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TRIASSIC LIMESTONE MICROFACIES AND MICROFOSSILS FROM THE TRANSYLVANIAN NAPPES (EAST CARPATHIANS). CASE STUDY OF THE LIMESTONE KLIPPE ON THE TIMON BROOK, THE RARĂU SYNCLINE

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Abstract

The studied limestone klippe is located in the northern part of the Suceava district, in the East Carpathians. The klippe is made up of massive, sometimes nodular and breccious limestones, mainly red to violet, light grey, yellow and white in colour.

Four types of microfacies were separated, namely packed, filament-bearing wackestones, involutinid foraminiferal wack-packstones, bioclastic wackestones with echinoderms, and fine-grained peloidal mudstones. The micropaleontological assemblage is very rich and diversified and consists of foraminifera, mollusks, brachiopods, gastropods, ostracods, bryozoans, echinoderms and rare microproblematica.

The foraminiferal assemblage with *Angulodiscus (Involutina) tenuis* Kristan, *Angulodiscus gaschei gaschei* Koehn-Zaninetti, *Angulodiscus impressus (Involutina impressa)* Kristan-Tollman, *Permodiscus minutus (Involutina minuta)* Koehn-Zaninetti, *Trochonella laevis* Kristan and *Miliolipora cuvillieri* Brönnimann & Zaninetti indicates an Upper Triassic, Late Norian to Early Rhaetian age.

Keywords: microfacies; Late Triassic; Transylvanian Nappes; Rarău Syncline; East Carpathians

Introduction

The studied limestone is situated on the Timon brook (fig. 1), in the Rarău Syncline, which represents the northern part of the Moldavian Compartment of the Crystalline-Mesozoic Area (East Carpathians) –Mediane Dacides (Săndulescu, 1984).

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The limestone klippe is particularly rich in Norian-Rhaetian fauna, which consists of foraminifera, brachiopods, echinoderms and mollusks. Several lithofacies were identified in the field, within the massive and breccious red limestones. Their study allowed a brief characterization of the main types of microfacies and the identification of a relatively rich foraminiferal assemblage.

The predominant type of microfacies is represented by wackestones and packstones with abundant involutinid foraminifera, filaments and echinoderms. They indicate a relatively deep–water carbonate environment containing elements derived from the platform margin, as well.

Geological setting

The geological structure of the Moldavian Compartment of the Crystalline-Mesozoic Area (East Carpathians) consists of several nappes (the Central Carpathian Nappe System). From bottom to top, these tectonic units are the following: the Infrabucovinian Nappes, the Subbucovinian Nappe, the Bucovinian Nappe and the Transylvanian Nappes. The latter have a higher structural position within the Central Carpathian Nappe System (Mediane Dacides, according to Săndulescu, 1984). This position facilitated their fragmentation during the obduction and slow decollation process.

The reconstruction of the Mesozoic sedimentary succession of the Transylvanian Nappes is very difficult because the majority of the lithostratigraphic units occur only as isolated klippes floating within the Hauterivian-Aptian wildflysch Formation of the Bucovinian Nappe. The size of the Transylvanian klippes is limited to several tens of meters, but they contain all the stratigraphic subdivisions of the Triassic, as confirmed by a rich paleontological association.

The klippe on the Timon brook, 20-30m in length, was discovered and described by Mutihac (1966, 1968), and has constituted, over the past 40 years, the subject of numerous papers by Turculeț (1966, 1970, 1971, 1972a, 1972b, 1976a, 1976b, 1980, 1981, 1983, 1984, 1986, 2000, 2001, 2003, 2004).

The klippe is located upstream the Timon brook, a right tributary of the Moldova River (fig. 1). The outcrop is situated on the left slope of the brook, at approximately 350m in the upper part of the massive dolomite deposits (that belong to the Bucovinian Nappe), in a place locally known as Ciungi.

Lithofacies

The Timon klippe is composed of three distinct lithologies: dark red to violet massive, sometimes nodular or breccious, limestone; light grey, yellow and white massive limestone; light red limestone breccias.

The white limestone has been exploited in a quarry. The dark red to violet limestone is very common in the outcrop.

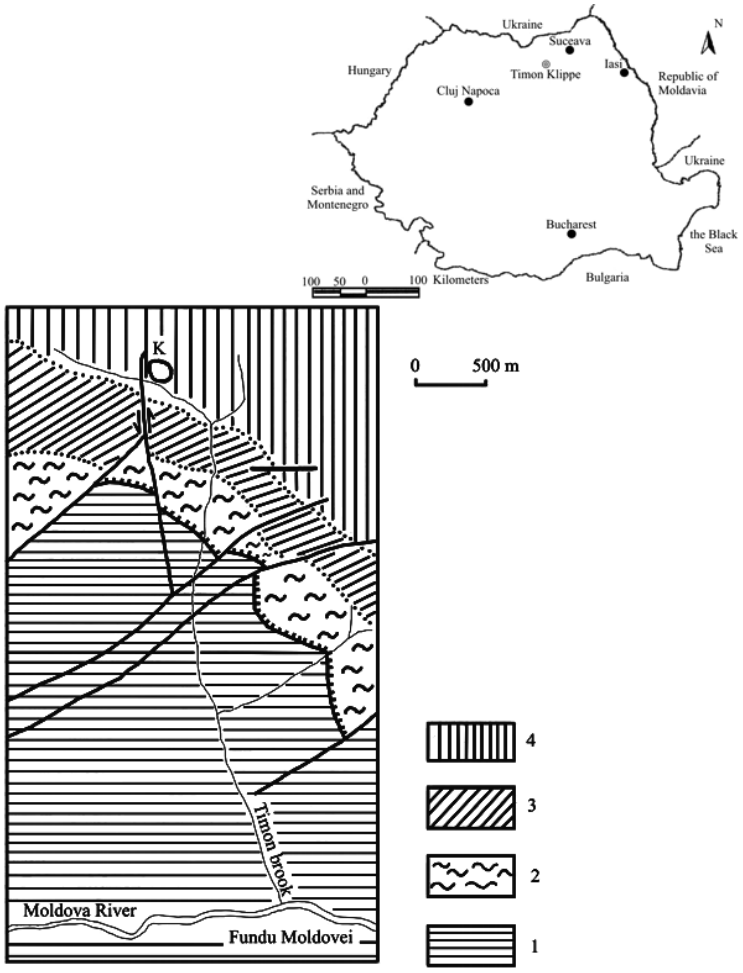

Fig. 1 Location and sketch map of the studied outcrop. Subbucovinian Nappe: 1 – Tulgheş metamorphic Series (Early Cambrian–Vendian). Bucovinian Nappe: 2 - Bretila-Rarău metamorphic Series (Precambrian); 3 – massive dolomites (Early Anisian); 4 – wildflysch (Early Cretaceous); K – studied limestone klippe

Microfacies

Most of the limestone consists of wackestones and mudstones. According to the dominant fossil group, four types of facies can be differentiated:

MF-1 Filament-bearing wackestones

This microfacies is characterized by abundant thin-shelled valves of bivalves and rare small gastropods occurring within a fine-grained, homogenous micritic matrix. (Fig. 1, Pl. I).

Rare ostracods. echinoderms, calcified sponge spicules and fragmented fenestrate bryozoans also occur. Many foraminifera are highly recrystallized. The foraminiferal assemblage consists of few lagenids, lituolids, ophthalmiids and nodosariids. The foraminifera identified at genus and species level are the following: *Pseudonodosaria vulgata multicamerata* Kristan-Tollmann (fig. 2, pl. I), *Pseudonodosaria* sp., *Ophthalmidium lucidum* Trifonova (fig. 3, pl. I) and *Ophthalmidium* sp. (fig. 4, pl. I). The echinoderm fragments are represented by echinoid spines of the *Cidaris* type (sample 136; fig. 5, pl. I) and crinoid plates (samples 129 and 130). In association with these, rare *Globochaete alpina* Lombard and calcispheres also occur.

Interpretation

Filaments are common constituents of Mesozoic deep-marine basinal limestones. They are associated with pelagic fossils such as foraminifera, *Globochaete*, calcispheres commonly occurring in open marine deep-shelf settings.

The only foraminifer that commonly occurs in protected areas, among reef builders, and in mud-rich reefs formed on the upper slope is *Ophthalmidium* (Flügel, 2004).

MF-2 Foraminiferal wack-packstones with involutinids

This microfacies is characterized by an abundance of involutinid foraminifera floating within a peloidal micritic matrix. The involutinid foraminifera include various species of *Permodiscus* (fig. 6-9, pl. I) and *Angulodiscus* (fig. 10-17, pl. I). In association with these, rare milioliporids (fig. 18-19, pl. I), trochonellids (fig. 20, pl. I; fig. 1-2, pl. II), nodosariids (fig. 3-4, pl. II), few textulariids (fig. 5, pl. II) and hemigordiopsids (tab. 1) also occur. Other common bioclasts in thin sections (samples 131 a-o, 132 a-x) are represented by filaments, echinoderms, brachiopod fragments, rare bryozoans, ostracods and calcispheres. Most of the echinoderm bioclasts are represented by crinoid columnals (circular stem plates) and echinoid spines (fig. 6-8, pl. II). The isolated columnal plates of stalked crinoids appear round in cross sections and elliptical in oblique sections. The stem plates have preserved the largely vanished original microstructure. The degree of preservation of fossil material is moderate, sometimes poor.

Interpretation

The involutinid foraminifera are abundant elements of reefal Late Triassic carbonate rocks. These foraminifera flourished both in platform and basinal settings (Piller, 1978; in Kiesling and Flügel, 2000). The microfacies study allows the separation of restricted and open shelf environments (according to Flügel, 2004). The abundance of thin-shelled involutinids can be interpreted as storm-induced accumulations within a protected area.

Tab. 1 Characteristic small foraminifera in different carbonate microfacies (ranged by frequency)

Foraminifera	Species	Microfacies type			
		MF-T1	MF-T2	MF-T3	MF-T4
Involutinidae	*Permodiscus pragsoides* Oberhauser		■		
	Permodiscus preatenuis Salaj, Borza&Samuel		■		
	Permodiscus minutus (Involutina minuta) Koehn-Zaninetti		■		
	Permodiscus sp.		■		
	Auloconus (Trocholina) permodiscoides Oberhauser		■	■	
	Angulodiscus tenuis (Involutina tenuis) Kristan		■		
	Angulodiscus (Involutina) cf. *gaschei gaschei* Koehn-Zaninetti&Brönnimann		■		
	Angulodiscus impressus (Involutina impressa) Kristan-Tollmann		■		
	Angulodiscus (Involutina) sp.		■		
	Aulotortus cf. *tenuis* Kristan-Tollmann			■	
Ophthalmidiidae	*Ophthalmidium lucidum* Trifonova	■			
	Ophthalmidium sp.	■			
Trochonellidae	*Trochonella (Trocholina) crassa* Kristan		■		
	Trochonella (Trocholina) laevis Kristan		■		
	Trochonella (Trocholina) acuta Oberhauser		■		
Milioliporidae	*Miliolipora cuvillieri* Brönnimann&Zaninetti		■		
	Miliolipora sp.		■		
Nodosariidae	*Pseudonodosaria vulgata multicamerata* Kristan-Tollmann	■		■	
	Pseudonodosaria sp.	■			
	Robuloides cf. *orientalis* Miklucho-Maklay		■		
	Nodosaria sp.		■		
	Ammobaculites sp.		■		
	Agathammina austroalpina Kristan-Tollmann&Tollmann		■		■
Textulariidae	*Textularia* sp.		■		

MF-3 Bioclastic wackestones with echinoderms

The most distinctive components of this facies are the echinoderm fragments occurring within a fine-grained matrix. The echinoderm fragments are represented by abundant crinoid plates with a reticulate structure (fig. 9, pl. II), and rare echinoid spines. The stem plates have a circular central perforation and elliptical outlines. The stalkless pelagic crinoids are star-shaped (fig. 10, pl. II). Most of the echinoderm plates are broken along the calcite cleavage planes. They have various sizes and shapes. Brachiopods with characteristic foliated lamellar structure and thin-shelled bivalves also occur. Ostracods are very rare. Many bioclasts have micritic borders. Rare foraminifera are represented by *Pseudonodosaria vulgata multicamerata* Kristan-Tollmann (fig. 11, pl. II), *Aulotortus* cf. *tenuis* Kristan-Tollmann (fig. 12, pl. II), *Auloconus (Trocholina) permodiscoides* Oberhauser (fig. 13, pl. II), some duostominids (fig. 14, pl. II) and lituolids (samples 133, 134 and 137).

Interpretation

Some foraminifera, the filaments, together with the micritic matrix, suggest a pelagic environment.

MF-4 Fine-grained peloidal mudstones

Facies consisting of abundant peloids are associated with common carbonate clasts. The large angular and rounded clasts are micritic and sparry limestones. The rare foraminifera are very strongly recrystallized and include oberhauserellids, lagenids and hemigordiopsids (*Agathammina austroalpina* Kristan-Tollmann & Tollmann; fig. 15, pl. II). In addition, thin isolated valves of pelecypods and rare echinoid spines also occur (samples 135, 135 a-k).

This microfacies is probably formed on the upper slope environment, with currents producing low sedimentation rates and erosion of carbonate clasts.

Biostratigraphic considerations

Thin valves of pelecypods, foraminifera and echinoderms are most abundant in the Triassic red limestones of the Timon klippe. Small foraminifera occurring in all shallow-marine types of facies are more abundant in MF-2 and MF-1.

Many species of the mentioned foraminifera, such as *Permodiscus minutus* Koehn-Zaninetti, *Auloconus (Trocholina) permodiscoides* Oberhauser, *Angulodiscus tenuis (Involutina tenuis)* Kristan, *Angulodiscus gaschei gaschei* Koehn-Zaninetti & Brönnimann, *Angulodiscus impressus (Involutina impressa)* Kristan, *Miliolipora cuvillieri* Brönnimann & Zaninetti, *Trochonella (Trocholina) crassa* Kristan etc., are found in various regions of the Alps, the Dinarides, the West Carpathians, the Romanian Carpathians, Iran etc.

(Zaninetti and Brönnimann, 1968, 1974; Zaninetti, 1968; Gazdzicki and Zawidzka, 1973; Salaj and Jendrejakova, 1967; Salaj, 1969; Salaj et al., 1983, 1988a, 1988b; Samuel et al., 1972; Săndulescu and Tomescu, 1978; Mirăuţă and Gheorghian, 1978).

These species are characteristic of the Norian-Rhaetian age. The foraminiferal assemblage found in the studied sections reinforces the age established based on assemblages of mollusks, brachiopods, algae and foraminifera (more than 140 species) by Turculeţ (1966, 1970, 1971, 1972a, 1972b, 1976a, 1976b, 1980, 1981, 1983, 1984, 1986, 2000, 2001, 2003, 2004).

Discussion and conclusions

The Triassic limestone klippe of the Timon brook consists of components originated both in open oceanic and in shallow carbonate environments. Open ocean biota is represented by thin-shelled bivalves (filaments) of the *Halobia* group and the planktonic alga *Globochaete*, e.g. *Globochaete alpina rumana* Turculeţ, *Globochaete alpina bucovinica* Turculeţ (Turculeţ, 1968), calcispheres, foraminifera and sponge spicules.

Nekton, e.g. ammonites (Turculeţ, 2004), are also predominant. Characteristic foraminifera of the basinal environment are: *Variostoma cochlea* Kristan-Tollmann, *Variostoma coniforme* Kristan-Tollmann, *Variostoma cattiliforme* Kristan-Tollmann, *Variostoma* aff. *pralongense* Kristan-Tollmann and *Variostoma exile* (Turculeţ, 1972a).

The *Halobia* group consists of few species: *Halobia styriaca* Mojs. (Mutihac, 1968), *Halobia (Rugohalobia) falax* Mojs. and *Halobia (Norihalobia) plicosa* Mojs. (Turculeţ, 2004).

Platform-derived components are diverse benthic foraminifera. Involutinid foraminifera are associated with lagenids, duostominids, nodosariids, lituolids, trochonellids, miliolids and ostracods.

Stenohaline forms, e.g. brachiopods, ammonoids, gastropods, ostracods and echinoderms, are abundant. The diversified shelly fauna indicates normal marine conditions: generally well-oxigenated water and normal salinity, with good current circulations (Flügel, 2004).

The existence of weak currents suggests deposition at depths of only a few hundred meters. Bottom currents controlled the deposition of fine carbonate mud, the input of nutrients and the oxygenation of bottom waters. The relatively uniform sedimentation (micrite and pelmicrite matrix in a normal marine and well-oxygenated environment) occurred on a wide spread neritic shelf. The resulted limestones are highly fossiliferous, sometimes giving rise to fossil-bearing wackestone.

The low sedimentation rates, near-bottom waters rich in oxygen, the absence of sulfate-reducing bacteria, as well as the local Eh/pH within the sediment and at the sediment/water interface, favored the development of the red colors of the studied limestones (Flügel, 2004).

The fossiliferous content and lithofacies features make the red limestone klippe on the Timon brook similar to the Late Triassic basinal Hallstatt limestones of the Alps.

The studied klippe resulted through the obduction and slow decollation of the Transylvanian Nappes process. This process determined the fragmentation of the

Transylvanian carbonate platform and the embedding of the carbonate klippes into the wildflysch Formation of the Bucovinian Nappe.

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PLATES CAPTION

Plate I

1. Filaments in fine-grained matrix. Sample136c.
2. *Pseudonodosaria vulgata multicamerata* Kristan-Tollmann. Sample 136d.
3. *Ophthalmidium lucidum* Trifonova. Sample 136j.
4. *Ophthalmidium* sp. Sample 136l.
5. Cross section of echinoid spine (*Cidaris* type) with open reticulate structure. Sample 136h.
6. *Permodiscus praetenuis* Salaj, Borza & Samuel (a) and *Permodiscus* sp. (b) floating in a micritic peloidal matrix. Sample 131d.
7. *Permodiscus minutus (Involutina minuta)* Koehn-Zaninetti (a), *Miliolipora* sp. (b) and echinoderm plate with open reticulate structure.Sample 131l.
8. *Permodiscus pragsoides* Oberhauser. Sample 131c.
9. *Permodiscus praetenuis* Salaj, Borza & Samuel. Sample 132s.
10. *Angulodiscus tenuis (Involutina tenuis)* Kristan (a), lunate crinoid arm plates (b) and filaments. Sample 132b.
11. *Angulodiscus tenuis (Involutina tenuis)* Kristan and filaments. Sample 132m.
12. *Angulodiscus tenuis (Involutina tenuis)* Kristan (a), crinoids plates (b) and echinoid spine (c). Sample 132p.
13. *Angulodiscus tenuis (Involutina tenuis)* Kristan (a), *Angulodiscus (Involutina)* sp. (b), echinoderm fragments (c). Sample 132t.
14. *Angulodiscus tenuis (Involutina tenuis)* Kristan (a), *Angulodiscus impressus (Involutina impressa)* Kristan-Tollmann (b). Sample 132x.
15. *Angulodiscus gaschei gaschei* Koehn-Zaninetti & Brönnimann. Sample 132v.
16. *Angulodiscus* cf. *gaschei gaschei* Koehn-Zaninetti & Brönnimann. Sample 132i.
17. *Angulodiscus (Involutina)* sp. Sample 132h.
18. *Miliolipora cuvillieri* Brönnimann & Zaninetti. Sample 131m.
19. *Ophthalmidium* sp. (a) and ?*Miliolipora* sp. (b). Sample 131j.
20. *Trochonella crassa* Krystan cut by a calcite vein. Sample 131n.

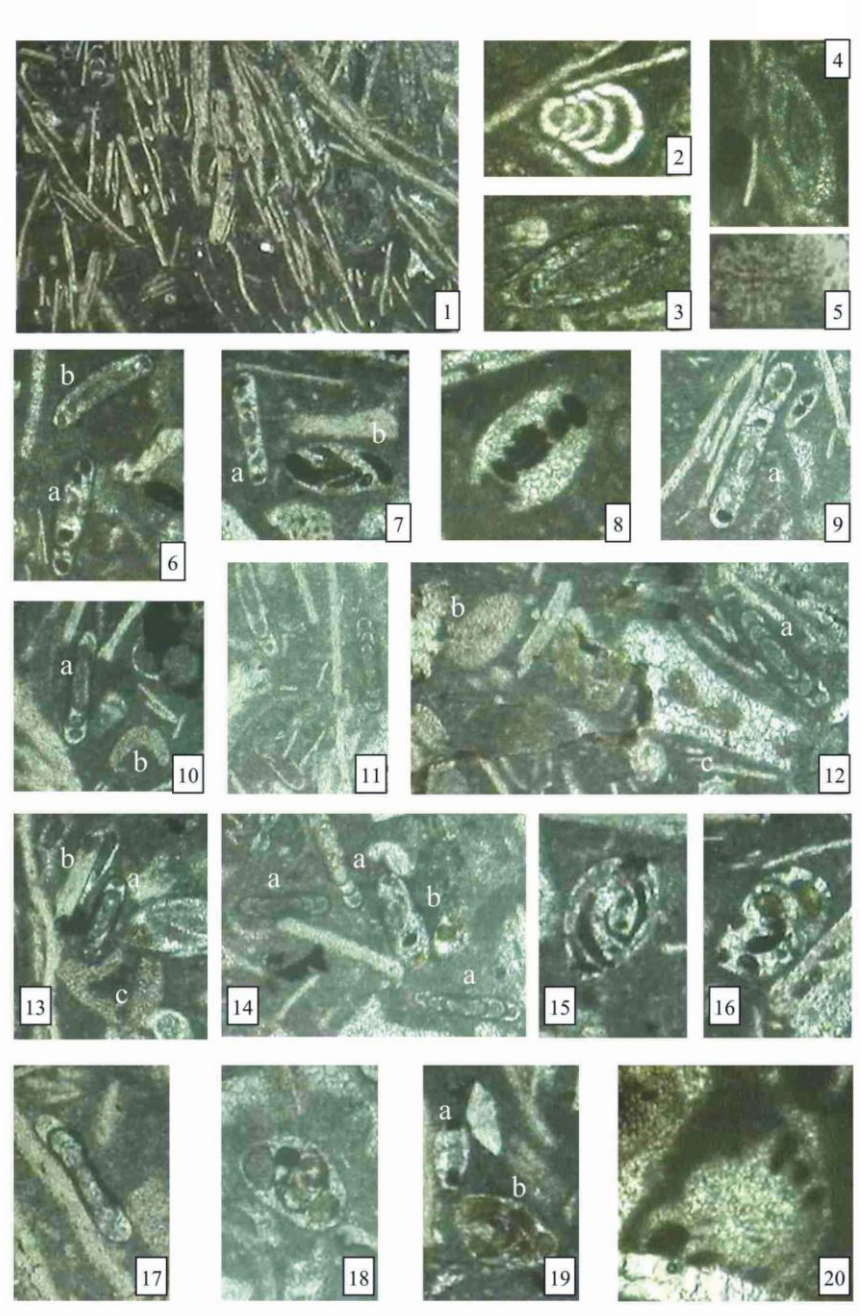
Fig. 1 – 5, MF-1; Fig. 6 – 20, MF–2; Fig. 1, x 40; Fig. 4-20, x70.

Plate II

1. *Trochonella crassa* Krystan (a). Sample 131h.
2. *Trochonella laevis* Kristan. Sample 131j.
3. ?*Robuloides* cf. *orientalis* Mikluklo-Maklay. Sample 132.
4. *Nodosaria* sp. Sample 132e.
5. ?*Textularia* sp. Sample 131j.
6. Cross section of fragmented echinoid spine of the *Diadema* type. Sample 131h.

7, 8. Echinoid spine. 27-sample 132f; 28-sample 132q.
9. Echinoderm plate with reticulate structure. Sample 133b.
10. Isolated stalkless crinoid columnal (star-shaped) with micritic borders. Sample 133e.
11. *Pseudonodosaria vulgata multicamerata* Kristan-Tollmann. Sample 133.
12. *Aulotortus* cf. *tenuis* Kristan-Tollmann with micritic border. Sample 133k.
13. *Auloconus (Trocholina) permodiscoides* Oberhauser with micritic border in micritic matrix. Sample 133g.
14. Duostominid with micritic border. Sample 133l.
15. *Agathamina austroalpina* Kristan-Tollmann & Tollmann. Sample 135f.

Fig. 1 – 8, MF–2; Fig. 9 – 14, MF–3; Fig. 15, MF–4; x70.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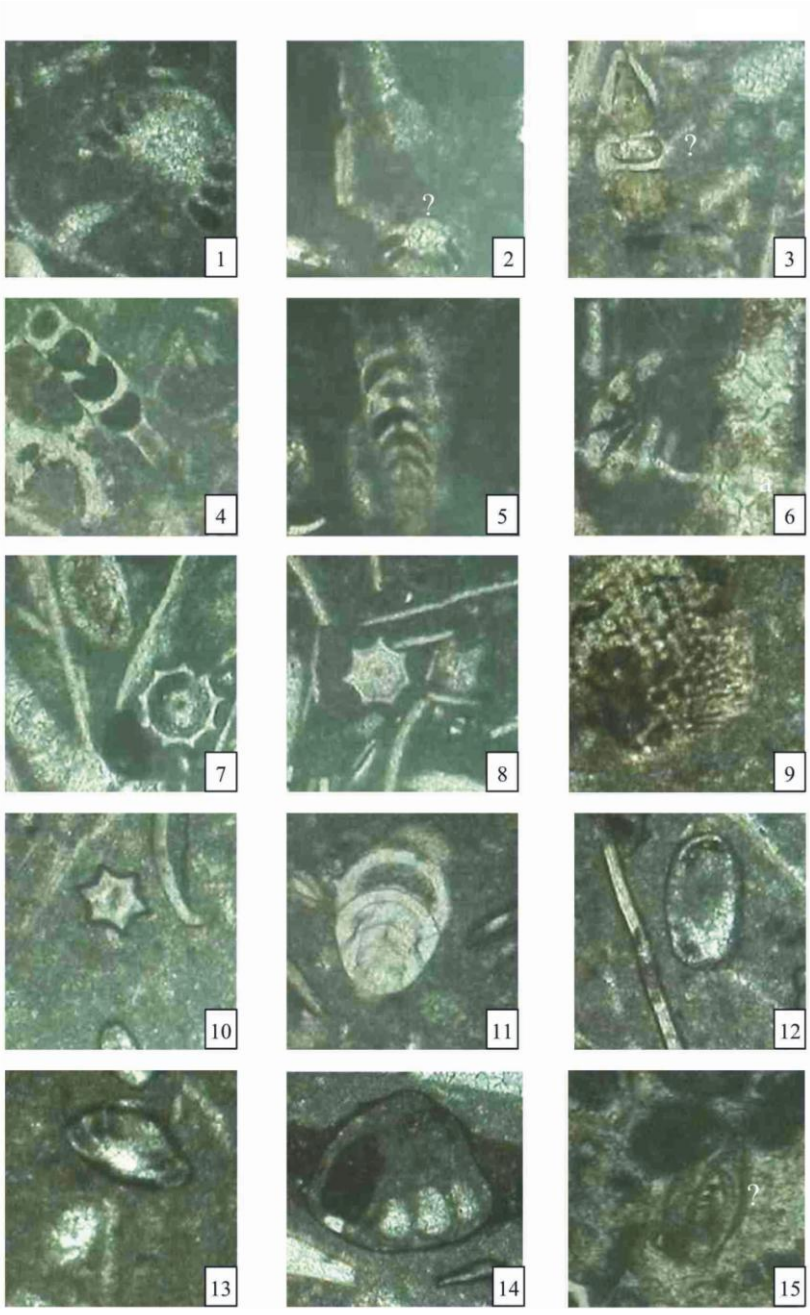
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