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New finds of *Rusophycus* from the lower Cambrian Ociesęki Sandstone Formation (Holy Cross Mountains, Poland)

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The Ociesęki Sandstone Formation represents the *Holmia-Schmidtiellus* and the *Protolenus-Issafeniella* zones. Seven ichnospecies of *Rusophycus*, including *Rusophycus exsilius* isp. nov, are recognized in this formation. Moreover, *Rusophycus* ispp. A, B, C are recognized. The diagnoses for *R. dispar*, *R. crebrus* and *R. magnus* have been emended and the stratigraphic range of *R. versans* has been extended. The presence of *Rusophycus dispar* may suggest a palaeozoogeographical connection between the Małopolska Block, the Baltica palaeocontinent and the Laurentia palaeocontinent.

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Key words: Holy Cross Mountains, Ociesęki, lower Cambrian, trace fossils, *Rusophycus*.

INTRODUCTION

The Cambrian system in the Holy Cross Mountains is composed of a succession of clastic deposits, with a total thickness in excess of 2500 m (e.g., Orłowski, 1975, 1988, 1992, 1997; Kowalczewski *et al.*, 2006).

The studied area is a part of the southern block (Kielce Unit) of the Holy Cross Mountains, which is the northern part of a larger tectonic block called the Małopolska Block (e.g., Buła, 2000; Cocks and Torsvik, 2005). The Ociesęki Sandstone Formation was deposited in a marine basin, which according to current views was situated close to the Baltica palaeocontinent (e.g., Cocks, 2002; Cocks and Torsvik, 2005, 2006).

The trilobites of the Ociesęki Sandstone Formation have been the topics of several papers (Samsonowicz, 1959; Orłowski, 1974, 1983, 1985, 1987; Żylińska and Masiak, 2007). Trace fossils from this formation were described by Orłowski *et al*. (1970), Pacześna (1985), Orłowski (1989, 1992) and Orłowski and Żylińska (2002). The cited papers contain systematic descriptions and data on the stratigraphic ranges of these trace fossils. The purpose of this study is to present new material of the ichnogenus *Rusophycus* from the lower Cambrian of the Ociesęki Sandstone Formation cropping out in the vicinity of Ociesęki, and to critically evaluate the ichnotaxonomy of *Rusophycus* in the Ociesęki Sandstone Formation. The specimens collected are housed in the Institute of Geological Sciences of the Jagiellonian University in Kraków. Several specimens from the Prof. Orłowski collection (Warsaw University) have been also analysed.

OUTLINE OF STRATIGRAPHY

The lower Cambrian Ociesęki Sandstone Formation in the Kielce Unit of the Holy Cross Mountains consists of siliciclastic deposits of poorly constrained thickness. According to Mizerski *et al.* (1986), its thickness exceeds 1200 m in the Ociesęki and the Zamczysko ranges, in the stratotype area of this formation.

The lower part of the Ociesęki Sandstone Formation contains the trilobites *Holmia marginata* Orłowski, 1974; *H. glabra* Orłowski, 1974; *Kjerulfia orcina* Orłowski, 1974; K. *orienta* Orłowski, 1974; *Schmidtiellus panovi* (Samsonowicz, 1959); *S. nodosus* Orłowski, 1985; *Strenuella polonica* Czarnocki, 1927; *S. sandomirensis* Orłowski, 1985 and *S. zbelutkae* Orłowski, 1985, which indicate the *Holmia-Schmidtiellus* Zone (Orłowski, 1974, 1985). The upper part of the formation contains the trilobites *Kingaspidoides santacrucensis* (Samsonowicz, 1959) and *Issafeniella orlowinensis* (Samsonowicz, 1959), which point to the late early Cambrian *Protolenus-Issafeniella* Zone (Orłowski, 1985; Mizerski *et al.*, 1986; Geyer, 1990; Żylińska and Masiak, 2007).

LOCALITIES INVESTIGATED

The outcrops studied are located in the Ociesęki, Zamczysko and the Orłowińskie ranges in the central part of the Kielce Unit. The material described has been collected at six exposures on the Sterczyna, Igrzyczna, Wysokówka hills and in the Koziel village (Fig. 1).

Most of the described specimens of *Rusophycus* come from the lower part of the Ociesęki Sandstone Formation, which consists mainly of fine-grained, yellow or gray, strongly bioturbated, thin- to medium-bedded graywakes and quartz arenites. The largest number of specimens of *Rusophycus* has been found in the small pits on the eastern slope of Sterczyna Hill (GPS coordinates: N 50°43.24.7'; E 020°58.44.2') and in a small quarry near the peak of this hill (GPS coordinates: N 50°43.45.2'; E 020°58.15.5'). A smaller number of speci-

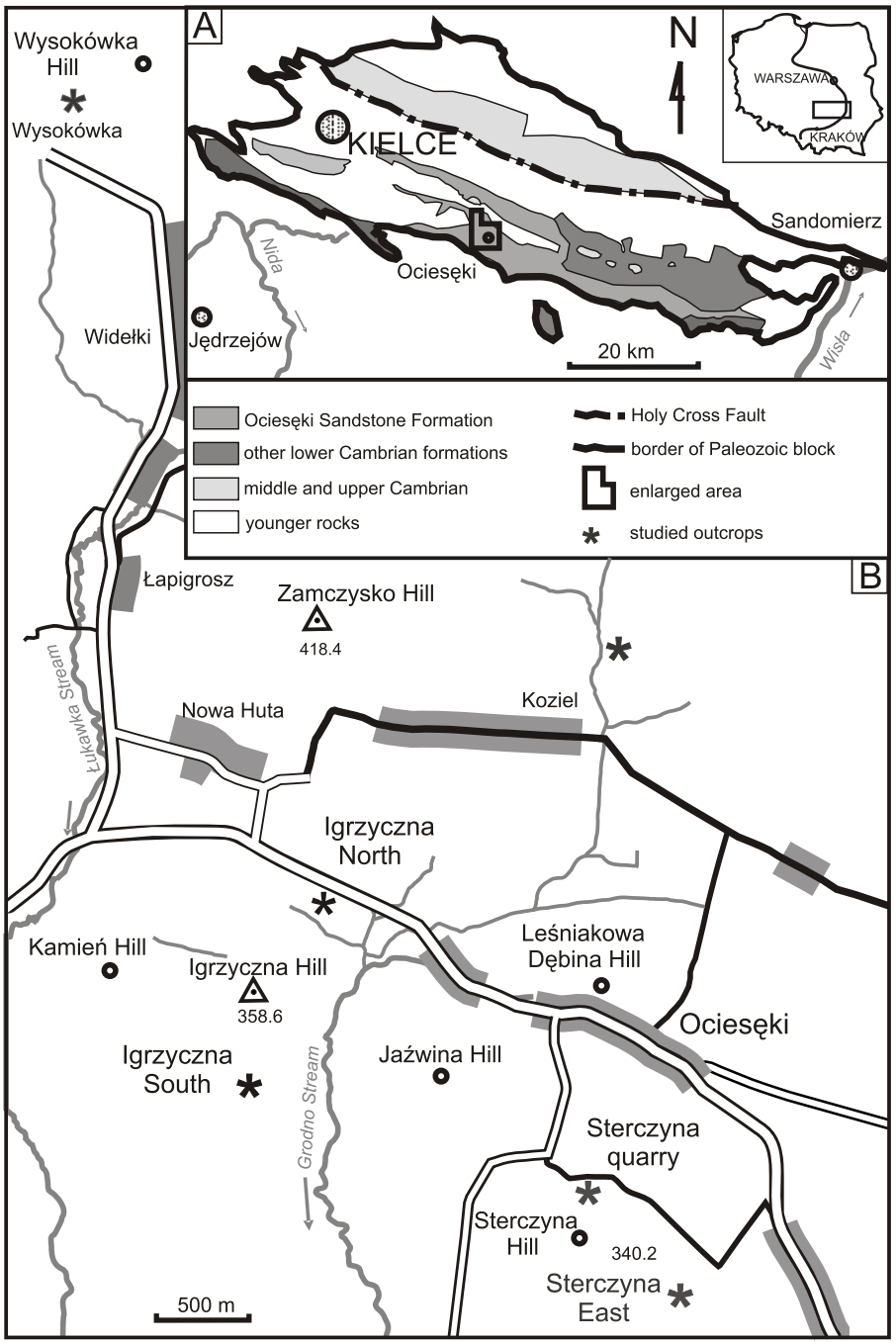

Fig. 1. Locality maps

A – locality and simplified geology map of the Paleozoic block of the Holy Cross Mountains; the geology is according to Orłowski (1975) and Mizerski *et al*. (1991);
B – topographic map of the Ociesęki area showing localities

mens has been collected in a pit at the northern foot of Igrzyczna Hill (GPS coordinates: N 50°44.39.0'; E 020°57.07.4') and in a natural exposure in the ravine on the southern slope of this hill (GPS coordinates: N 50°44.13.9'; E 020°56.44.0'). The upper part of the Ociesęki Sandstone Formation in the vicinity of Ociesęki consists of mainly hard, fine-grained, white or gray, medium-bedded quartz arenites, with varying degree of bioturbation. Four specimens of *Rusophycus* has been found here on Wysokówka Hill and only one specimen in a small pit in Koziel village (GPS coordinates: N 50°45.14.7'; E 020°58.32.5') and on the slopes of Wysokówka Hill.

SYSTEMATIC PART

Ichnogenus *Rusophycus* Hall, 1852

D i a g n o s i s. – Short, bilobate, rarely multilobate traces. Lobes predominantly bilaterally symmetrical. Convex forms (hypichnia) with a distinct median furrow; concave forms (epichnia) with median ridge. Outline ovate to coffee-bean-shaped; sculptured with oblique to transverse or longitudinal striae in various arrangements, or almost smooth (after Schlirf and Uchman in: Schlirf *et al*., 2001).

D i s c u s s i o n. – Seilacher (1970) included short oval forms, coffee-bean-shaped and long, ribbon-like traces in the ichnogenus *Cruziana* d'Orbigny, 1842. However, most authors (e.g., Keighley and Pickerill, 1996; Schlirf and Uchman in: Schlirf *et al*., 2001) retain the ichnogenus *Rusophycus* Hall, 1852. According to Keighley and Pickerill (1996), the ichnogenus *Cruziana* d'Orbigny, 1842 includes forms in which the length to width ratio is more than 2:1. This criterion, distinguishing between *Cruziana* and *Rusophycus*, is followed in this paper. *Rusophycus* is commonly interpreted as the resting or burrowing trace of arthropods (e.g., Seilacher, 2007). The Paleozoic specimens of *Rusophycus* are interpreted almost exclusively as trilobite traces (e.g., Osgood, 1970; Rindsberg, 1994). The post-Paleozoic occurences of *Rusophycus* are usually interpreted as notostracan traces (e.g., Schlirf and Uchman in: Schlirf *et al*., 2001).

Rusophycus dispar Linnarsson, 1869
(Fig. 2A–D)

*1869, *Rhysophycus dispar* n. sp. – Linnarsson, p. 353.
1871, *Cruziana dispar* Linnarsson – Linnarsson, p. 14, pl. 3.17–19.
nom. nud. 1970, "*Cruziana rusoformis* isp. nov." – Orłowski *et al*., s. 348, pl. 1a–c.
v 1970, *Cruziana* sp. – Orłowski *et al*., s. 348, pl. 1d.
1974, *Cruziana rusoformis* Orłowski, Radwański and Roniewicz, 1970 – Orłowski, p. 7, pl. 6.1–2.
1988, *Cruziana* cf. *dispar* Linnarsson, 1869 – Bergström and Peel, p. 50, fig. 8.
1990, *Rusophycus dispar* Linnarsson, 1869 – Pickerill and Peel, p. 30, fig. 12C, D.
v 1992, *Cruziana dispar* Linnarsson, 1871 – Orłowski, p. 18, figs. 3, 4.1–3.
v 1992, *Cruziana rusoformis* Orłowski, Radwański and Roniewicz, 1970 – Orłowski, p. 19, fig. 5.1–3.
v non 1992, *Cruziana dispar* Linnarsson, 1871 – Orłowski, p. 20, fig. 4.4 [retained in *Cruziana* herein].
1997, *Rusophycus dispar* Linnarsson, 1869 – Jensen, p. 81, figs. 54A, C, 55A, C.
partim 1997, *Cruziana rusoformis* Orłowski, 1992 – Jensen, p. 41, figs. 28B, 29, 30.
1999, *Cruziana rusoformis* Orłowski, Radwański and Roniewicz, 1970 – Mizerski *et al*., p. 360, pl. 1.3, 7.
2008, *Cruziana rusoformis* Orłowski, 1992 – Pacześna and Żylińska, p. 10, fig. 11.

M a t e r i a l. – Ten specimens (INGUJ214P/Mr1–6, Mr35–36, Mr57, Mr/90), and a few specimens in the collection of Prof. Orłowski (Warsaw University).

E m e n d e d d i a g n o s i s. – High, oval, symmetric hypichnion with a narrow, more or less distinct median furrow, which separates two lobes. The lobes are covered by distinct V-shaped ridges, which meet in the median furrow at an angle of 60–180°. The width of the ridges in the front and rear of the lobes can be different. The V-shaped patterns formed by the ridges are usually directed in opposite directions at the front and rear of the traces.

D e s c r i p t i o n. – Oval or slightly elongate, bilobate convex hypichnion, 70–120 mm long, 40–60 mm wide, 20–40 mm high, without distinct margins. On the surface of the lobes, distinct, regular ridges (interpreted as moulds of scratch marks), 1–3 mm wide, 3–4 mm apart, which meet in the median furrow at an angle of 60–100° and form a V-shaped pattern, oriented in one direction or in opposite directions in the front and rear parts of the oval. Generally, the ridges are thick, showing different widths in the front and rear parts of the lobes. Some of the specimens display thinner, second-order ridges on the margin of the hypichnion (e.g., Fig. 2B).

R e m a r k s. – The original diagnosis of *C. dispar* proposed by Seilacher (1970) reads:

"Deep resting tracks or nests. The proverse front leg markings with impressions of at least two small side claws on exposed front sides. Rear leg markings retroverse and finer, but always preserved except in rare procline furrows". This diagnosis has been emended here, because it was based on behaviour of the trilobite not on morphology, contrary to the recommendation of Bertling *et al*. (2006) accepted herein.

The specimens described differ in length-to-width ratios, width of the ridges and the varied angle between the meeting ridges. The ridges are moulds of scratch marks of the arthropod tracemaker.

According to Seilacher (1970), this ichnospecies typically displays oppositely-directed V-shaped casts of scratch marks. Indeed some specimens of *R. dispar* show oppositely directed V-shaped casts of scratch marks in the front and rear parts of the hypichnion while others display only unidirectional casts (Fig. 2A, B, D). Also, Pickerill and Peel (1990) included in

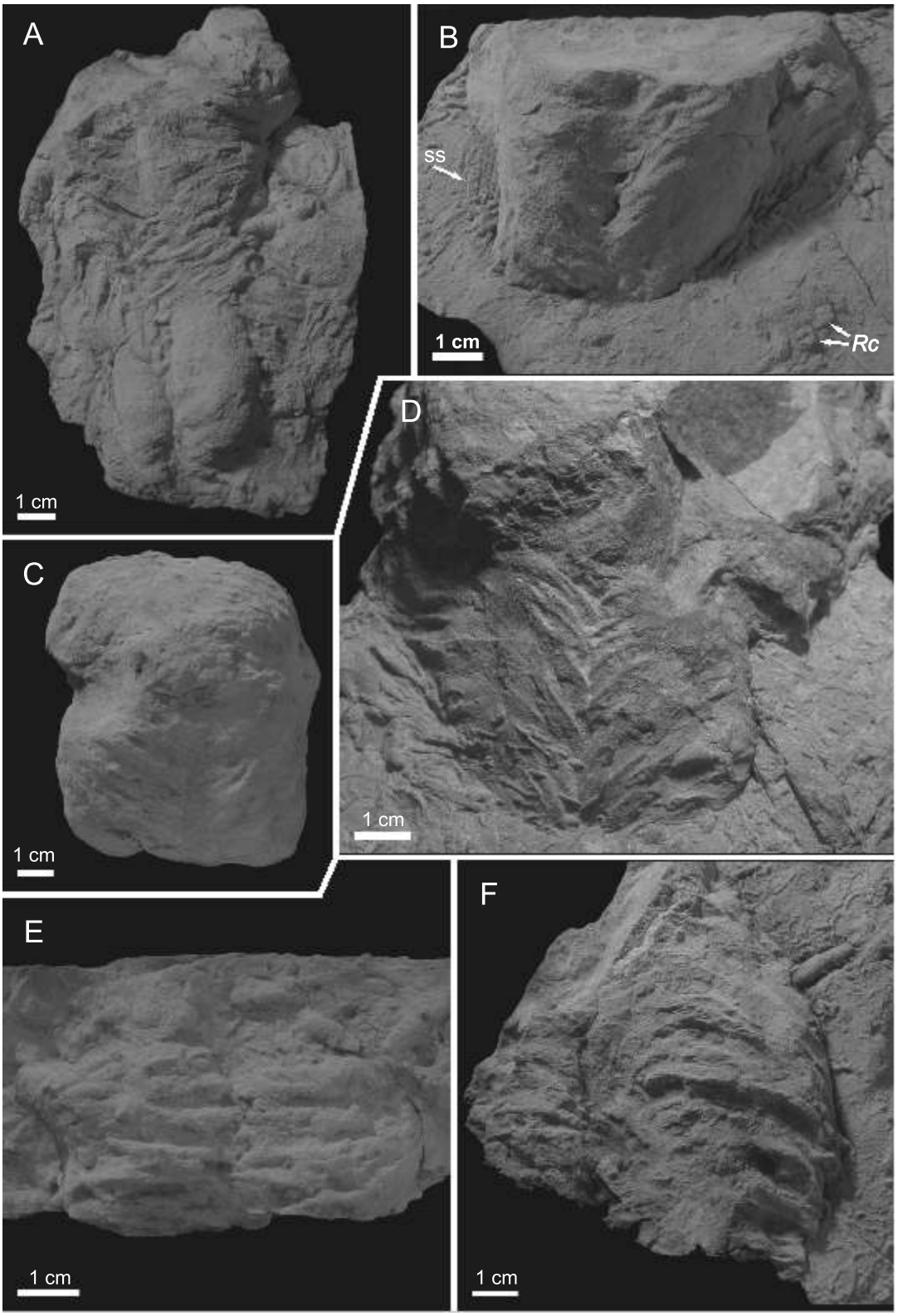

Fig. 2A–D – *Rusophycus dispar* Linnarsson, 1869; E, F – *Rusophycus* cf. *avalonensis* Crimes and Anderson, 1985; lower Cambrian, Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone

All specimens are preserved as positive hyporeliefs on the bases on thin beds of quartz arenite; A – INGUJ214P/Mr35, B – INGUJ214P/Mr1 (ss – second order scratches, *Rc* – *Rusophycus carbonarius*), C – INGUJ214P/Mr2, D – INGUJ214P/Mr4, E – INGUJ214P/IgS1, F – INGUJ214P/Mr14; A–D, F – eastern slope of Sterczyna Hill, E – southern slope of Igrzyczna Hill

R. dispar specimens without obverse scratches. According to these cited authors, Seilacher's (1970) presentation of *R. dispar* is highly schematic, without consideration of the more typical preservational variants of the ichnospecies. Linnarsson (1871) described *R. dispar* under the ichnogenus *Cruziana* d'Orbigny, 1842, but only specimens in which the length to width ratio is greater than 2 might be placed in *Cruziana* (see Keighley and Pickerill, 1996). Orłowski (1992) included slightly elongate specimens of *R. dispar* in *Cruziana* d'Orbigny, 1842, but according to the criteria for separation adopted here the short specimens should be placed in the ichnogenus *Rusophycus* Hall, 1852. Only the specimen in his fig. 4.4, is distinctly elongate and should be placed in *Cruziana*. *Cruziana rusoformis* described by Orłowski (1992) is regarded as a synonym of *R. dispar* because its differences in morphology are not clearly visible (see Pickerill and Peel, 1990). Orłowski mentioned that *C. rusoformis* differs from *R. dispar* by smaller size, but his measurements suggest otherwise. Some of the specimens of *C. rusoformis* represent an intermediate form between the typical *Rusophycus* (cubichnion) and the typical *Cruziana* (repichnion). According to Keighley and Pickerill (1996) most of the specimens previously described as *C. rusoformis* (Orłowski *et al.*, 1970; Orłowski, 1974; Orłowski, 1992; Jensen, 1997) can be placed in *Rusophycus*. The specimen described as a topotype of *C. rusoformis* (Pacześna and Żylińska, 2008, fig. 11) is a typical short cubichnion and represents *R. dispar*.

Orłowski (1992) regarded *C. dispar* as trilobite trace fossils, however, Bergström (1973) considered a non-trilobite, aglaspidid origin.

O c c u r r e n c e. – Lower Cambrian: Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone, Sterczyna Hill (this paper), Igrzyczna and Malkowska hills (Orłowski, 1992), Dallas Bugt Formation, north-west Greenland (Bergström and Peel, 1988), Norretorp Formation, Scania, Sweden (Bergström, 1973), Bastion Formation, Greenland (Pickerill and Peel, 1990), Mickwitzia Sandstone Member, Sweden (Linnarsson, 1871; Jensen, 1997).

Rusophycus cf. *avalonensis* Crimes and Anderson, 1985
(Fig. 2E, F)
Synonyms for *R. avalonensis*

* 1985, *Rusophycus avalonensis* isp. nov. – Crimes and Anderson, p. 331, figs. 5.2–3, 12.2.
? 1992, *Cruziana regularis* isp. nov. – Orłowski, p. 19, figs. 6.1–2, 4.
1999, *Rusophycus avalonensis* – MacNaughton and Narbonne, p. 107, fig. 9A.
v 2004, *Rusophycus ?avalonensis* Crimes and Anderson, 1985 – Erdoğan *et al.*, p. 352, fig. 8A.
? 2008, *Cruziana regularis* Orłowski, 1992 isp. – Pacześna and Żylińska, p. 10, fig. 10 [regarded as *Rusophycus* herein].

M a t e r i a l. – Four specimens (INGUJ214P/Mr/13–15, /IgS6).

D i a g n o s i s. – For *R. avalonensis*. *Rusophycus* consisting of fine scratch marks in bundles of five or more, arranged obliquely or transversely to the median line (after Crimes and Anderson, 1985).

D e s c r i p t i o n. – Low, bilobate, oval hypichnion about 50 mm long, 55 mm wide, 5–10 mm high, preserved in convex semirelief with indistinct margins. The lobes are separated by a shallow indistinct furrow. The surface of the lobes is covered by a few (8–9) thick slightly curved ridges, which are almost perpendicular to the median furrow. The ridges are up to 4 mm thick, 3–4 mm apart. Some ridges split into a few thinner ridges in the proximity of the margin of the hypichnion.

R e m a r k s. – The specimens analysed are similar to *Rusophycus avalonensis* Crimes and Anderson, 1985, because of the overall shape and the divided ridges but the ridges (mould of scratch marks) are not arranged in bundles.

O c c u r r e n c e. – Lower Cambrian: Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone, eastern slope of Sterczyna Hill, southern slope of Igrzyczna Hill.

Rusophycus crebrus (Orłowski, 1992) nomen correctum
(Fig. 3A, B)

*v 1992, *Rusophycus crebus* ichnosp. nov. – Orłowski, p. 28, figs. 11, 12.6.
v 2008, *Rusophycus crebrus* Orłowski – Pacześna and Żylińska, p. 13, fig. 17.

M a t e r i a l. – Four collected specimens (INGUJ214P/Mr10–11, St121, St123), four specimens in the collection of Prof. Orłowski (Warsaw University).

E m e n d e d d i a g n o s i s. – Hypichnial convex symmetrical, coffee-bean-shaped semirelief, which consists of two lobes separated by a shallow furrow. The lobes are covered by longitudinal, delicate sets of ridges. Two series of paired, rectangular lobes or longitudinal, delicate ridges can be preserved close to the median furrow. The margin of the hypichnion can be serrated.

D e s c r i p t i o n. – A coffee-bean-shaped hypichnion, with convex semirelief, which consists of two symmetrical, curved lobes separated by a shallow furrow. The entire surface of the lobes is covered by sets of delicate ridges, which are less than 1 mm wide. In the internal part of the lobes, near the furrow, small, longitudinal ridges stand 1–1.5 mm above the lobe surface. In the median furrow there may be two series of subrectangular second-order, paired lobes (interpreted as moulds of coxa) separated by a very narrow and shallow furrow. One of the specimens (INGUJ214P/Mr10; Fig. 3A) shows a serrated margin. The largest specimen is about 120 mm long, about 70 mm wide, about 50 mm high. The median furrow is 20–25 mm wide. The longest flank of the subrectangular lobes is about 8 mm long, the serrations on the margin are 10 mm long. The smallest specimen is about 50 mm long and about 45 mm wide.

R e m a r k s. – In the original description (Orłowski, 1992) this ichnospecies was described as *R. crebus*, but the correct name should be crebrus (from Latin *crebro* – repeatedly,

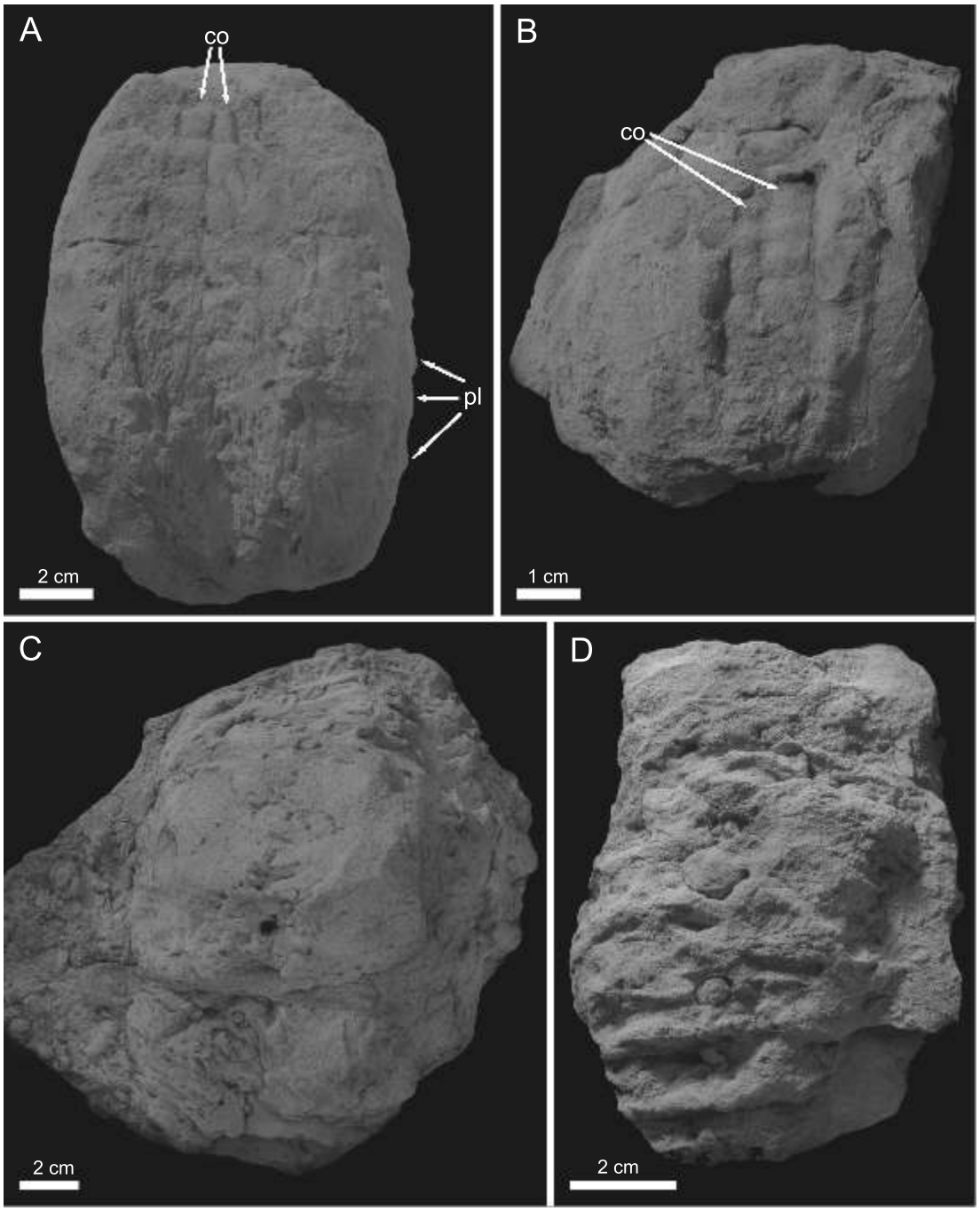

Fig. 3A, B – *Rusophycus crebrus* Orłowski, 1992, lower Cambrian, Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone, eastern slope of Sterczyna Hill; C, D – *Rusophycus magnus* (Orłowski, 1992), lower Cambrian, Ociesęki Sandstone Formation, *Protolenus-Issafeniella* Zone

Positive hyporeliefs on the bases of thin beds of quartz arenite; A – INGUJ214P/Mr10, B – INGUJ214P/Mr11 (co – moulds of coxae, pl – moulds of pleurae); C – INGUJ214P/W8, Wysokówka Hill, D – INGUJ214P/K2, Koziel

often, one after the other). An informal nomen correctum was given by Orłowski and Żylińska (2002, p. 136 and 137) and Pacześna and Żylińska (2008, p. 13). The original diagnosis (Orłowski, 1992, p. 28) reads: "Resting trace, regular, completely covered by delicate, longitudinal scratches, produced by exopodite". This diagnosis is emended herein, because the earlier diagnosis (Orłowski, 1992) contains elements of interpretation of trilobite behaviour instead of description of morphology.

The most important features of *Rusophycus crebrus* Orłowski, 1992, are the distinct lobes entirely covered by delicate, longitudinal ridges and the absence of transverse scratch marks (see Orłowski, 1992). The holotype described by Orłowski (1992) lacks some details visible in the specimens described herein, i.e. imprints of coxa and pleura. The absence of these details in the specimens in the Orłowski collection may be the result of shallower burrowing. Some of the specimens analysed herein are very similar to *Rusophycus polonicus*

Orłowski, Radwański and Roniewicz, 1970. However, *R. crebrus* form much more regular, coffee-bean-shaped shapes, having the narrowest furrow in a more central part than *R. polonicus* and having moulds of longitudinal scratch marks, which are absent in *R. polonicus* (see Orłowski *et al.*, 1971).

O c c u r r e n c e. – Lower Cambrian: Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone: Rybnica Hill (Orłowski, 1992), Sterczyna Hill (this paper).

Rusophycus magnus (Orłowski, 1992) (Fig. 3C, D)

*v 1992, *Cruziana magna* isp. nov. – Orłowski, p. 22, fig. 6.4, p. 25, fig. 8.
v 2008, *Cruziana magna* Orłowski, 1992 – Pacześna and Żylińska, p. 9, fig. 9 [with comment that included in *Rusophycus*].

M a t e r i a l. – Five collected specimens (INGUJ214P/W8–10, I/W13, /K2), two specimens in the collection of Prof. Orłowski (Warsaw University).

E m e n d e d d i a g n o s i s. – Large *Rusophycus* covered by thick ridges perpendicular to the median furrow separating the lobes. The ridges can be split into bundles of thinner ridges close to the burrow margin.

D e s c r i p t i o n. – Elongate, bilobate, convex semi-relief with an indistinct median furrow. The surface of the lobes is covered by distinct, thick ridges perpendicular or almost perpendicular to the furrow. The trace fossil is about 150 mm long and about 100 mm wide. The ridges are 2–4 mm wide and high, 2–4 mm apart. Some of the specimens are preserved only as fragments of simple lobes (e.g., INGUJ214P/K2; Fig. 3D).

R e m a r k s. – The original diagnosis (Orłowski, 1992, p. 25) reads: “Large traces with single, thick scratches associated on the lateral sides with bundles of up to five delicate scratches”. The diagnosis is emended herein because the original one (Orłowski, 1992) is based on the behaviour of the tracemaker (trilobite), and not solely on the morphology of the trace fossil.

Orłowski (1992) included this ichnospecies in *Cruziana* d’Orbigny, 1842, but its morphometric parameters (see Keighley and Pickerill, 1996) do not fit this ichnogenus.

O c c u r r e n c e. – Lower Cambrian: Ociesęki Sandstone Formation, *Protolenus-Issafeniella* Zone, Koziel (this paper) and Wysokówka Hill (Orłowski, 1992; this paper).

Rusophycus carbonarius Dawson, 1864 (Fig. 4A–E)

* 1864, *Rusophycus carbonarius* – Dawson, p. 364, fig. 3.
2002, *Rusophycus carbonarius* (Dawson, 1864) – Orłowski and Żylińska, p. 144, fig 6a.
More synonyms in Schlirf *et al.* (2001).

M a t e r i a l. – Seventeen sandstone slabs containing twenty five specimens (INGUJ214P/Ig113–114, Ig130, Mr17–29, Mr56, Mr64).

D i a g n o s i s. – Small, coffee-bean-shaped form with transverse to oblique, generally fine striations. Lobes are parallel or slightly divergent (after Schlirf and Uchman in: Schlirf *et al.*, 2001).

D e s c r i p t i o n. – Convex, coffee-bean-shaped hypichnia, 4–6 mm long, 3–5 mm wide, which consist of two symmetrical lobes separated by a distinct furrow. The lobes are parallel or divergent. The surface of the lobes is smooth. In some specimens, the median furrow does not run for the full length of the hypichnion (INGUJ214P/Mr21; Fig. 4A) resulting in a horseshoe-like shape.

R e m a r k s. – The specimens analysed do not display the stripes on the surface of lobes, perpendicular or oblique to the furrow, which is typical of *R. carbonarius* (see Schlirf *et al.*, 2001). However, according to Keighley and Pickerill (1996), the specimens analysed with smooth lobes are considered taphonomic variants of *R. carbonarius*. This ichnospecies can be produced by different arthropods. The early Cambrian *R. carbonarius* herein described was possibly produced by small or juvenile trilobites. Similar, non-trilobitic *R. carbonarius* are known also from Triassic deposits (see Schlirf *et al.*, 2001 and references therein).

O c c u r r e n c e. – Lower Cambrian: Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone, Sterczyna and Igrzyczna hills (Orłowski and Żylińska, 2002; this paper). Upper Triassic: Hassberge Formation, Vetter (Schlirf *et al.*, 2001).

Rusophycus versans Schlirf and Uchman, 2001 (Fig. 4F)

* 2001, *Rusophycus versans* isp. nov. – Schlirf and Uchman in: Schlirf *et al.*, p. 80, fig. 9, 10A–E.
2008, *Rusophycus versans* Schlirf *et al.*, 2001 – Pollard *et al.*, p. 402, fig. 4A–D.
2008, *Rusophycus versans* Schlirf and Uchman, 2001 – Machalski and Sadlok, p. 73 [not figured].
2010, *Rusophycus versans* Schlirf and Uchman, 2001 – Sadlok and Machalski, p. 119, pl. 1.1–6.

M a t e r i a l. – One specimen (INGUJ214P/Mr26).

D i a g n o s i s. – Clusters of short, poorly sculptured, bilobate, coffee-bean-shaped, hypichnial mounds, displaying additional, more or less fan-like or irregularly arranged lateral lobes (after Schlirf *et al.*, 2001).

D e s c r i p t i o n. – Convex hypichnion, 20 mm long, consisting of a few (about 7) coffee-bean-shaped elements displaced with regard to each other and partly overlapping, resulting in a morphology similar to *Rusophycus carbonarius* Dawson, 1864. These elements contain more or less distinct lobes, which are separated by a furrow. Three of the elements are arranged in a curved ribbon, other elements form a fan-like arranged rosette. The simple elements are about 4 mm long and about 2 mm wide.

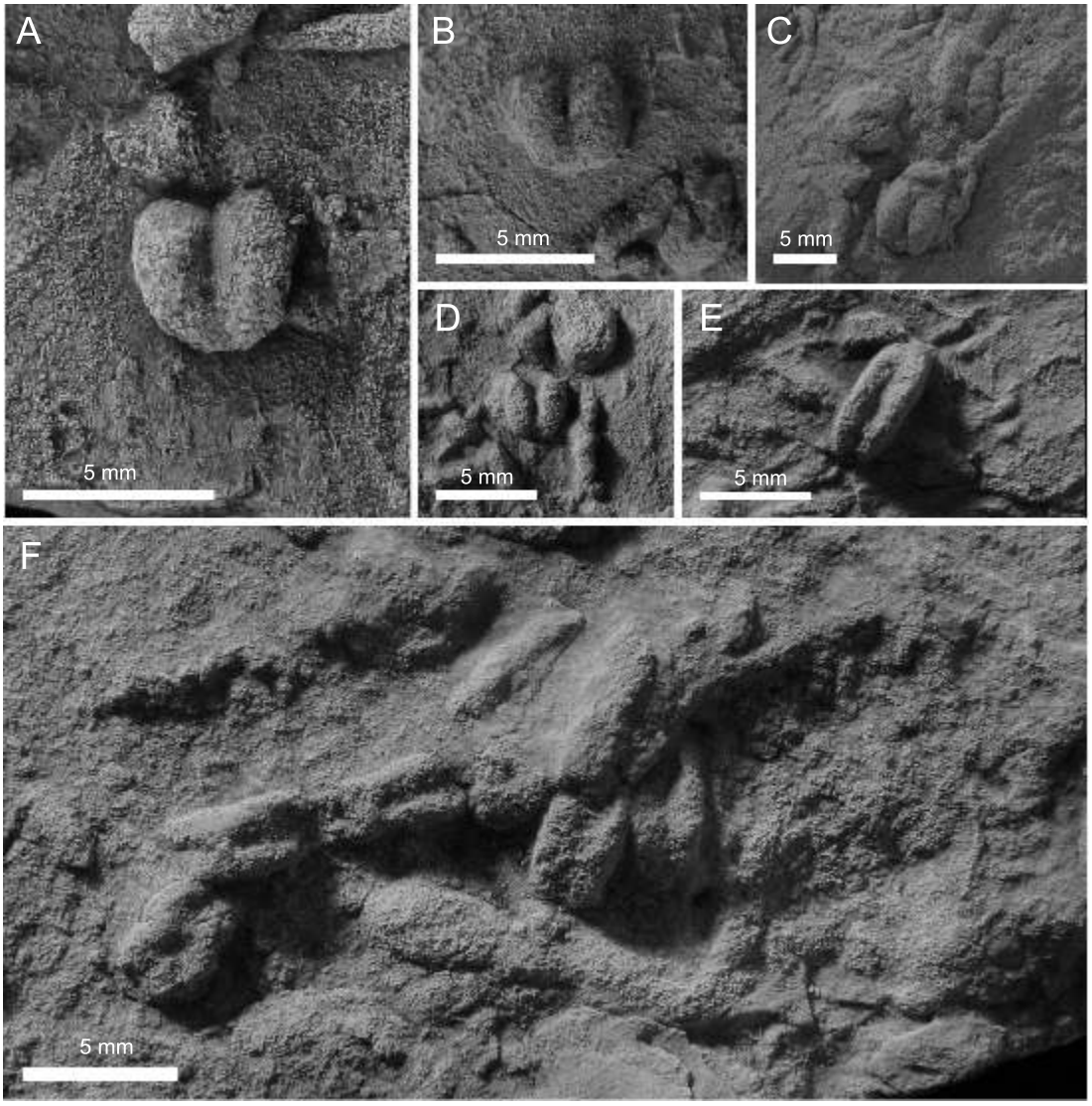

Fig. 4A–E – *Rusophycus carbonarius* Dawson, 1864; F – *Rusophycus versans* Schlirf and Uchman, 2001; lower Cambrian, Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone

Positive hyporeliefs on the bases of thin beds of quartz arenite; A – INGUJ214P/Mr21, B – INGUJ214P/Mr19, C – INGUJ214P/Mr17, D – INGUJ214P/Mr18, E – INGUJ214P/Ig113, F – UJ215P/Mr26; A–D, F – eastern slope of Sterczyna Hill, E – northern slope of Igrzyczna Hill

R e m a r k s. – The specimen analysed is similar to *Rusophycus versans* Schlirf *et al*., 2001, which is interpreted as a structure formed during rotary motion of the tracemaker, enabling it to exploit the sediment more efficiently (Schlirf *et al.*, 2001). The type material of this species was probably made by notostracan crustaceans (Schlirf *et al.*, 2001), whereas the Cambrian specimens were probably produced by trilobites (Sadlok and Machalski, 2010). The presence of *R. versans* in the lower Cambrian of the Ociesęki Sandstone Formation extends the stratigraphical range of this ichnospecies, which had been described so far from the upper Cambrian (Machalski and Sadlok, 2008; Sadlok and Machalski, 2010), Carboniferous (Pollard *et al.*, 2008) and Upper Triassic (Schlirf *et al.*, 2001).

O c c u r r e n c e. – Lower Cambrian: Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone, Sterczyna Hill (this paper). Upper Cambrian: Wiśniówka Sandstone Formation (Machalski and Sadlok, 2008; Sadlok and Machalski, 2010). Upper Carboniferous: Lancashire, Great Britain (Pollard *et al*., 2008). Upper Triassic: Hassberge Formation, Vetter (Schlirf *et al*., 2001).

Rusophycus exsilius isp. nov.
(Fig. 5A–D)

? 1963, hieroglyph of a trilobite trace of a change of in its resting place – Radwański and Roniewicz, p. 264, pl. 3.2.

Derivatio nominis Exsilio (Latin) – to bounce, to jump.

Types holotype: INGUJ214P/Mr32, paratypes: INGUJ214P/Mr30, Mr31, Mr33.

Locus typicus: eastern slope of Sterczyna Hill.

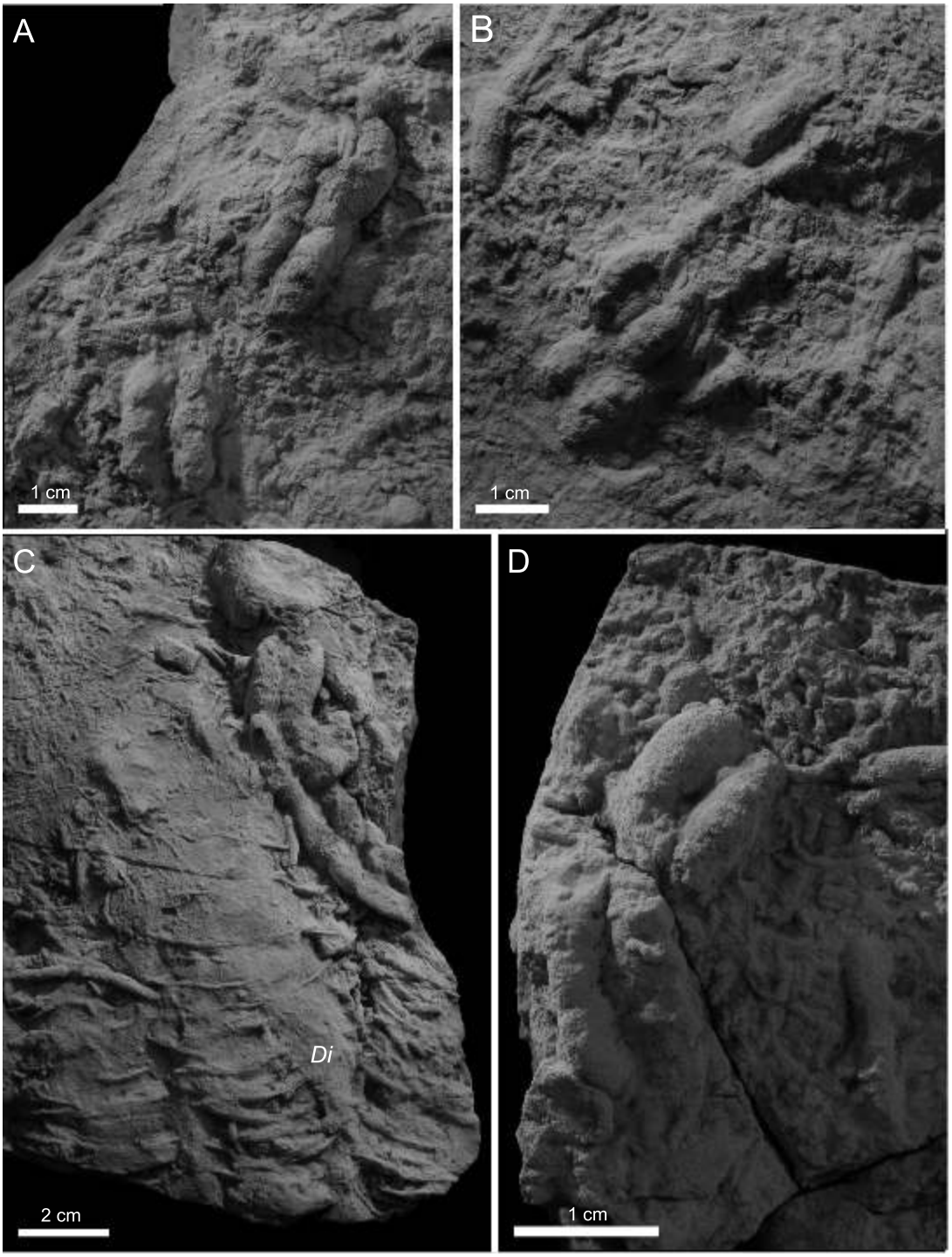

Fig. 5A–D – *Rusophycus exsilius* isp. nov., positive hyporeliefs on thin, bioturbated beds of graywakes; lower Cambrian, Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone, eastern slope of Sterczyna Hill

A – INGUJ214P/Mr31, B – INGUJ214P/Mr32 (holotype),
C – INGUJ214P/Mr33 (*Di* – cf. *Diplichnites* isp.), D – INGUJ214P/Mr30

Stratum typicum: Ociesęki Sandstone Formation.

D i a g n o s i s. – Small, convex, distinctly bilobate *Rusophycus*, which occur in clusters of a few specimens forming longitudinal, discontinuous, straight or curved ribbons.

D e s c r i p t i o n. – Clusters of 3 to 6 bilobate, symmetrical hypichnia, which consist of two lobes separated by a distinct median furrow. The surface of the lobes is smooth or slightly irregular, without ridges. Individual hypichnia are 8–15 mm long, 9–12 mm wide; the median furrow is 1–3 mm wide. The lobes are 3–4 mm high above the bedding surface. Individual hypichnia are displaced with respect to each other, locally partly overlapping. Some of them form ribbons, which resemble discontinuous *Cruziana* trails (Fig. 5C).

R e m a r k s. – The specimens analysed represent a new ichnospecies, which expresses a different behaviour of the tracemaker to that of most *Rusophycus* ichnospecies. The new trace fossil is not a typical resting trace (*cubichnion*), but a series of resting traces of a trilobite penetrating the sandy sediment and locally the underlying silty layer repeatedly along its path. Some of the specimens analysed, which form a ribbon-like series of cubichnia, are similar to *Cruziana* d'Orbigny, 1842, but differ in that it does not form a continuous trail. Very similar specimens, from the upper Cambrian of the Holy Cross Mountains have been illustrated by Radwański and Roniewicz (1963). The clusters of *Rusophycus moyensis* Mángano, Buatois and Muñiz Guinea, 2002, from the Santa Rosita Formation (Argentina) (Mángano *et al*., 2002, 2005) show a similar behaviour of the trace-maker. One sandstone slab containing *Raaschichnus gundersoni* Hesselbo, 1988 illustrated by Hesselbo (1988, p. 140, fig 1D) shows similar behaviour of the tracemaker. Nevertheless, *Raaschichnus* differs from *Rusophycus* by different shape of lobes.

O c c u r r e n c e. – Lower Cambrian: Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone, eastern slope of Sterczyna Hill (this paper). Probably the upper Cambrian: Wiśniówka Sandstone Formation, Wiśniówka Duża quarry (Radwański and Roniewicz, 1963).

Rusophycus isp. A
(Fig. 6A)

M a t e r i a l. – One specimen (INGUJ214P/St120).

D e s c r i p t i o n. – Oval, bilobate hypichnion, about 80 mm long, 55 mm wide, preserved in convex semirelief, which consists of two symmetrical lobes, separated by a distinct median furrow. The furrow does not separate the lobes for the entire length; the lobes are linked at one end to form a horseshoe-shaped structure. The surface of the lobes is smooth or covered by narrow ridges. In the rear part of the trace, a cylindrical structure about 10 mm in diameter is present. The median furrow is about 10 mm wide; the ridges on the lobes are 2–3 mm wide, The lobes are about 30 mm high.

R e m a r k s. – This specimen has a cylindrical structure in the rear part of trace, which may be a print of reproductive structures and suggest behaviour of trilobites depositing eggs below the surface of muddy sediment.

O c c u r r e n c e. – Lower Cambrian: Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone: Sterczyna Hill (this paper).

Rusophycus isp. B
(Fig. 6B)

M a t e r i a l. – One specimen (INGUJ214P/IgS7).

D e s c r i p t i o n. – An oval, bilobate hypichnion about 30 mm long, 22 mm wide, preserved in convex semirelief, which consists of two symmetrical lobes separated by a distinct median furrow. The surface of the lobes is rough. A cylindrical, elongate structure perpendicular or oblique to bedding penetrates the *Rusophycus*.

R e m a r k s. – Specimen display a cylindrical structure, which is interpreted as intersecting with *Planolites*.

O c c u r r e n c e. – Lower Cambrian: Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone, Igrzyczna Hill (this paper).

Rusophycus isp. C
(Fig. 6C)

M a t e r i a l. – Nine specimens (INGUJ214P/St136, Ig117–118, Mr12, Mr30–33).

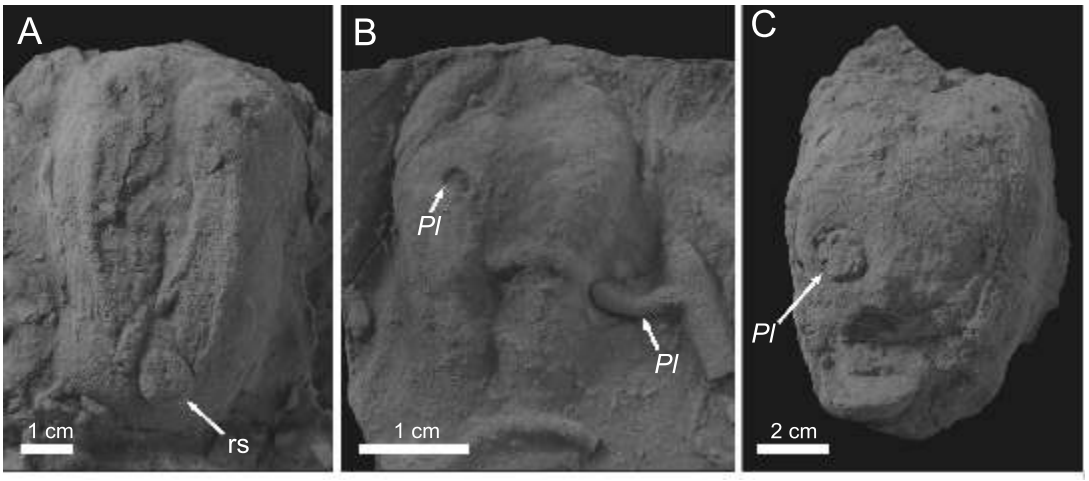

Fig. 6A–C – *Rusophycus* ispp., lower Cambrian, Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone

Positive hyporeliefs on thin beds of quartz arenite; A – *Rusophycus* isp. A (INGUJ214P/St120, rs – ?reproductive structure imprint) Sterczyna Hill; B – *Rusophycus* isp. B (INGUJ214P/IgS7, *Pl* – ?*Planolites*) southern slope of Igrzyczna Hill; C – *Rusophycus* isp. C (INGUJ214P/Mr12, *Pl* – ?*Planolites* isp. crossing the *Rusophycus*) eastern slope of Sterczyna Hill

D e s c r i p t i o n. – An oval, bilobate hypichnion 40–100 mm long, 20–60 mm wide, 10–40 mm high, preserved in a convex semirelief, which consists of two symmetrical or almost symmetrical lobes separated by a more or less distinct median furrow. The surface of the lobes is usually rough. In some of the specimens, a cylindrical structure perpendicular to bedding intersects the trace fossil.

R e m a r k s. – Some specimens, which display the cylindrical structure (intersection with specimens of *Planolites*) can be interpreted as traces of trilobite predation on a worm-like organism (see Jensen, 1997). Nevertheless, some specimens of ?*Planolites* cut the *Rusophycus* and must be younger (Fig. 6C).

O c c u r r e n c e. – Lower Cambrian: Ociesęki Sandstone Formation, *Holmia-Schmidtiellus* Zone, Sterczyna and Igrzyczna hills (this paper).

DISCUSSION

The *Rusophycus* ichnospecies from the lower Cambrian Ociesęki Sandstone Formation are quite diverse in comparison to other Cambrian formations of the Holy Cross Mountains (see Orłowski, 1992; Orłowski and Żylińska, 2002). It is surprising that *Cruziana* is almost totally absent. Only one specimen illustrated by Orłowski (1992, p. 20, fig. 4.4) can be ascribed to this ichnogenus. Other specimens described by this author as *Cruziana dispar* and *C. rusoformis*, according to the criteria by Keighley and Pickerill (1996), should be included in *Rusophycus*. The specimen described by Orłowski as *Cruziana* isp. (Orłowski, 1992, p. 25, figs. 6.3 and 9) in fact represents the ichnogenus *Psammichnites* Torell, 1870 (probably *P. gigas* Torell, 1870 = *Arcuatichnus wimani* Kowalski, 1978) (see Kowalski, 1978, p. 339, pl. 1.1–3; Seilacher, 2008, p. 44, 45).

The presence of *Rusophycus dispar* in the Holy Cross Mountains, which has been also described from localities in Scandinavia (see Linnarsson, 1871; Bergström, 1973; Bergström and Peel, 1988; Jensen, 1997) and Greenland (Pickerill and Peel, 1990) may confirm a palaeozoogeographical connection between the Małopolska Block, the Baltica palaeocontinent and the Laurentia palaeocontinent during the early Cambrian. Biogeography of the Cambrian of the Holy Cross Mountains, so far based on the trilobites is not, however, an unambiguous indicator. Trilobites from the lower Cambrian Ociesęki Formation clearly point to connections with the Baltic province but middle Cambrian trilobites are dominated by species typical of Gondwana (see Orłowski, 1985; Żylińska, 2002*a*, *b*; Nawrocki, 2006; Nawrocki *et al*., 2007), however, trilobites from the upper Cambrian of the Łysogóry Block (northern part of the Holy Cross Mts.) have mixed Avalonian-Baltic character (Żylińska 2002*a*). Palaeozoogeographical connection between the Małopolska Block, Baltica and Laurentia palaeocontinent is possible, because these continents were very close to each other (e.g., Torsvik and Cocks, 2005).

CONCLUSIONS

1. Seven ichnospecies of *Rusophycus* have been recognized in the Ociesęki Sandstone Formation: six in the lower part (*Holmia-Schmidtiellus* Zone) and one in the upper part (*Protolenus-Issafeniella* Zone) of this formation. Moreover, *Rusophycus* ispp. A, B, C are described.

2. One new ichnospecies of *Rusophycus*, *R. exsilius* isp. nov. has been described.

3. The diversity of *Rusophycus* in the Ociesęki Sandstone Formation is much higher than in the other Cambrian formations in the Holy Cross Mountains.

4. The presence of *Rusophycus dispar* in the Holy Cross Mountains, also known in Scandinavia and Greenland, suggests a palaeozoogeographical connection between the Małopolska Massif, the Baltica palaeocontinent and the Laurentia palaeocontinent.

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REFERENCES

BERGSTRÖM J. (1973) – Organization, life, and systematics of trilobites. Fossils and Strata, **2**: 1–69.

BERGSTRÖM J. and PEEL J. S. (1988) – Lower Cambrian trace fossils from northern Greenland. Rapport Grønlands Geologiske Undersrgelse, **137**: 43–53.

BERTLING M., BRADDY S. J., BROMLEY R. G., DEMATHIEU G. R., GENISE J., MIKLULÁŠ R., NIELSEN J. K., NIELSEN K. S. S., RINDSBERG A. K., SCHLIRF M. and UCHMAN A. (2006) – Names for trace fossils: a uniform approach. Lethaia, **39**: 265–286.

BUŁA Z. (2000) – The lower palaeozoic of Upper Silesia and West Małopolska (in Polish with English summary). Prace Państw. Inst. Geol., **171**: 1–63.

COCKS L. R. M. and TORSVIK T. H. (2005) – Baltica from late Precambrian to mid-Palaeozoic times: the gain and loss of terrane's identity. Earth Sc. Rev., **72**: 39–66.

CRIMES T. P. and ANDERSON M. M. (1985) – Trace fossils from the Late Precambrian-Early Cambrian strata of southeastern Newfoundland (Canada): temporal and environmental implications. J. Paleont., **59**: 310–343.

DAWSON J. W. (1864) – On the fossils of the genus *Rusophycus*. Canadian Natur. Geol., new series, **1**: 363–367.

ERDOĞAN B., UCHMAN A., GÜNGOR T. and ÖZGUL N. (2004) – Lithostratigraphy of the Lower Cambrian metaclastics and their age based on trace fossils in the Sandıklı region, southwestern Turkey. Geobios, **37**: 346–360.

GEYER G. (1990) – Die marokkanischen Ellipsosephalidae (Trilobita: Redlichidia). Beringeria, **3**: 3–363.

HESSELBO S. P. (1988) – Trace fossils of Cambrian aglaspid arthropods. Lethaia, **21**: 139–146.

JENSEN S. (1997) – Trace fossils from the Lower Cambrian Mickwitzia sandstone, south-central Sweden. Fossils and Strata, **42**: 1–111.

KEIGHLEY D. G. and PICKERILL R. K. (1996) – Small *Cruziana*, *Rusophycus*, and related ichnotaxa from eastern Canada: the nomenclatural debate and systematic ichnology. Ichnos, **4**: 261–285.

KOWALCZEWSKI Z., ŻYLIŃSKA A. and SZCZEPANIK Z. (2006) – Kambr w Górach Świętokrzyskich. In: Procesy i zdarzenia w historii geologicznej Gór Świętokrzyskich, Materiały LXXVII Zjazdu Naukowego Polskiego Towarzystwa Geologicznego w Ameliówce k. Kielc, 28–30 czerwca 2006 (eds. S. Skompski and A. Żylińska): 14–27. Pol. Geol. Inst., Warszawa.

KOWALSKI W. R. (1978) – Critical analysis of Cambrian ichnogenus *Plagiogmus* Roedel, 1929. Rocz. Pol. Tow. Geol., **48** (3, 4): 333–344.

LINNARSSON J. G. O. (1869) – On some fossils found in the Eophyton sandstone at Lugnas in Sweden. Geol. Mag., **6**: 393–406.

LINNARSSON J. G. O. (1871) – Geognostiska och paleontologiska lakttagelser öfver Eophytonsandstein i Vestergötland. Kungliga Svenska Vetenskaps-Akademiens Handlingar, **9**: 1–19.

MacNAUGHTON R. B. and NARBONNE G. M. (1999) – Evolution of ecology of Neoproterozoic-Lower-Cambrian trace fossils, NW Canada. Palaios, **14**: 97–115.

MACHALSKI M. and SADLOK G. (2008) – *Rusophycus versans* from the Upper Cambrian at Wiśniówka (Holy Cross Mts., central Poland) – another analogy linking trilobite and notostracan trace fossils. In: The Second International Congress on Ichnology, Cracow, Poland, August 29–September 8, 2008, Abstract Book and Intra Congress Field Trip Guidebook (ed. A. Uchman): 73. Pol. Inst. Geol.

MÁNGANO M. G., BUATOIS L. A. and MUÑIZ GUINEA F. (2002) – *Rusophycus moyensis* n. isp. en la transición cámbrica tremadociana del noroeste Argentino: implicancias paleoambientales y bioestratigráficas. Revista Brasileira de Paleontologia, **4**: 35–44.

MÁNGANO M. G., BUATOIS L. A. and MUÑIZ GUINEA F. (2005) – Ichnology of the Alfarcito Member (Santa Rosita Formation) of northwestern Argentina: animal-substrate interactions in a lower Paleozoic wave-dominated shallow sea. Ameghiniana, **42**: 641–668.

MIZERSKI W., ORŁOWSKI S. and RÓŻYCKI A. (1986) – Tectonic of the Pasmo Ociesęckie and Pasmo Zamczyska ranges in the Góry Świętokrzyskie Mts. (in Polish with English summary). Geol. Quart., **30** (2): 187–200.

MIZERSKI W., ORŁOWSKI S. and WAKSMUDZKI B. (1991) – New data on geology of the Kamieniec Shale Formation (Lower Cambrian, Holy Cross Mts). Geol. Quart., **35** (2): 149–162.

MIZERSKI W., ORŁOWSKI S., PRZYBYCIN A. and SKUREK-SKURCZYŃSKA K. (1999) – Large-scale erosional channels in the Lower Cambrian sandstones, Gieraszowice environments (Kielce Block, Holy Cross Mts.). Geol. Quart., **43** (3): 353–364.

NAWROCKI J. (2007) – Paleogeografia Gór Świętokrzyskich we wczesnym paleozoiku. In: Procesy i zdarzenia w historii geologicznej Gór Świętokrzyskich, Materiały LXXVII Zjazdu Naukowego Polskiego Towarzystwa Geologicznego w Ameliówce k. Kielc, 28–30 czerwca 2006 (eds. S. Skompski and A. Żylińska): 9–13. Pol. Geol. Inst., Warszawa.

NAWROCKI J., DUNLAP J., PECSKAY Z., KRZEMIŃSKI L., ŻYLIŃSKA A., FANNING M., KOZŁOWSKI W., SALWA S., SZCZEPANIK Z. and TRELA W. (2006) – Late Neoproterozoic to Early Palaeozoic palaeogeography of the Holy Cross Mountains (Central Europe): an integrated approach. J. Geol. Soc., **164**: 405–423.

ORŁOWSKI S. (1974) – Lower Cambrian biostratigraphy in the Holy Cross Mts., based on the trilobite family Olenellidae. Acta Geol. Pol., **24** (1): 1–16.

ORŁOWSKI S. (1975) – Cambrian and upper Precambrian lithostratigraphic units in the Holy Cross Mts. (in Polish with English summary). Acta Geol. Pol., **25** (3): 431–448.

ORŁOWSKI S. (1983) – A Lower Cambrian aglaspid from Poland. N. Jb. Geol. Paläont., Mh., **1983**: 237–241.

ORŁOWSKI S. (1985) – Lower Cambrian and its trilobites in the Holy Cross Mts. Acta Geol. Pol., **35** (3– 4): 231–250.

ORŁOWSKI S. (1987) – Stratigraphy of the Lower Cambrian in the Holy Cross Mountains, Central Poland. Bull. Pol. Acad. Sc. Earth Sc., **35** (1): 91–96.

ORŁOWSKI S. (1988) – Stratigraphy of the Cambrian System in the Holy Cross Mts. Geol. Quart., **32** (3/4): 525–532.

ORŁOWSKI S. (1989) – Trace fossils in the Lower Cambrian sequence in the Świętokrzyskie Mountains, Central Poland. Acta Palaeont. Pol., **34** (3): 211–231.

ORŁOWSKI S. (1992) – Trilobite trace fossils and their stratigraphical significance in the Cambrian sequence of the Holy Cross Mountains, Poland. Geol. J., **27**: 15–34.

ORŁOWSKI S. (1997) – Fundamental stratigraphic problem of the Cambrian in the Holy Cross Mts. – discussion. Geol. Quart., **41** (1): 77–84.

ORŁOWSKI S. and ŻYLIŃSKA A. (2002) – Lower Cambrian trace fossils from the Holy Cross Mountains, Poland. Geol. Quart., **46** (2): 135–146.

ORŁOWSKI S., RADWAŃSKI A. and RONIEWICZ P. (1970) – The trilobite ichnocoenosis in the Cambrian sequence of the Holy Cross Mountains. Geol. J. Spec. Issue, **3**: 345–360.

ORŁOWSKI S., RADWAŃSKI A. and RONIEWICZ P. (1971) – Ichnospecific variability of the Upper Cambrian *Rusophycus* from the Holy Cross Mts. Acta Geol. Pol., **21** (3): 341–348.

OSGOOD R. G. Jr (1970) – Trace fossils of the Cincinnatti area. Palaeontograph. Am., **6**: 281–444.

PACZEŚNA J. (1985) – Ichnogenus *Paleodiction* Meneghini from the Lower Cambrian of Zbilutka (Holy Cross Mts) (in Polish with English summary). Geol. Quart., **29** (3/4): 589–596.

PACZEŚNA J. and ŻYLIŃSKA A. (2008) – Lower Palaeozoic (Cambrian) and Upper Palaeozoic (Devonian). In: Types of Invertebrate Trace Fossils from Poland: an illustrated catalogue (ed. A. Uchman): 5–16. Pol. Geol. Inst., Warszawa.

PICKERILL R. K. and PEEL J. S. (1990) – Trace fossils from the Lower Cambrian Bastion Formation of North-East Greenland. In: Lower Cambrian Trace Fossils from Greenland (ed. J. S. Peel). Rapport Grønlands Geologiske Undersrgelse, **147**: 4–43.

POLLARD J., SELDEN P. and WATTS S. (2008) – Trace fossils of the arthropod Camptophyllia from the Westphalian (Carboniferous) rocks of Lancashire, UK and their palaeoenvironmental context. Palaeogeogr. Palaeoclimatol. Palaeoecol., **270**: 399–406.

RADWAŃSKI A. and RONIEWICZ P. (1963) – Upper Cambrian trilobite ichnocoenosis from Wielka Wiśniówka (Holy Cross Mountains, Poland). Acta Palaeont. Pol., **8**: 259–280.

RINDSBERG A. K. (1994) – Ichnology of the Upper Mississippian Hartselle Sandstone of Alabama, with notes on other Carboniferous Formations. Geol. Sur. Alabama, Bull., **158**: 1–107.

SADLOK G. and MACHALSKI M. (2010) – The trace fossil *Rusophycus versans* from the Furongian (Upper Cambrian) of central Poland – an example of behavioural convergence amongst arthropods. Acta Geol. Pol., **60**: 119–123.

SAMSONOWICZ J. (1959) – On *Strenuaeva* from Lower Cambrian in Klimontów Anticlinorium. Bull. Acad. Pol. Sc., Sér. sc. géol. géogr., **7**: 521–525.

SCHLIRF M., UCHMAN A. and KÜMMEL M. (2001) – Upper Triassic (Keuper) non-marine trace fossils from the Haßberge area (Franconia, south-eastern Germany). Paläontologische Zeitschrift, **75**: 71–96.

SEILACHER A. (1970) – *Cruziana* stratigraphy of "non-fossiliferous" Palaeozoic sandstones. Trace fossils. Geol. J. Spec. Issue, **3**: 447–476. Liverpool.

SEILACHER A. (2007) – Trace fossil analysis. Springer. Berlin.

SEILACHER A. (2008) – Fossil Art. An exhibition of the Geologisches Institut Tuebingen University, Germany. CPM Publ., Laasby.

TORSVIK T. H. and COCKS L. R. M. (2005) – Norway in space and time: a centennial cavalcade. Norwegian J. Geol., **85**: 73–86.

ŻYLIŃSKA A. (2002*a*) – Stratigraphic and biogeographic significance of Late Cambrian trilobites from Łysogóry (Holy Cross Mountains, central Poland). Acta Geol. Pol., **52**: 217–238.

ŻYLIŃSKA A. (2002*b*) – Znaczenie biogeograficzne kambryjskich trylobitów z Gór Świętokrzyskich. Prz. Geol., **50** (9): 795–796.

ŻYLIŃSKA A. and MASIAK M. (2007) – Cambrian trilobites from Brzechów, Holy Cross Mountains (Poland) and their significance in stratigraphic correlation and biogeographic reconstructions. Geol. Mag., **144**: 661–686.