclastic wackestone–floatstone with whole fossils and well preserved epifauna: *Paraphylum* (Pa), dasycladalean algae (Da), *Sporolithon* (Spr), orbitolinid foraminifera (Orb), crinoid ossicles (Cr), oyster bivalves (Oys), bryozoans (Bry), bivalve shells fragments (Bv), planktonic foraminifera (Fo), calcispheres (Ca), extraclasts (Ex), *Agardhiellopsis* (Ag). IDs of the UBB thin sections: a - 13; b - 17; c - 28; d, e - 29; f - 40; g, h - 42.

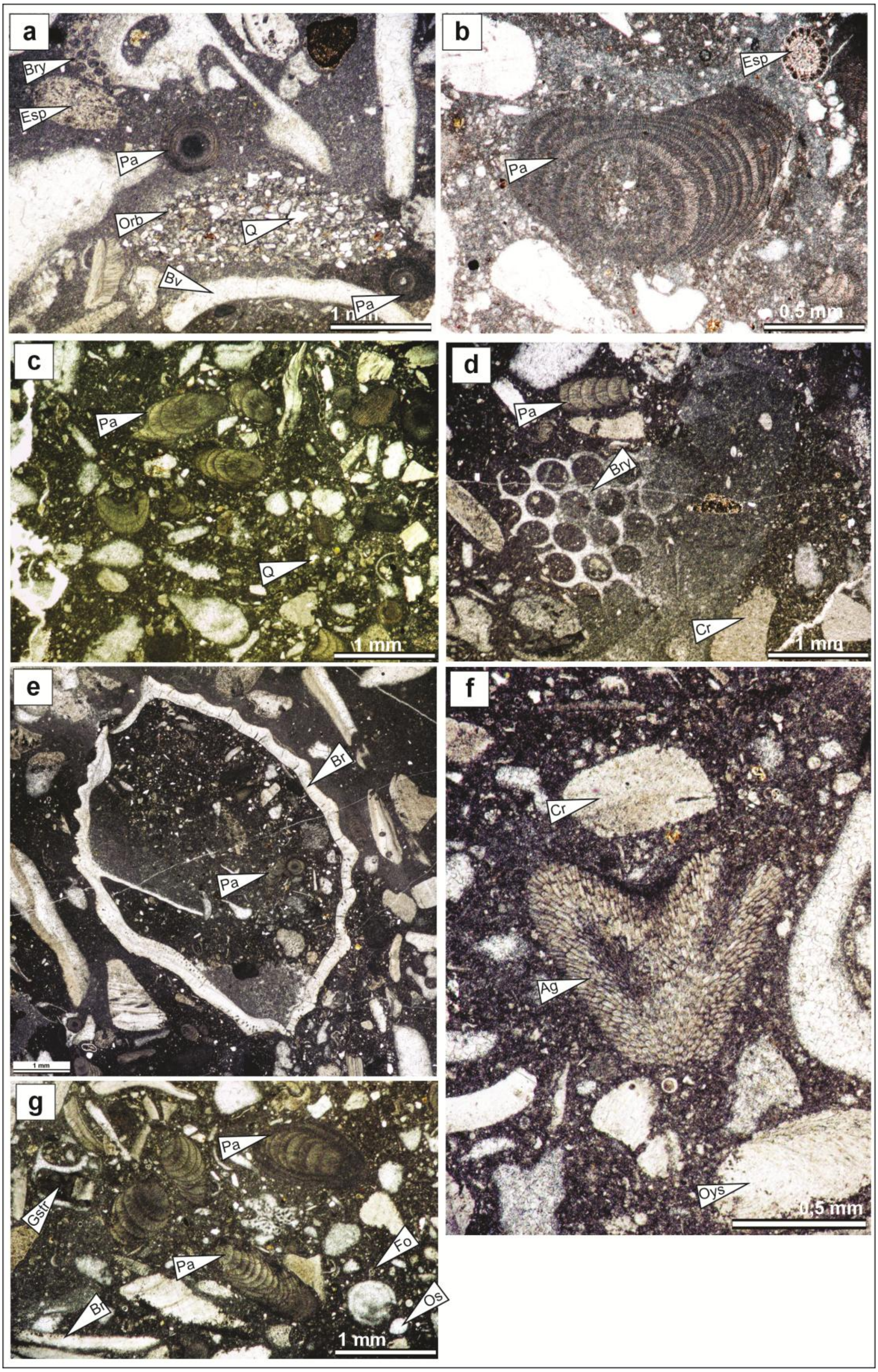

Figure 9. a-g. Microfacies identified in the studied section, MFT3 Bioclastic wackestone–floatstone with whole fossils and well preserved epifauna: *Paraphylum* (Pa), orbitolinid foraminifera (Orb), quartz grains (Q), echinoid spine (Esp), bryozoans (Bry), bivalve shells fragments (Bv), oyster bivalves (Oys), brachiopod shell (Br), crinoid ossicles (Cr), planktonic foraminifera (Fo), ostracods (Os), *Agardhiellopsis* (Ag). IDs of the UBB thin sections: a - 45; b - 46; c - 47; d - 55; e - 71; f - 82; g - 47.

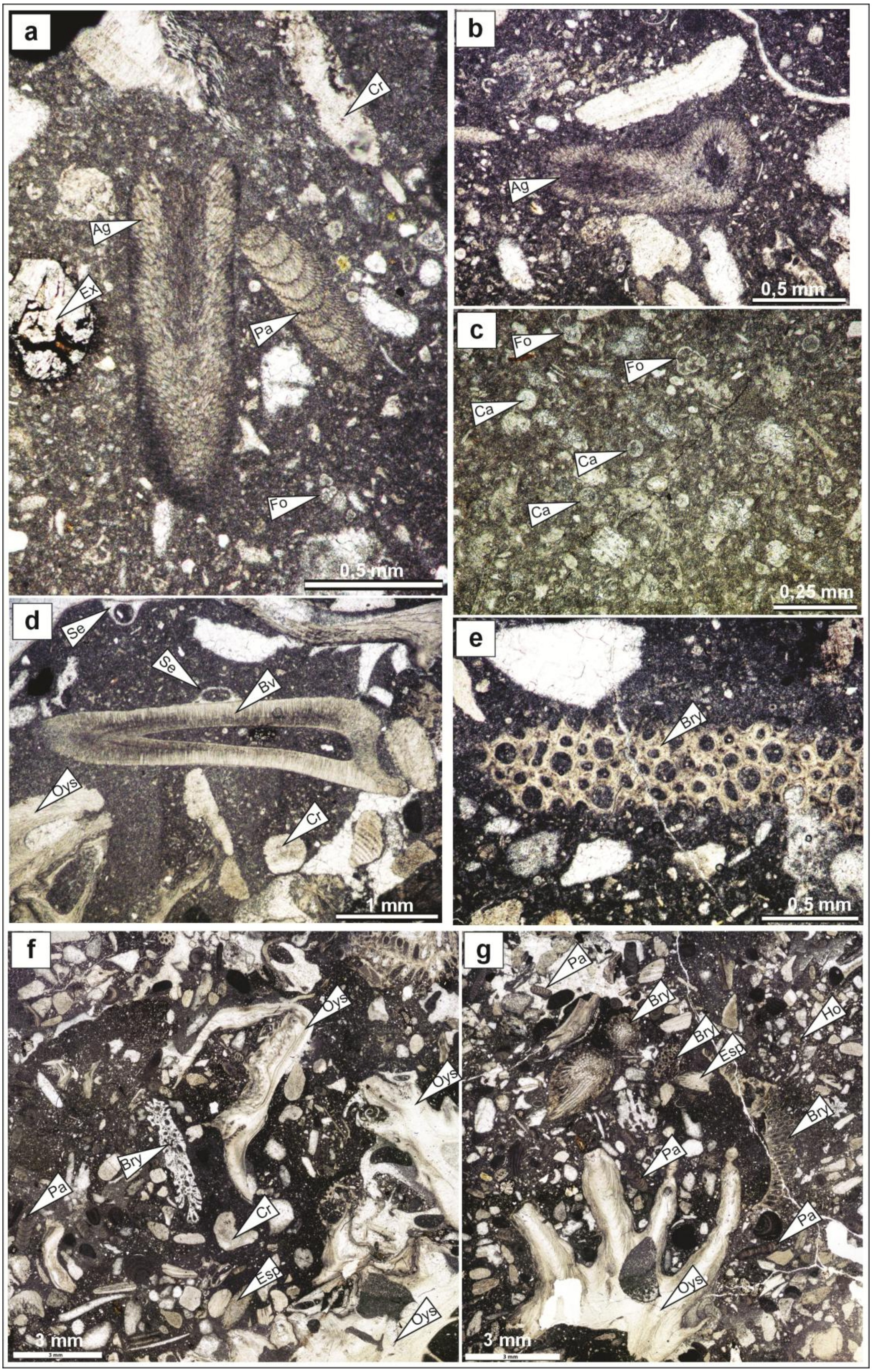

Figure 10. a-g. Microfacies identified in the studied section, MFT3 Bioclastic wackestone–floatstone with whole fossils and well preserved epifauna: *Agardhiellopsis* (Ag), *Paraphylum* (Pa), crinoid ossicles (Cr), extraclasts (Ex), planktonic foraminifera (Fo), calcispheres (Ca), serpulid worms encrusting (Se), bivalve shells (By), oyster shells strongly bioeroded (Oys), bryozoans (Bry), echinoid spine (Esp), holothurian sclerite (Ho). IDs of the UBB thin sections: a - 92; b - 74; c - 79; d - 94; e - 107; f - 96; g - 109.

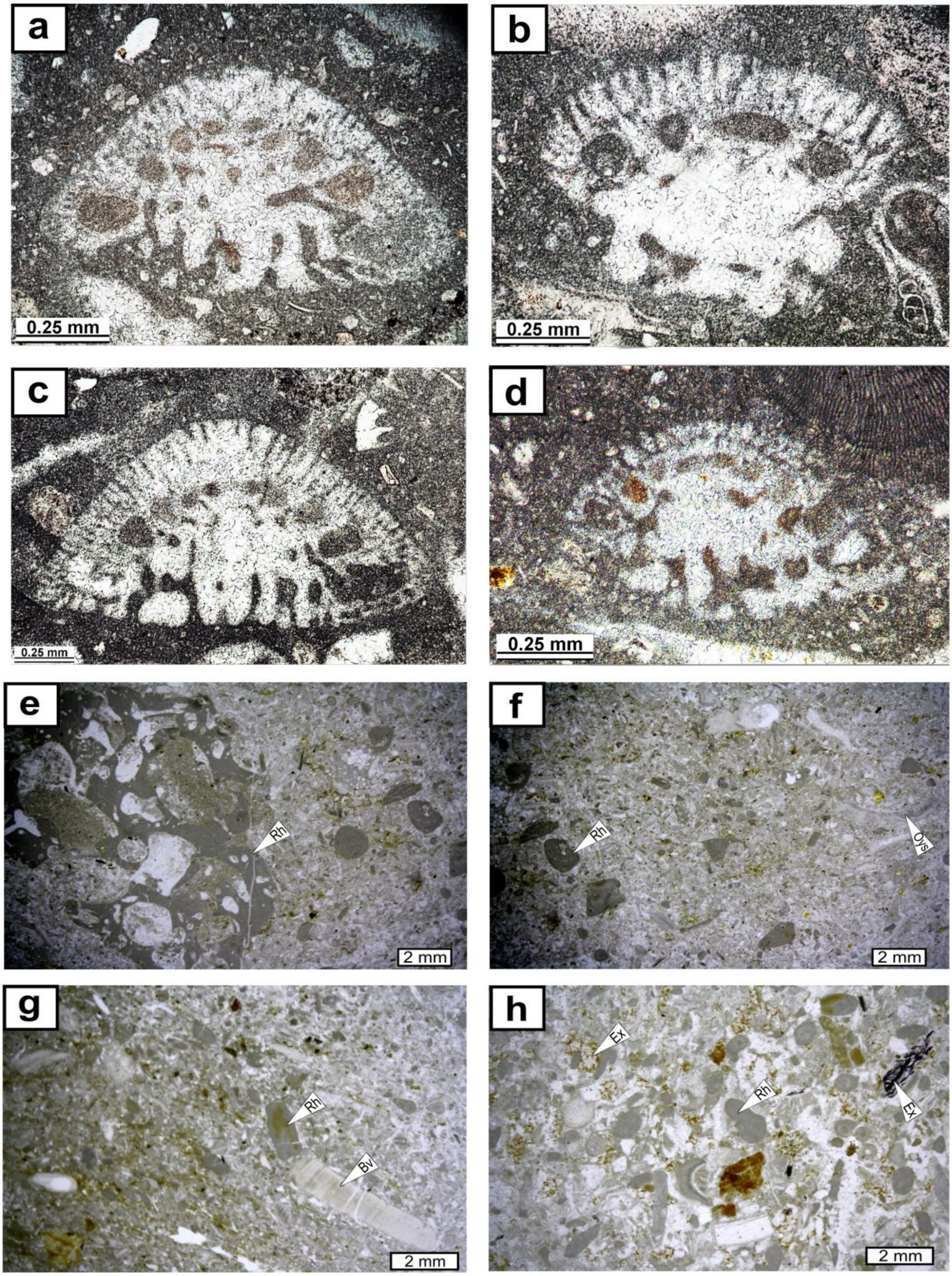

Figure 11. a-d. *Hensonipapillus* sp. (foraminifera); **e-h.** MFT4 Grainstone-packstone with abundant red algae: red algae fragments strongly bioeroded (Rh), extraclasts (Ex), oyster bivalves (Oys), bivalve shells fragments (probably inoceramids) (Bv). IDs of the UBB thin sections: a, b - 26; c – 53; d - 25; IDs of the LPB thin sections: e, f - 2689; g - 2690; h - 2690a.

1925 *Archaeolithothamnium rude* sp. nov. - Lemoine, p. 3, pl. 1, figs. 1, 2, Aptian, South-Western France.
1972 *Archaeolithothamnium rude* Lemoine – Mutihac et al., pl. 3, fig. 1, Aptian-Albian, Northern Dobrogea, Babadag Basin, South-Eastern Romania.
1981 *Archaeolithothamnium rude* Lemoine – Bucur, p. 33, pl. 1, figs. 1-4; pl. 2 figs, 1-6, Aptian
1988 *Archaeolithothamnium rude* Lemoine – Misra & Kumar, p. 45, pl. 4, figs. 6, 8, 16, Cretaceous, India.
1989 *Archaeolithothamnium rude* Lemoine - Bucur & Urian, p. 37, pl. 1, fig. 1, Upper Cretaceous, N-E of Gilău Mountains, North-Western Romania.
1991 *Archaeolithothamnium rude* Lemoine – Schlagintweit, p. 46, pl. 16, figs.1-2.
1996 *Sporolithon rude* (Lemoine) comb. nov. - Ghosh & Maithy, p. 67, pl. 1, fig. 8, Cretaceous, India.

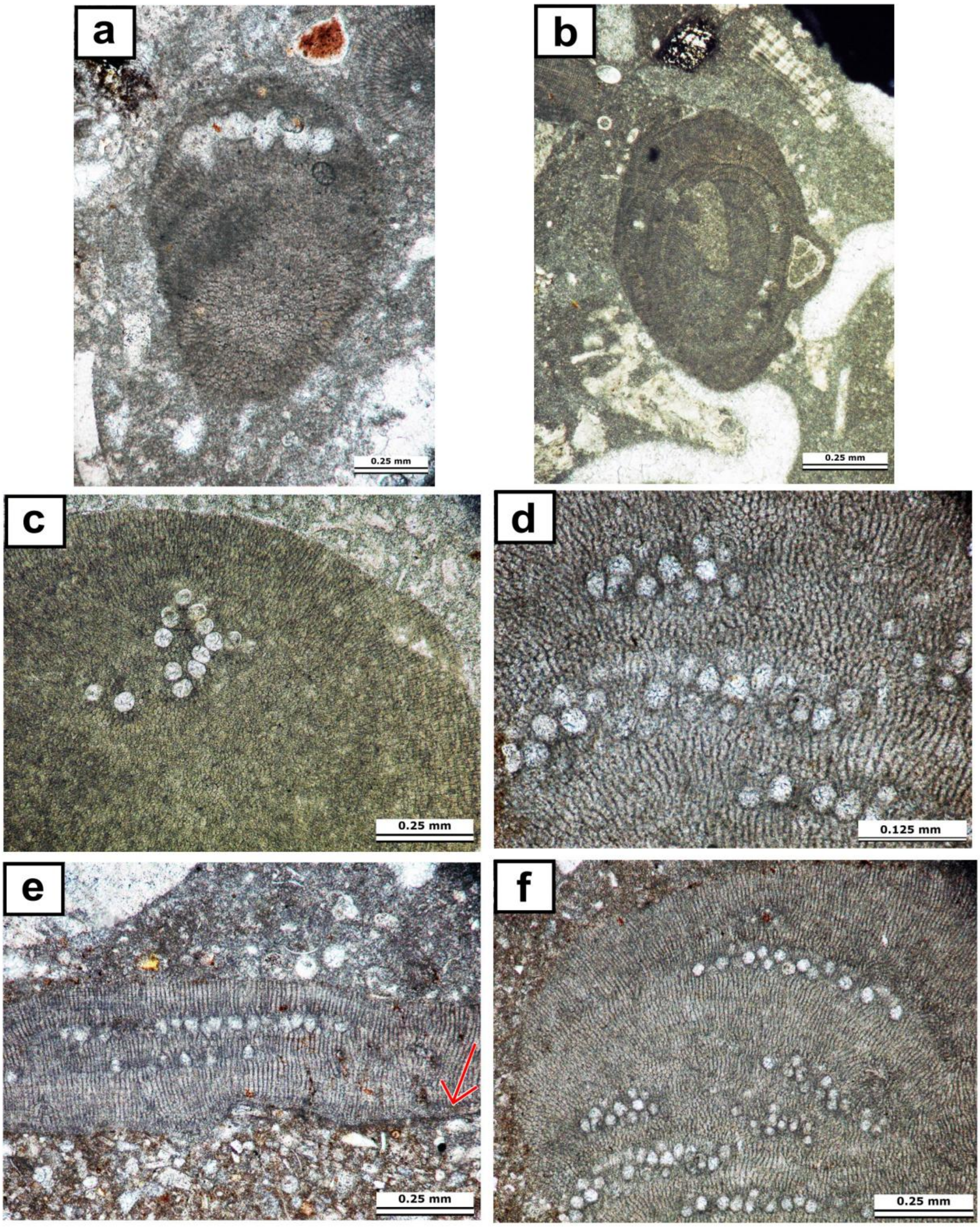

Figure 12. a-f. *Sporolithon rude* (Lemoine) Ghosh and Maithy, 1996; **a-d, f.** nodular growth form, **e,** encrusting growth form; note in **e** the non-coaxial hypothallus (red arrow). The characteristic sori reproductive structures can be seen on all specimens, as small round cavities that develop close to each other within the thallus. IDs of UBB thin sections: a - 17; b - 3; c - 6; d, f - 13; e - 28.

2002 *Sporolithon rude* (Lemoine) - Bucur & Baltres, p. 95, pl. 6, figs. 2, 3, 5, Cenomanian, Northern Dobrogea, Babadag Basin, South-Eastern Romania.
2007 *Sporolithon rude* (Lemoine) – Tomás et al., p. 89, fig. 6, A-F; p. 90, fig. 7, A-F, Late Hauterivian, Eastern Spain.

Material: 5 thin sections from the Babeş-Bolyai University collection (sections ID 3, 6, 13, 17 and 28) and two thin sections from LPB Collection from (2689 and 2690a).

Description: The thalli of *Sporolithon rude* specimens are composed of branched filaments of cells. The observed thalli fragments generally have a round growth form (Fig. 12a, b, c, d, f), but some can reach more elongated forms (Fig. 12e). The dimensions vary considerably, with some reaching lengths of 1-2 mm and widths of 0.8-1 mm. The thalli are monomeric and non-coaxial. One of the defining characteristics of the genus *Sporolithon* is the abundance of sporangial compartments that are usually found burried within the thalli of representative taxa, forming groups of calcareous "sori" structures (Fig. 12c, d, e, f). The groups contain many sporangial compartments, numbering at least 8-10 in each sorus. The diameter of these cavities is around 0.06 mm each.

Occurrences: India (Tamil Nadu, Cretaceous), France (Vimport, Albian), Spain (Iberian Chain, Upper Hauterivian), Austria (Northen Calcareous Alps, Aptian-Albian pebbles in Upper Cretaceous conglomerates), Romania (Reşiţa zone, upper Barremian-Aptian; Babadag Basin, uppermost Albian-Cenomanian; N-E of Gilău Mountains, Upper Cretaceous (cf. synonymy list).

Sporolithon phylloideum (Bucur & Dragastan) Tomás et al., 2007

Fig. 13 a-f

1986 *Archaeolithothamnium phylloideum* sp. nov. – Bucur & Dragastan p. 228, pl. 1, figs. 1-9, Aptian of Reşiţa-Moldova Nouă zone and Apuseni Mountains, Romania.
1987 *Parakymalithon phylloideum* (Bucur & Dragastan) comb. nov. - Moussavian, p. 189, pl.36, figs. 1-5, Hauterivian, Eastern Spain.
2007 *Sporolithon phylloideum* (Bucur and Dragastan) comb. nov. - Tomás et al., p. 86, fig. 5, A-D, Hauterivian, Eastern Spain.

Material: 6 sections from the Babeş-Bolyai University collection (sections ID 11, 13, 35, 53 76 and 81).

Description: The superimposed thalli are monomeric with coaxial arrangement, emphasized by dark brown shades. They reach up to 2.8 mm in length and 2 mm in width. This species stands out due to its characteristic "jet d'au" (Bucur & Dragastan, 1986) or "fountain" arrangement of filaments (Tomás et al., 2007). In the central area of the hypothallus, the filaments are arranged parallel to the ventral surface, but as they grow towards the perithallus, they begin to curve in two opposite directions (Fig. 13e).

Asexual reproductive structures were observed on the thalli of some specimens, in the form of sporangial compartments grouped in fused sori that look almost like multiporate conceptacle reproductive structures (Fig. 13f). A sorus contains about 7 sporangial compartemnts. The dimensions of each individual compartment measure approximately 0.18 mm length and 0.125 mm width.

Occurrence: Spain (Iberian Chain, Hauterivian), Romania (Babadag Basin, uppermost Albian-Cenomanian; south of Doman, Reşiţa zone, Aptian).

Genus ***Paraphyllum*** Lemoine, 1970

Paraphyllum primaevum Lemoine, 1970

Fig. 14 a-i

1970 *Paraphyllum primaevum* sp. nov. - Lemoine, pl. 8, fig. 2; pl. 9, fig. 2; pl. 10, fig. 1; pl. 11, fig. 1; pl. 12, fig. 1, Aptian-Albian, Southern France.
1973 *Paraphyllum primaevum* Lemoine - Masse & Philip, p. 213, fig. 2, Albian, Mount Combe, Southern France.
1978 *Paraphyllum primaevum* Lemoine - Berthou & Poignant, p. 119, pl. 1, fig. 1-5, Cenomanian, S-E of Lisbon, Portugal.
1991 *Paraphyllum primaevum* Lemoine – Schlagintweit, p. 46, pl. 7, fig. 7 (pars), pl. 16, fig. 3 (pars), figs. 5-6.
2002 *Paraphyllum primaevum* Lemoine - Bucur & Baltres, p. 94, pl. 5, fig. 1-9, Cenomanian, Northern Dobrogea, Babadag Basin, Romania.
2024 *Paraphyllum primaevum* Lemoine – Bucur et al., p. 7, pl. 1., fig. G, H, Aptian-Albian, Southern Carpathians, Reșița-Moldova Nouă, Romania.

Material: 25 thin sections from the Babeş-Bolyai University collection (sections ID 1, 3, 13, 18, 19, 23, 25, 34, 35, 42, 36, 47, 50, 53, 62, 68, 77, 84, 85, 90, 92, 94, 99, 108 and 109) and 13 thin sections from Laboratory of Paleontology, University of Bucharest (LPB: 2674, 2676, 2677, 2678, 2679, 2680, 2683, 2684, 2685, 2687, 2689, 2690 and 2690a).

Description: The thalli are cylindrical in shape. Some thalli consist of a single segment (Fig. 14a, b, e, f, h, i), while others are branched (Fig. 14c, d, g). The longitudinal sections are 1-2.7 mm long and approximately 0.25-0.75 mm wide, while the oblique ones are up to 1 mm long and 0.25-0.6 mm wide. The thalli are monomeric, with a clear distinction between the arrangement of the filaments of the hypothallus and those of the perithallus. The cell filaments of the hypothallus develop in concentric rows, revealing a characteristic coaxial arrangement. They curve sideways and form the

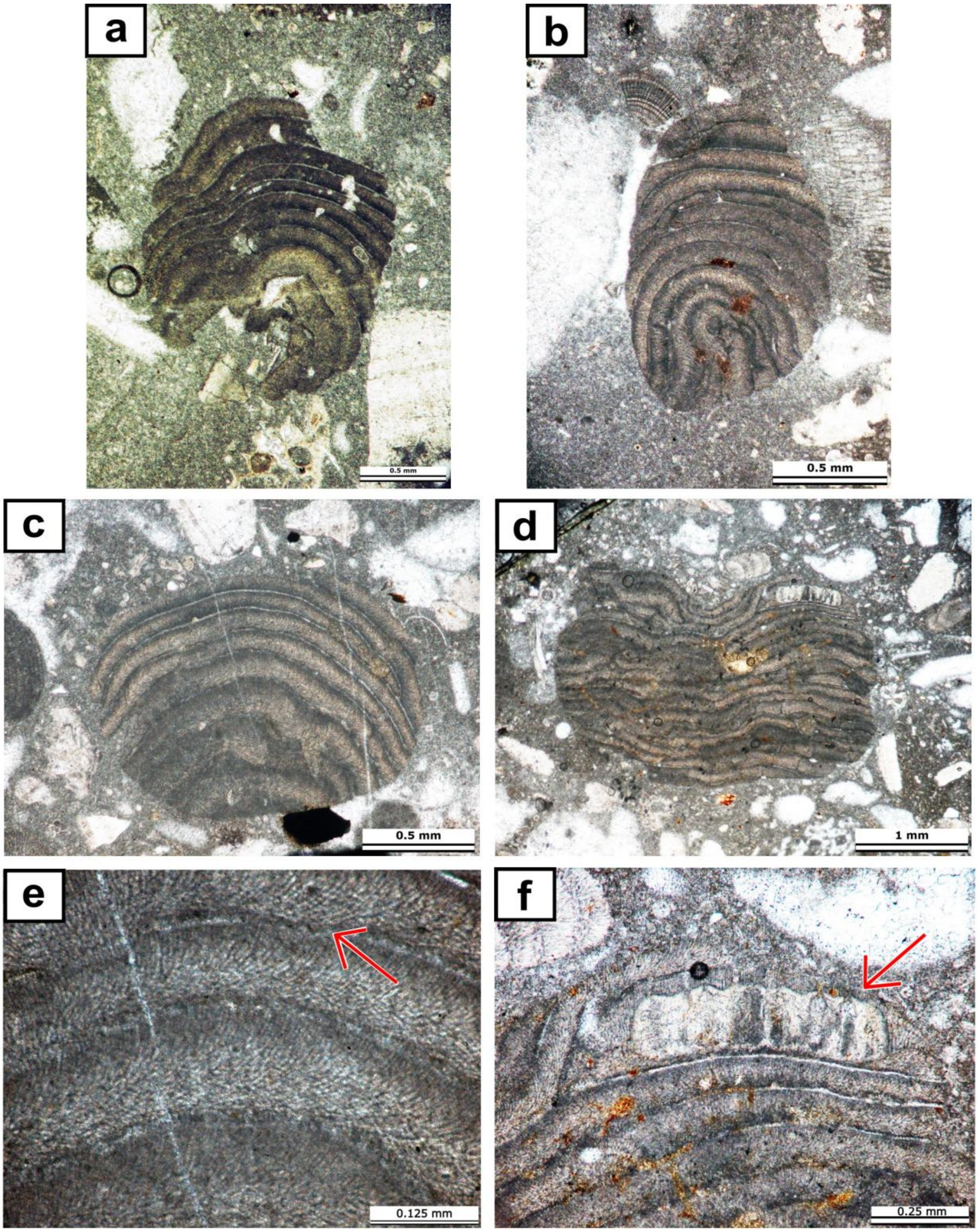

Figure 13. a-f. *Sporolithon phylloideum* (Bucur & Dragastan) Tomás et al., 2007. Note in **e** superimposed thallus with filaments having a distinctive, "fountain"-like distribution (red arrow); note in **f** fossil traces of reproductive structures grouped in sori, found in the perithallus (red arrow). IDs of the UBB thin sections: a - 13; b - 53; c, e - 76; d, f - 35.

perithallus, which is often darker (Fig. 14a, d). In a single specimen, traces of reproductive organs were identified within the perithallus, in the form of sporangial compartments grouped together (Fig. 14f). The compartments measure approximately 0.1 mm in length and 0.04 mm in width.

Occurrences: France (Mount Combe, Albian), Portugal (SE of Lisbon, Cenomanian), Austria (Northen Calcareous Alps, Aptian-Albian pebbles in Upper Cretaceous conglomerates), Romania (Northern Dobrogea, Cenomanian; Reșița-Moldova Nouă zone, uppermost Aptian-Albian; Șopot Area, Cenomanian; Șureanu Mountains, Turonian-Coniacian).

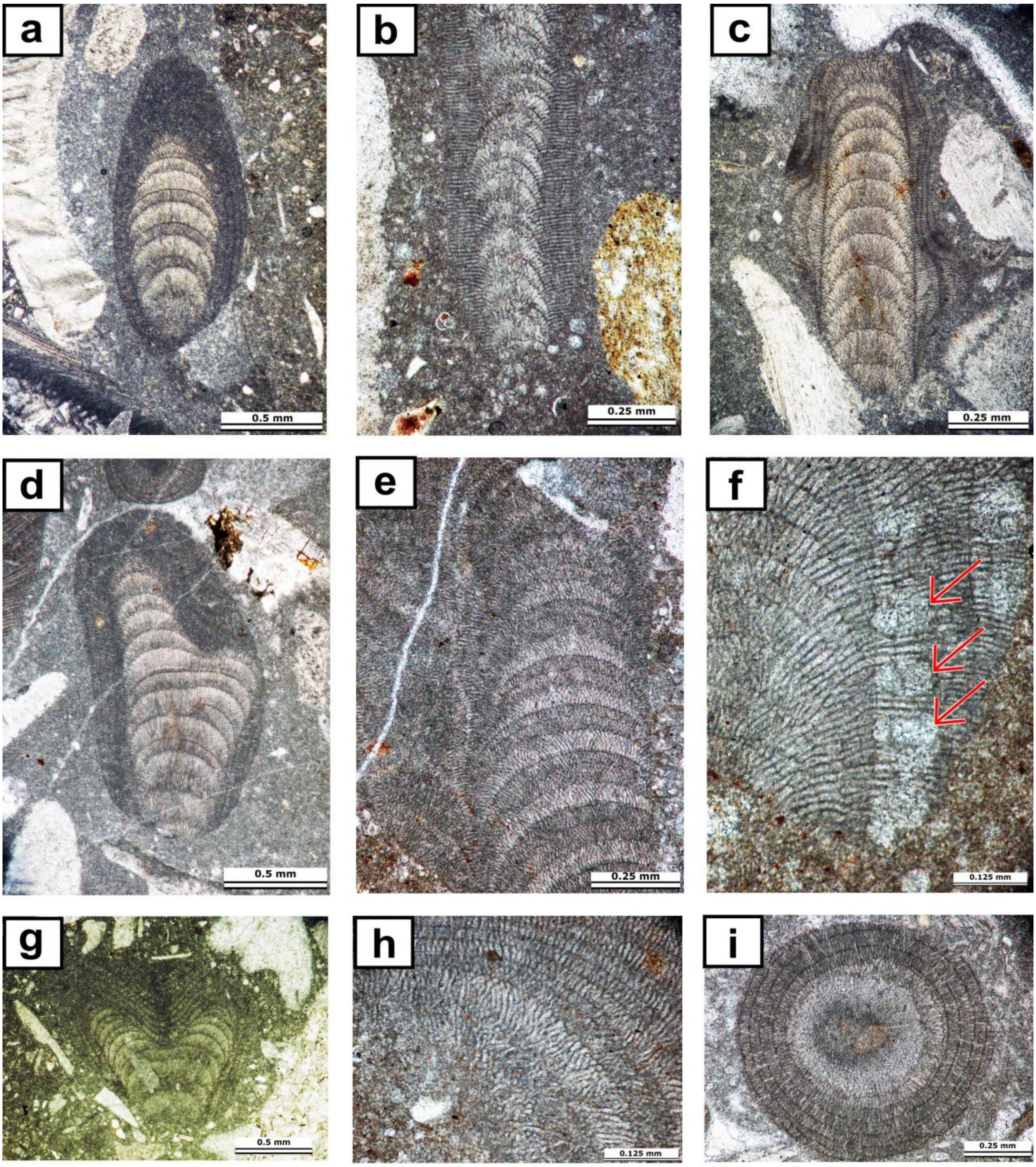

Figure 14. a-i. *Paraphyllum primaevum* Lemoine, 1970; **a**, **d**, **g,** oblique sections; **b**, **c**, **e**, **f**, longitudinal sections; **h, i,** transversal sections; note the branching of the thallus in **c**, **d** and **g,** the coaxial-type hypothallus, and the reproductive structure in **f** (red arrows). IDs of the UBB thin sections: a - 34; b - 18; c - 94; d - 23; e - 90; f - 13; g - 3; h - 46; i - 19.

Order **CORALLINALES** Silva & Johansen 1986
Family **CORALLINACEAE** Lamouroux, 1812
?Subfamily **LITHOPHYLLOIDEAE** Setchell, 1943

?Genus ***Lithophyllum*** Philippi, 1837

?*Lithophyllum* sp.
Fig. 15 a-c

Material: Found in just two sections representative for the studied Cretaceous limestones from the Babeș-Bolyai University collection (sections ID 25, 36).

Description: The thalli are represented by what appear to be fragments of perithallus. On average their lengths exceed 0.75 mm and their widths can reach up to 1.7 mm.

Both cell fusions (Fig. 15c) and secondary-pit connections are visible. A characteristic feature are the

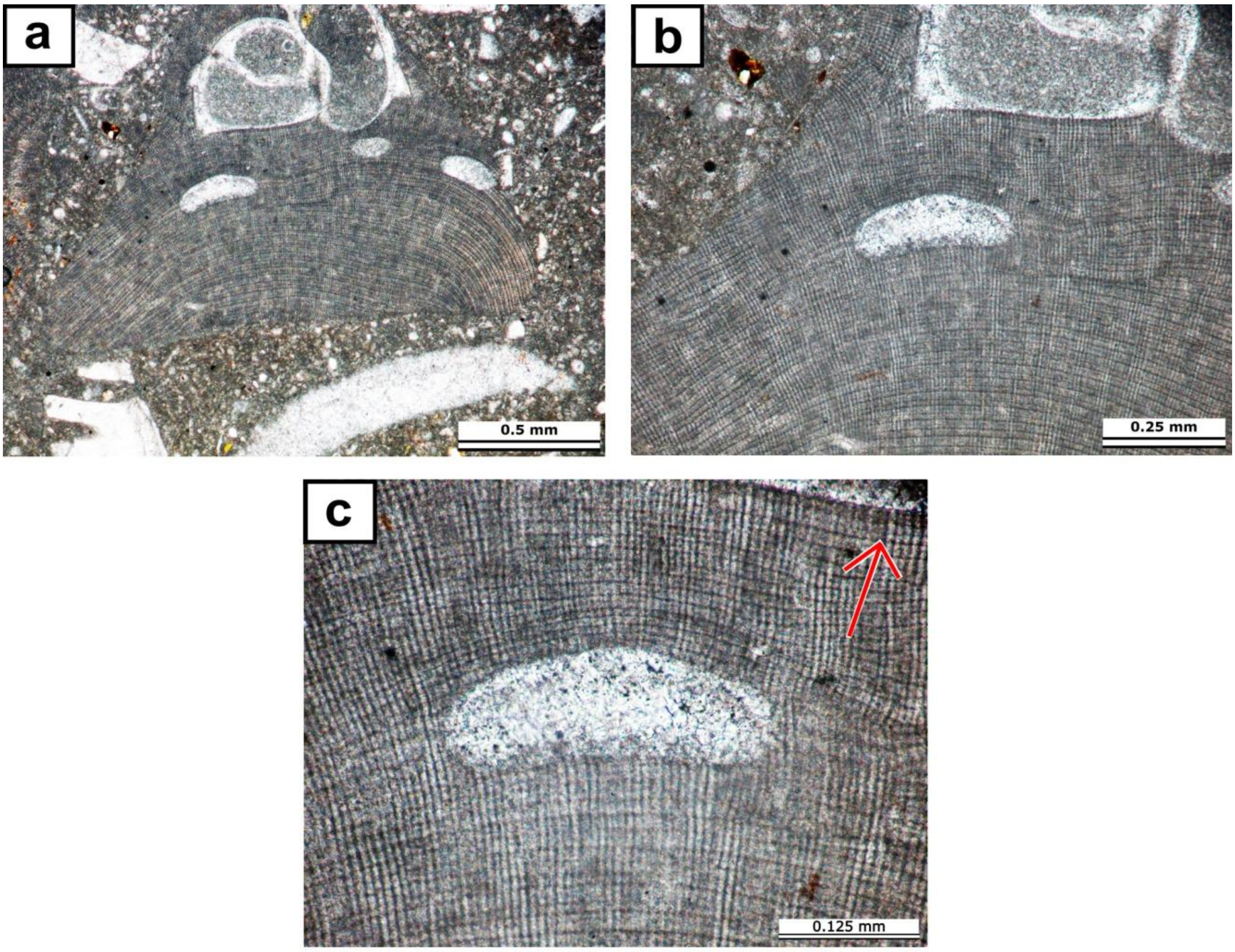

Figure 15. a-c. ?*Lithophyllum* sp.; **b** and **c** are close-up views of the specimen in **a**; note in **c** cell fusions (red arrow); note the non-coaxial thallus and the presence of ?uniporate conceptacles. ID of the UBB thin section: a, b, c - 25.

oval-shaped ?uniporate conceptacles within the thallus (Fig. 15a, b, c), about 0.3 mm in length and 0.1 mm in width.

Uncertain Order and Family

Genus ***Agardhiellopsis*** Lemoine, 1964

Agardhiellopsis cretacea **Lemoine, 1964**
Fig. 16 a-i

1964 *Agardhiellopsis cretacea* sp. nov. - Lemoine, pl. 1, figs. 1-4, Aptian-Albian, Southern France; Northern Spain.
1970 *Agardhiellopsis cretacea* Lemoine - Lemoine, pl. 11, fig. 2; pl. 13, fig. 1; pl. 14, figs. 1-3; pl. 15, figs. 1, 2, Aptian-Albian, Southern France.
1972 *Agardhiellopsis cretacea* Lemoine – Mutihac et al., pl. 1a, figs. 3-4; pl. 2, fig. 1, Aptian-Albian, Northern Dobrogea, Babadag Basin, South-Eastern Romania.
1973 *Agardhiellopsis cretacea* Lemoine - Masse & Philip, p. 213, fig. 1, Albian, Mount Combe, Southern France.
1986 *Agardhiellopsis cretacea* Lemoine – Bucur & Duşa, p. 157, pl. I, pl. II, figs ,1-2; pl. 3, figs. 1-2; pl. 4, fig. 3 (pars).
?1989 *Agardhiellopsis cretacea* Lemoine – Bucur & Urian, p. 36, pl. 4, fig. 4., Upper Cretaceous, N-E of Gilău Mountains, North-Western Romania.
1991 *Agardhiellopsis cretacea* Lemoine – Schlagintweit, p.46, pl. 7, fig. 7 (pars), pl. 16, fig. 3 (pars), fig. 4.
2002 *Agardhiellopsis cretacea* Lemoine – Bucur & Baltres, p. 95, pl. 6, fig. 8, 9, Cenomanian, Northern Dobrogea, Babadag Basin, Romania.
2024 *Agardhiellopsis cretacea* Lemoine – Bucur et al., p. 7, pl. 1, fig. E, I, uppermost Aptian-Albian, Southern Carpathians, Reșița-Moldova Nouă zone, Romania.

Material**:** About 12 thin sections from the Babeş-Bolyai University collection (sections ID: 13, 15, 40, 42, 43, 45, 53, 82, 90, 92, 107 and 109).

Description**:** The thalli of the *Agardhiellopsis* specimens are cylindrical in shape and can be either simple fragments (Fig. 16a, b, c, d, e, h, i) or branched (Fig. 16f, g). Some specimens have been sectioned longitudinally or oblique-longitudinally (Fig. 16a, b, c, d, e, f, g), others obliquely or transversally (Fig. 16h, i). The

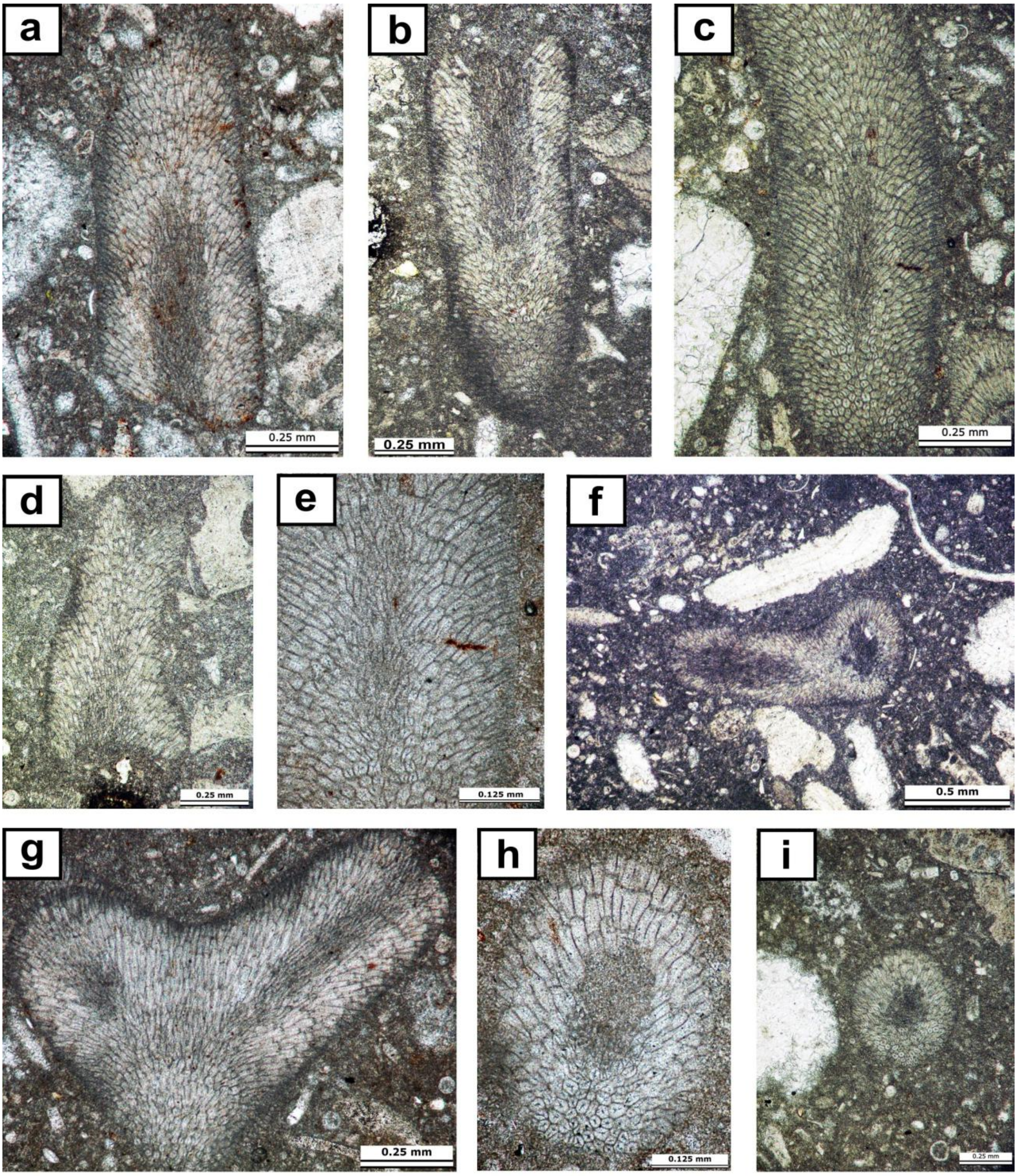

Figure 16. a-i. *Agardhiellopsis cretacea* Lemoine, 1964; **a-g,** longitudinal-oblique sections; note the branching of the thallus in **f** and **g**, and the darker medullary area; the club-shaped cells of the outer medullary zone are well visible in **e** and **h**. IDs of the UBB thin sections: a, i -13; b - 92; c, e, g - 15; d - 40; f - 74; h - 42.

medullary zone consists of rows of small cells aligned parallel to the longitudinal axis. The cells of the medullary zone have undergone a weak calcification process, resulting in a characteristic dark-brown hue. Towards the outer part of the medullary zone, the cell filaments curve and begin to form the perithallus. The cells of this outer zone are larger and have the characteristic club-shape outline. The perithallial filaments are rarely preserved, as one or two rows of smaller cells (Fig. 16g). Most of the thalli observed reach a maximum of 1-1.5 mm in length and approximately 0.25-0.5 mm in width.

Regarding the systematic assignment of *Agardhiellopsis cretacea*, it is unlikely that this alga belongs to the Gigartinales, namely the Solieriaceae family as stated by Lemoine (1964). The general morphology of the thallus and especially the sporolithacean-type of the reproductive organs (e.g., Bucur & Duşa, 1986) that are usually associated with this species would rather lean towards the Sporolithaceae, but this subject is still debated (Bucur et al., 2024).

***Occurence*:** France (Mount Combe, Albian; Aude, Ariège, Basses-Pyrénées and Lande, Aptian-Albian); Spain (Navarre, Aptian-Albian); Austria (Northen Calcareous Alps, Aptian-Albian pebbles in Upper Cretaceous conglomerates), Romania (Babadag Basin, Cenomanian; Southern Apuseni Mountains, Albian; Reşiţa-Moldova Nouă, upper Aptian-Albian) (cf. synonymy list).

DISCUSSIONS AND INTERPRETATION

Depositional environments

The base of the section is represented by a transgressive basal carbonate breccia (MFT1) containing centimetre-sized angular carbonate clasts from the underlying Triassic deposits. In the following almost 18 meters of the studied section, the depositional texture varies from bioclastic wackestone–packstone (MFT2) and bioclastic wackestone–floatstone with complete/unbroken fossils and well preserved epifauna (MFT3) up to grainstone-packstone with abundant red algae (MFT4) with an intense degree of compaction. The contacts between the stratification surfaces with different textures are sharp, erosional, suggesting the action of short-term currents and waves. The sorting effect can be observed in thin sections in the form of finely crushed grains, accumulated in laminae (Fig. 5f). The shallow-water benthos with numerous bivalves (mainly oysters), brachiopods, gastropods along with algae, foraminifera, bryozoans, serpulid worms suggest an open-marine platform interior environment within the euphotic zone, above fair-weather wave base, such as open shelf lagoons. The environment was connected with the open sea maintaining the normal salinity considering the presence of abundant brachiopods in the assemblage (Flügel, 2010). The high abundance of corallinacean and sporolithacean red algae indicate water depths of few meters to tens of meters (Sarkar et al., 2024; Sarkar, 2025). The high abundance of *Paraphyllum* red algae suggest a marine environment with reduced luminosity (Flügel, 2010). The presence of red algae, bryozoans and echinoids suggest shallow-marine carbonates, deposited in somewhat temperate seas (Flügel, 2010). However, the presence of locally patch reefs is suggested by fragments of colonial corals. The presence of rare orbitolinids also indicate shallow warm waters of normal salinity. Rare bioclasts such as calcispheres, planktonic foraminifera, calcified spicules and fine bioclastic detritus are remarkable, suggesting deep water influxes to the proximal shelf areas. Bucur & Baltres (2002) described similar carbonate facies of Iancila Formation from the cores of two wells drilled at around 20 kilometres north-west direction from the Enisala section (Fig. 1c), indicating the extension of the lower Cenomanian carbonate facies in that direction.

Age of the carbonate succession

Grădinaru et al. (2006) described a brachiopod assemblage dated as Vraconian (Latest Albian). These authors considered the age of the Enisala member deposits to be Vraconian, based on the brachiopod associations and a single ammonoid belonging to the species *Lepthoplites enisalaensis* Grădinaru (Grădinaru, 2002). Bucur & Baltres (2002) studied the limestones belonging to the Enisala Member of the Iancila Formation, obtained from two boreholes in the Babadag Basin. Based on microfossils of benthic foraminifera [*Orbitolina* (*Orbitolina*) *conica*, *Cuneolina pavonia*, *Pseudotextulariella cretosa*] and identified CRA (*Sporolithon rude*, *Paraphyllum primaevum*, and *Agardhiellopsis cretacea*), the authors determined that the age of these limestones is early Cenomanian. Taking into account all this data, together with the rare presence of the foraminifer species *Hensonipapillus* (Fig. 11 a-d), the age of the studied deposits covers the late Albian-early Cenomanian interval.

CONCLUSIONS

Five taxa of rhodophyta algae have been identified and described from the carbonate succession represented by the Enisala Member, Iancila Formation which crops out in the Enisala area, North Dobrogea.

The microfacies analyses and the fossil assemblages described from the studied section indicate an open-marine platform interior environment within the euphotic zone, with normal salinity, in depths of few meters to tens of meters featuring reduced luminosity, with temporary influence of deep-water influxes.

Based on microfossils of benthic foraminifera, CRA and the brachiopod fauna, the Enisala Member limestones correspond to the latest Albian–early Cenomanian time-interval.

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