UBINIA JIPAI N. ISP. AND *MEGAGRAPTON* ISP. (GRAPHOGLYPTIDA) IN THE MIDDLE MEMBER OF THE SINAIA FORMATION (UPPER BERRIASIAN-LOWER HAUTERIVIAN) FROM PRAHOVA VALLEY (ROMANIA)

Titus BRUSTUR

[1]*National Institute of Marine Geology and Geo-Ecology (GeoEcoMar), 23-25 Dimitrie Onciul St., 024053 Bucharest, Romania*
e-mail: tbrustur@geoecomar.ro

DOI: 10.5281/zenodo.7491418

Abstract. The paper firstly presents, two biogenic sedimentary structures (trace fossils) belonging to the ichnofamily Graphoglyptidae, represented by the ichnogenera *Ubinia* and *Megagrapton* from the middle member of the Sinaia Formation in the Prahova valley. The new ichnospecies *Ubinia jipai* is described. Advancing the hypothesis of the complex structure, of the *Megagrapton-Ubinia* type, it is not excluded that this morphological configuration represents an unknown ichnotaxon from the bottom of the deep Cretaceous seas.

Key words: trace fossils, Graphogliptida, *Ubinia* new ichnospecies, Sinaia Formation, Early Cretaceous, Romania

1. INTRODUCTION

One of the most spectacular formations of the internal flysch in the Eastern Carpathians is the Sinaia Formation, a lithostratigraphic entity representative of the Ceahlău Nappe from the outer Dacides (Săndulescu, 1984). However, the complete development of this lithostratigraphic entity is recognized exclusively in the Bratocea and Ciuc digitations (Săndulescu *et al.*, 1981).

The Sinaia Formation, made up of three members (lower, middle and upper), is almost devoid of fossil remains. Thus, Patrulius (1969, p. 125) notes the "rarity of traces left by currents and bioglyphs"[1] in the lower member from which belemnites come (Murgeanu *et al.*, 1965) and microfaunal assemblages with calpioneles, *Nannoconus*, radiolarians and sponge spicules (Murgeanu *et al.*, 1965; Vinogradov & Dragastan, 1965). In the middle member, "bioglyphs and mechanoglyphs are relatively common at the lower surface of the beds" (Patrulius, 1969, p. 126), the macrofauna consisting of *Peregrinella (P.) multicarenata* (Lamarck) (= *P. peregrina* Von Buch) and *Lamellaptychus* sp. (cf. *seranonis* Coquand) and the microfauna consisting of the calpioneles, calcitized radiolarians and *Globochaete alpina* (Patrulius, 1969). In the upper member, with relatively abundant macrofauna and microfauna, "finely granular calcareous rocks contain fucoids, also present on fine and silty sandstones" (Patrulius, 1969, p.131). Thus, the rarity and lack of determinations at least at the ichnogenus level of the trace fossils from the Sinaia Formation in the Prahova Valley area and the surroundings of Pietroşiţa, on the Ialomiţa Valley was observed (Ştefănescu, 1995). In the Ciucului Mountains, Săndulescu (1964) mentions "numerous hieroglyphs", and Dinu (1985) reports only "organic marking" in the Sinaia

[1] The term „bioglyph" was introduced into the geological literature of Romania by Pauliuc (1962), after the genetic classification proposed by the Russian geologist N.B. Vassoevich in 1948. He designated all the textures of animal origin on the base of the sandstone layers in the flysch, as opposed to the „hieroglyph", of mechanical origin. Today, this term refer the ornament resulting from the vital activity of the trace-making organism (Bromley *et al.*, 1984, p. 494).

Formation in the Trotuş Valley. The thin sandstones of the Sinaia Formation contain "hieroglyphs", represented mainly by bioglyphs (Patrulius *et al.*, 1962). South of the Bicaz Valley, in the middle Sinaia 'Beds', traces of *Scolicia prisca* de Quatrefages (e.g., Paleobullia and Subphyllochorda morphotypes) are cited by Contescu (2016, p. 137). In the northern sector of the Ceahlău Nappe, between the Bistrița and Moldova Valleys, Cernea (1958) cites, in addition to the *Aptychus* fragments, the "calpioneles and fucoids" and Alexandrescu (1969) large "hieroglyphs". Recently, Sandy *et al.* (2012) mention "trace fossils" in laminated silty sandstones and "burrows" in limestone or massive marls from the upper member of Sinaia Formation from Vârghiş, where *Peregrinella* is associated with chemosynthesis-based seep environments.

Until now, the only ichnospecies determined in the Sinaia Formation from Bucovina is *Helminthopsis abeli* Ksiazkiewicz (*sensu* Uchman, 1998, p. 179), previously attributed to the ichnospecies *H.* aff. *hieroglyphica* Heer by Alexandrescu & Brustur (1980, p. 23-24, pl. VII).

This paper presents, for the first time, two biogenic sedimentary structures belonging to the ichnofamily Graphoglyptidae (*sensu* Seilacher, 1977), represented by the ichnogenera *Ubinia* and *Megagrapton*, on the same layer surface belonging to the middle member of the Sinaia Formation from the Prahova Valley (Fig. 1). *Ubinia jipai n. isp.* is described, and advancing the hypothesis of the complex structure, of the *Megagrapton-Ubinia* type is proposed.

2. GEOLOGICAL SETTING

In the Eastern Carpathians, the Early Cretaceous succession from the upper basin of the Prahova Valley belongs to the outer Dacides (Săndulescu, 1984). From a paleo-environmental point of view, in this succession occur talus slope deposits (Stanley & Hall, 1978; Olariu *et al.*, 2014) and deep-water deposits accumulated in the sedimentary basin. The Sinaia 'Beds' are considered turbiditic deposits from the deepest area of the Carpathian basin (Contescu, 1968; Patrulius, 1969). The region around the city of Sinaia, where the complete series of Early Cretaceous deposits develops, belongs, from a tectonic point of view, to the Baiu Scale of the Bratocea Digitation (Fig. 1a). The oldest deposits of the Cretaceous succession belong to the Sinaia Formation.

The lower member consists mainly of clayey limestones and silty clays, whose stratigraphic range starts with the Upper Tithonian and ends in the Berriasian (Murgeanu *et al.*, 1963; Patrulius, 1969; Pop, 1997).

The middle member consists of medium-granular sandstones that interbedded with clays (flysch facies), attributed to the Upper Berriasian-Lower Hauterivian (Murgeanu *et al*, 1963; Patrulius, 1969). In the upper member predominates clays with thin intercalations of fine-granular sandstones and layers (sometimes metric) of medium-granular breccias, whose age is Upper Hauterivian-Lower Barremian (Murgeanu *et al.*, 1963; Avram & Matei, 1964). Overlying the Sinaia Formation there are the deposits of the Moroeni Formation (Barremian-Lower Albian), represented by clay-sandstone in flysch facies. The Early Cretaceous succession ends with the conglomerates and sandstones of the Bucegi Formation (Albian) which belong to the post-tectonic cover of the units with Early Cretaceous orogenic pulse (cf. Ştefănescu, 1980). According to Melinte-Dobrinescu & Jipa (2007) and Briceag *et al.* (2009), the age of the Sinaia Formation is also confirmed by the content of calcareous nannoplankton belonging to the NJKb - NK3B biozones.

The ichnofossiliferous point is located on the western edge of the road that bypasses the city of Sinaia, about 900 m south of Sinaia railroad station (Fig. 1b). The outcrop contains typical middle member deposits of the Sinaia Formation (Fig. 1c), described in detail by Jipa (in Murgeanu & Filipescu *et al.*, 1961, p. 42-45) and later by Patrulius (1969, p. 125-129). Thus, in the vicinity of Sinaia town, the middle member consists of calcareous sandstones (40%), marly limestones (30%) and marls and clay-marls (30%). The sandstones are made of quartz and meta-quartz granules and rarely muscovite, with an abundant clay-limestone matrix, more or less recrystallized. The gray marly limestones have a lithographic appearance cracked. Marly sandstones and limestones have a laminar, parallel, wavy or oblique texture (current lamination), mechanoglyphs and oblique lamination indicating re-sedimentation processes. According to Jipa (1964), the sedimentary features of sandstones and limestones indicate their turbiditic origin.

3. SYSTEMATIC ICHNOLOGY

Ichnogenus Ubinia Grossgeim, 1961

Emended diagnosis (Wetzel & Uchman, 1997, p. 152): Trace fossils preserved as a hypichnial, straight or slightly winding, axial string extending from which are arcuate or straight simple branches.

Type-ichnospecies: *Ubinia wassoevitschi* Grossgeim, 1961
Ubinia jipai n. isp.
Fig. 2 (U1, U2), Fig. 4a-d

Etimology. In memory of the eminent Romanian sedimentologist Dan C. Jipa (1935-2020).

Diagnosis. *Ubinia* with slight zigzag-shaped axial string; the straight simple and robust branches, mostly nearly perpendicular alternately both sides to the central string, arranged at a relatively constant distance from each other.

Holotype. Specimen U2 illustrated in Figs 2 and 4b, housed in the Laboratory of Paleontology Collection Bucharest University, no. LPBIIIich 0082.

Paratype. Specimen U1, Figs 2, 4a.

Horizon and locality. Middle member of the Sinaia Formation, Prahova Valley, Sinaia.

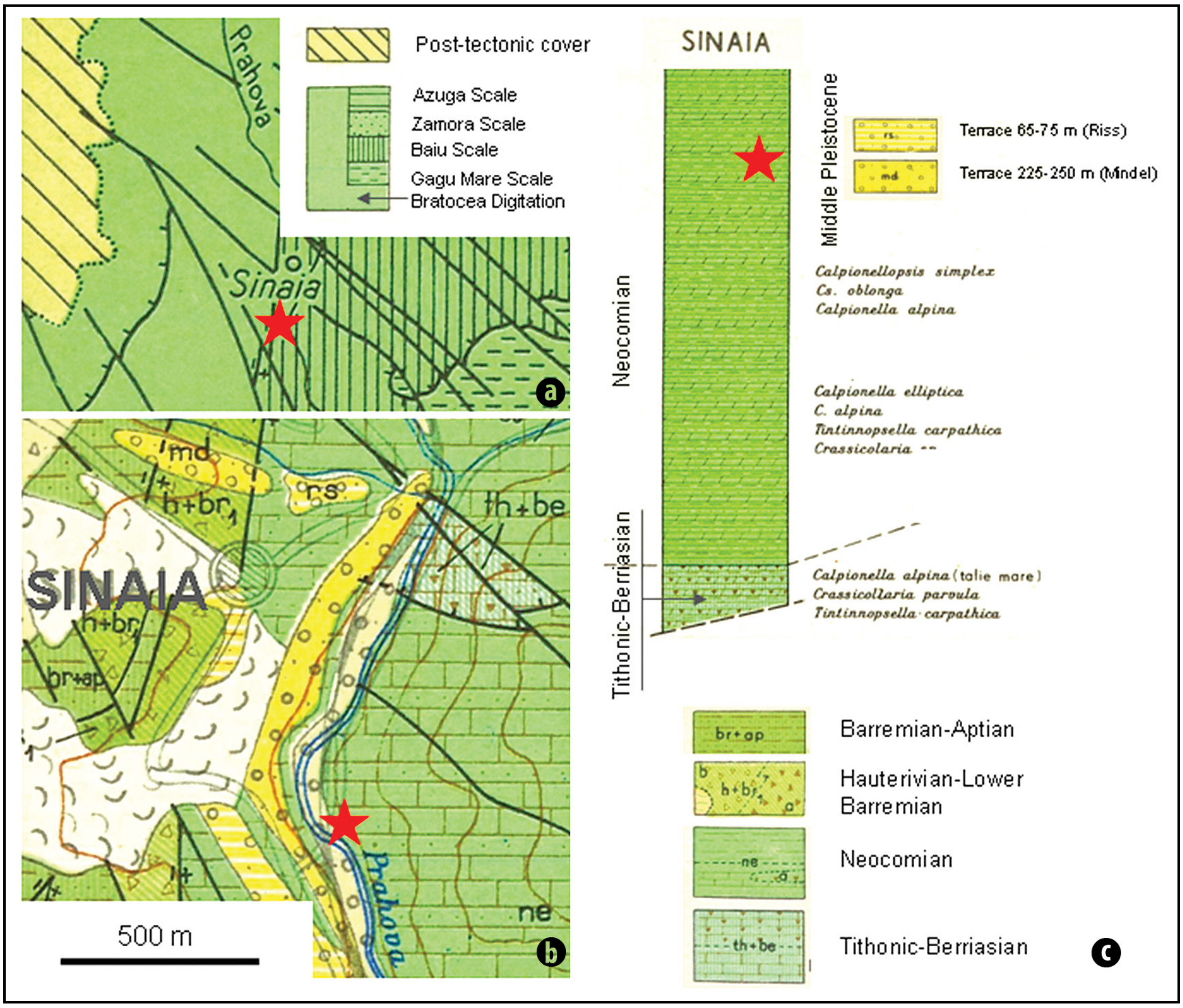


Fig. 1. Ichnofossiliferous site (red stars) location on the tectonic map (**a**), geological map (**b**) and litostratigraphic column of the middle member of the Sinaia Formation (**c**) (simplified, acc. to Ştefănescu, 1980 – 111c Baiu sheet, scale 1: 50,000).

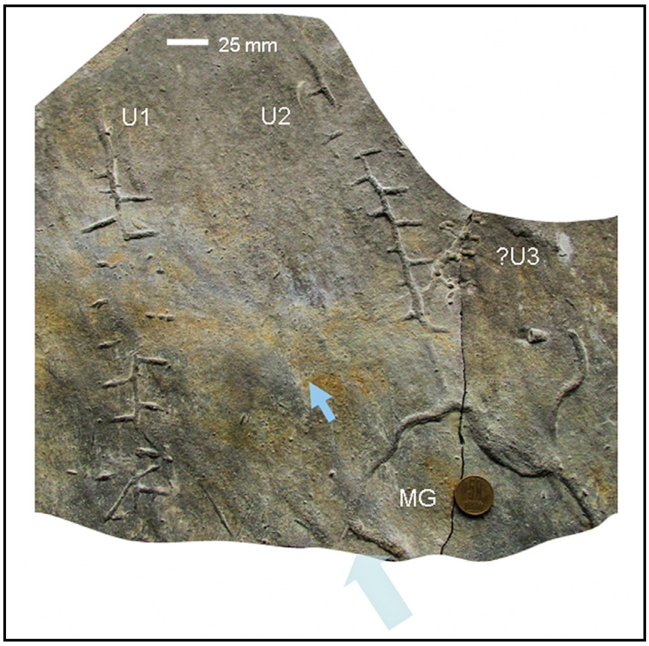
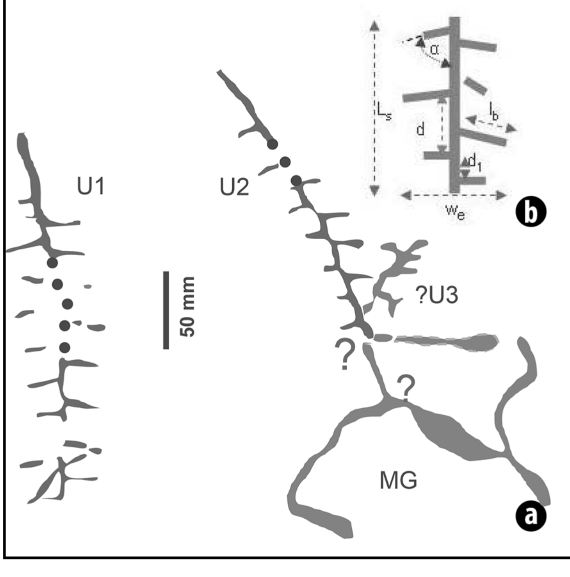


Fig. 2. *Megagrapton* (MG) and *Ubinia* (U1, U2, ?U3) from the middle member of the Sinaia Formation, at Sinaia (blue arrow – paleocurrent direction) (Coll. Dr. D. Jipa, September 2017)

Material. Two specimens (U1, U2) on the fine-grain, grey-greenish calcareous sandstone plate (40 x 35 cm,1.5-2.5 cm thickness), collected from the Prahova Valley.

Description. Two burrows (U1, U2) horizontal semi-cylindrical, with alternately arranged branches, on both sides of the central gallery (Figs 2, 3a). They have a total length of 253 mm, respectively 190 mm (or 230 mm, if we admit the junction with *Megagrapton* isp.), with a diameter between 2.66 to 6.14 mm (mean 4.10 mm), respectively between 2.82 to 7.55 mm (mean 4.90 mm); the semi-cylindrical branches have variable lengths, between 13 to 33 mm (U1) and 11 to 32 mm (U2), with a diameter between 2.9 to 3.9 mm (mean 3.4 mm) and between 2.8 to 3.9 mm (mean 3.5 mm); the distance between the branches varies between 20 to 32 mm (mean 27 mm) at holotype (U2) and between 6 to 34 mm (mean 23 mm) at paratype (U1); the distance between two alternating branches, relatively constant, is between 7 to 20 mm (mean 13.6 mm) for the holotype, respectively between 10 to 20 mm (mean 13.5 mm) for the paratype; the angle of connection of the branches to the central axis is between 73º to 90° (mean 84°) for the holotype and between 68º to 90° (mean 80°), for the paratype; the total width of the holotype is ≈50 mm and of the paratype is ≈35 mm. Parameter measurement, performed on the Fig. 3b, with Electronic digital caliper PowerFix, shows the values contained in the attached table of Fig. 3. It should be noted that the central galleries of the two specimens are slightly curved, and parts of them have the characteristic zigzag shape, with an angle of juncture of ± 155°, the insertion of the branches being usually in its tip (Figs 4a, 4b). In relation to the support rock, the filling of the galleries is made of exotic material, consisting of submillimeter granules, mostly rounded or flattened, contrasting with the fundamental mass made up, most likely, of the crushed material of epizonal, chlorito-sericite metamorphites (Fig. 4c). The arrangement of the granular material in two branches affected by erosion (Figs 4d, 4e) highlights the passive type filling. In fact, the contribution of metamorphic detrital material and basic eruptive material, present in the Sinaia Formation, was proved by Murgeanu & Patrulius (1959) and Vinogradov (1964), invoking as a source the Leaota cordillera and the ophiolites from the Azuga Beds.

Remarks. Branched gallery specimens, with the general form "TV antenna"-like, show affinities and differences with respect to those of the *Dendrotihnium* and *Ubinia* ichospecies specified below. Thus, as shown in Table 1, although the numerical values of the length and diameter of the central gallery and the branches bring *Dendrotichnium seilacheri* Kozur, Kreiner & Mostler, 1996 closer to our specimens, the arrangement of the branches on one side of the axial gallery, lacking the zigzag, obviously distinguishes it from the Carpathian specimens. Compared to the known ichnospecies of *Ubinia* (see Table 1), our specimens are quite close in size to *Ubinia alternans*, but differ from this ichnospecies by the lack of arched, symmetrically arranged branches and connected to the central axis at sharp angles. Relatively close in size to ichnospecies *Ubinia llarenai*, our specimens show the zigzag arrangement of the axial gallery. The presence of symmetrical pairs of arched branches on both sides of the central axial gallery, as well as their connection angles, are elements that distinguish the ichnospecies *Ubinia wassoevischi* and *U. haenscheli* from the Prahova specimens. The above morphological details, to which is added the relatively constant distance between the alternate branches, justify the individualization of the ichnospecies *Ubinia jipai*, as a new member of the family Graphoglyptidae.



mm	U1		U2	
	range	mean	range	mean
Lenght string (L_s)	253	-	190 (?230.3)	-
Diameter string	2.86-6.14	4.1 (n=9)	2.82-7.55	4,9 (n=9)
No. branches	17		12	
Length branches (l_b)	13-33	21.5 (n=17)	11-32	16.4 (n=9)
Diameter branches	2.86-3.89	3.4 (n=9)	2.79-3.90	3.5 (n=8)
Distance between two branches (d)	6-34	23.0 (n=17)	20-32	27.0 (n=8)
Distance between two alternate branches (d_1)	7-20	13.5 (n=9)	10-20	13.6 (n=9)
Branching angles	68-90	80 (n=17)	73-90	84 (n=11)
External width (w_e)	≈50		≈35	

Fig. 3. Graphic illustration of the *Ubinia* (U) and *Megagrapton* (MG) specimens (**a**), measurements (**b**), and summary range and mean values of the U1 and U2 parameters (table)

Fig. 4. (**a**) *Ubinia jipai* – U1 paratype; (**b**) *Ubinia jipai* – U2 holotype; (**c**) *Ubinia jipai* – partially central axial stem and straight simple branches from U2, preserved as hemicylindric burrows with presumed agglutinated grains: red sandstone (1), metamorphic rocks (2), limestone (3), ?forams (4), and basic eruptive rocks (5) all including in fine gray-greenich clastic chlorite-schists; (**d**, **e**) pasive fill (red headarrow) in break branches [? probable film of mucus (white headarrow)]

Table 1. Comparative morphological parameters and numerical data for *Ubinia* ichnospecies and *Dendrotichnium seilacheri*

Ref.	Ichnospecies	Length string mm	Ø string mm	Length branches mm	Ø branches mm	Branches interval mm	Branches: one side/ both side/arcuate/ non-arcuate	Branching angle°	Obs.
1	*Ubinia wassoevitschi*	45	≈1.5/2		≈1.5/2.0	/6-15	both sides, arcuate, paired symmetrically	90	
2	*Ubinia llarenai*	7-30/ 20-30	?1-2	10-12	?1-2	≈10	both sides, alternate, non-arcuate	sometimes 90	straight or somewhat curved stem
3	*Ubinia haentzscheli*	63/≈80	4/≈10	12-20/	3-4/1-3	5-7/?	both sides, alternate, non-arcuate	30-45/ 40-70	
4	*Ubinia alternans*	90-100	1-3	10-20	1-3	8-15	both sides, alternate, arcuate paired symmetrically	acute	zigzag shaped stem
5	*Dendrotichnium seilacheri*	≈90	3.3-4.2	5-17	3.3	10-32	one side, non-arcuate	≈90	
6	*Ubinia jipai* n.isp.	253 (U1) 190 (U2)	2.8-6 2.8-7.5	13-33(U1) 11-32(U2)	2.8-3.9 2.8-3.9	6-34 (U1) 20-32 (U2)	both sides, alternate, non-arcuate	68-90 (U1) 73-90 (U2)	slight zigzag shaped stem

References: **1**. Uchman *et al.*, 2004, p. 220/Wetzel & Uchman, 1997, p. 152; **2**. Häntzschel, 1975, p. W58/Sudan *et al.*, 2002, p. 552; **3**. Han & Pickerill, 1994, p. 229/ Sabhaya *et al.*, 2021, p. 43; **4**. Wetzel & Uchman, 1997, p. 152 (neotype); **5**. Kozur *et al.*, 1996, p. 136.

Ichnogenus Megagrapton Ksiazkiewicz, 1968
Ichnospecies-type: *Megagrapton irregulare* Ksiazkiewicz, 1968
Megagrapton isp.
Fig. 2

Graphoglyptid in the form of an irregular network (quasi-square), with a diagonal of 137.4 mm, consists of a horizontal gallery, semi-cylindrical, slightly wavy, with a variable diameter, between 4.8 to 6.6 mm (mean = 4.6 mm; n = 7), with one of the arms connected at an angle close to 90°. A segment of the gallery, with a length of 64.5 mm and a width of 15.5 mm, is deformed due to the action of the bottom current.

4. DISCUSSION AND FINAL REMARKS

4.1. New ichnospecies of the Ubinia Grossgeim, 1961

A brief history and stratigraphic spread of the ichnogenus *Dendrotichium*, *Dendrorhaphe* and *Ubinia* are presented in Table 2. Without going into too much ichnotaxonomic detail, we note that Wetzel & Uchman (1997, p. 152) amends the diagnosis of the ichnogenus *Ubinia*, considering synonyms the ichnospecies *U. alternans* and *Dendrotichnium alternans* Seilacher, 1977 as well *D. häntzscheli* Farrés, 1967 and in *U. wassoevitschi* with *Dendrotichnium llarenai*. The ichnogenus *Dendrorhaphe* was designated by Seilacher (1977, p. 318), with the ichnospecies type *Dendrotichnium haentzscheli*, but considered by Kozur *et al.* (1996, p. 134) synonymous with *Dendrotichnium* to which *D. seilacheri* ichnospecies is attributed (for details see Häntzschel, 1975; Han & Pickerill, 1994; Kozur *et al.*, 1996; Wetzel & Uchman, 1997).

In the morphological classification of the burrows, based on the hierarchy of ichnotaxobases (*sensu* Bromley, 1990, p. 147-156), proposed by Knaust (2012, Fig. 2), the ichnogenus *Ubinia* and *Dendrotichnium* belong to the group of "branched sub-horizontal galleries cylindrical (*Ubinia*) or biserial (*Dendrotichnium*), with passive fill and no lining". This group contains the ichnogenus *Dendrotichnium, Glockerichnus, Desmograpton* and *Oscillorhaphe*, attributed to graphoglyptides. It should be noted that Knaust's list includes 20 ichnogenera belonging to the graphoglyptides from which is missing *Megagrapton*, and *Punctorhaphe* has unclear taxonomic status. In his PhD thesis on graphoglyptide analysis using quantitative methods and chaos theory, Lehane (2014) cataloged a number of 29 ichnogenera, including *Dendrorhaphe* (radiating graphoglyptids), *Megagrapton* (network forms) and *Ubinia* (branching forms). Buatois *et al.* (2017, p. 105-106, Table 1), places between the 28 graphoglyptide ichnogenera, *Dendrotichnium* and *Ubinia* at "uniramous meandering graphoglyptids" and *Dendrorhaphe* at "radial graphoglyptids". Recently, the inventory of all graphoglyptides by Fan *et al.* (2018), lists 28 ichnogenera with 79 ichnospecies, including *Dendrorhaphe hantzscheli*, *Ubinia wassoevitschi*, *Ubinia alternans*, *Megagrapton submontanum* and *Megagrapton irregulare*.

The use of the topological method[2] in the study of graphoglyptides (Fan *et al.*, 2018), includes the *Ubinia* ichnospecies to prototype B-4-1 (straight or slightly curved

[2] The topology (branch of mathematics) studies the properties of space under continuous deformation which consists of stretching, crumbling and bending, but without tearing or gluing. In the case of graphoglyptides, the concepts regarding the connected component and the organization of the branch points take precedence, being recognized three major topological groups: liniar, arborescent and networked (cf. Fan *et al.*, 2018, p. 2-3).

tunnel, with bisected branches = *U. wassoevitschi*) or to prototype B-5-1 (linear tunnel multilink = *Ubinia alternans*). According to this classification, *Ubinia jipai* falls under the prototype B-4-1 "Straight or gently curved series", with straight and alternating bi-series branches (cf. Fan *et al.*, 2018, fig. 3). According to Lehane (2014, p. 123, 130), *Ubinia* belongs to the topological branching form group. In terms of functional morphology, Fan *et al.* (2018, p. 16) consider that the geometric graphoglyptids of subgroup B-4 (in which we included ichnospecies *Ubinia jipai*), can be produced by some small crustaceans, with sophisticated construction behaviors.

Regarding the architecture of the *Ubinia jipai* ichnospecies gallery system and possible its role in the feeding and/or breeding behavior of the alleged producer, a surprising analogy is with that of the gallery system produced by the larvae of the European bark beetle *Xyloterus lineatus* (fam. Scolytidae). According to Faccoli (2015, p. 126), *Xyloterus lineatus*, common to coniferous forests, has a reproductive system composed of egg galleries developed in wood. Adults dig 2-3 main galleries with a diameter of 1.5-1.7 mm spread over 12-18 cm in length, parallel to the annual growth rings. From the main galleries there are many short orthogonal galleries (approx. 5 mm long), alternating and parallel to the wood fibers. Each of these galleries houses larvae that feed on fungi.

Although *Ubinia* is considered a very rare graphoglyptid (Uchman *et al.*, 2004, p. 220), *U. jipai* ichnospecies is the second occurrence in the Early Cretaceous, after *U. wassoevitschi*-type ichnospecies in the Caucasus (see Table 2).

4.2. Brief comparative ichnology: Sinaia Formation vs Cieszyn 'Beds'

The facies resemblance of the Sinaia 'Beds' in the Eastern Carpathians to the Cieszyn 'Beds' (Teschen) from the Polish Carpathians was first noticed by Stanislaw Wdowiarz in 1957 (cf. Murgeanu & Filipescu *et al.* 1961, p. 43), followed by Ksiazkiewicz (1962) on the similarity between the middle Sinaia 'Beds' of the Prahova Valley and the upper Cieszyn 'Beds'.

Table 2. Ichnogenera *Dendrotichnium, Dendrorhaphe, Ubinia* – history and stratigraphic range

Author(s), year(s)	Ichnogenus/Ichnospecies	Age/Country
Gomez de Llarena, 1949	*Dendrotichnium**	?Late Cretaceous-?Eocene, Spain
Grossgeim, 1961	*Ubinia***	Early Cretaceous, Caucasus
Farrés, 1967	*Dendrotichnium llarenai****	Late Cretaceous, Spain
Farrés, 1967	*Dendrotichnium haentzscheli*	Late Cretaceous, Spain
Hantzschel, 1975	*Dendrotichnium llarenai*	Late Cretaceous, Spain
Seilacher, 1977	*Dendrotichnium alternans*	Late Cretaceous, Spain
Seilacher, 1977	*Dentrotichnium llarenai*	Late Cretaceous, Spain
Seilacher, 1977	*Dendrorhaphe*****	Late Cretaceous, Spain
Crimes *et al.*, 1981	*Dendrotichnium häntzscheli*	Paleocene, Switzerland
Kim *et al.*, 1992	*Dendrotichnium haentzscheli*	Late Ordovician, Korea
Yang Hang-Fu, 1992	*Dendrotichnium pachycladus******	Triassic, Qinling Mts., China
Han & Pickerill, 1994	*Dendrotichnium haentzscheli*	Early Devonian, Canada
Kozur *et al.*, 1996	*Dentrotichnium seilacheri*	Early Permian, Italy (Sicily)
Wetzel & Uchman, 1997	*Ubinia=Dendrotichium* Seilacher, 1977	Eocene, Switzerland
Wetzel & Uchman, 1997	*Ubinia alternans* (Seilacher,1977)	Eocene, Switzerland
Wetzel & Uchman, 1997	*Ubinia wassoevitschi*	Eocene, Switzerland
Jensen & Musta, 1999	*Dendrorhaphe* isp. ******	Cambrian, Latvia
Uchman, 1999	*Dendrorhaphe* cf. *haentzscheli*	Eocene, Austria
Uchman, 2003	*Ubinia* isp.	Cambrian, p. 127, fig. 3
Uchman, 2003	*Ubinia alternans*	Late Cretaceous, Ukraine
Uchman *et al.*, 2004	*Ubinia* isp.	Late Cretaceous, Turkey
Uchman, 2007	*Ubinia alternans*	Paleocene, Italy
this paper	*Ubinia jipai* n. isp.	Upper Beriassian-Lower Hauterivian, Romania

*ichnogenus *nomen nudum*, without ichnospecies desingnation (in Häntzschel, 1975, p. W58); ** type-ichnospecies *Ubinia wassoevitschi* Grossgeim, 1961 (in Wetzel & Uchman, 1997, p. 152); *** type-ichnospecies for *Dendrotichnium*; **** type-ichnospecies = *Dendrotichnium haentzscheli* (*Dendrorhaphe* = *Dendrotichium*, cf. Kozur *et al.*, 1996, p. 134); ***** in Jensen & Mens, 1999, p. 191; ****** = probably *Trichichnus appendicus* (cf. Uchman *et al.*, 2004, p. 220)

Subsequently, Patrulius *et al.* (1965) and Patrulius (1969) attributing the Upper Berriasian-Lower Hauterivian age to the middle Sinaia 'Beds', associating them with the Upper Cieszyn 'Beds'.

The paleoichnological content of the Sinaia Formation from the Eastern Carpathians is very poor (fucoidae indet., (?) *Scolicia prisca*, and *Helminthopsis abeli* - see *supra*) compared with the ichnofauna of the Upper Cieszyn 'Beds', reported by Ksiazkiewicz (1975, 1977) and revised by Uchman (1998) where 12 ichnospecies are cited, of which 4 graphoglyptides (related to the genera *Glockerichnus*, *Lorenzinia*, *Belorhaphe*, *Paleodictyon*). The ichnofauna of the upper member of the Sinaia Formation is so far represented only by the ichnospecies *Ubinia jipai* and *Megagrapton* isp. It is important to note that although Ksiazkiewicz (1962) does not recognize a term comparable to Csieszyn Limestone (very rich paleoichnologically, with 28 ichnospecies, including 9 graphoglyptides) in the Neocomian of the outer Dacides from Romania, Patrulius (1969, p. 143) draws attention to the presence of common sequences with it in the lower member of the Sinaia Formation from Azuga and in what Cernea (1958, p. 44) described in the Bistrița Valley, as reef limestones. In our opinion, an important observation that can stimulate the systematic paleoichnological study of this interesting formation in the outer Dacides. According to Ksiazkiewicz (1977, p. 39, Table 10), the ichnofauna of the Upper Csiezyn 'Beds' indicates probable intermediate facies (according to microfauna and sedimentary structures), accumulated in the epibathial domain, between 200 and 600 m water depth, paleobathimetric context proper for sedimentation on the continental slope, according to Stanley & Hall (1978) and Olariu *et al.* (2014) for a part of the Sinaia Formation from the Baiului anticline.

4.3. Megagrapton & Ubinia jipai is a compound or composite trace fossil?

Except for the two specimens (U1, U2), attributed to the ichnospecies *Ubinia jipai*, the examined sample (Fig. 2) highlights a morphological context that we define as "the Gordian ichno-knot" (Fig. 5).

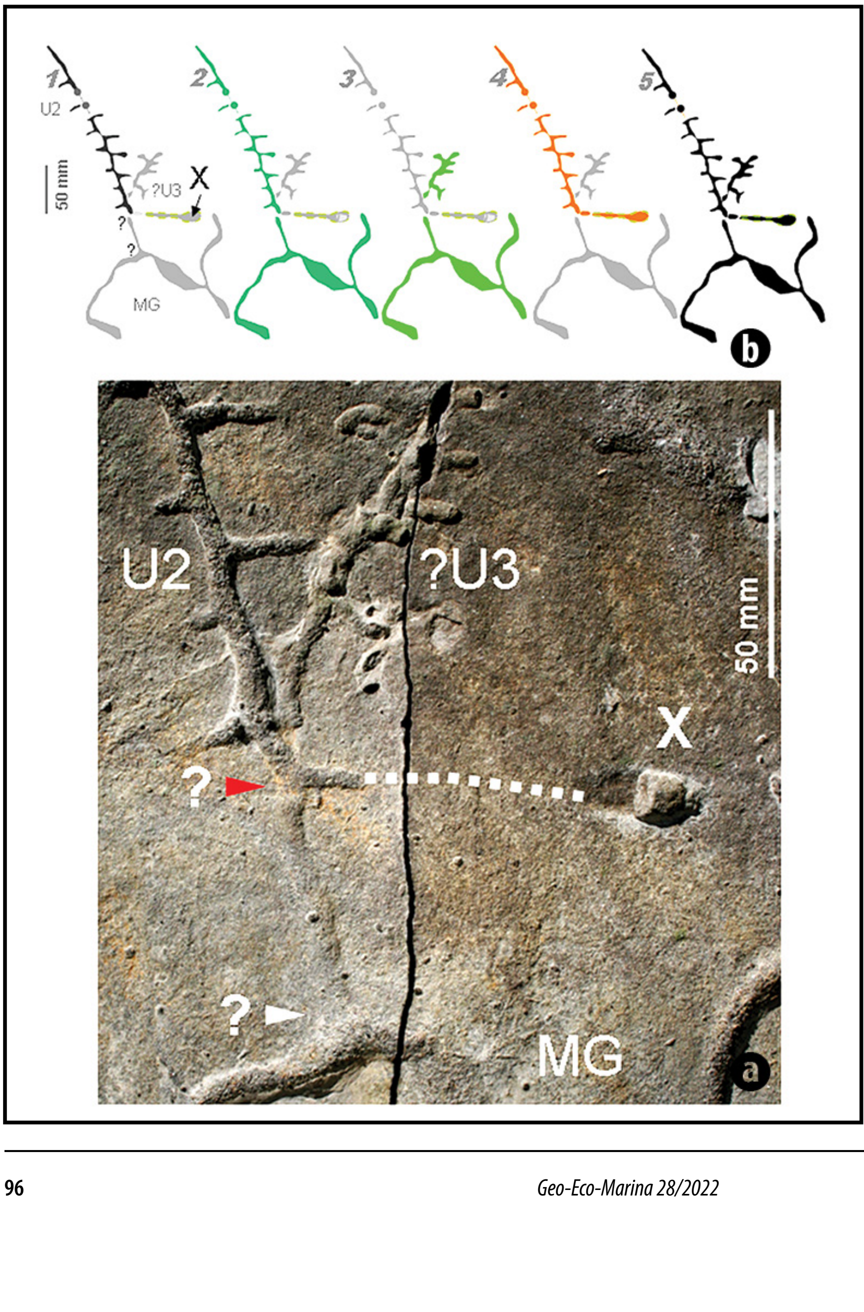


Fig. 5. (**a**) The „Gordian ichno-knot" of the possible junction MG-U2-?U3-X (? lower junction (white headarrow; ? upper junction (red headarrow); (**b**) The working hypoyhesis junction: 1. single *Ubinia jipai*; 2. *Megagrapton* and *Uninia jipai*; 3. *Megagrapton* and ?U3: 4. *Ubinia jipai* and „X"; 5. Possible compound or composite trace fossils.

Indeed, a brief examination can give the impression of a junction between *Megagrapton* and *Ubinia* by means of a robust gallery, with two points of connection: one lower, with *Megagrapton* and another upper, with *Ubinia* (Fig. 5a). If the lower connection point is insufficiently expressed, the upper one seems to end abruptly, in the form of a flared collar.

This ambiguity sends us to the hypothetical field, assuming the following configurations: a) the independence of the branched structure of *Ubinia* type (Fig. 5b, *1*); b) the *Megagrapton-Ubinia* junction (Fig. 5b, *2*); c) *Megagrapton*-?U3 junction (probably *Ubinia* in juvenile stage) (Fig. 5b, *3*); d) the *Ubinia*-X junction (X = probably a pupal-like chamber structure) (Fig. 5b, *4*); e) the junction of all these components in a "compound or composite trace fossil" type structure (Fig. 5b, *5*). At this stage, difficult to solve, the problem remains open, a possible formal designation having to wait for more material or a special methodological approach.

- The existence of laminae with abundant terrestrial macrophytodetritus (millimeter fragments of black plant tissue) in calcareous sandstone with *Ubinia* and *Megagrapton*, can be explained by invoking the mechanism proposed by Uchman (2007, p. 233) according to the material of this type was transported at the same time as the sand brought from the shelf on the continental slope.
- According to Seilacher (1977), graphoglyptides represents open gallery systems, built by some organisms as traps for meiobenthos or microbial farming, assigned by Ekdale (1985, p. 66) in the ethnological category *agrichnia*, still insufficiently documented (cf. Miller III, 1991; Uchman, 2007a). In this context, the statement of Miller III (1991, p. 310) regarding the morphological radiation of graphoglyptides is justified, due either to the massive flow of vegetal detritus from the Cretaceous or to the evolutionary changes of the pelagic plankton.
- In our case, advancing the hypothesis of the complex structure, of the *Megagrapton-Ubinia* type, it is not excluded that this morphological configuration represents an unknown ichnotaxon from the bottom of the deep Cretaceous seas.

ACHNOWLEDGEMENTS

The author thanks Acad. Nicolae Panin, and Prof. Vlad Codrea for the constructive comments that improved this work. Prof. Iuliana Lazar and Dr. Alina Floroiu for the inventory of fossil material in the Collection of the Paleontology Laboratory of the University of Bucharest. Acknowledgements to Dr. Mihaela C. Melinte-Dobrinescu and researcher Lucian Stanciu for granting access to important publications, and to Dr. Andrei Briceag for editing the article. This work was supported by a grant of the project number PN-III-P4-ID-PCED-202-0971, within PNCDI III.

REFERENCES

Alexandrescu Gr. (1969) Stratigrafia şi structura pînzei interne superioare din flişul cretacic dintre valea Bistriţei şi valea Moldovei (Carpaţii Orientali). *D. S. Inst. Geol.*, **LIV**(*3*): 143-152.

Alexandrescu Gr., Brustur T. (1980) Asupra unor urme de activitate animală (trace fossils) din flişul Carpaţilor Orientali (Partea I). *D. S. Inst. Geol. Geofiz.*, **LXV**(*3*): 17-30.

Avram E., Matei V. (1964) Date palaeontologice noi privind flişul cretacic din partea de NE a bazinului Doftanei. *St. cerc. geol. geofiz., geogr., geologie*, **9**(*2*): 321-327.

Briceag A., Jipa D., Melinte M.C. (2009) Early Cretaceous deposits of the Ceahlău Nappe (Romanian Carpathian Bend region). *Geo-Eco-Marina*, **15**: 37-45.

Bromley R. G. (1990) Trace fossils, Biology and Taphonomy. Unwin Hyman, London, 280 p.

Bromley R.G., Pemberton S.G., Rahmani R.A. (1984) A Cretaceous woodground: the Teredolites ichnofacies. *J. of Paleontology*, **58**(*2*): 488-498.

Buatois L. A., Wisshak M., Wilson M.A., Mangano M.G. (2017) Categories of architectural designs in trace fossils: A measure of ichnodisparity. *Earth-Science Reviews*, **164**: 102-181.

Cernea G. (1958) La zone interne du flysch comprise entre les vallées de la Moldova et de la Bistriţa. *An. Com. Géol.,* **XXIV-XXV**: 39-99.

Contescu L. (1968) Préflysch et postflysch, deux formations géosynclinales syndiastrophiques. *Ann. Soc. Géol. Pologne*, **37**(*1*): 67-78.

Contescu R. L. (2016) Flişul cretacic intern din Carpaţii Moldavi. Geologie, sedimentologie, paleogeografie. Edit. GeoEcoMar, Bucureşti, 269 p.

Dinu C. (1985) Geologic study of the Cretaceous flysch deposits in the upper course of the Trotuş Valley (East Carpathians). *An. Inst. Geol. Geofiz.,* **LXV**: 5–142.

Ekdale A. A. (1985). Palaeoecology of the marine endobenthos. *Palaeogeography, Palaeo-climatology, Palaeoecology*, **50**: 63-81.

Faccoli M. (2015) European bark and ambrosia beetles: types, characteristics and identification of mating systems. WBA Handbooks, 5, Verona: 1-160. https://www.researchgate.net/publication/275330664

Fan Ruo-ying, Gong Yi-ming, Uchman A. (2018) Topological analysis of graphoglyptid trace fossils, a study of macrobenthic solitary and collective animal behaviors in the deep-sea environment. *Paleobiology*, page 1 of 20 DOI: 10.1017/pab.2018.1

Han Y., Pickerill R.K. (1994) Palichnology of the Lower Devonian Wepsake Formation, Perth-Andover-Mount Carleton region, northwestern New Brunswick, eastern Canada. *Atlantic Geology*, **30**: 217-245.

Häntzschel W. (1975) Trace fossil and problematica. In: Teichert C. (ed.) *Treatise on invertebrate paleontology, Part W, Miscellanea, Supl*. **1**: W1-W269.

Jensen S., Mens K. (1999) A Lower Cambrian shallow-water occurrence of the branching „deep-water" type trace fossil Dendrorhaphe from the Lontova Formation, eastern Latvia. *Paläontologische Zeitschrift, Stuttgart*, **73**(1-2): 187-193.

Jipa D. (1964) Asupra genezei şi nomenclaturii unor calcare eocretacice din flişul Carpaţilor Orientali. *St. cerc. geol., geofiz., geogr., geologie*, **IX**(2): 525-532.

Kim J.Y., Seo Y.S., Park S.I. (1992) Trace fossils from the Yeongheung Formation, Yeongweol, Korea. *Jour. Korean Earth Science Soc*., **13**(3): 313-326.

Knaust D., 2012, Trace-fossil systematics. *In*: Knaust D. & Bromley R.G. (eds.) Trace fossils as indicators of sedimentary environments. *Developments in sedimentology*, **64**: 79-101.

Kozur H.W., Krainer K., Mostler H. (1996) Ichnology and sedimentology of the Early Permian deep-water deposits from the Lercara-Roccapalumba area (Western Sicily, Italy). *Facies*, **34**: 123-150.

Książkiewicz, M., 1962. Sur quelques analogies lithostratigraphiques entre les Carpates roumaines et polonaises. *Bull. Acad. Pol. Sci., Sér. Sc. géol. géogr*., **10**(*1*): 11-17.

Ksiazkiewicz M. (1975) Bathymetry of the Carpathian flysch basin. *Acta Pal. Polonica*, **25**(*3*): 309-367.

Ksiazkiewicz M. (1977) Trace fossils in the flysch of the Polish carpathians. *Palaeontologia Polonica, Warszawa-Krakow*, **36**, 208 p.

Lehane J.R.W. (2014) Applications of quantitative methods and chaos theory in ichnology for analysis of invertebrate behavior and evolution. Univ. Utah, PhD thesis, 484 p.

Melinte-Dobrinescu M.-C., Jipa C. D. (2007) Stratigraphy of the Lower Cretaceous sediments from the Carpathian Bend area. *Acta Geol. Sinica*, **81**(*6*): 949-956.

Miller W, III. (1991) Paleoecology of graphoglyptids. *Ichnos*, **1**: 305-312.

Murgeanu G., Patrulius D. (1959) Flişul cretacic din regiunea pasului Predeluş. *St. cerc. geol*., **IV**(*1*): 25-35.

Murgeanu G., Filipescu M. G. *et al*. (1961) *Asoc. Geol. Carp.- Balc., Congr. V, Bucureşti, Ghidul excursiilor B. Carpaţii Orientali*, 42-45.

Murgeanu G., Patrulius D., Contescu R., Jipa D., Mihăilescu N., Panin N. (1963) Stratigrafia şi sedimentogeneza terenurilor cretacice din partea internă a curburii Carpaţilor. *Geol. Carp.-Balk. Assoc., Congress V*, **III**(*2*): 31-58.

Murgeanu G., Ştefănescu M., Avram E., Matei V., Zamfirescu M., Butnăreanu C. (1965) La nature des apparitions de schistes cristallins de la région Zamura-Prislop (Carpates Orientales). *Rev. Géol., Géophys., Géogr. (Géol.)*, **9**(*1*): 3-8.

Olariu C., Jipa D.C., Steel R., Melinte-Dobrinescu M.C. (2014) Genetic significance of an Albian conglomerate clastic wedge, Eastern Carpathians (Romania). *Sedimentary Geology*, **299**: 42-59.

Pauliuc S. (1962) Contribuţiuni la studiul texturilor superficiale ale gresiilor paleogene din zona externă a flişului Carpaţilor Orientali. *D. S. Com. Geol*., **XLVI**: 305-316.

Patrulius D. (1969) Geologia masivului Bucegi şi a culoarului Dîmbovicioara. Edit. Acad. RSR, Bucureşti, 321 p.

Patrulius D., Contescu L., Butac Al. (1962) Observaţii asupra flişului cretacic din valea superioară a Trotuşului şi împrejurimile oraşului Miercurea-Ciuc (Carpaţii Orientali). *St. cerc. geologie*, **VII**(*3-4*): 409-428.

Patrulius D., Jipa D., Ştefănescu M. (1965) Le flysch tithonique-néocomien des Carpates roumaines. *Carp.-Balk. Geol. Assoc., VII Congr., Sofia, Reports* **II**(*1*): 251-255.

Sabhaya M.B., Patel R.A., Solanki P.M. (2021) Palaeoichnology of Jurassic sequence of Jara Dome, Kachchh, western India. *Science, Technology and Development*, **X**(*V*): 41-50.

Sandy M.R., Lazăr I., Peckmann J., Birgel D., Stoica M., Roban R.D. (2012) Methane-seep brachiopod fauna within turbidites of the Sinaia Formation, Eastern Carpathian Mountains, Romania. *Paleogeography, Palaeoclimatology, Palaeoecology*, **323-325**: 42-59.

Săndulescu M. (1964) Stratele de Sinaia şi stratele de Bistra dintre Răchitiş şi izvorul Ciobănuşului (munţii Ciucului). *D. S. Com. Geol.,* **L**(*2*): 371-382.

Săndulescu M. (1984) Geotectonica României. Ed. Tehnică, Bucureşti, 336 p.

Săndulescu M., Ştefănescu M., Butac A., Pătruţ I., Zaharescu P. (1981) Genetical and structural relations between flysch and molasse (the East Carpathians model). Inst. Geol. Geophys., Bucharest, *Carp.-Balk. Geol. Assoc., XII Congr., Guide to exursion* **A5**, 94 p.

Seilacher A. (1977) Pattern analysis of Paleodictyon and related trace fossils. In: Crimes T.P. & Harper J.C. (eds.) *Trace fossils 2. Geol. Jour. Spec. Issue* **9**: 289-334.

Stanley D.J., Hall B. (1978) The Bucegi conglomerates: a Romanian Carpathian submarine slope deposit. *Nature*, **276**: 60-64.

Sudan C.S., Singh B.P., Sharma U.K. (2002) Ichnofacies of the Murree Group in Jammu area and their ecological implications during Late Palaeogene in the NW Himalaya. *Jour. Geol. Soc. of India*, **60**: 547-557.

Ştefănescu M. (red.) (1980) Harta geologică a României, sc. 1: 50 000, foaia 111c Baiu (Sinaia). Inst. Geol. Geofiz., Bucureşti.

Ştefănescu M. (1995) Stratigraphy and structure of Cretaceous and Paleogene flysch deposits between Prahova and Ialomiţa Valleys. Inst. Geol. Rom., Bucureşti, *Rom. J. of Tect. & Reg. Geol*., **76**: 3-49.

Uchman A. (1998) Taxonomy and ethology of flysch trace fossils: revision of the Marian Ksiazkiewicz collection and studies of complementary material. *Ann. Soc. Geol. Poloniae*, **68**: 105-218.

Uchman A. (1999) Ichnology of the Rhenodanubian Flysch (Lower Cretaceous-Eocene) in Austria and Germany. *Beringeria*, **25**: 67-123.

Uchman A. (2003) Trends in diversity, frequency and complexity of graphoglyptid trace fossils: evolutionary and palaeoenvironmental aspects. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **192**: 123-142.

Uchman A. (2004) Phanerozoic history of deep-sea trace fossils. In: McIlory D. (ed.) The Application of Ichnology to Palaeoenvironmental and Stratigraphic Analysis, *Geol. Soc. Spec. Publ., London*, **228**:125-139 (supliment in http://www.geolsoc.org.uk/SUP18209).

Uchman A. (2007) Trace fossils of the Pagliaro Formation (Paleocene) in the North Apennines, Italy. *Beringeria*, **37**: 217-237.

Uchman A. (2007a) Deep-sea ichnology: development of major concept. In: Miller W. III. (ed.) *Trace fossils: Concepts, Problems, Prospects.* Elsevier, 248-267.

Uchman A., Jambu N.E., Nemec W. (2004) Trace fossils in the Cretaceous-Eocene flysch of the Sinop-Boyabat Basin, Central Pontides, Turkey. *Ann. Soc. Geol. Poloniae*, **74**: 197-235.

Vinogradov C. (1964) Contribuţii la cunoaşterea fundamentului anticlinoriului Zamura şi a magmatismului ofiolitic legat de stratele de Sinaia. *Anal. Univ. Bucureşti, seria geol.-geogr*., **XIII**(*1*)**:** 83-92.

Vinogradov C., Dragastan O. (1965) Micrographic study of limey-marls from the Sinaia beds (Eastern Carpathians*)*. *Carp.-Balk. Geol. Assoc., Sofia*, **II**: 61-65.

Wetzel A., Uchman A. (1997) Ichnology of deep-sea fan overbank deposits of the Ganei Slates (Eocene, Switzerland) – classical flysch trace fossil locality studied first by Oswald Heer. *Ichnos*, **5**: 139-162.