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SEDIMENTOLOGIC AND MICROPALAEONTOLOGICAL STUDY OF AN UPPER CRETACEOUS (SANTONIAN-CAMPANIAN) REGRESSIVE FACIES DEVELOPMENT - FROM BASIN TO UPPER SLOPE SEDIMENTS (GILĂU MOUNTAINS, PLESCUȚA VALLEY, NW-ROMANIA)

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Abstract: The sequence of 137 m thickness is composed in the lower part of 80 m (Santonian) deep marine sediments of a flysh basin and in the upper part (Lower Campanian) of 57 m thick mixed siliciclastic-carbonate sediments of an Upper slope position. The flysh contains some intercalations of thin-bedded, graded bioclastic grainstones. The carbonate sediments of the upper slope contain collapsed reef blocks from the shelf edge, avalanche-type deposits from the shelf margin, flow deposits and sediments of submarine fans.
Regarding the associations of calcareous nannoplankton, the most resistant species are prevailing. The main component of the association is represented by *Watzanaueria barnaese* followed by *Retecapsa crenulata*, *Cribrosphaerella ehrenbergii, Eiffelithus eximius*, *Micula staurophora*. Seldom forms of *Nannoconus*, *Russelia* and *Arkhangelskiella* have also been noted. The marker species *Micula staurophora* (CC14 Zone), *Calculites obscurus* (CC17 Zone) and *Broinsonia parca* (CC18 Zone) indicate Santonian-Campanian age according the zonations of Perch-Nielsen (1985).

Keywords: Romania, Upper Cretaceous sediments, Gilau Mountains, Apuseni, sedimentary facies, biostratigraphy, calcareous nannofossils.

I. INTRODUCTION

Upper Cretaceous Santonian and Campanian sediments occur on the eastern border of the Gilau Mountains. They overlay metamorphic rocks of the Baia de Aries Nappe in the west and are limited by Paleogene sediments in the east (Fig. 1). Two sedimentary complexes have been previously defined: (a) shallow marine mixed siliciclastic-carbonate sediments including blocks of the Gosau facies type rich in large rudists and (b) deep marine basin flysh sediments (Moisescu 1960; Lupu 1960; Vlaicu-Tătărâm 1963; Bucur & Urian 1986, 1989; Bucur *et al.* 1991, 2004). The profiles recently analysed in the Pleşcuța Valley and the Corni quarry comprehends both sedimentary complexes.

Tătărâm (1963) was the first who studied a profile of Upper Cretaceous sediments in the Pleşcuța Valley (Eghei Valley) just by detailed petrographical description without any interpretation of the sedimentary development. The author described an interlayering of conglomerates consisting of crystalline schist fragments in carbonate cement, carbonate breccia, fine or coarse micaceous sandstones, greyish sandy marls and thick (up to 1 m) layers of greyish limestones with hippurites, gastropods and corals. The mixed siliciclastic-carbonate sediments with blocks of the Gosau-type (Moisescu 1960; Lupu 1960; Vlaicu-Tătărâm 1963; Bucur & Urian 1986, 1989; Bucur *et al.* 1991, 2004) occurring in the Corni quarry indicate a shallow marine depositional environment (Săsăran & Săsăran 2003; Săsăran *et al.* 2004).

The aim of the recent study is predominantly to present a detailed facies analysis of the shallow marine carbonate rocks which crop out in the Pleşcuța Valley and along the access road to the Corni quarry. Furthermore, the paper contains the first identification of calcareous nannoplankton associations, and of new biozones.

II. DEPOSITIONAL SYSTEMS AND FACIES ASSOCIATIONS

Two main types of depositional systems overlying eachother were identified in the succession along the Pleşcuța Valley and the access road to the Corni quarry (Fig. 1 and 2): (1) deep marine basin-floor system, and (2) shelf slope system.

II.1. Deep marine basin-floor system

The deep marine system of basin floor sediments consists of cohesive density flows (debris flows), hyperconcentrated density flows (granular flows), and turbiditic flows (*sensu* Mulder & Alexander 2001) which are interlayered within hemipelagic and pelagic marls (Fig. 2).

II.1.a. Cohesive density flows (debris flows)

These sediments occur in isolated patches in the lower part of the succession and are typically lens-shaped (Fig. 2). They reveal a massive internal structure and predomiantly are composed of fragments of rudists, corals and carbonate lithoclasts (Pl.1/1). Furthermore, metamorphic clasts of different lithology occur (Pl.1/2) varying from boulder to pebble size with angular to subangular shapes, embedded in a clayey-sandy matrix.

The microfacies indicates floatstones and coarse-grained, bioclastic packstones (Pl.1/2 and

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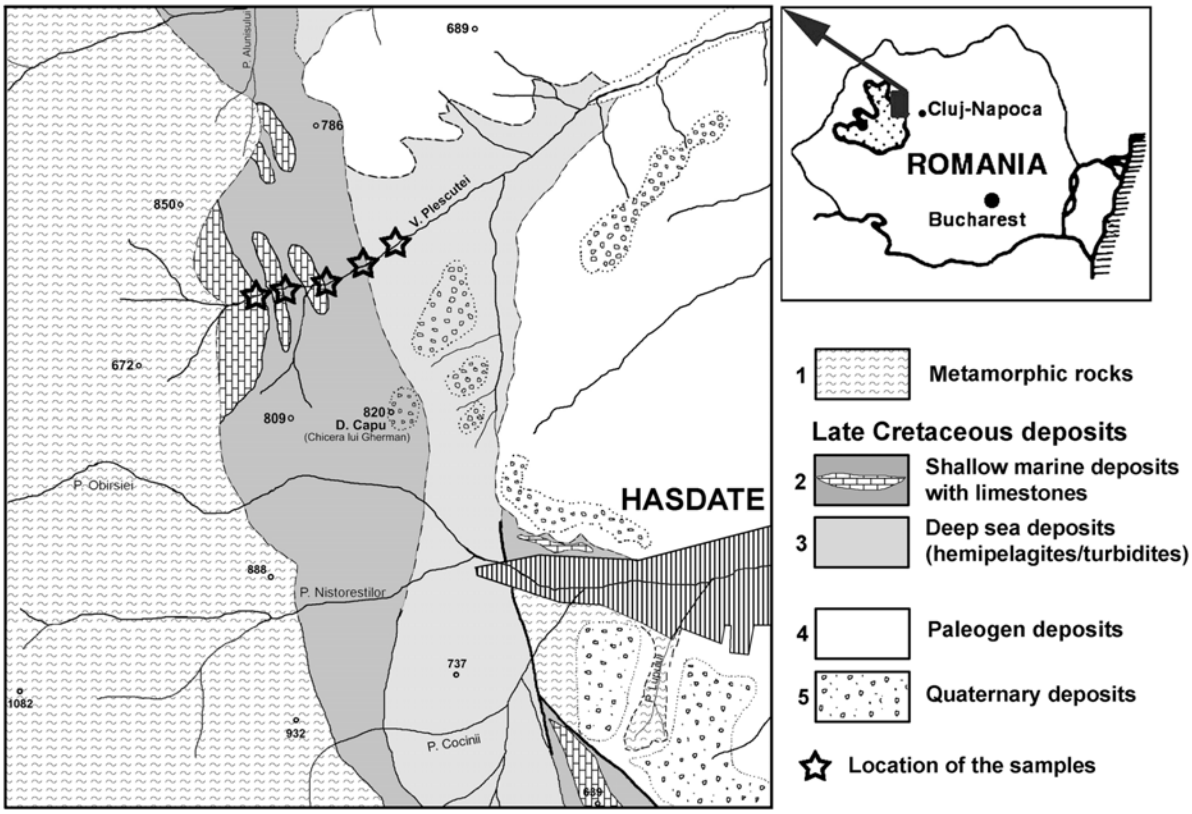

Fig. 1 - Location of the studied area

3). Fragments of rudists, corals, echinoid plates and radioles, corallinaceans as well as benthonic foraminifers (miliolids) of a shallow marine environment and rare benthonic foraminifers (*Lenticulina* sp.) of shelf margin environments can be observed. The biogenic allochems indicate reworking from a shallow marine environment and redeposition as bottom sediments in a deeper shelf slope position.

The matrix consists of lithoclastic-bioclastic mudstone/wackestone with coal fragments, corallinaceans and rare planktonic foraminifers (globigerinids and globotruncanids).

The sedimentary bodies with unstructured, massive fillings and structures of a clast supported muddy breccia most represent cohesive debris flows as described by Middleton & Hampton (1976) and Lowe (1982), or cohesive density flows as decsribed by Mulder & Alexander (2001).

II.1.b. Deposits of the hyperconcentrated density flows (granular flows)

Decimetre-sized, lens/tabular-shaped bodies represent granular flows. They contain large fragments of rudists and corals embedded in a coarse, bioclastic sandy matrix (Pl.1/4 and 5). These deposits are associated with cohesive density flows (Fig. 2).

The composition of the matrix is the distinctive element that discriminates the two types of sedimentary flows. According to Shanmugan (1996) cohesive density flows are characterized by a very high sand content which can be up to 25-30% of the total volume.

Coarse, bioclastic rudstone and grainstone represent the dominant microfacies types. The matrix consists of bioclastic-lithoclastic grainstone and very rarely of lithoclastic-bioclastic packstone. The biogenic allochems are identical with those identified in the cohesive density flows. Comparable sediments are defined as granular flows, non-cohesive debris flows, sandy debris flows, or as hyperconcentrated density flows according to Shanmugan (1996), Middleton & Hampton (1976), and Mulder & Alexander (2001).

II.1. c. Deposits of the turbidite flows

Sandy tabular/sheet-like bodies of 5-20 cm thickness and up to tens of meters lateral extension (Pl.2/1) are associated with sediments of cohesive/hyperconcentrated density flows or occur as intercalated in hemipelagic marly sediments in the lower part of the succession (Fig. 2). Only locally layers of microconglomerates occur in the lower part of each sedimentation unit. Erosional structures (flute casts and longitudinal scour casts) and subdivisions of the Bouma (1962) sequence can be observed in each tabular/sheet-like bodies. Generally, normal grading, horizontal laminations and oblique small-scale ripple-structures are characteristic for these sediments (Pl.2/2). Bioclastic-lithoclastic grainstones are the dominant microfacies types (Pl.2/3 and 4).

Based on the sedimentary structures, the sandy intercalations can be genetically assigned to turbidite flows according to the definitions by Middleton & Hampton (1976), Lowe (1982), Mulder & Alexander (2001), and Gani (2004). Sedimentary

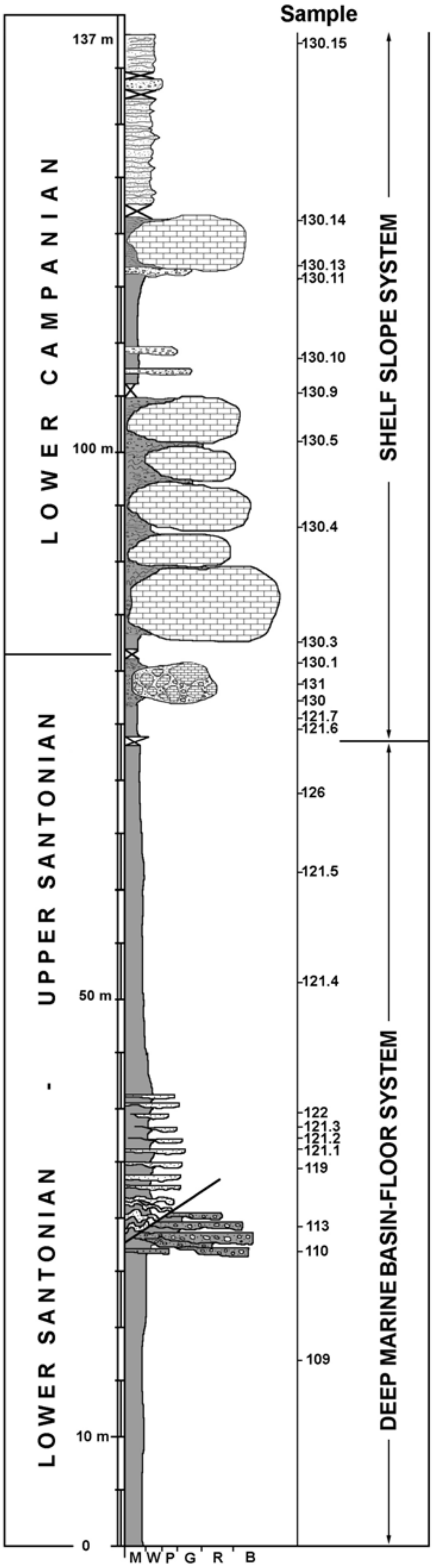

Fig. 2 – Sedimentological standard profile of the outcrops in the Pleşcuța Valley.

bodies showing these geometries, structures and textures are characteristic for the marginal areas of submarine channels (levee-type deposits, Pickering 1982), or to distal turbiditic lobes (Walker 1981; Stow 1996).

The study of the calcareous nannofossils indicated the presence of the CC14 biozone (with *Micula staurophora*). The following taxa are characteristic: *Micula staurophora* GARDET, *Amphiyzgus brooksii* BUKRY, *Corollithion signum* STRADNER, *Cribrosphaerella ehrenbergii* ARKHANGELSKI, *Lithastrinus septenarius* FORCHHEIMER, *Eprolithus floralis* STRADNER, *Gartnerago segmentatum* STOVER, *Placoyzgus fibuliformis* REINHARDT, *Prediscosphaera cretacea* ARKHANGELSKI, *Retecapsa crenulata* BRAMLETTE & MARTINI, *Tranolithus orionatus* REINHARDT, *Watznaueria barnaese* BLACK in BLACK & BARNES, *Zeugrhabdotus* spp., *Nannoconus* spp., *Chiastozygus* spp., and *Eiffellithus* spp. (Pl. 4).

Based on the biozonation documented by Sissingh (1977) and Perch-Nielsen (1985) the age of the deposits can be determined as Lower Santonian. This age corresponds to the UC11c biozone of Burnett (1998) defined by the the first occurrence (F.O.) of *Lucianorhabdus cayeuxii* to the last occurrence (L.O.) of *Lithastrinus septenarius* (event identified in the sample 121.3).

II.1. d. Hemipelagic and pelagic deposits

These sediments are well developed at the lower part of the succession (Fig. 2). They are mainly represented by lithoclastic-bioclastic clayey mudstone/wackestone (Pl. 2/5 and 6), rich in planktonic foraminifers (Globotruncanides and Globigerinides) besides coal rests.

The calcareous nannofossil association was assigned to the CC17 biozone (with *Calculites obscurus*) defined by the FO of *Calculites obscurus* (bioevent identified in sample 121.4) up to the FO of *Broinsonia parca parca*. Sissingh (1977) and Doeven (1983) mentioned the occurrence of *Calculites obscurus* in Upper Santonian deposits, while Perch-Nielsen (1985) and Almogi-Labin *et al.* (1991) have noticed it in Campanian deposits. The dominant species in this area are a follows: *Watznaueria barnaese* BLACK in BLACK & BARNES, *Eiffellithus eximius* STOVER, *Prediscosphaera cretacea* ARKHANGELSKI, *Cribrosphaerella ehrenbergii* ARKHANGELSKI, *Retecapsa crenulata* BRAMLETTE & MARTINI, *Tranolithus orionatus* REINHARDT, *Gartnerago segmentatum* STOVER and *Nannoconus* spp. Besides, rare forms of A*rkhangelskiella confusa* BURNETT, *Braarudosphaera bigelowii* GRAN & BRAARUD, *Helicolithus trabeculatus* GORKA, *Eprolithus floralis* STRADNER, *Chiastozygus* spp., and *Russellia* spp. have been identified (Pl. 4).

II. 2. Slope system sediments (olistoliths)

The shelf slope system is well represented in outcrops out along the access road from the Pleşcuța Valley to the Corni quarry (Figs. 1, 2). Large blocks (tens of meters in size) of carbonate rocks are included in a clayey-sandy matrix (Pl.3/1). The size of “olistoliths” varies from decimetres- to metres. Within this sequence, the clast-pattern vary from grain-supported to matrix-supported. The limestone blocks are represented by rudist bioconstructions (*Vaccinites* sp., elongated-cylindrical with diameters up to 10 cm), reef breccias or mixtures of blocks with rudists with terrigenous cobbles (the latter dominated by metamorphic clasts) (Pl.3/2 and 3). The clayey-sandy matrix contains a marine fauna represented by planktonic foraminifers (Globotruncanides) and fragments of echinoderms, rudists and corallinaceans.

In the matrix of these sediments the calcareous nannofossil association identified can be assigned to the CC17 (with *Calculites obscurus*) and CC18 (with *Broinsonia parca*) biozones defined by the FO of *Broinsonia parca parca* (event identified in sample 130.1) to the LO of *Marthasterites furcatus* – event that could not be emphasized in the studied section. The association is dominated by *Watznaueria barnaese* BLACK in BLACK & BARNES, *Retecapsa crenulata* BRAMLETTE & MARTINI, *Cribrosphaerella ehrenbergii* ARKHANGELSKI, *Tranolithus orionatus* REINHARDT, *Eiffellithus eximius* STOVER and *Gartnerago segmentatum* STOVER. Besides, the following species have been noticed: *Arkhangelskiella cymbiformis* VEKSHINA, *Calculites ovalis* STRADNER, *Helicolithus trabeculatus* GORKA, *Broinsonia* spp., and *Russellia* spp. (Pl. 4).

Based on the identified calcareous nannofossil association the sediments have been assigned to the Lower Campanian.

Locally layers of unstratified, highly deformed marls and sandstones occur within the matrix containing limestone blocks. Such layers are petrographically homogeneous (being dominated by calcareous marls, marls and sandstones) and reveal processes of gravitational movement. Therefore they are interpreted as lense-shaped local slump deposits of some meters in thickness. They are associated with conglomerates and breccias dominated by metamorphic rocks. The clasts are subangular to rounded, indicating incipient reworking before their accumulation.

The sequence containing "olistolithes" indicates collapsed reef blocks derived from the slope areas of the shelf, or avalanche-type deposits at the shelf's margin (Middleton & Hampton 1976; Pickering *et al.* 1989; Einsele 1991; Stow *et al.* 1996). The matrix containing highly internally deformed layers are genetically interpreted as slump deposits according to Einsele (1991) and Stow *et al.* (1996). The associated conglomerates and breccias occur to the submarine fans-system.

III. CONCLUSIONS

The megascopic sedimentological field analysis as well as microfacies development indicate two depositional systems overlying eachother: (1) a deep marine basin system, and (2) an upper shelf slope system.

The deep marine basin system contains pelagic and hemipelagic facies types (lithoclastic-bioclastic clayey mudstone/wackestone rich in planktonic foraminifers), as well as the deposits genetically related to gravitational processes reflecting a depositional environment at the base of the shelf slope. Fragments of biogenic constituents derived from the shelf slope or a nearby ridge and have been reworked until finally deposited in the deep marine sediments (pelagites and hemipelagites). Carbonate turbidites were deposited in marginal areas of submarine channels or in distal turbidite lobes as indicated by their specific sedimentary structures (e.g. erosional structures, normal grading, horizontal laminations and oblique small-scale ripple-structures).

The sediments of the upper shelf slope system show collapsed reef blocks from the shelf's slope, avalanche-type deposits from the shelf's margin, flow deposits as well as sediments of submarine fans (slump deposits and olistoliths).

These processes are related to the instability of the slope sediments caused by the overloading of the shelf edge. The overloading is a result of the bioconstructions aggrading, the high siliciclastic supply and tectonic movements tied to the early phases of the laramian tectogenesis in Apuseni Mountains (Săndulescu 1984; Bucur *et al.* 1991).

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EXPLANATION OF PLATES

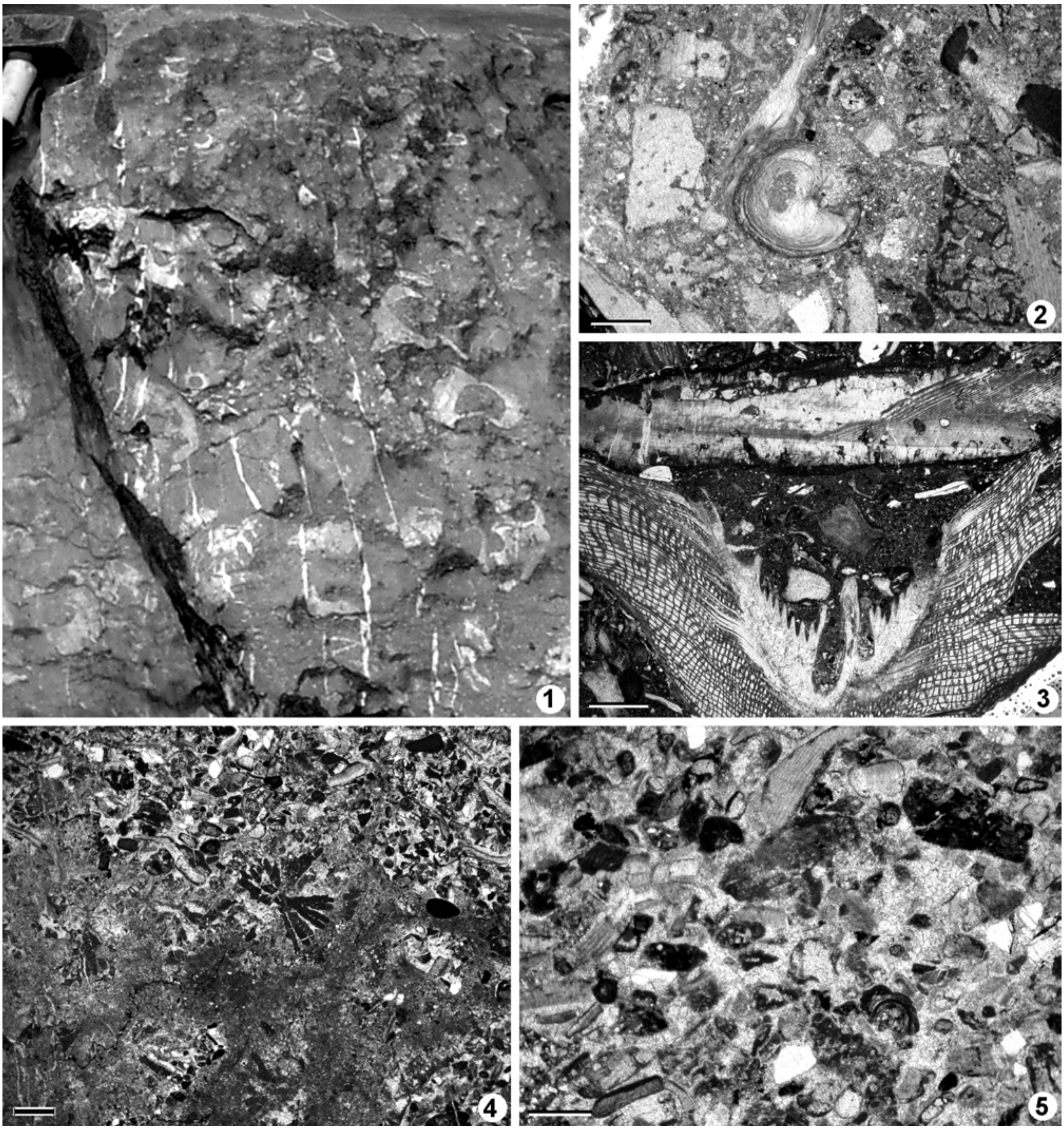
PLATE 1 - Deposits generated by cohesive density flows and hyperconcentrated density flows. Foto 1 - clast supported muddy breccia with fragments of rudists, corals and fragments of former lithified carbonate rocks (hammer lenth 20cm); Foto 2 – lithoclastic-bioclastic wackestone/packstone with coal fragments, red algae (fragments of corallinacenas) and rare planktonic foraminifers; Foto 3 – floatstones with fragments of rudists; Foto 4 - coarse, bioclastic rudstone with fragments of corals; Foto 5 - lithoclastic-bioclastic grainstone/packstone with red algae and fragments of rudists. Scale-bar is 1 mm (foto 2-5).

PLATE 2 - Deposits generated by turbidite flows (foto 1-4) and by hemipelagic sedimentation (foto 5-6). Foto 1 – sheet-like carbonate beds of 5-10 cm thickness alternate with clay-rich pelagic and hemipelagic deposits; Foto 2 - normal grading (a), horizontal laminations (b) and small-scale oblique structures (ripples)(c) within the turbidite deposits; Foto 3, 4 - lithoclastic-bioclastic grainstone with red algae (fragments of corallinacenas), fragments of rudists and benthonic foraminifers; Foto 5, 6 – lithoclastic-bioclastic wackestone with planctonic foraminifers. Scale-bar is 1 mm (foto 3-6).

PLATE 3 - Shelf slope sediments. Foto 1 – The large limestone block consist of a rudist bioconstructions (*Vaccinites* sp.) and lays in a clayey-sandy matrix; Foto 2, 3 - limestone blocks with rudists occur together with terrigenous cobbles.

PLATE 4 - The calcareous nannofossil association. Foto 1 - *Braarudosphaera bigelowii* GRAN & BRAARUD; Foto 2 - *Broinsonia furtiva* BUKRY; Foto 3 - *Broinsonia parca expansa* WISE & WATKINS *in* Wise; Foto 4 - *Broinsonia parca parca* STRADNER; Foto 5 - *Broinsonia signata* NOËL; Foto 6 - *Calculites obscurus* DEFLANDRE; Foto 6 - *Calculites ovalis* STRADNER; Foto 7 - *Eiffelithus eximius* STOVER; Foto 8 - *Eiffelithus gorkae* REINHARDT; Foto 9 - *Eiffelithus turriseiffelli* DEFLANDRE *in* Deflandre & Fert; Foto 10 - *Gartnerago segmentatum* STOVER; Foto 11 - *Helicolithus trabeculatus* GORKA; Foto 12 - *Lithastrinus grillii* STRADNER; Foto 13 - *Loxolithus armilla* BLACK *in* Black & Barnes; Foto 14 - *Lucianorhabdus cayuexii* DEFLANDRE; Foto 15 - *Lucianorhabdus maleformis* REINHARDT; Foto 16 - *Manivitella pemmatoidea* DEFLANDRE *in* Manivit; Foto 17 - *Micula staurophora* GARDET; Foto 18 - *Nannoconus truitti frequens* DERES & ACHERITEGUY; Foto 19 - *Microrhabdulus decoratus* DEFLANDRE; Foto 20 - *Placozygus fibuliformis* REINHARDT; Foto 21 - *Prediscosphaera cretacea* ARKHANGELSKI; Foto 22 - *Prediscosphaera* sp.; Foto 23 - *Russellia* sp.; Foto 24 - *Staurolithites laffittei* CARATINI; Foto 25 - *Staurolithites* sp.; Foto 26 - *Tranolithus orionatus* REINHARDT; Foto 27 - *Watznaueria barnaese* BLACK *in* Black & Barnes; Foto 28 - *Zeugrhabdotus diplogrammus* DEFLANDRE *in* Deflandre & Fert; Foto 29 - *Zeugrhabdotus embergeri* NOËL. Light microscope x 6000.

PLATE 1



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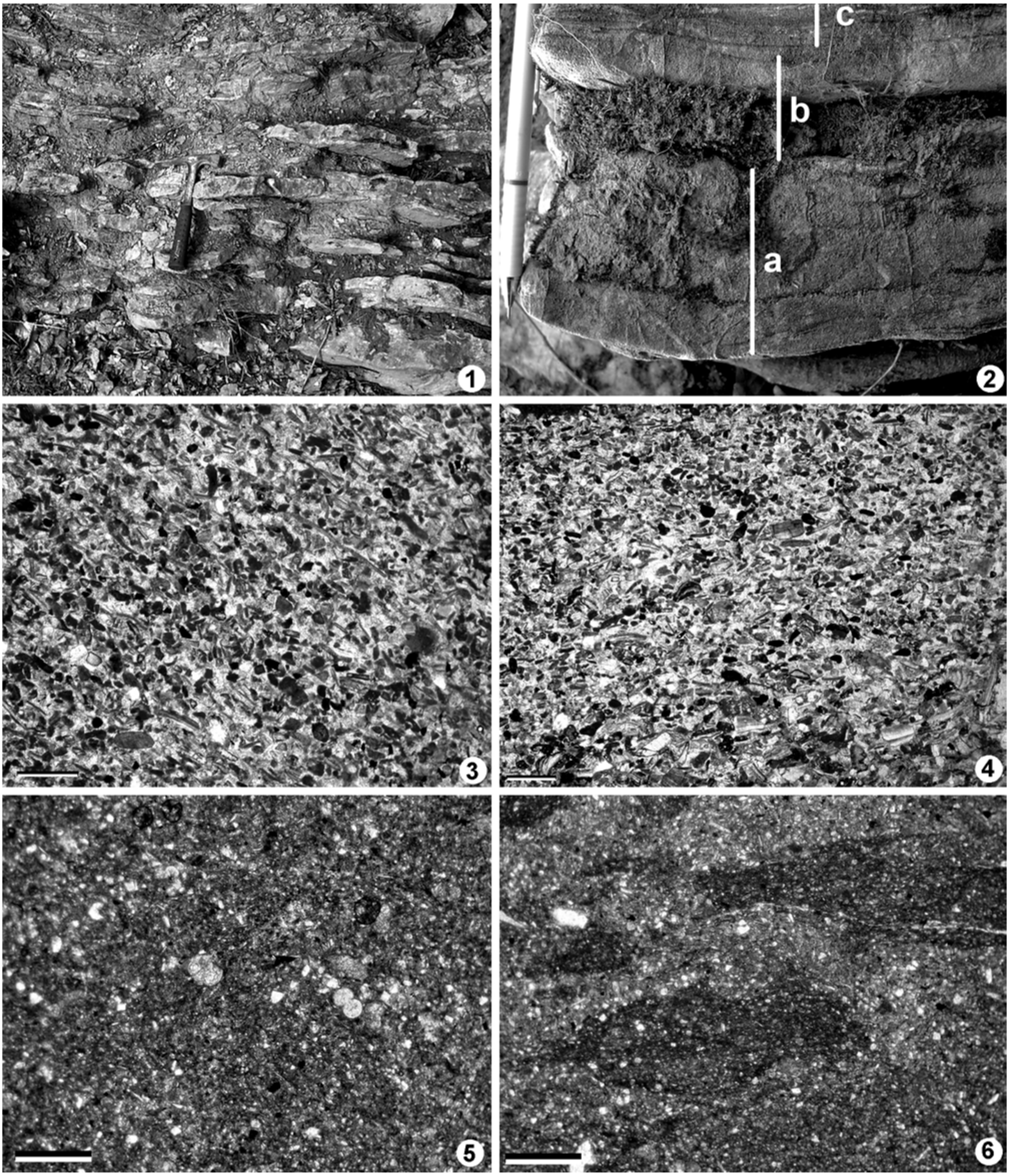

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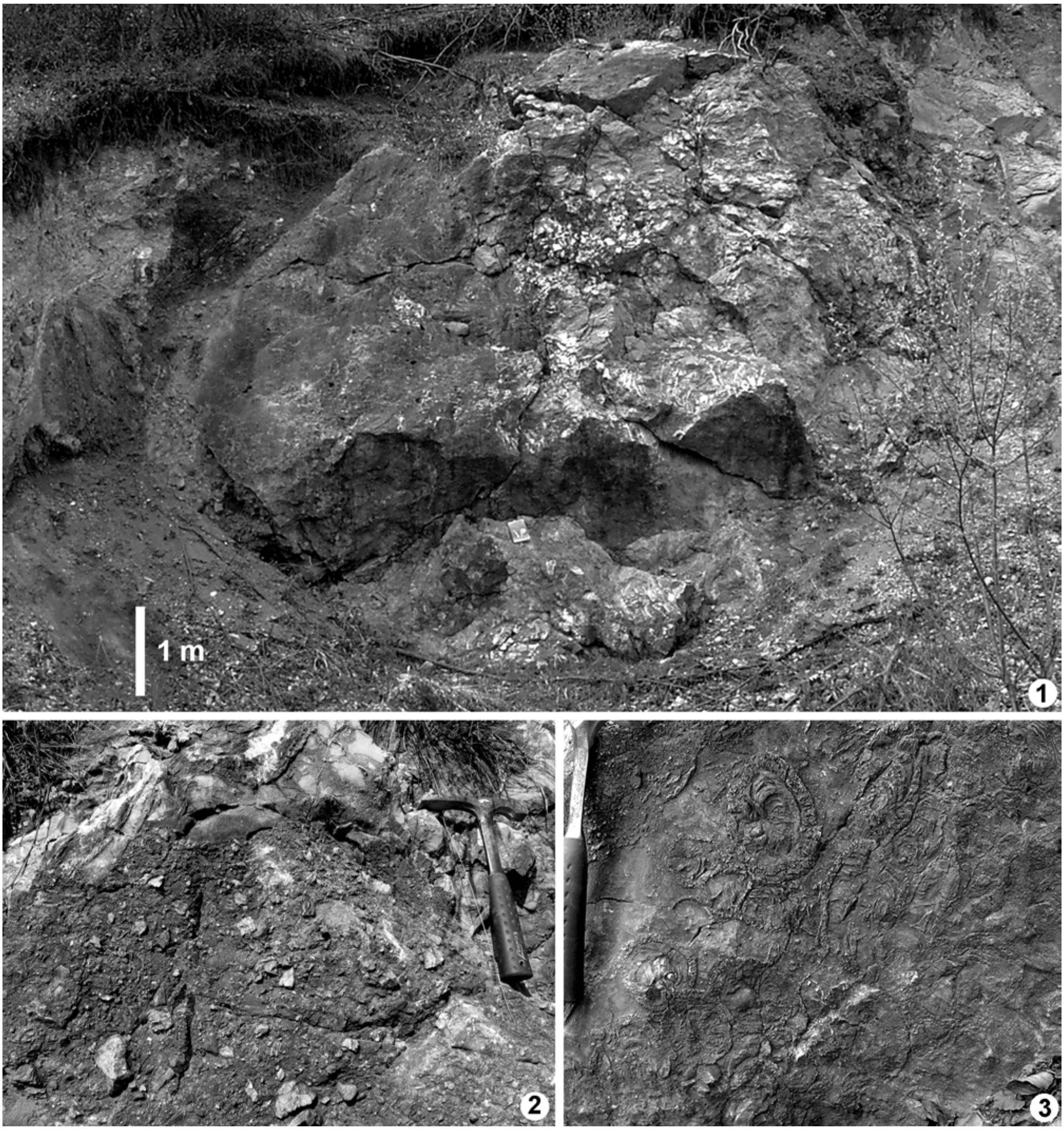
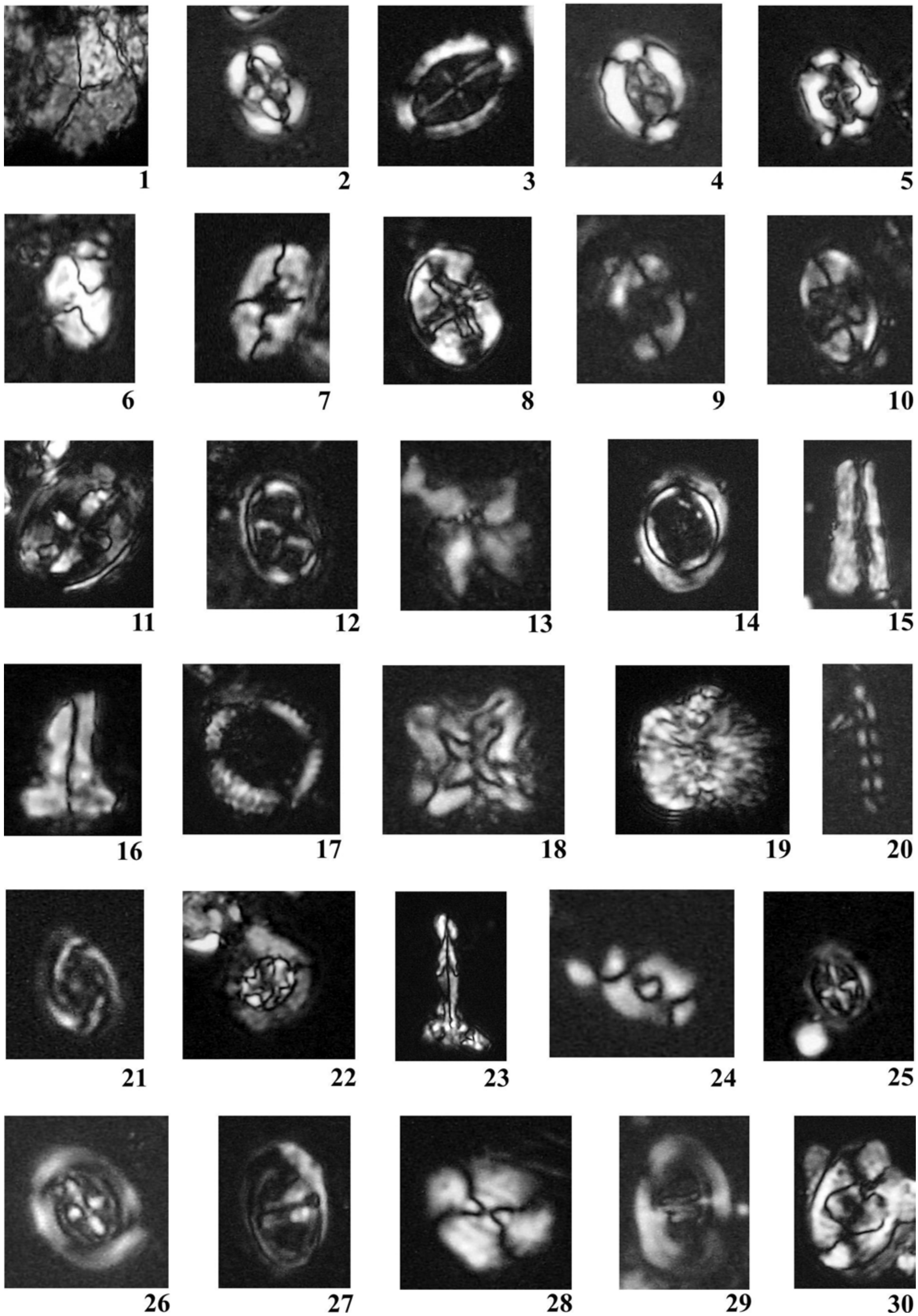


PLATE 4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