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Rosarichnoides sudeticus igen. et isp. nov. and associated fossils from the Coniacian of the North Sudetic Synclinorium (SW Poland)

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A new ichnogenus and ichnospecies *Rosarichnoides sudeticus* is proposed for a large, exceptionally well-preserved crustacean burrow, which has been found in the Upper Cretaceous (Coniacian) Quadersandstein of the North Sudetic Synclinorium (Czaple Quarry). Some of its specimens have been assigned to *Thalassinoides saxonicus* (Geinitz, 1842). It is unbranched, a characteristic rosary-shaped trace fossil, which consists of alternating chambers (swellings) and constrictions. The burrow has no wall, usually lacks ornamentation and has a passive fill. It should be included in the ophiomorphid group *sensu* Bromley (1996). This unique finding resembles modern crustacean burrows produced by shrimps or crabs. Additionally, *Thalassinoides paradoxicus* (Woodward, 1830), the starfish *Astropecten scupini* Andert, 1934, the inoceramids *Inoceramus kleini* Müller, 1888 and *Inoceramus* sp. were found in the same sandstones. The trace fossils are indicative of the archetypal *Skolithos* ichnofacies that is typical of foreshore to middle shoreface settings.

Key words: crustacean burrows, *Rosarichnoides sudeticus* igen. et isp. nov., *Thalassinoides*, palaeoenvironment, Sudetes, Poland.

INTRODUCTION

Ichnological studies of ophiomorphids from the Cretaceous deposits of Silesia, Saxony and Bohemia have a very long history, probably since the 18th century (Schulze, 1760) and certainly from the first half of the 19th century (Geinitz, 1842; Göppert, 1842). Incompleteness and different states of preservation, besides the historical uncertainty of what a trace fossil is, led to these trace fossils being classified in different taxonomic groups (as crinoid remains, sponges, algae, foraminifers, trace fossils).

The *Ophiomorpha*–*Thalassinoides*–*Spongeliomorpha* group (Bromley, 1996) or informally named "ophiomorphids group" (Uchman, 1995; Seilacher, 2007) includes crustacean burrows of various architectures, the most typical forming branching tunnel networks, which commonly have swellings. Fürsich (1973) and Schlirf (2000) proposed synonymizing these ichnogenera, but this was not accepted (see Bromley and Frey, 1974; Bromley, 1996; Schlirf, 2005). According to Gibert (1996), *Sinusichnus* should also be included to this group (see Belaústegui et al., 2014). *Gyrolithes* Saporta, 1884, *Ardelia* (Chamberlain and Baer, 1973) and *Parmaichnus* Pervesler and Uchman, 2009 are also proposed to represent ophiomorphids (Bromley and Frey, 1974; Netto et al., 2007; Seilacher, 2007; Pervesler and Uchman, 2009). *Ophiomorpha* (Lundgren, 1891) has a characteristic pelleted wall, *Spongeliomorpha* (Saporta, 1887) shows a criss-cross ornament of sublongitudinal ridges and grooves, which represented abundant wall scratchings, whereas *Thalassinoides* (Ehrenberg, 1944) refers to a three-dimensional system of burrows, usually unlined or thinly walled. A diagnostic feature of the last ichnogenus is T- or Y-shaped branches. Recently, Hyžný et al. (2015) included the new ichnogenus *Egbellichnus* to the group of trace fossils made by decapod crustaceans, while Belaústegui et al. (2016) first reported *Lepeichnus*, which is interpreted as probably produced by crustaceans.

A new type of ophiomorphid specimen has been found in the Upper Cretaceous Quadersandstein (Coniacian) of the North Sudetic Synclinorium. It is the first such large and finely preserved crustacean burrow from the North Sudetic Synclinorium (Fig. 1A) and the Sudetes. It was prepared from a block of sandstone during mining work in the Czaple Quarry B (Fig. 1B) in 1996 by A.M. Sroka and is housed at the Geological Museum of the University of Wrocław (MGUWr 6650s).

Designation of the specimen was made complicated by similarities with some specimens assigned to *Thalassinoides saxonicus* (Geinitz, 1842), especially those found by German geologists in the 19th century. However, these trace fossils as well as the specimen in question are unbranched. For this reason they should be excluded from *Thalassinoides* Ehrenberg, 1944 and the proposal of a new ichnogenus seems necessary.

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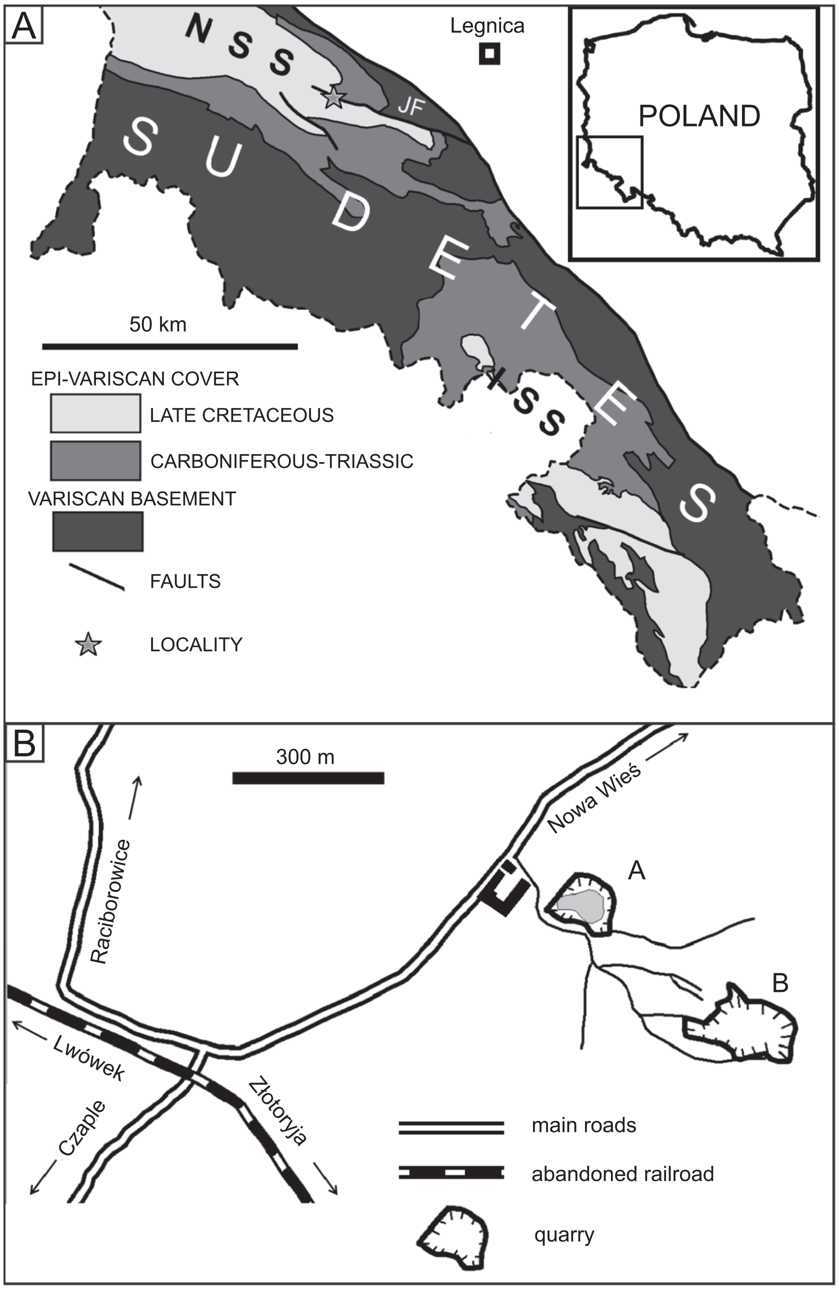

Fig. 1. Location of the study area

A – site under investigation on the map of the current extent of the Late Cretaceous deposits in the Sudetes, NSS – North Sudetic Synclinorium, ISS – Intra Sudetic Synclinorium, JF – Jerzmanice Fault (based on Sawicki, 1967, simplified); B – location of the quarries A and B between Czaple and Nowa Wieś

Thalassinoides saxonicus (originally *Spongites saxonicus* Geinitz, 1842), an exceptionally rare crustacean burrow, was reported mainly from the Upper Cretaceous (Cenomanian, Turonian, Coniacian) of Saxony, Bohemia and Lower Silesia (Geinitz, 1842; Otto, 1852; Frič, 1883; Dettmer, 1912; Andert, 1934). All these authors interpreted *T. saxonicus* as a sponge. The very similar structure of *Cylindrites spongioides* Göppert, 1842, assigned to algae (fucoids), was also reported from these regions (Göppert, 1842, 1847; Dunker, 1856). Some of these specimens are undoubtedly trace fossils. Häntzschel (1962, 1975) and Kennedy (1967) assigned *Spongites saxonicus* to the trace fossil *Thalassinoides* and gave a list of its synonyms.

This paper gives a formal description of a new trace fossil, *Rosarichnoides sudeticus*, on the basis of the significant differences in shape from other ophiomorphids. We compared this specimen with other similar forms illustrated in the published literature and with a part of the Göppert's collection from Saxony, Bohemia, Harz and the Sudetes, which were re-discovered in the Geological Museum of the University of Wrocław. In our opinion some unbranched specimens formerly assigned to *T. saxonicus* should also be included in this new ichnospecies. In this paper other associated trace fossils and body fossils of starfish and inoceramids from the Coniacian of the North Sudetic Synclinorium (Czaple, Żerkowice quarries) are also de-

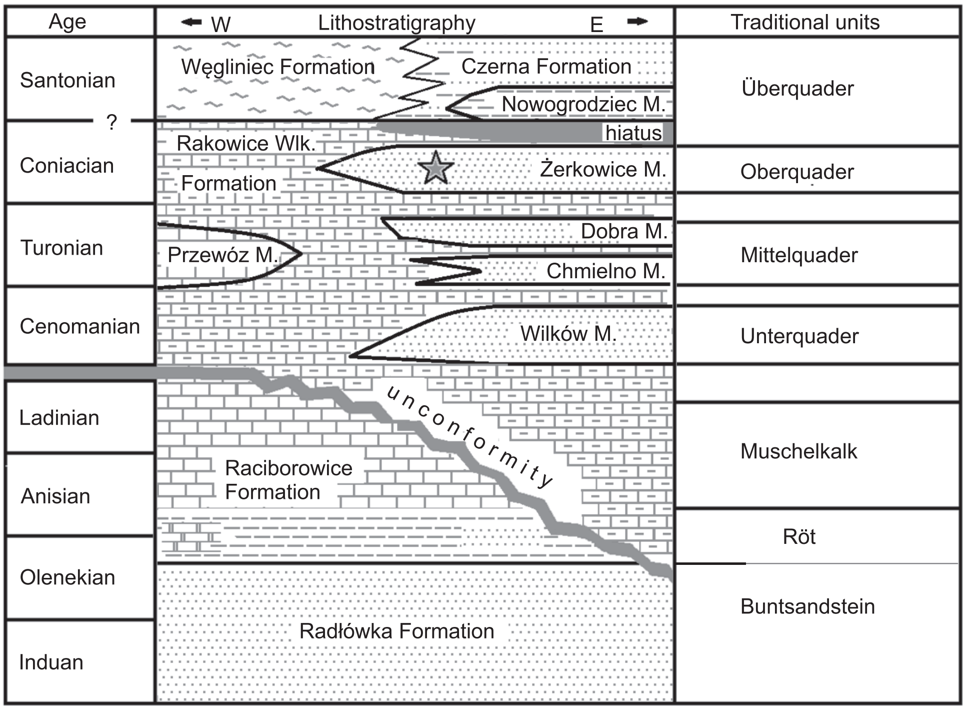

Fig. 2. Stratigraphic position of the site under investigation, marked by a star

Lithostratigraphic units after Milewicz (1985) and Leszczyński (2010), modified (without Keuper deposits which occur only in the most NW part of the NSS), traditional lithostratigraphic units of the Germanic Triassic after Alberti (1834), Beyrich (1849, 1855), Noetling (1880), Scupin (1907, 1912–1913, 1933), Holdefleiss (1915), Beyer (1933), correlation with age units after Lepper et al. (2002), Menning et al. (2012) and Chrząstek (2013a)

scribed. On the basis of the fossils collected, some interpretation of the depositional environment is made.

GEOLOGICAL SETTING

The sites studied are located in the central part of the North Sudetic Synclinorium (NSS) south of the WNW–ESE trending Jerzmanice Fault (Fig. 1A). The study was conducted in two quarries in the Coniacian sandstones near Czaple and Nowa Wieś villages (Fig. 1B).

The North Sudetic Basin (NSB) is a post-Variscan basin located within the northern Sudetic Foreland above the low-grade Kaczawa Metamorphic Unit (Baranowski et al., 1990). It forms the southeastern prolongation of the East Brandenburg Basin (Musstow, 1968). After the Cretaceous, tectonic inversion of the NSB took place and the North Sudetic Synclinorium was formed (Solecki, 1994).

The Pennsylvanian–Triassic part of the NSB infill includes detrital continental deposits of Rotliegend facies with abundant Early Permian bimodal volcanic rocks (Baranowski et al., 1990). These are overlain by Upper Permian marine marls, carbonates and evaporites (Zechstein facies), followed by Lower Triassic continental Buntsandstein sandstones. The Triassic marine transgression resulted in sedimentation of marls, carbonates and evaporites followed by the Middle Triassic Muschelkalk sequence of marls and limestones (Fig. 2). Locally, in the NW part of the basin the Upper Triassic Keuper evaporites are preserved (Milewicz, 1985; Chrząstek, 2002).

The transgressive Upper Cretaceous marine sedimentary sequence overlies the older basement with slight angular unconformity and a significant hiatus (Fig. 2). In the southern part of the NSS, the Upper Cretaceous marine sedimentary sequence overlies mainly Lower Triassic (Buntsandstein) strata, locally the Rotliegend and rocks of the Kaczawa Metamorphic Unit, while north of the Jerzmanice Fault the Middle Triassic deposits of the Muschelkalk form its basement (Scupin, 1912–1913; Beyer, 1933, 1934; Milewicz, 1997).

The Upper Cretaceous sequence (Rakowice Wielkie Formation *sensu* Milewicz, 1985, 1997) consists of marine Cenomanian to upper Coniacian (lower Santonian according to Walaszczyk, 2008) marls that locally pass into limestones intercalated by sandstones and mudstones, covered in the eastern part of the study area by the limnic and deltaic deposits of the Czerna Formation (Fig. 2), which are composed of white kaolinitic sandstones intercalated with calcareous kaolinitic clays with lignite. In the more western part of the NSS, shallow marine mudstones of the Węgliniec Formation form the cover of the Rakowice Wielkie Formation (Fig. 2).

According to Walaszczyk (2008), the Cretaceous deposits of the NSB represent a single, major T-R cycle consisting of several minor, unspecified cycles. This is in line with Milewicz's (1997) opinion that the Coniacian–Santonian deposits of the NSB form the top of a regressive phase of a transgressive-regressive cycle. According to Leszczyński (2010), the Czerna and Węgliniec formations represent the final, complex regressive phase of the minor transgressive-regressive cycles.

Sandstones of the Rakowice Wielkie Formation interpreted by Milewicz (1985) as sandy wedges within predominantly marly or even calcareous deposits have been formally divided into the Wilków, Chmielno, Dobra and Żerkowice members. The lowermost Wilków Member and the uppermost Żerkowice

Fig. 3. Coniacian sandstones in the Czaple Quarry B (photo by M. Wypych)

Member correspond to the Unterquader and the Oberquader respectively, of the traditional lithostratigraphy (Fig. 2). The calcareous Przewóz Member occurs in the more western part of the NSS.

Walaszczyk (2008) correlated the boundary between the Rakowice Wielkie Formation and the overlying formations with the middle/upper Coniacian transition and put the Coniacian/Santonian boundary within the Czerna and Węgliniec formations. In the eastern part of the NSS, a significant hiatus between the Rakowice Wielkie Formation and the Nowogrodziec Member of the Czerna Formation is present (Milewicz, 1956, 1965, 1979, 1997; Walaszczyk, 2008; Leszczyński, 2010).

Leszczyński (2010) studied the Żerkowice Member exposed in the Rakowice Małe and Żerkowice quarries. The Coniacian sandstones of the Żerkowice Member exposed in the Czaple quarries (Figs. 2 and 3) are fine to medium-grained arenites (see Leszczyński, 2010). The deposits studied are well-sorted but poorly-rounded (see Milewicz, 1997). Sedimentary structures within them are not easily visible. Parallel lamination, ripple marks and large-scale cross-stratification occur locally. The laminae dip mainly to the south and south-east, towards the shore of the basin (Leszczyński, 2010). The thickness of individual sandstone beds is up to few metres. In their upper part, the sandstones are covered with a limonite crust (see Leszczyński, 2010). According to the author cited, the Coniacian sandstones are interpreted as bar and storm deposits.

A part of the Cretaceous sedimentary sequence has been uplifted and eroded due to tectonic Turonian–Paleogene activity (Solecki, 1994). The present-day remains of the North Sudetic and Intra Sudetic Cretaceous basins originally formed a narrow, shallow marine strait (Scupin, 1910, 1936) being influenced by both the Boreal and Tethyan realms (Fig. 4). The northeastern and southwestern boundaries of this strait are marked by non-depositional areas of the so-called Eastern and Western Sudetic islands, ESI and WSI respectively (Biernacka, 2012). From the palaeogeographic point of view, the sites under investigation were located at the northwestern outlet of a shallow connection where deltaic to shallow marine clastic sedimentation prevailed (Wilmsen et al., 2014).

DESCRIPTION OF THE TRACE FOSSILS

Rosarichnoides igen. nov.

Derivation of name. – After the rosary-shaped form in which the type ichnospecies occurs, Greek *ichnos* = trace, and *-oides* – after ancient Greek “likeness”.

Type ichnospecies. – *Rosarichnoides sudeticus* isp. nov., type and only known ichnospecies.

Diagnosis. – A rosary-shaped and unbranched structure, which consists of regularly and alternately placed chambers (swellings) and constrictions. Chambers are spherical, elongated to pear-shaped. The burrow is without any wall and has a passive, structureless fill, similar to the host sediment. The surface of the burrow is unornamented, and rough rather than smooth.

Comparison with other ichnogenera. – *Rosarichnoides* morphologically resembles ophiomorphids in comprising tunnels with swellings (‘turn-arounds’). The presence of large swellings (diameter up to 7 cm), a passive fill and lack of a wall are similar to *Thalassinoides saxonicus* (Geinitz, 1842). By contrast with the characteristic T- or Y-shaped branchings of *Thalassinoides* (e.g., Myrow, 1995), *Rosarichnoides* is unbranched. The only very large *Thalassinoides saxonicus* was recently reported by Göhler (2011a, b) from the Cenomanian of Saxony (Germany), illustrated mainly by drawings. Its dimensions, especially of the swollen chamber (up to 7 cm), are similar to those of our specimen. It differs from *Rosarichnoides* in having branches and a single swelling at the end of the tunnel. In comparison to *Ophiomorpha* Lundgren, 1891, the new ichnogenus does not have a pelleted wall (see Frey et al., 1978). *Rosarichnoides* also does not possess as abundant scratches (distinctive, longitudinal ridges) as does *Spongeliomorpha* Saporta, 1887.

This new ichnogenus shows some similarities to Type II (multiple-resting-place type) specimens of *Psilonichnus quietis* Myint, 2001 in having swollen chambers connecting with tunnels (Myint, 2001: fig. 2B). The swellings of this *Psilonichnus* have four different shapes (Myint, 2001: fig. 5), but only one of them (Myint, 2001: fig. 5B) resembles swellings of *Rosarichnoides*. However, in comparison to the oval to pear-shaped chambers of *Rosarichnoides,* this type of swelling in *Psilonichnus* is distinctly semi-triangular shaped (e.g., Myint, 2001: figs. 11, 14A; 2009: fig. 2). In addition, these swellings are pointed in the same direction and the constrictions of *Psilonichnus quietis* are much longer than those of *Rosarichnoides*. On the other hand, the diameter of the new ichnogenus is twice as large as is *Psilonichnus quietis*.

Regular bulb-shaped swellings also characterize *Asterosoma ludwigae* Schlirf, 2000, but these radiate from a circular central axis and have internal concentric structures (see Neto de Carvalho and Rodrigues, 2007). *Rosarichnoides* differs from *Asterosoma* in having a different orientation and in the shape (pear-shaped) of the swollen chambers, which are structureless.

A similar morphology of the burrow, which consists of a cylindrical tunnel with regularly distributed chambers, is seen in *Halimedides* Lorenz von Liburnau, 1902. In comparison to

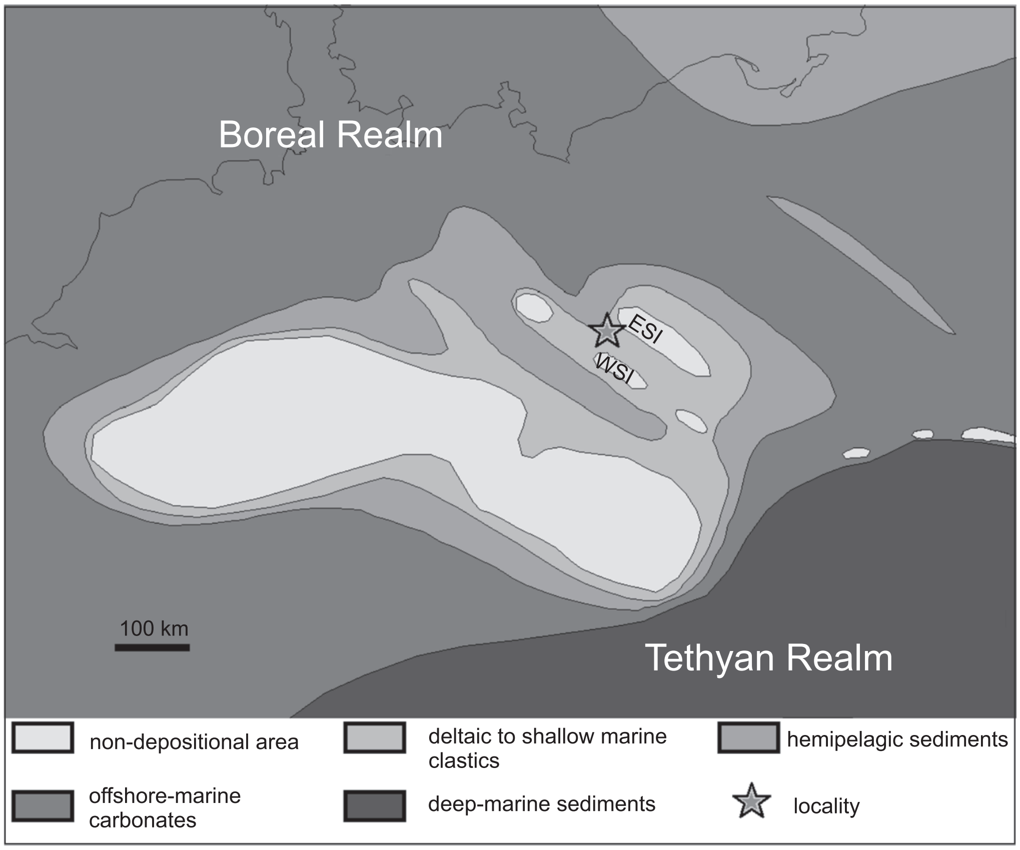

Fig. 4. Palaeogeographic position of the site under investigation (based on Wilmsen et al., 2014, modified)

WSI – Western Sudetic Island, ESI – Eastern Sudetic Island

Rosarichnoides this ichnogenus has heart-shaped chambers (two chambers symmetrically and bilaterally distributed on the both sides of tunnel; see Gaillard and Olivero, 2009: figs. 10, 15-17) and much smaller dimensions (up to 2.5 mm tunnel diameter, 100 mm length of tunnel).

A rosary-like trace (resembling pearls) of unknown origin (see Häntzschel, 1975: fig. 43/3; Uchman, 1998: fig. 11) is also seen in *Hormosiroidea* Schaffer, 1928. This consists of very small hemispherical or spherical chambers (up to 1 cm) connected by a horizontal thin string (diameter up to 2 mm). It differs from *Rosarichnoides* not only in dimensions, but also in the different shape of the bulbs, and in the occurrence of additional oblique strings, locally branched, emerging from the chambers. Additionally, the surface of some specimens of *Hormosiroidea* is coarsely granulose.

Rosarichnoides sudeticus isp. nov.
(Fig. 5A–L)

?partim 1842 *Spongites Saxonicus m. Schultze* – Geinitz, p. 96, Taf. XXIII, fig. 2.
partim 1852 *Spongia saxonica* Geinitz (*Cylindrites spongioides* Göppert) – Otto, p. 20–21, Taf. 6, fig. 1.
?partim 1909 *Cylindrites spongioides* Goepp. emend. – Richter, p. 8–11, Taf. XI, fig. 1.

Type material and occurrence. – Holotype – one specimen (natural cast of the burrow) figured in Figure 5A and its eight parts figured in Figure 5B–I, a private collection of A.M. Sroka now housed at the Geological Museum of the University of Wrocław (MGUWr 6650s). The specimen has been extracted from an isolated block of medium-grained sandstone in the Czaple Quarry B (Fig. 1B), Coniacian in age, North Sudetic Synclinorium.

Derivation of name. – After the Sudety Mountains, the region where the species was found.

Diagnosis. – The burrow consists of asymmetrical, mainly pear-shaped chambers connecting with a tunnel. The constrictions are distinctly shorter than the swellings (chambers). The diameter of the swellings is over twice as large as the diameter of the constrictions. The surface of the trace fossil is rather rough, mostly unornamented, but local sand knobs, furrows and ridges can be present.

Description. – The orientation of the specimen studied is unfortunately unknown, because it was found in a sandstone block. It comprises a sand-filled burrow, with alternating swellings and constrictions and lacking branches. This large burrow is 127 cm long, but this is not the total length, because the specimen is broken at both ends. It consists of 8 asymmetrical, spherical to pear-shaped chambers (swellings), 5.6–6.4 cm across, and constrictions between them, which are 2.06–2.86 cm across (Fig. 5A; Table 1). The chambers are arranged on both sides of the tunnel at different angles (Fig. 5A). Their length (parameter c; Fig. 6) varies from 9.55 to 12.5 cm (Table 1). The constrictions are 2.6–8.5 cm long. Parameter b1/a1 varies from 2.2 to 2.8 (Fig. 6; Table 1). The burrow is elliptical or rarely circular in cross-section and its parameter a1/a2

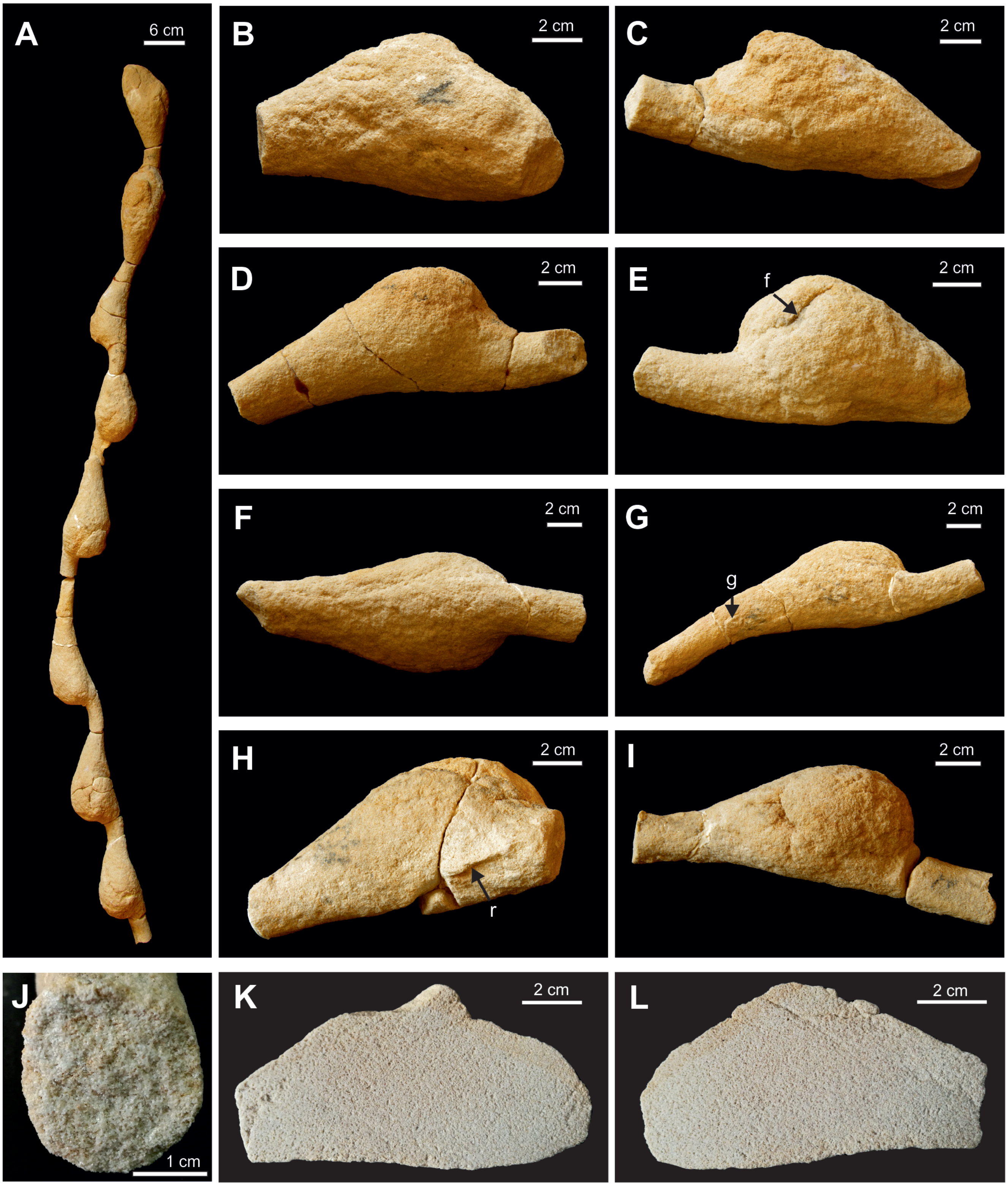

Fig. 5. *Rosarichnoides sudeticus* igen. et isp. nov. from the Czaple Quarry B, housed at the Geological Museum of the University of Wrocław (MGUWr 6650s)

A – the whole specimen (eight elements); **B–I** – isolated fragments of *Rosarichnoides sudeticus* igen. et isp. nov. illustrated in order from 1 (B) to 8 (I); **J** – cross-section of the constriction (fragment of the burrow shown in Fig. 5I); **K, L** – longitudinal sections of the swollen chamber illustrated in Figure 5B; f – furrow, g – sand granule (knob), r – ridge

Table 1

Values of morphometric parameters of *Rosarichnoides sudeticus* igen. et isp. nov. [cm]

No. of part	a1	a2	a3	a4	b1	b2	c	d = b1 – a1	l	a1/a2	a3/a4	b1/b2	b1/a1
1	2.5	2.43	2.73	2.06	5.85	4.4	11.5	3.35	16	1.029	1.325	1.33	2.34
2	2.22	2.36	2.1	2.35	5.6	5.21	12.5	3.38	21	0.941	0.894	1.075	2.5225
3	2.46	2.25	2.34	2.2	6.35	5.5	11.32	3.89	17.5	1.093	1.064	1.155	2.5813
4	2.23	2.1	–	–	6.4	5.75	9.55	4.17	14.17	1.062	–	1.113	2.87
5	2.62	2.46	–	–	6.02	5.08	11.62	3.4	11.62	1.065	–	1.185	2.2977
6	2.5	2.36	2.64	2.38	6.06	5.7	11.84	3.56	16.2	1.059	1.109	1.063	2.424
7	2.86	2.45	2.23	2.37	6.24	5.38	11.6	3.38	12.5	1.167	0.941	1.16	2.1818
8	2.7	2.45	2.55	2.19	5.97	5.46	10.18	3.27	13.84	1.102	1.164	1.093	2.2111

For parameters see Figure 6

varies from 0.94 to 1.17; parameter a3/a4 is between 0.89–1.32 and parameter b1/b2 varies from 1.06 to 1.32 (Table 1; Fig. 6). The burrow is without any wall or lining. The cross-sections of the burrow show that the fill is passive and structureless (Fig. 5J–L), the same as the host rock. The outer surface is rather rough and usually lacks ornamentation. Four indistinct oval sand knobs (measuring 0.5/0.7 cm; 0.6/1 cm; 0.9/1cm; 0.7/1.2 cm) have been observed on two swellings (Fig. 5G). On the outer surface of the swellings, rare furrows, 2-5 cm long, are also present (Fig. 5E). They are variously oriented, mostly obliquely, and they might be poorly preserved scratch traces. Additionally, one short thin "ridge", 3 cm long and ~2 mm wide, occurs on the surface of a swelling (Fig. 5H).

Discussion. – Designation of the studied specimen was difficult because the most similar forms were described or illustrated in 19th and at the beginning of the 20th centuries. These forms are incomplete, showing various preservation conditions and were classified in different taxonomic groups. However, part of Göppert's 19th century collection was re-discovered in the Geological Museum of the University of Wrocław, which allowed observation of some details on the real specimens and comparison with the form studied.

Similar forms, undoubtedly trace fossils, probably *Thalassinoides*, were first described by Schulze (1760: tab. 2, figs. 1–5) as crinoid remains or cavities left by vagile starfish. This ichnotaxon was originally described by Geinitz (1842) as a sponge, *Spongites saxonicus*. However, only one of his specimens is unbranched and has two spherical swellings (Taf. 23, fig. 2) and the other (Taf. 23, fig. 1) is branched and has a narrow longitudinal ridge on the upper part and a clearer granular ornamentation. The latter specimen was ascribed by Kennedy (1967) to *Thalassinoides saxonicus,* while the first one was included in *Ophiomorpha nodosa*. In our opinion, the last assignation should be revised. Geinitz's specimen (tab. 1, fig. 2) is unbranched and has alternating oval swellings and constrictions, similar to *Rosarichnoides sudeticus* isp. nov., which indicates the affiliation to this ichnogenus.

Granular ornamented forms with swollen and narrowing chambers were also described by Göppert (1842) as the fucoid alga *Cylindrites spongioides* (tabs. XLVI/1–5; XLVIII/1–2, p. 115), but they are undoubtedly ichnofossils. According to Kennedy (1967), Göppert's figures 1–4 in tab. XLVI may show crustacean burrows, possibly *Ophiomorpha*. We agree with his opinion. Additionally, a part of the Göppert's Wrocław collection, which has not been published, supports this view. Specimens (cat. no. MGUWr – 2883p from Bohemia, MGUWr – 7372p from Saxony, MGUWr – 5648p from Bystrzyca Kłodzka) assigned to *Cylindrites spongioides* Göpp. have some features of ophiomorphids (Fig. 7A–D). Three of them (2883p – two specimens; 7372p; Fig. 7A, D) are horizontal tunnels (from 2 to 4 cm across) with Y-shaped bifurcations and granulated walls, which are characteristic of *Ophiomorpha* (see Bromley and Frey, 1974; Frey et al., 1978). One of them (5648p; Fig. 7B, C) is a fragment of a much thinner tunnel (1.3 cm across), 22 cm long, with one flat extended chamber (3.5 cm across), which displays a poorly visible granulated wall. It is probably *Ophiomorpha* too. According to many authors (e.g., Gibert and Ekdale, 2010; Wiest et al., 2016). *Thalassinoides* never possesses pelleted walls. It is not excluded that the difficulties in recognition of these ichnotaxa are caused by the possibility that some of them are transitional forms between *Thalassinoides* and *Ophiomorpha* (see Uchman, 1991).

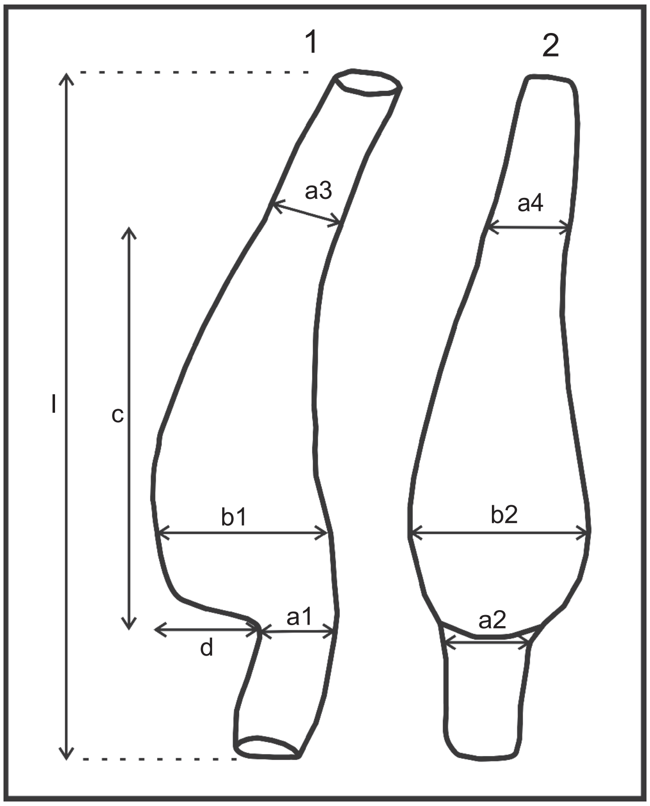

Fig. 6. Drawing of a swollen chamber and constriction of *Rosarichnoides sudeticus* igen. et isp. nov. and morphometric parameters which have been measured

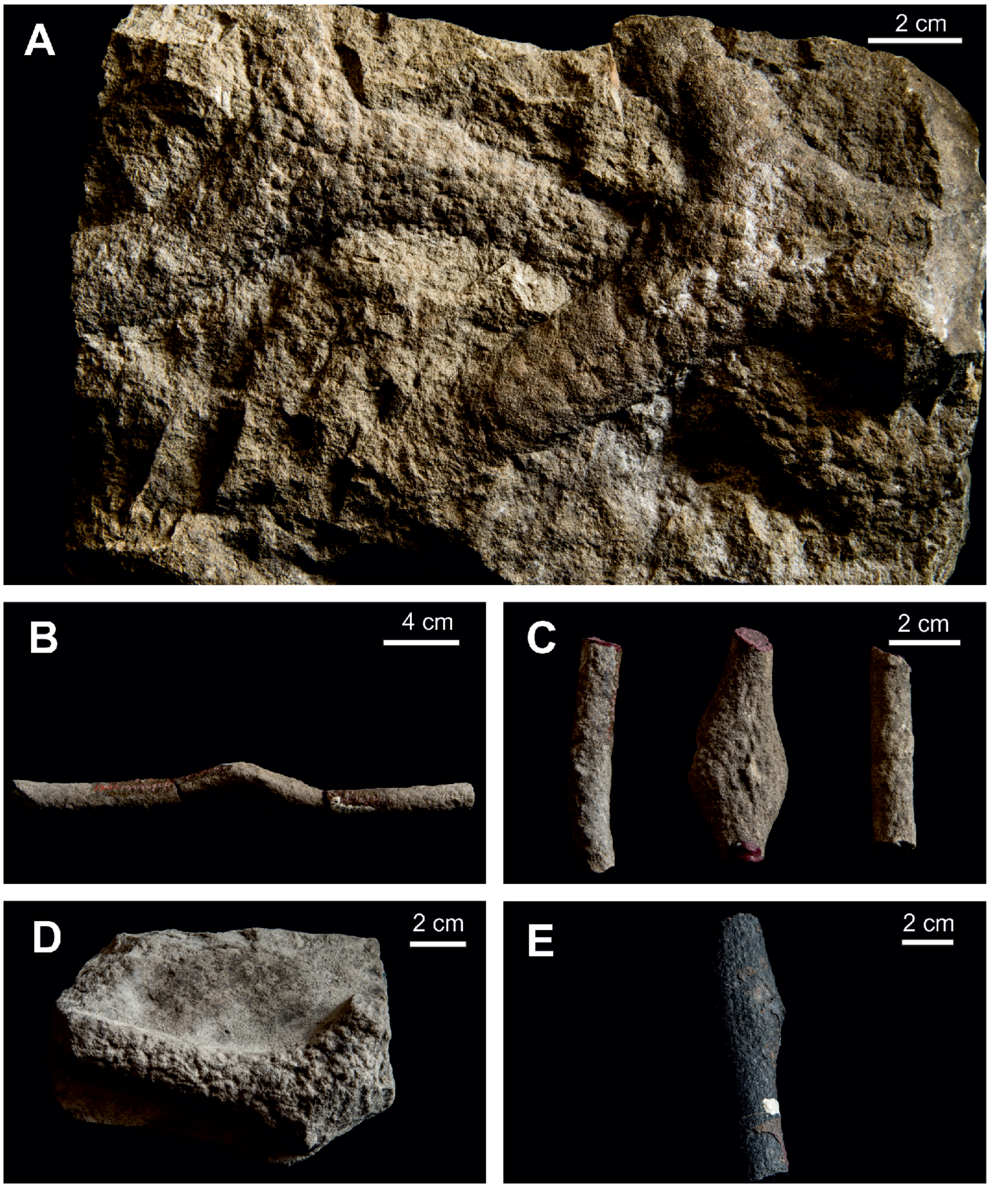

Fig. 7. Specimens from Göppert's collection from the Geological Museum of Wrocław University assigned to *Cylindrites spongioides* Göppert

Specimens A–D are ophiomorphids (probably *Ophiomorpha nodosa*), whereas specimen E is alga; **A** – cat. no. MGUWr – 2883p; **B**, **C** – MGUWr – 5648p; **D** – MGUWr – 7372p; **E** – MGUWr – 5569p

Göppert (1847) described other specimens of *Cylindrites spongioides* from the Quadersandstein (Turonian) of Bystrzyca Kłodzka. However, they have characteristic plant structures on the surface and in our opinion might be considered as algae; Göppert (1847), in describing fucoids (algae), cited ?*Spongites saxonicus*. One specimen from Göppert's Wrocław collection from Harz (cat. no. MGUWr – 5569p; Fig. 7E) is similar. It is 10.3 cm long, 1.7–2.8 cm across. It has a carbonized wall with a regular structure (alternately arranged knobs), and is probably of plant origin.

Otto (1852: Taf. VI, figs. 1–3) illustrated *Spongia saxonica* Geinitz (*Cylindrites spongioides* Göppert) from the Quadersandstein at Banewitz near Dresden. Only his specimen shown in fig. 1 is unbranched, rather smooth and has four spherical swollen chambers. Otto (1852) interpreted it as probably a juvenile form of *Spongia saxonica* Geinitz. In our opinion this specimen might represent *Rosarichnoides sudeticus* igen. et isp. nov. Kennedy (1967) cited two other branched Otto specimens illustrated on figures 2 and 3 on Taf. VI as synonyms of *Thalassinoides saxonicus* (Geinitz).

Dunker (1856) described *Cylindrites spongioides* (s. 183, Taf. XXXV, fig. 5) as algae from Blankenburg (Harz, Saxony, Germany). This specimen, with granulated swellings, is the most similar to Göppert's forms (1842) and belongs probably to *Ophiomorpha*.

Unbranched, rather smooth forms similar to *Rosarichnoides sudeticus* isp. nov., but with only one swollen chamber were reported by Frič (1883) and Dettmer (1912) from the Cretaceous of the Bohemian Basin (the Turonian of Mlada Boleslav) and Saxony (the Cenomanian and Turonian) respectively. Frič (1883) described *Spongites saxonicus* Gein. (fig. 128) and classified it within the Coelenterata, whereas Dettmer (1912) figured two specimens of *Spongites saxonicus* Geinitz (=*Cylindrites spongioides* Göppert; Taf. VIII, figs. 5, 6) and included them within the fucoides (algae). These sketched specimens are fragmentarily preserved and have longer constrictions than swollen chambers. Additionally, the shape of their swollen chambers is slightly different (symmetrical, more spherical than pear-shaped) than the chambers of *Rosarichnoides sudeticus*. The state of preservation of these specimens does not allow for assignation to *Rosarichnoides sudeticus*, but they might belong to this ichnogenus. The other Dettmer (1912) specimen of *Spongites saxonicus* Geinitz (=*Cylindrites spongioides* Göppert) is branched (Taf. VIII, fig. 4), without swollen chambers, and resembles *Thalassinoides*.

Počta (1885) described *Spongites saxonicus* (without any illustrations) as sponges (Ceratospongiae) – "body bulge-shaped or cylindrical, bifurcated with large, elongated swollen nodes from the Kreideformation of Bohemia". This description is in agreement with typical features of *Thalassinoides.*

Richter (1909) described *Cylindrites spongioides* Goepp. emend. as plant remains and illustrated them in Taf. XI–XIII, but only figure 1 in Taf. XI might be regarded as probably *Rosarichnoides sudeticus* igen. et isp. nov., while other three specimens (Taf. XI/fig. 7, Taf. XII/fig. 5, Taf. XIII/6) seem similar to *Ophiomorpha* as noted by Kennedy (1967). Richter's specimen shown in figure 1 (Taf. XI) is unbranched, has a rather rough surface and consists of two pear-shaped swollen chambers connecting with a constricted tunnel, but by contrast with *Rosarichnoides* the constrictions are longer than the swellings.

Häntzschel (1962) included *Spongites saxonicus* Geinitz and *Cylindrites spongioides* Göppert in *Ophiomorpha*, while *Spongites saxonicus* Geinitz (*nomen nudum)*, *Cylindrites spongioides* Goeppert (*nom. nud*.) and ?*Aschemonia* Dettmer, 1915 in *Thalassinoides.* Kennedy (1967) provided a detailed synonymy of *Thalassinoides saxonicus*, but he incorrectly listed some names, pages or figures in the synonymy list. He designated as lectotype of this ichnospecies one specimen of *Spongites saxonicus* Geinitz, 1842 (only fig. 1 in Geinitz). The identification of the best specimens of *T. saxonicus* in Kennedy's opinion (Kennedy, 1975: pl. 5, fig. 2; pl. 6, fig. 3) is difficult because they are covered with *Chondrites* isp. Häntzschel (1975) included *Spongites saxonicus* Geinitz, 1842 (*partim*) and *Cylindrites spongioides* Göppert, 1842 (*partim*) in *Ophiomorpha*. *Spongites* was illustrated by Häntzschel (1975) only by a drawing (fig. 1/74). The author included *T. saxonicus* (Häntzschel, 1975: fig. 70/2b) in *Thalassinoides*. Worth noticing that fig. 70/2a, described as *Thalassinoides* sp., is the same as fig. 1/74 illustrated as „*Spongites*" (see Häntzschel, 1975). In the diagnosis of the ichnogenus, the author cited typical swellings at points of branching or elsewhere. He also noted that rare transitional forms with the tuberculate structure of *Ophiomorpha* have been described.

The names *Spongites* and *Cylindrites* are not available, as they are pre-occupied. The genus *Spongites* Kützing, 1841 is assigned to algae (see Woelkerling, 1985) and the genus *Cylindrites* Sowerby, 1824 represents gastropods (Kennedy, 1967; Kollmann, 2002; Morris and Lycett, 2015).

Tracemaker and ethology. – The specimen studied resembles modern crustacean burrows. The most complex burrow systems typical of ophiomorphids are produced by members of the decapod infraorders Gebiidea and Axiidea (formerly known as thalassinideans, see Hyžný et al., 2015 and references therein). One of the most characteristic features of these infraorders is the presence of swellings (mostly interpreted as turn-arounds).

A classification of "thalassinidean" shrimp burrows based on morphological and ecological characteristics was proposed by Griffis and Suchanek (1991). Geometrically *Rosarichnoides sudeticus* igen. et isp. nov. shows similarities to Type 2 (simple branches) made by deposit feeders, which produce mounds of sediment at their opening and usually do not store seagrass in burrow chambers. This type of burrow is a simple, twisting shaft, vertically oriented, with swollen chambers. In the upper part of the burrow a Y-shaped connection to the sediment surface is observed (Griffis and Suchanek, 1991). This last feature is missing in our material, probably due to its incompleteness. Though the position of the specimen studied is unknown, it is not excluded that it was vertically oriented. The Griffis and Suchanek (1991) generalized model was criticized by some authors (Dworschak and Ott, 1993; Nickell and Atkinson, 1995; Gibert and Ekdale, 2010; Hyžný et al., 2015) due to some features, such as the lack of mounds at the openings and number of openings in the fossil record and the difficulty of assigning certain species to a burrow type.

Ethologically, *Rosarichnoides* igen. et isp. nov. represents a fodinichnion, however an agrichnion is not excluded. It seems that it is a record of a simple process of burrowing through sediments in search for food. Nevertheless such numerous and regularly distributed swollen chambers suggest the possibility of the storage of seagrass or algae, or even of gardening behaviour on the burrow chamber walls. However, there is no other evidence for these behaviours. Most callianassids are assumed to be deposit feeders and in this case they create complicated burrow systems (Hyžný and Klompmaker, 2015 and references therein). Studies on modern crustaceans (e.g., Stamhuis et al., 1996) show that they usually represent a mixture of feeding strategies.

The tracemaker of the new ichnogenus was rather a deposit or detritus feeder, which probably could leave the burrow to collect organic material for later consumption. The possible producer of this burrow was a decapod crustacean (ghost or mud shrimp or crab). According to Griffis and Suchanek (1991), 72% of the "*Callianassa*" species (infraorder Axiidae) construct Type 2 (simple branches) of the burrows. Some of the contemporary mud shrimp burrows studied by Sepahvand et al. (2014) show a similar morphology to *Rosarichnoides* (a single oblique shaft with multiple turning chambers – see fig. 4 therein). Their producer is the gebiidean *Upogebia carinicauda*, the burrows of which vary depending on the habitat type and on the physical characteristics of the sediments. According to Hyžný (2011) members of the Gebiidea and Axiidea are known to construct very complex burrow systems which can reach >1 m in depth. Some resemblance to the semitriangular swellings of Type II of *Psilonichnus quietis* Myint, 2001 (see fig. 5B therein), which was produced by deposit feeding/or scavending brachyuran crabs, also suggest these organisms as the potential tracemakers of *Rosarichnoides*.

The role of the swollen chambers in crustacean burrowing has been discussed by many authors (e.g., D'Alessandro and Bromley, 1995; Stamhuis et al., 1996; Dworschak, 2001; Lewy and Goldring, 2006). Swellings are mainly interpreted as turn-arounds, where a tracemaker could change its direction of movement. Other ethological behaviors have also been proposed (reproduction, meeting, brooding, nursery, storage). Gaillard and Olivero (2009) also proposed farming behaviour for the similar burrow *Halimedides*. According to Myint (2009), the swollen chambers of Type II of *Psilonichnus quetis* might have played different roles than turn-arounds. They are interpreted as: pauses during the process of burrowing, shelter for the trace-maker, space utilization (in some cases for breeding) and the position of greatest stability against collapse. Gaillard and Olivero (2009) suggested that the configuration of the chambers along the tunnel in *Halimedides* was organized for the ventilation of the burrow system. These authors, as well as Lukeneder et al. (2012), connected the densely and sparsely chambered burrows with various oxygenation levels of the sea floor and the character of the substrate (stiffground to firmground).

Among contemporary macrofaunal burrows, Koo and Koh (2013) described a burrow of the polychaete *Periserrula leucophryna*, which consists of a main vertical, unbranched shaft with several bulges (diameter up to 10 cm) for turn-around. Despite its general similarity to *Rosarichnoides*, this type of burrow has distinct characteristics. Its shaft is slightly sinuous, the constrictions are much longer and bulges have an irregular/oval shape and a thin short "peduncule". For these reasons such a tracemaker (a polychaete) could not produce *Rosarichnoides*.

Ichnogenus *Thalassinoides* Ehrenberg, 1944
Thalassinoides paradoxicus (Woodward, 1830)
(Fig. 8A)

1967 *Thalassinoides paradoxica* (Woodward), Kennedy, p. 142–148, pl. 3, pl. 4, pl. 8, fig. 5, pl. 9, fig. 2, text-figs 4, 5A, B.
2011 *Thalassinoides paradoxicus* (Woodward), Tiwari et al., p. 1139, pl. 4e.

Material. – One specimen found in the Żerkowice Quarry, Coniacian, North Sudetic Synclinorium.

Diagnosis. – "Sparsely to densely but irregularly branched, subcylindrical to cylindrical burrows oriented at various angles with respect to bedding; T-shaped intersections are more common than Y-shaped bifurcations, and offshoots are not necessarily the same diameter as the parent trunk" (after Howard and Frey, 1984: 213).

Description. – The specimen studied is a horizontal, irregularly branched, cylindrical and unlined burrow with a T-rather than Y-shaped branching pattern. It has variable diameter (1.0–3.0 cm) and rare swellings. The visible length is 25 cm. At the end of the burrow, Y-shape branching appears. Two T-shaped branchings are also observed (Fig. 8A). The burrow fill is the same as the host rock. The irregular pattern of branching and variable diameter allows it to be assigned to *Thalassinoides paradoxicus*.

Remarks. – *Thalassinoides* is interpreted as a fodinichnion (Bromley, 1996), domichnion (Myrow, 1995) and occasionally agrichnion (Ekdale and Bromley, 2003). According to Buatois et al. (2016), *Thalassinoides* is regarded mostly as fodinichnion. Thalassinid shrimps, ghost shrimps, lobsters, crayfish, crabs as well as fish, anemones and enteropneusts are mainly suggested as the potential tracemakers (Frey et al., 1984; Myrow, 1995; Kim et al., 2002; Ekdale and Bromley, 2003; Neto de Carvalho et al., 2007).

This eurybathic ichnotaxon may occur in the *Psilonichnus*, *Cruziana*, and even in the *Teredolites* ichnofacies (MacEachern et al., 2007, 2012). It appears also in the *Nereites* and *Zoophycos* ichnofacies. It may characterize firmgrounds (*Glossifungites* ichnofacies) and hardgrounds (*Trypanites* ichnofacies; Myrow, 1995).

This ichnogenus occurs in different marine environments, more commonly in shallow marine settings (Ekdale and Bromley, 2003; Rodríguez-Tovar and Uchman, 2004a, b, 2010; Malpas et al., 2005). In siliciclastic storm deposits, *Thalassinoides* is abundant from the distal lower shoreface to offshore settings (Pemberton et al., 2012). *Thalassinoides* is known from the Cambrian to the Recent (Myrow, 1995; Sprechmann et al., 2004; Mángano and Buatois, 2016), but is most abundant in the Mesozoic and the Cenozoic (Rodríguez-Tovar and Uchman, 2004a, b).

DESCRIPTION OF THE ASSOCIATED FOSSILS

Type: Mollusca
Class: Bivalvia
Order: Praecardioida
Family: Inoceramidae Zittel, 1881
Genus: *Inoceramus* Sowerby, 1814
Inoceramus kleini Müller, 1888
(Fig. 8C)

19121–3 *Inoceramus Kleini* Müll. var – Scupin, p. 209, Taf. 11, fig. 4a, b.
1934 *Inoceramus kleini* Müller – Andert, p. 115–117, Taf. 4, figs. 9–11, Taf. 5, figs. 1–2.
1960 *Inoceramus kleini* Müller – Radwańska, tab. 1, fig. f.
1991 *Inoceramus kleini* Müller – Tarkowski, p. 109–110, tabl. 13, fig. 7; tabl. 14, figs. 2, 3.
1996 *Inoceramus kleini* Müller – Walaszczyk, p. 386, fig. 8E.

Material. – One external imprint of a right valve found in the Czaple Quarry A (Fig. 1B).

Description. – The valve is very convex, small, with a strong and sharp beak. Axial length is 7 cm. Secondary axis is ~5.5 cm. Ventral margin is gently rounded. Hinge line is partially visible. Ornamentation of the valve consists of concentric and regular rugae. The ribs are 0.5–0.8 cm apart. The specimen does not differ from similar specimens described by Scupin (1912–1913), Radwańska (1960), Tarkowski (1991) and Walaszczyk (1996).

Occurrence. – Scupin (1912–13) described this species from the upper Coniacian of the North Sudetic Synclinorium (Gaszów, formerly Gehnsdorf). Radwańska (1960) cited this taxon from the Coniacian of the Upper Nysa Kłodzka Graben. According to Tarkowski (1991), this species occurs in the lower Coniacian of East Europe, the middle Coniacian of the Opole Trough, the Coniacian of Germany and Poland. Walaszczyk (1996) described *I. kleini* from the lower middle Coniacian of Saxony and Bohemia. Walaszczyk et al. (2004) cited early forms of *Inoceramus kleini*, from the upper lower and lower middle Coniacian of the Euramerican biogeographic region.

Inoceramus sp.
(Fig. 8B)

Material. – One specimen of a left valve, the Czaple Quarry A (Fig. 1B).

Description. – Large, convex valve, with a strong beak. Axial length is 20 cm. Secondary axis is ~14 cm. Ventral margin is gently rounded. Hinge line is partially visible. Ornamentation of the valve consists of concentric, regular rugae (up to 1.5 cm spacing), which are poorly visible due to the state of preservation.

Remarks. – The specimen is very similar to Scupin's form (1912–13: Taf. 9, fig. 14) of the upper Coniacian of Czaple (former Hockenau). The author described large inoceramids, which are 18–24 cm long as *Inoceramus* nov. spec. (ex. aff.

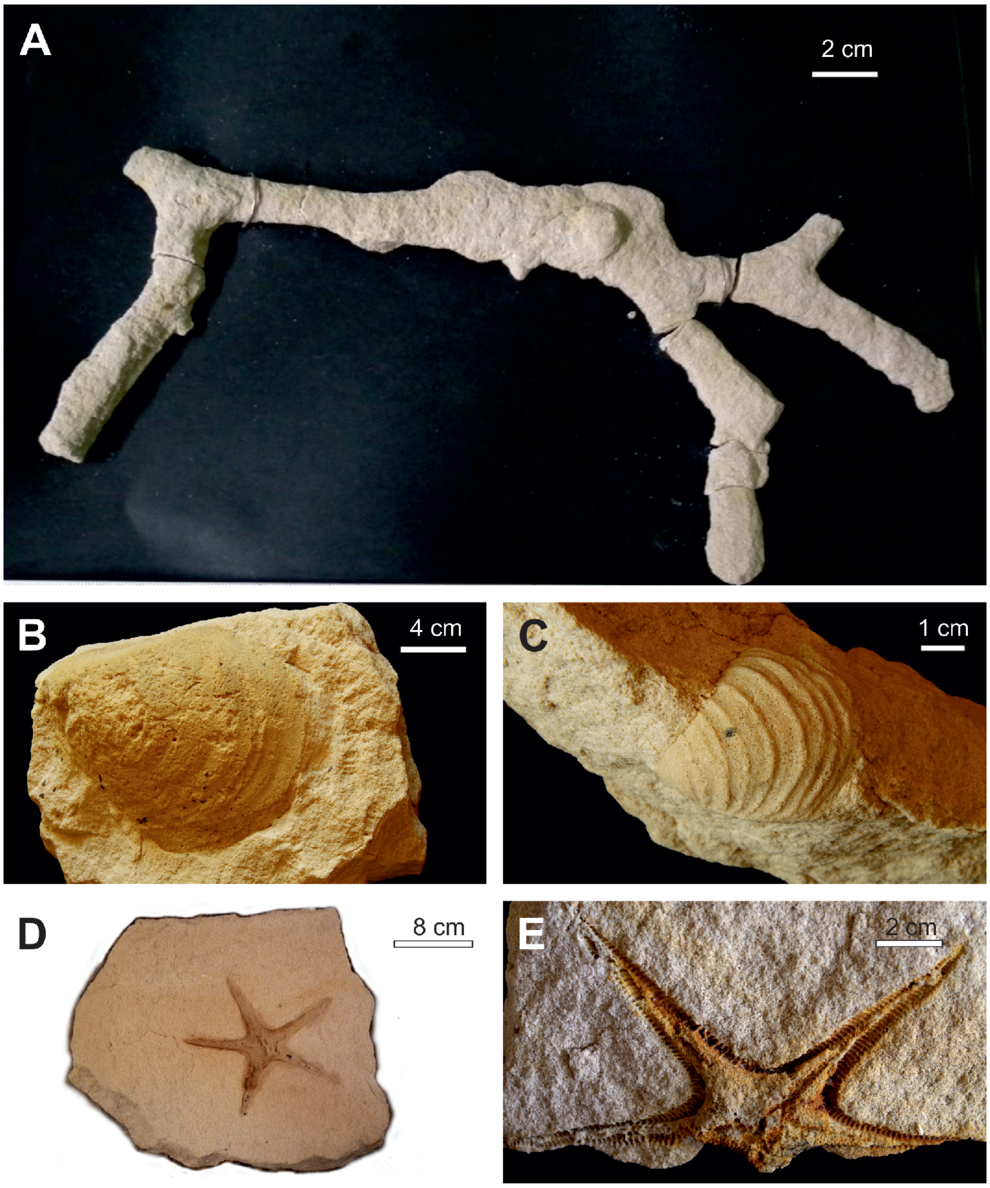

Fig. 8. Associated trace and body fossils

A – *Thalassinoides paradoxicus* (Woodward, 1830), Żerkowice Quarry; **B** – *Inoceramus* sp., Czaple Quarry A; **C** – *Inoceramus kleini* Müller, 1888, Czaple Quarry A; **D**, **E** – *Astropecten scupini* Andert, 1934, Czaple Quarry B (the same specimen, positive and negative)

cycloidis Wegner). The poor state of preservation of our specimen does not allow determination at the species level.

Types: Echinodermata
Class: Asteroidea
Order: Paxillosida
Family: Astropectinidae Gray, 1840
Genus: *Astropecten* Gray, 1840
Astropecten scupini Andert, 1934
(Fig. 8D, E)

19121–3 *Astropecten* nov.spec. – Scupin, p. 256, Taf. 15, fig. 5.
1934 *Astropecten scupini* n. sp. – Andert, p. 71, Taf. 19, fig. 24.

Material. – One imprint of the oral part of the endoskeleton found in the Czaple Quarry B (Fig. 1B).

Description and remarks. – Pentagonal form with well-preserved marginal spines. Its arms are elongate and pointed. The diameter is 16 cm and the length of the arm from the centre is ~8 cm. The ambulacral groove is only partially preserved. Mouth is not visible.

Occurrence. – Scupin (1912–13) described this species from the upper Coniacian of Czaple (Hockenau) of the North Sudetic Synclinorium. Andert (1934) cited this taxon from the upper Turonian of Saxony and Sudetes, and Soukup (1938) from the upper Turonian of Jičin (Czech Republic).

PALAEOENVIRONMENT

In the Coniacian sandstone of the Żerkowice Member (Czaple and Żerkowice quarries), a poor assemblage of fossils and trace fossils was found. Among them the interesting crustacean burrows *Rosarichnoides sudeticus* igen. et isp. nov. and

Thalassinoides paradoxicus (Woodward, 1830) are present. A very well-preserved starfish *Astropecten scupini* Andert, 1934 and some inoceramids *I. kleini* Müller, 1888 and *Inoceramus* sp. were also found.

The most probable tracemakers of the new ichnogenus *Rosarichnoides* belong to decapod crustaceans (shrimps or true crabs), which are important elements of marine as well as brackish and freshwater environments (Dworschak, 2000; Hyžný et al., 2015). Dworschak (2000) cited the worldwide distribution of recent axiidean and gebiidean mud shrimps in all oceans from temperate, tropical and subtropical latitudes (60° north and south). According to Dworschak (2000, 2005), 95% of known callianassid crustacean species inhabit shallow-water (0–200 m) environments. Most of the fossil ghost shrimps have been reported from shallow-water deposits and they are the most important bioturbators (see Hyžný and Klompmaker, 2015). Burrowing crabs are typical of intertidal areas (upper-intertidal zone) and they do not build their burrows below the fair-weather wave-base (see Hyžný et al., 2015 and references therein).

Thalassinoides is a common trace fossil in the *Cruziana* ichnofacies. It characterizes mainly the proximal *Cruziana* ichnofacies (see ichnological-sedimentological model of Pemberton et al., 2001, 2012), which is located in the distal lower shoreface. The occurrence of *Thalassinoides* in such an environment (distal lower shoreface/upper offshore) was reported by several authors (e.g., Uchman and Krenmayr, 2004; Pervesler et al., 2011; Angulo and Buatois, 2012). Individual occurrences of this ichnogenus may be found in shallower settings such as the upper and middle shoreface (Leszczyński, 2010; Buatois and Mángano, 2011; Mayoral et al., 2013). *Thalassinoides* is an indicator of a well-oxygenated environment (Buatois and Mángano, 2011) and its most probable producers (shrimps) prefer shallow water of normal salinity (Weimer and Hoyt, 1964; Frey et al., 1978).

In the Sudetes, *Thalassinoides* has been described from the Carboniferous by Muszer and Uglik (2013), from the Middle Triassic, Lower Muschelkalk (Chrząstek, 2013a) and from the Upper Cretaceous (Rotnicka, 2005; Leszczyński, 2010; Chrząstek, 2013b, c; Chrząstek and Sołczerski, 2016). Rotnicka (2005) cited this ichnogenus from the Cenomanian and Turonian of the Stołowe Mountains (Intra-Sudetic Synclinorium) from offshore/shelf settings. Leszczyński (2010) recorded this ichnogenus from the Żerkowice Member (Rakowice Małe, Coniacian), from foreshore to upper shoreface deposits, and from the Nowogrodziec Member (Rakowice Małe, Santonian) from a coastal plain setting. Chrząstek (2013b, c) and Chrząstek and Sołczerski (2016) described this ichnogenus from the middle Turonian and Coniacian of the Upper Nysa Kłodzka Graben (Bystrzyca, Długopole, Idzików, Stary Waliszów) from lower shoreface to upper offshore deposits.

Inoceramids (*Inoceramus kleini* and *Inoceramus* sp.), as found in the Coniacian sandstones, are very common and cosmopolitan in Mesozoic marine shelf environments (see Ozanne and Harries, 2002; Kumagae et al., 2011; Chrząstek, 2012). As eurytopic organisms they had broad ecological tolerances and are known from well-oxygenated, shallow marine to poorly oxygenated, deep-marine settings (Harries and Ozanne 1998; Ozanne and Harries, 2002).

The presence of the starfish *Astropecten scupini* also suggests shallow marine settings. Astropectenids used to occur in abundance down to a water depth of 50 m (Beddingfield and McClintock, 1993). According to Villier et al. (2004), astropectenids are found predominantly in shallow shelf environments (shoreface). These starfish are well-adapted to soft-bottom substrates, being detritivores and predators of gastropods, bivalves and crustaceans (Caregnato et al., 2009; Blake and Guensburg, 2016). According to these authors, starfish (including astropectenids) live in up to 30 m water depth, in some cases up to ~80 m. However, Baeta et al. (2016) reported *Astropecten* from the nearshore to offshore (5–150 m) with small individuals prevailing in the nearshore (5–50 m), and larger forms in the deeper areas (50–150 m). The presence of the starfish *Astropecten scupini* suggests a shoreface setting.

Leszczyński (2010) interpreted the Coniacian sandstones of the Żerkowice Member as bar and storm deposits, which were deposited mainly in the foreshore to upper shoreface setting. This is supported by opposite directions of large-scale cross-stratification, which indicate significant variations in wave/current direction and occasionally energetic hydrodynamic conditions. However, Leszczyński (2010), who studied the deposits of the Rakowice Quarry, stated that in the adjacent quarry at Żerkowice a more diverse assemblage of trace fossils occurs, in which horizontal burrows *Ophiomorpha* and *Thalassinoides* prevail. This suggests short calmer periods and periodic conditions characteristic of the distal expression of the *Skolithos* ichnofacies (Leszczyński, 2010), located in the middle shoreface setting.

Our studies are in agreement with the sedimentological analysis of Leszczyński (2010). In the Czaple quarries we observed fine-grained, well-sorted quartz sandstones with the same sedimentary structures as Leszczyński (2010) described, which are represented by planar stratification, ripple marks and large-scale cross-stratification. In most cases the sandstones are structureless. HCS (hummocky cross-stratification) was not found. In our opinion, sedimentation took placed above the fair-weather wave base, in a moderate to high energy environment with some calmer episodes.

The assemblage of trace and body fossils studied is of low diversity. As Leszczyński (2010) stated, "the rarity of trace fossils in the Żerkowice Member may result from low stability of the sandy substrate caused by high water energy and deficiency of food in the depositional environment". The presence of the trace fossils studied (*Rosarichnoides sudeticus*, *Thalassinoides paradoxicus*) and body fossils (starfish *Astropecten scupini*, inoceramids: *Inoceramus kleini*, *Inoceramus* sp.) suggests deposition of the Coniacian sandstones in a shallow-marine environment, probably upper part of the shoreface. Recently, Chrząstek and Wypych (2016) reported a more diverse trace fossil assemblage from the Coniacian sandstones of the Czaple–Nowa Wieś Grodziska quarries, comprising *Planolites*, *Phycodes*, *Gyrochorte*, *Ophiomorpha* and *Thalassinoides* that together point to shoreface environments. On the basis of previous sedimentological and ichnological studies (Leszczyński, 2010; Chrząstek and Wypych, 2016) as well as our studies, it can be concluded that the sedimentation of the Żerkowice Member sandstones is typical of a soft-bottom, well-oxygenated and normal salinity shallow marine environment, above the fair-weather wave base (up to the middle shoreface).

CONCLUSIONS

The unique trace fossil described as *Rosarichnoides sudeticus* igen. et isp. nov. has been found in the Coniacian sandstones of the North Sudetic Synclinorium (Rakowice Wielkie Formation, Żerkowice Member, Czaple Quarry B). *Rosarichnoides* is interpreted as a characteristic rosary-shaped, unbranched and unwalled burrow, which consists of alternating asymmetrical oval to pear-shaped chambers (swellings) and constrictions. Its fill is passive and structureless, similar to the host sediment. The surface of the burrow is rough rather than smooth, but some ridges and sand knobs or furrows may occur. This new ichnogenus is distinguished from other ichnotaxa by a lack of branching, and the different orientation and shape of swellings. It may be considered a representative of an "ophiomorphid" group. Based on burrow morphology the tracemaker of *Rosarichnoides* may have been a deposit or detritus feeder among decapod crustaceans (most probably a shrimp or crab). Additionally, *Thalassinoides paradoxicus* (Woodward, 1830) as well as the starfish *Astropecten scupini* Andert, 1934, inoceramids *Inoceramus kleini* Müller, 1888, *Inoceramus* sp. have also been encountered.

The trace fossil assemblage and macrofossils support the palaeoenvironmental interpretation of the the Żerkowice Member by Leszczyński (2010). The Coniacian sandstones studied were probably deposited in the foreshore to middle shoreface (archetypal *Skolithos* ichnofacies). Sedimentation took place in a shallow epicontinental sea, above the fair-weather wave base. Waters were well-oxygenated (*Thalassinoides*) and of normal salinity (shrimps, starfish). The sedimentation of the sandstones studied was related to the regression that started after uplift of the southeastern part of the North Sudetic Basin.

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