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Lower Cenomanian trace fossils and transgressive deposits in the Cracow Upland

ABSTRACT: Lower Cenomanian abrasion surfaces of the Cracow Upland abound in borings of lithophags such as sponges, polychaetes, pelecypods and echinoids. Of many trace fossils occurring in these surfaces, the form *Pseudopolydorites radwanskii* ichnogen. et ichnosp. nov., attributable to polychaetes, has been established as a new one.

INTRODUCTION

During the studies on the Mesozoic deposits of the Central Polish Uplands, the writers paid their attention to the transgressive Cenomanian deposits occurring in a few outcrops near Cracow (Fig. 1). Especially were studied the Cenomanian abrasion surfaces in which numerous borings of lithophags had for the first time been found.

The writers' stratigraphic considerations have been aided by a collection of the Cenomanian ammonites from Iwanowice, housed at the Polish Academy of Sciences, Museum of the Earth, and which was made available for the studies by courtesy of Dr. S. Mączyńska.

THE OUTCROPS

Sudół

The outcrops of the transgressive Cenomanian deposits at Sudół, described for a long time, are of a fundamental importance for the stratigraphy of this stage in the environs of Cracow (Zaręczny 1878, 1894; Pa-

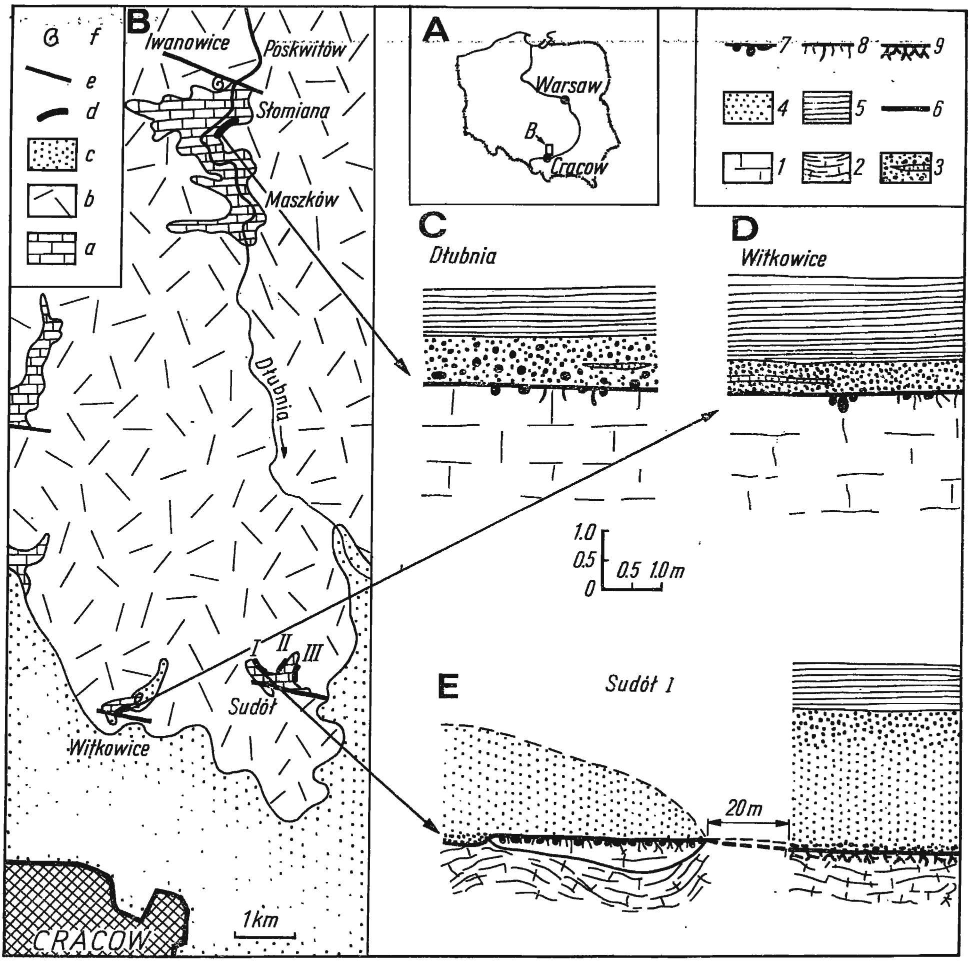

Fig. 1

Location of the investigated profiles

A Position of the area in Poland. *B* Geological sketch-map (after Gradziński 1960) showing situation of the described profiles: *a* Upper Jurassic, *b* Upper Cretaceous, *c* Tortonian, *d* investigated abrasion surfaces, *e* faults, *f* occurrence site of the Lower Cenomanian ammonites at Iwanowice. *C* Profile in the Dłubnia valley, *D* Profile at Witkowice, *E* Profiles at Sudół Upper Jurassic: *1* limestones, *2* marls; Cenomanian: *3* conglomerates with intercalations of sandy limestones, *4* sandstones; Senonian: *5* marls; *6* Cenomanian abrasion surface; *7* borings of pelecypods; *8* borings of polychaetes; *9* burrows of decapod crustaceans

now 1934; Bukowy 1957, 1960a). The most important profile occurs in a now filled up quarry (Fig. 1*B*, locality *I*). In 1970, this profile has been exposed by the writers by dug holes (Fig. 1*E*).

In this profile, deposits of the Upper Jurassic submarine slump, consisting of marls and blocks of butty limestones (Głazek & Wierzbowski 1972) are truncated by a flat Cenomanian abrasion surface, which displays various traces of the life activity, strongly differentiated and depending on the type of the substrate.

In the marly substrate, these are the burrows filled up with the Cenomanian material. Most numerous of the burrows has a tubular forked appearance, and such forms were described by Zaręczny (1878, Table IV) as *„Scyphia sudolica"*. These are most similar to *Thalassinoides* Ehrenberg, 1944, which are interpreted as a result of life activity of the decapod crustaceans (Häntzschel 1962, Kennedy 1967).

In the limestone substrate, these are very numerous borings left by various organisms (Pl. 1, Fig. 1) which are described in systematic part of the present paper. The borings of sponges (*Entobia* Bronn, 1837, emend. Bromley, 1970), polychaetes (*„Potamilla* Malmgren, 1867"; *Pseudopolydorites radwanskii* ichnogen. et ichnosp. nov.), pelecypods and echinoids (Pl. 1, Figs 1 and 2; Pl. 2, Figs 1—4) have been determined. These borings are abraded to a varying degree, but frequently superposed what points to several generations of the lithophags.

The limy conglomerate (*lower conglomerates* of Zaręczny, 1878, 1894; Panow 1934; Kamieński & Piątkowski 1950), *c.* 10 cm in thickness, overlaying the Upper Jurassic marls, is the oldest Cenomanian deposit. This is of the puddingstone type with larger pebbles of black, slightly rounded flints reaching 8 cm in diameter and smaller, well rounded pebbles of quartz to 2 cm in diameter. An abundant matrix consists mostly of the psammitic quartz material, together with glauconite and a considerable amount of heavy minerals. These gravels penetrate into the *Thalassinoides* burrows. The conglomerate does not occur on abraded limestone blocks, instead there are only single quartz pebbles in sandy infillings of the lithophag borings. The infillings are considerably enriched in heavy minerals, among which garnet, magnetite, amphiboles or pyroxenes and glauconite have been stated. Fragments of a silicified Jurassic fauna (crinoid debris, echinoid spines) are also met with. The walls of borings are pitted by sand grains (cf. Radwański 1965b).

A slightly cemented sandstone, either gray or secondarily stained by iron compounds, with its thickness varying between 1.2 and 2.3 m overlies the abraded Upper Jurassic limestone blocks and the lower conglomerate (Zaręczny 1878, 1894; Bukowy 1957, 1960a).

Higher up, indistinctly separated from sandstones, there occurs a layer of strongly limy conglomerate, *c.* 1 m thick (*upper conglomerates* of Zaręczny, 1878, 1894; Panow 1934; Kamieński & Piątkowski 1950). The upper, much the same as lower conglomerate is of the puddingstone type but it is characterized by a smaller amount and grain-size of the clastic material. A fairly numerous fauna is recorded in this layer (Zaręczny 1878, 1894; Panow 1934).

These beds are overlain by marls attributed to the Senonian (Panow 1934, Bukowy 1960a).

Batowice-Sudół railroad station

Traces of abraded pelecypod borings may be found in the abrasion surface truncating the Upper Jurassic limestones in now abandoned quarries situated near the Batowice railroad station (Fig. 1*B*, localities *II* and *III*). Higher up, there are conglomerates with quartz pebbles (Bukowy 1960a) similar to the lower conglomerate from the outcrop described above.

Witkowice

In the village Witkowice, a set of quarries (Fig. 1*B*) in which Upper Jurassic limestones are truncated by a fairly even abrasion surface, stretches on the eastern edge of a deep valley of the Garliczka stream. Irregularly distributed borings of lithophags occur on this surface. In the northeastern outcrops, only rare, strongly abraded, probably pelecypod borings may be observed on the abrasion surface. In the western part, this surface displays excellently preserved (Pl. 1, Fig. 3 and Pl. 2, Fig. 5) single borings of pelecypods of the genus *Myopholas* Douvillé, 1907. In the southern part, the abrasion surface abounds in borings of polychaetes „*Potamilla* Malmgren, 1867" and pelecypods.

The abrasion surface is covered with a limy conglomerate, composed of well rounded, flat quartz pebbles reaching 4 cm in diameter, and the layer being up to 0.7 m in thickness (Zaręczny 1878, Bukowy 1956). In the western outcrops, a wedged-out intercalation of sandy limestones (Fig. 1*D*) occurs in the lower part of the conglomerate. The conglomerate is overlain by Senonian marls (Bukowy 1956).

Dłubnia valley

On the slopes of both edges of the Dłubnia valley, the Upper Jurassic limestones, truncated by a relatively even abrasion surface (Fig. 1*B*), are outcropping, along the distance of *c*. 4 kms, between Iwanowice and Maszków.

In the northern outcrops, a well-known locality is situated near Iwanowice from which the Cenomanian fauna was collected (Panow 1934, Mączyńska 1958, cf. also Kamieński & Piątkowski 1950). As a result of the writers' studies another profile has been stated on the eastern edge of the valley between Poskwitów and Maszków (Fig. 1*B*).

The outcrops with the abrasion surface begin south-west of the mouth of a ravine descending from the village Słomiana. In this locality, the limy Cenomanian conglomerate, composed mostly of quartz pebbles to 1.5 cm in diameter, overlies the Upper Jurassic limestones, truncated by an abrasion surface. Dark phosphorite concretions, also up to 1.5 cm in size occur in this conglomerate.

Abraded pelecypod and polychaete („*Potamilla* Malmgren, 1867") borings, and frequent diagenetic pits (cf. Radwański 1965b) of quartz pebbles, occur on the abrasion surface. Marls, usually assigned to the Senonian, overlie the conglomerate.

In a large quarry, about 300 m further to the west (Fig. 1*C*), the Upper Jurassic limestones are truncated by an abrasion surface bored by a similar assemblage of pelecypods and polychaetes (Pl. 1, Fig. 4). The surface is overlain by a layer of the Cenomanian conglomerate, *c.* 1 m thick, and composed of scattered, flat and well-rounded quartz pebbles to 3 cm in diameter, large pebbles and fragments of Jurassic flints, reaching 8 cm in diameter and, finally, similarly sized dark-gray phosphorite concretions. The echinoid *Pyrina laevis* Ag. and crinoid debris are to be found in this conglomerate. The green colour of the sediment and a green substance (glauconite?) coating the abrasion surface and some of the pebbles is a very characteristic feature of this layer. A micritic matrix with foraminifers has been stated in thin sections here. The pebbles are mostly of metamorphic quartzites, less frequently vein quartz and larger, poorly rounded flints. A fine quartz sand with an admixture of glauconite occur in the conglomerate along with the pebbles. On the whole, the conglomerate resembles the upper conglomerate from Sudół, described by Kamieński & Piątkowski (1950).

STRATIGRAPHIC POSITION

According to the previous authors (Panow 1934; Bukowy 1956, 1960a; Alexandrowicz 1960b), the deposits, which overlie the abrasion surface under study, belong to the Cenomanian. The older Cretaceous deposits in the Cracow Upland do not occur in the profiles studied by the writers and, met with here and there, they only fill up the depressions in the Jurassic substrate. These are sands devoid of fauna and conventionally assigned to the „Vraconian" or Uppermost Albian (Panow 1934; Bukowy 1956, 1960). The Cenomanian deposits in the Cracow Upland were subdivided by Panow (1934) on the basis of the Sudół profile (cf. Fig. 1*E*). The conglomerate, directly overlaying the Jurassic deposits, with *Parahibolites tourtiae* (Weigner), was assigned by Panow to the Lower Cenomanian [1]. The overlaying sands and sandstones devoid of fauna

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[1] In addition to the outcrops under study, conglomerates from Korzkiew, containing *Pecten asper* Lam. (cf. Panow 1934), have also been attributed to the Lower Cenomanian. This pelecypod is, however, known from various parts of the Cenomanian and its occurrence depends on the facial development (Häntzschel 1933, Tröger 1969).

were regarded as transition beds between the Lower and Middle Cenomanian. The cephalopods *Schloenbachia varians* (Sow.), *Baculoides baculoides* Mant. and *Scaphites aequalis* Sow. were regarded by Panow (1934) as documenting the Middle Cenomanian age of the upper conglomerate.

The Cenomanian deposits occurring in other discussed profiles (Witkowice, Iwanowice) were, mostly on the basis of lithological criteria, correlated with the upper conglomerate from Sudół and, consequently, considered as Middle Cenomanian (Panow 1934, Panow *in* Kamieński & Piątkowski 1950). The Cenomanian deposits from the Dłubnia valley, south of Iwanowice (cf. Fig. 1*C*) are also similar in lithological character to those from Witkowice and Iwanowice.

In all the profiles elaborated, the deposits, recognized thus far to be the Middle Cenomanian, are overlain by marly deposits attributed to the Senonian.

The ammonite fauna, collected from the conglomerate at Iwanowice (Fig. 1*B*) which has so far been assigned to the Middle Cenomanian (Panow *in* Kamieński & Piątkowski 1950, Mączyńska 1958) is represented (the Museum of the Earth's collection, numbers *Mz VIII/Mc-1301-1304*) by the following species: *Schloenbachia* cf. *varians* (Sow.), *S. subvarians* Spath, *S. subtuberculata* (Sharpe), *S. ventriosa* Stiel.

In the bipartite division of the Cenomanian, widely applied in Poland (cf. Cieśliński 1959, 1965; Marcinowski 1970), these species occur in the Lower Cenomanian, Schloenbachia varians Zone (Wright & Wright 1951). In the tripartite division of the Cenomanian (Hancock 1959, Kennedy 1969), all the above listed species of *Schloenbachia*, are known both from the Lower and lowermost parts of the Middle Cenomanian. At present, there are no paleontological evidences indicative of the younger members of the Cenomanian in the environs of Cracow. The age of the conglomerate from Podgórze and Pychowice, considered by Panow (1934) as Upper Cenomanian on the basis of *Orbirhynchia cuvieri* (d'Orb.), is rather debatable, since this brachiopod is known from the Cenomanian through the Santonian (E. Barczyk *in* Marcinowski 1970).

As follows from the presented stratigraphic considerations, all abrasion surfaces with borings, are of Lower Cenomanian (in bipartite division) age.

SYSTEMATIC DESCRIPTION OF LITHOPHAGS

Sponges

(Pl. 1, Fig. 1; Pl. 2, Figs 2—3)

Borings of sponges are among rare forms and have been found only at Sudół. They represent the ichnogenus *Entobia* Bronn, 1837, which, according to Bromley (1970), corresponds to the borings of sponges of the family Clionidae. Due to a rather poor state of preservation and the lack of a comparative material, a more detailed determination of these borings to the rank of ichnospecies is impossible.

The borings stretch over a few square centimetres and form a system of closely spaced, fine, irregularly shaped galleries (0.3—0.8 mm in diameter). It is difficult to estimate to what an extent the pattern of galleries visible is an original system and to what an extent it might have been destructed. Surely, however, this could not be a system with extremely large chambers as in *Entobia cretacea* Portlock (cf. Bromley 1970). A system of small borings belonging to the ichnogenus *Entobia* and much more similar to our specimens was described by Stephenson (1952) as *Cliona retiformis* from the Cenomanian of Texas. The Texan borings are, however, of a conspicuously „camerate" type. A particularly strong similarity to our specimens are displayed by the borings of *Entobia* described by Roniewicz (1970) as *Cliothosa* sp. from the Eocene of the Tatra Mts.

Polychaetes

Tubular and *U*-shaped borings, in all probability attributable to polychaetes, belong to the most frequent forms occurring in the material under study. The tubular borings have been identified as „*Potamilla* Malmgren, 1867", while *U*-shaped ones represent a new ichnogenus *Pseudopolydorites*. The former have been found at Sudół, Witkowice and in the Dłubnia valley, the latter only at Sudół.

„*Potamilla* Malmgren, 1867"
(Fig. 2; Pl. 2, Figs 1*a*—*b*)

The name „Potamilla" in ichnology. — The borings, being described by various authors in the fossil state and morphologically comparable to borings of the Recent sabellid polychaetes of the genus *Potamilla* or species *Potamilla reniformis* (Müller) were usually named the same as these latter ones. Such *Potamilla* borings were described from the Middle Jurassic of Western Europe (Hölder & Hollmann 1969) and those of *Potamilla reniformis* (Müller) from the Rhaetic and Lower Jurassic of the Tatra Mts (Radwański 1959), Paleogene of the Paris Basin (Ellenberger 1947), Eocene of the Tatra Mts (Roniewicz 1966, 1970) and Miocene of the Holy Cross Mts (Radwański 1969, 1970 and earlier works therein referenced).

Certain doubts may sometimes be aroused by the relationship of these fossil borings and the Recent genus *Potamilla*. This particularly concerns the Rhaetic — Middle Jurassic borings. Some of such borings, described by Hölder & Hollmann (1969) as *Potamilla* from the Middle Jurassic are so little characteristic that they arouse doubts whether they come from the polychaetes or phoronids (cf. Voigt 1970).

Under such circumstances, the writers decided — in reference to the Cenomanian borings under study which are similar to those of *Potamilla* — to use quotation marks with the name and thus to emphasize its more ichnological rather then zoological character.

In future, the necessity will probably arise to introduce a new ichnogeneric name determining the „*Potamilla*" borings. There is also a possibility of extending the limits of already existing ichnotaxons. Here, we may mention that the borings called the *Trypanites* Mägdefrau, 1932, are very similar to some borings of the „*Potamilla*" type (cf. Hölder & Hollmann 1969, Voigt 1970).

Material. — Three types of the „*Potamilla*" borings, designated in the present paper by successive letters of the alphabet, occur in the Lower Cenomanian abrasion surfaces under study.

„*Potamilla*" type *A* (Figs 2*a*—*c* and 2*f*—*g*). Blindly terminated tubular borings about 2.5 to 5 cm long, round in section, between 1 mm and nearly 3 mm in diameter and variously, sometimes sharply winding a few times. Some of the borings „*Potamilla*" type *A* begin at the end of a „*Potamilla*" type *B* boring (Figs 2*f*—*g*). The „*Potamilla*" type *A* borings resemble those described as *Potamilla reniformis* (Müller) from the Rhaetic (Radwański 1959, Fig. 9), Paleogene (Ellenberger 1947, Fig. 7*D*) and Miocene (Radwański 1969, Fig. 2), as well as some of *Trypanites* from the Muschelkalk (Müller 1956, Fig. 2) and Kimmeridgian (Kaźmierczak & Pszczółkowski 1968, Fig. 5).

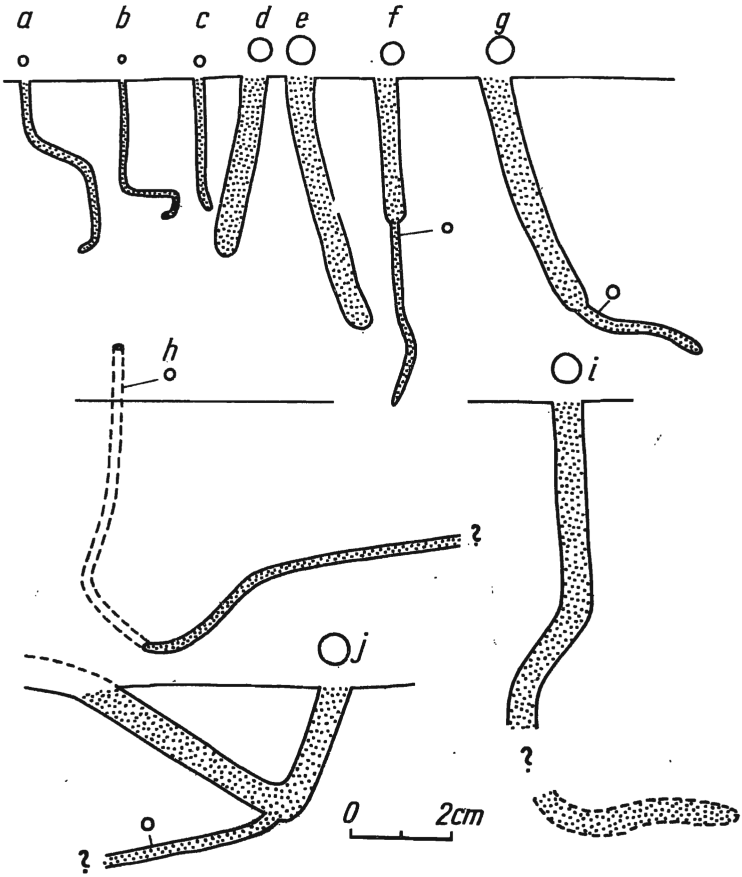
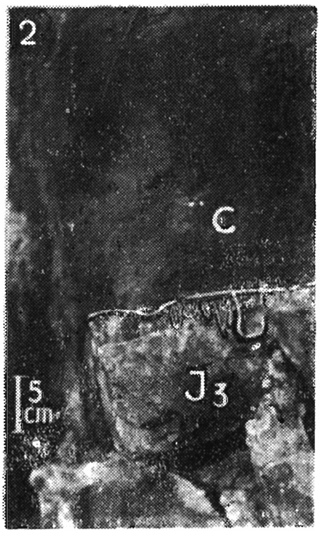
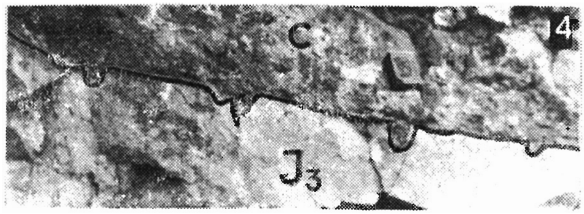


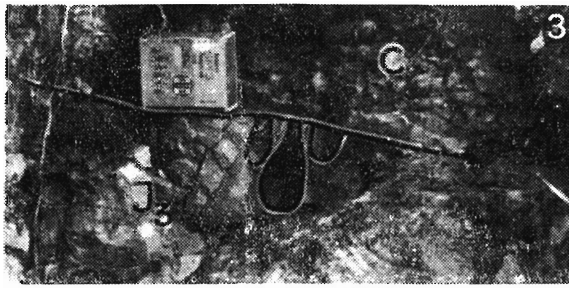
Fig. 2

Borings of polychaetes "*Potamilla*" at Sudół

a—*c* borings of "*Potamilla*" type *A*; *d*—*e* borings of "*Potamilla*" type *B*; *f*—*g* borings of "*Potamilla*" type *A* developed in borings of "*Potamilla*" type *B*; *h*—*i* borings of "*Potamilla*" type *C*; *j* boring of "*Potamilla*" type *C* developed in a bigger (older) boring of the same type





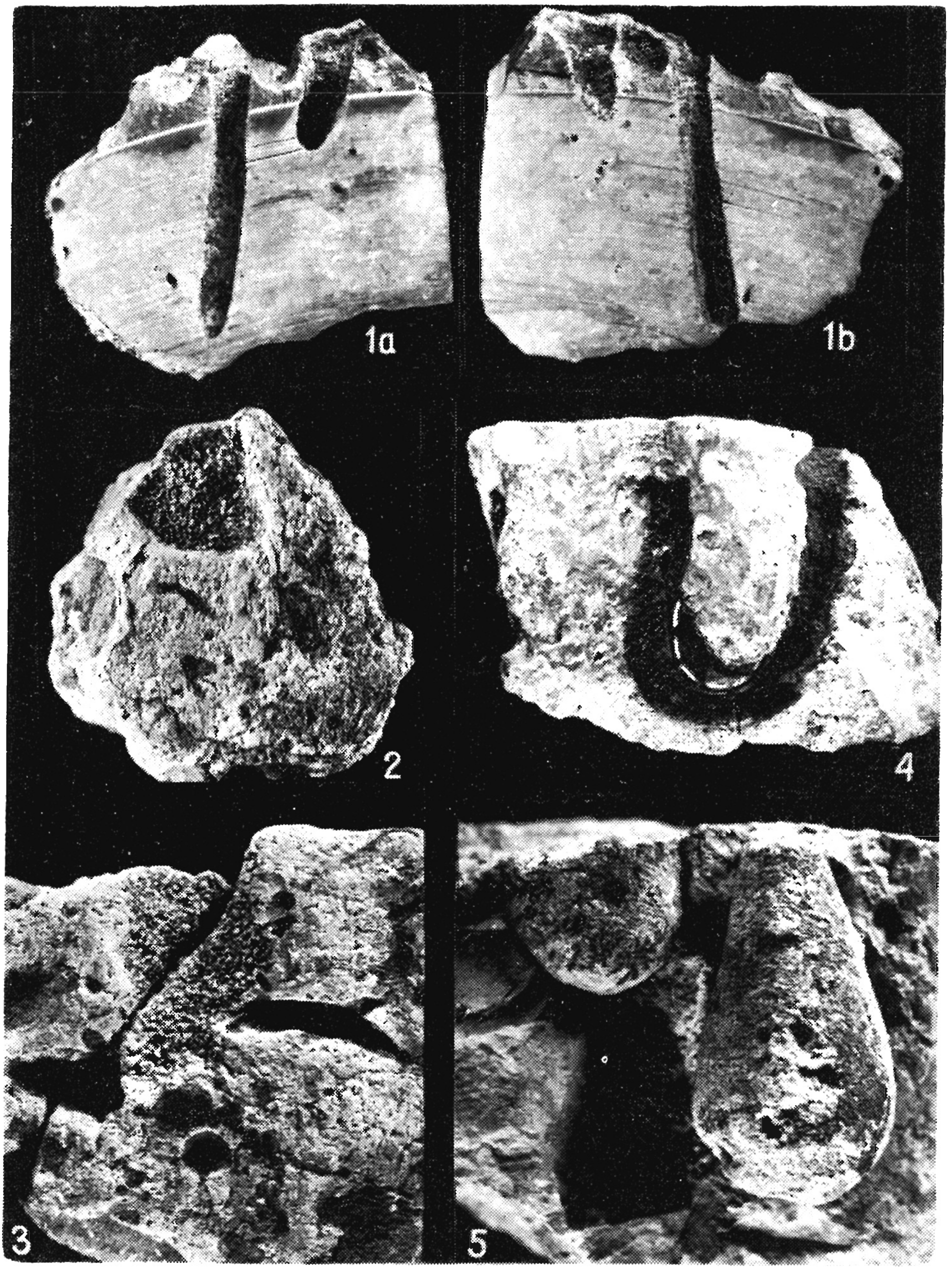


1 — Lower Cenomanian abrasion surface on the Upper Jurassic limestones at Sudół. The borings are: *a* — *Entobia*, *b* — polychaetes, *c* — pelecypods, *d* — echinoids.

2 — Borings in Upper Jurassic limestones (J_3) covered by Lower Cenomanian sandstones (*C*) at Sudół.

3 — Borings of *Myopholas* in Upper Jurassic limestones (J_3) covered by Lower Cenomanian conglomerate (*C*) at Witkowice.

4 — Borings of pelecypods and polychaetes in Upper Jurassic limestones (J_3) covered by Lower Cenomanian conglomerate (*C*) at Dłubnia.



1a-b — Two sides of the same section of "*Potamilla*" type *B* (cf. Text-fig. 2*d*) and opening of the boring *Pseudopolydorites radwanskii* ichnogen. et ichnosp. nov. (cf. Text-fig. 3*c*); Lower Cenomanian, Sudół.

2-3 — *Entobia;* Lower Cenomanian, Sudół.

4 — *Pseudopolydorites radwanskii* ichnogen. et ichnosp. nov. (holotype, cf. Text-fig. 3*a*); Lower Cenomanian, Sudół.

5 — Borings of *Myopholas;* Lower Cenomanian, Witkowice.

All figures of nat. size

„Potamilla” type *B* (Figs *2d—g;* Pl. 2, Figs *1a—b*). Blindly terminated tubular borings about 3 to 5 cm long, round in section and about 4 to 6 mm in diameter. These borings are almost completely straight, rarely vertical, mostly arranged obliquely to an abrasion surface. Borings with much the same diameters, identified as *Potamilla reniformis* (Müller) were described from the Paleogene (Ellenberger 1947).

„Potamilla” type *C* (Figs *2h—j*). Blindly terminated tubular borings between 12 to more than 15 cm long, round in section and between 2 and 6 mm in diameter. The borings are as a rule strongly, sometimes a few times winding. Fairly long sectors stretching approximately horizontally are characteristic feature of theirs. Due to the distinct winding of the borings, the abrasive truncation causes sometimes the formation of widely open and fairly shallow, *U*-shaped forms (Fig. *2j*). Now and then, younger borings of the *„Potamilla”* type *C* begin at the points of deflection of older borings (Fig. *2j*). There are also borings located in the borings of pelecypods. The tubular borings of the *„Potamilla”* type *C* differ from those of the type of *Potamilla* described so far in their tendency to form *U*-shaped bends and in their dimensions, particularly in their longer length.

Pseudopolydorites ichnogen. nov.

Type ichnospecies: *Pseudopolydorites radwanskii* ichnosp. nov.
Derivation of name: after a seeming similarity to the ichnogenus *Polydorites* Douvillé, 1908.

Diagnosis. — The tubular, *U*-shaped boring with a few centimeters long limbs, the interspace of which is, composed of non-reworked rock.

Stratigraphic position. — Lower Cenomanian.

Remarks. — *Pseudopolydorites* distinctly differs from the ichnogenus *Polydorites* Douvillé, 1908 in a different material of the limb interspace. In *Pseudopolydorites* the interspace is composed of an original, non-reworked rock, while in *Polydorites,* which corresponds to the borings of some Recent *Polydora* (*P. hoplura* and *P. ciliata*), the interspace is formed by the material excavated from the sides and base of the boring. In all likelihood, some of the *U*-shaped borings, described from the Middle Jurassic (Hölder & Hollmann 1969) as *Polydorites,* have their interspace composed of an original rock and, consequently, they would also belong to the ichnogenus *Pseudopolydorites.*

Pseudopolydorites markedly differs from *U*-shaped, fine cavities met within shells and belonging to the ichnogenera *Caulostrepsis* Clarke, 1908, and *Ostreoblabe* Voigt, 1965, which are embedding forms (cf. Bromley 1970).

Pseudopolydorites radwanskii ichnosp. nov. (Figs *3a—c*; Pl. 2, Figs. *1a—b* and 4)

Holotype: the specimen presented in Fig. *3a* and Pl. 2, Fig. 4.
Type horizon: Lower Cenomanian.
Type locality: Sudół near Cracow.
Derivation of name: after the name of Docent Andrzej Radwański (Warsaw University), an author of several ichnological works.

Diagnosis. — Tubular, *U*-shaped borings, probably left by polychaetes, round in section and about 6 to 8 mm in diameter. The limbs of the *U*-shaped loop are usually 3 to 5 cm long, this length being sometimes shortened as a result of an abrasion (Fig. *3c*). The space between the limbs, about 1.2 cm to 1.8 cm wide,

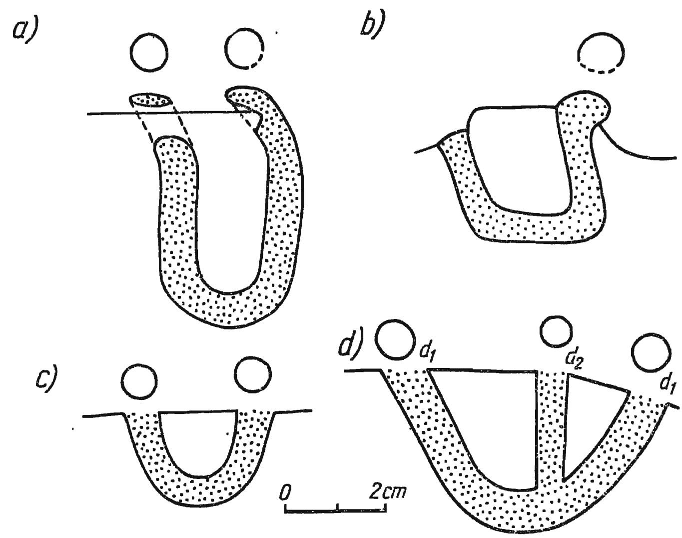


Fig. 3

U-shaped borings of polychaetes at Sudół

a—c borings of *Pseudopolydorites radwanskii* ichnogen. et ichnosp. nov., variously abraded (*a* presents the holotype); *d* superposed borings of either (?)*Pseudopolydorites* or (?)"*Potamilla*" type *C* (d_1) and (?)"*Potamilla*" type *B* (d_2)

composed of an original, non-reworked, solid rock. Boring openings on the surface round, without a funnel-like depression. In the near-opening part, the limbs display a characteristic deflection of their trace in relation to the deeper parts of the boring (Figs 3*a*—*b*), which are situated in one plane.

Remarks. — The discussed borings cannot be considered as abrasively truncated borings of the „*Potamilla*" type, which never display such closely spaced and deep *U*-shaped loop (cf. Figs 2*h*, *j*). Certain doubts may only be aroused by the borings shown in Fig. 3*d*. They may be interpreted as two forms superposed on each other as a result of the destruction of an intervening partition. The first *U*-shaped form (Fig. 3d_1), larger in diameter, belongs to the ichnogenus *Pseudopolydorites* or, which is less likely, represents a very sharp bend of an abraded „*Potamilla*" type *C* boring; the second straight form, smaller in diameter (Fig. 3d_2), is probably „*Potamilla*" type *B*.

Pelecypods
(Pl. 1, Fig. 3; Pl. 2, Fig. 5)

Borings of pelecypods are among frequent forms, found in all the outcrops studied. A considerable majority of them are strongly abraded which makes the determination of their full shape impossible. No remains of the boring pelecypods have been found in all borings.

Some less strongly abraded borings from Witkowice (Pl. 1, Fig. 3; Pl. 2, Fig. 5) are characteristically pear-shaped, their chamber parts gently passing into a neck, whose upper part is, however, abrasively truncated. A maximum diameter of the chamber varies between 1.5 and 2.5 cm, while a maximum length of a preserved boring amounts to *c.* 5 cm. In all likelihood, these borings may be interpreted as belonging to the genus *Myopholas* Douvillé, 1907, which is known in the fossil state from the Middle Jurassic through the Upper Albian (Cox 1969). In Poland, borings of this genus were noted from the Lower Kimmeridgian of the Holy Cross Mts (Kaźmierczak & Pszczółkowski 1968).

Echinoids

Not very numerous and strongly destroyed rounded pits (Pl. 1, Fig. 1) were found in the abrasion surface at Sudół. Their diameter amounts to *c.* 3.5 to 4 cm and depth to *c.* 1 cm. The walls of pits are fairly steep and bottoms slightly flattened. In some cases, the bottom is not completely even and bears traces of reworked older borings (of ?pelecypods).

The pits under study are similar in character to those bored by regular echinoids. Such borings have been noted in the fossil state from the Cenomanian of Rhineland (Kahrs 1927) and Miocene of the Holy Cross Mts (Radwański 1965a, 1969, 1970).

PALEOGEOGRAPHICAL REMARKS

Of the many localities of Cretaceous abrasion surfaces, varying in age, which are known in the Cracow Upland (Dżułyński 1953; Alexandrowicz 1954, 1960; Bukowy 1956), the borings were found only in the Lower Cenomanian surfaces.

Abrasion surfaces bored by lithophags were formed during the maximal development of the Albian-Cenomanian transgression, which gradually invaded vast areas of Poland (cf. Cieśliński 1959, 1965) and which in the Lower Cenomanian, probably completely covered the Cracow Upland. The studied Cenomanian littoral structures resemble to some extent the structures formed during the Miocene transgression onto the southern slopes of the Central Polish Uplands (cf. Radwański 1965a, 1968, 1969, 1970). However, considerable differences are also recorded between the littoral structures of these two transgressions.

All the Cenomanian abrasion surfaces described are flat and, consequently, have the nature of abrasional platforms which are rare among the Miocene abrasion forms (cf. Radwański 1968, 1969). It may be assumed that the Cenomanian transgression was marked by a more intensive abrasional activity and, therefore, it more strongly levelled the substrate, leaving only abrasional platforms, while the autochthonous, limestone rubble was completely destroyed. A considerable difference occurs between the materials covering abrasion surfaces in the two compared transgressions. The Miocene deposits contain mostly autochthonous material, whereas the Cenomanian ones are composed mostly of the allochthonous quartz gravel and sand. The clastic quartz material dragged by waving, played the grinding role which intensified the abrasive activity of waving. Sweeping the material has been confirmed at Sudół by the lack of lower conglomerate on the limestones truncated by abrasion surface, while only single quartz pebbles and heavy minerals have been preserved as trapped in the lithophag borings.

The Lower Cenomanian assemblage of lithophags of the Cracow Upland differs from the Miocene assemblage in the lack of borings similar to those made by Recent *Polydora,* and in the presence of *Pseudopolydorites* ichnogen. nov. Both these assemblages display, however, a far-reaching analogies in the amount and systematic assignment of all remaining lithophags.

It should be added that the Albian-Cenomanian and Miocene transgressions entered an uneven limestone substrate, in the depressions of which older sandy sediments, reworked by the transgressing sea or deposited in the initial stages of transgression, have been preserved here and there (cf. Bukowy 1960b, Radwański 1967, Bałuk & Radwański 1968).

The littoral structures described are the result of Albian-Cenomanian transgression, which gradually invaded the Meta-Carpathian arch, uplifted in the Lower Cretaceous (Głazek & Kutek 1970). Flooding this arch which comprised the Cracow Upland, by the Cenomanian sea broke, in the higher Cretaceous stages, the inflow of a considerable amount of the sandy material to the surrounding basins. The Cracow Upland remained, however, as a part of the rise which separated deeper sedimentary basins, that is, the Carpathian geosyncline in the south and the platform (epicontinental) basin in the north. This is the reason why younger abrasional surfaces and many stratigraphic gaps are now met with in the Upper Cretaceous deposits of the Cracow Upland (cf. Panow 1934; Dżułyński 1953; Alexandrowicz 1954, 1960; Barczyk 1956; Bukowy 1956).

The discussed littoral structures are a unique phenomenon in the Polish Cretaceous. Despite the fact that vast areas were covered by the Albian-Cenomanian transgression, no conditions were produced — except for the environs of Cracow — favourable to the formation of abrasion surfaces and appearance of lithophags. The occurrence of such a numerous assemblage of lithophags on the Cretaceous abrasion surface is also exceptional on a world-scale. The only occurrence of the Cenomanian abrasion surface with echinoid and ?pelecypod borings known to the present writers is that in Rhineland (Kahrs 1927).

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SPOSTRZEŻENIA NAD SKAŁOTOCZAMI, STRATYGRAFIĄ I SEDYMENTACJĄ TRANSGRESYWNEGO CENOMANU W OKOLICACH KRAKOWA

(Streszczenie)

W czasie badań stratygraficznych i paleogeograficznych mezozoiku w strefie wyżyn środkowopolskich autorzy zainteresowali się transgresywnymi utworami cenomanu w kilku odsłonięciach w okolicach Krakowa (fig. 1*B*). Szczególną uwagę zwrócono na charakter powierzchni abrazyjnych, w których stwierdzono po raz pierwszy liczne wydrążenia skałotoczy (fig. 1*C*—*E*, 2—3 oraz pl. 1—2).

Na podstawie dotychczas cytowanej z cenomanu krakowskiego fauny (Zaręczny 1878, 1894; Panow 1934; Mączyńska 1958) i oznaczenia przez R. Marcinowskiego amonitów z Iwanowic: *Schloenbachia* cf. *varians* (Sow.), *S. subvarians* Spath, *S. subtuberculata* (Sharpe) i *S. ventriosa* Stiel., autorzy wskazali, że w rejonie Krakowa udowodniony faunistycznie jest wyłącznie cenoman dolny (przyjmując dwudzielny podział tego piętra stosowany obecnie w Polsce — *por.* Cieśliński 1959, 1965; Marcinowski 1970).

Z powierzchni abrazyjnych wieku dolnocenomańskiego opisano wydrążenia gąbek (*Entobia* Bronn, 1837, emend. Bromley, 1970), wieloszczetów („*Potamilla*

Malmgren, 1867", *Pseudopolydorites radwanskii* ichnogen. et ichnosp. nov.), małżów (*Myopholas* Douvillé, 1907) i jeżowców. Wskazano, że formy opisane przez S. Zarecznego (1878) pod nazwą *„Scyphia sudolica"* i uważane za gąbki są w istocie pozostawionymi przez organizmy ryjące kanałami typu *Thalassinoides* Ehrenberg, 1944, rozwiniętymi na ścinanych abrazyjnie w dolnym cenomanie miękkich marglach górnojurajskich.

W nawiązaniu do paleogeografii górnej kredy w rejonie krakowskim rozpatrzono dokładniej charakter transgresji cenomańskiej na tym obszarze.

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