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Ichnospecific variability of the Upper Cambrian *Rusophycus* from the Holy Cross Mts

ABSTRACT: The rusophyci, *i.e.* the resting places of the trilobites, from the Upper Cambrian deposits outcropping at Wielka Wiśniówka in the Holy Cross Mts, are presented and their variability explained. All these rusophyci belong to one ichnospecies, *Rusophycus polonicus* Orł., Radw. & Ron., the taxonomical importance of which is discussed. Regarded is also an ichnospecific variability of these trace fossils, being the result of various behaviour of the trace-making trilobites and, on the other hand, the effect of environmental conditions.

INTRODUCTION

The aim of the present paper is to contribute on some problems of the *Rusophycus*, the resting places of the trilobites, which were the subject of a few papers of the writers (Radwański & Roniewicz 1960, 1963; Orłowski, Radwański & Roniewicz 1970). All the material discussed come from a well known locality for the trilobite traces, *i.e.* the Wielka (Great) Wiśniówka quarry in the Holy Cross Mts, Central Poland (cf. Orłowski, Radwański & Roniewicz 1970, Fig. 1). The present paper is to be regarded as an additional note to the paper read at „*An International Conference on Trace Fossils*” (Liverpool, January 6, 7, 8th 1970), and published in the Conference Volume — *Trace Fossils* (edited by T. P. Crimes and J. C. Harper as *Geological Journal Special Issue, No. 3, Seel House Press, Liverpool 1970*).

The reason of presenting this contribution arose from a necessity of discussion of some opinions presented in this Conference Volume. It mostly concerns the taxonomy of the discussed trace fossils and conception of the previously postulated ichnospecies.

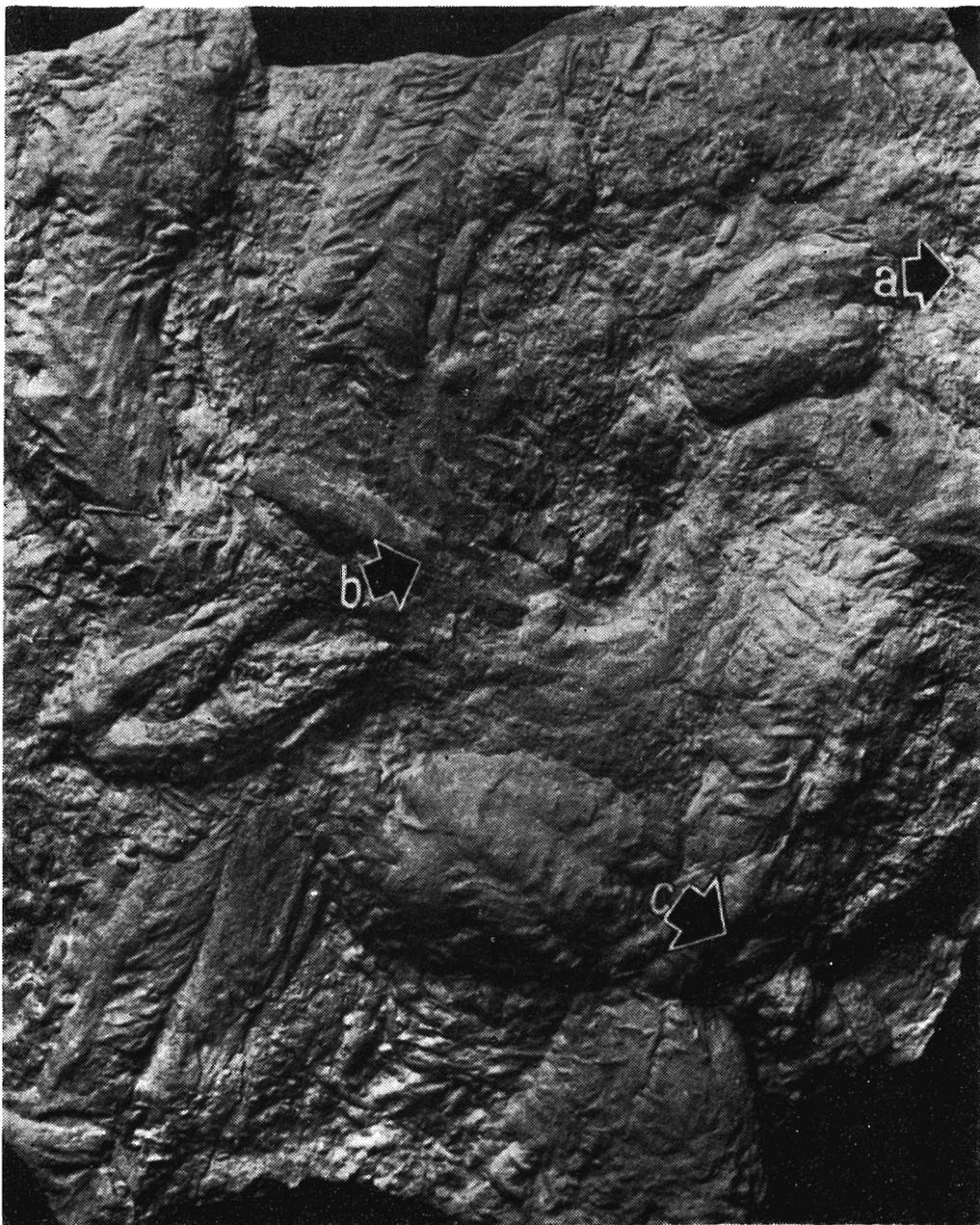
GENERAL VIEW ON THE ICHNOTOPE

The Wielka Wiśniówka ichnotope is set within a c. 350 m thick complex of quartzitic sandstones intercalated by more or less distinct packets of silt- and claystones most of which bear at their topsides various sedimentary structures formed by currents and/or wave action (cf. Radwański & Roniewicz 1960, 1963). The trace fossils attributable to trilobites and other animals are mostly occurring in these packets of finer grained clastics. Most of the traces appear in the individualized horizons, being very numerous through the sequence, and these cover the undersides of particular layers. Thus, most of the traces are the hieroglyphs (cf. Radwański & Roniewicz 1963) whereas true traces left by animals on the sea bottom (topside of the layers) are quite exceptional (cf. Fig. 1a in Pl. 6 of this paper, and Radwański & Roniewicz 1963, Pl. 3, Fig. 1).

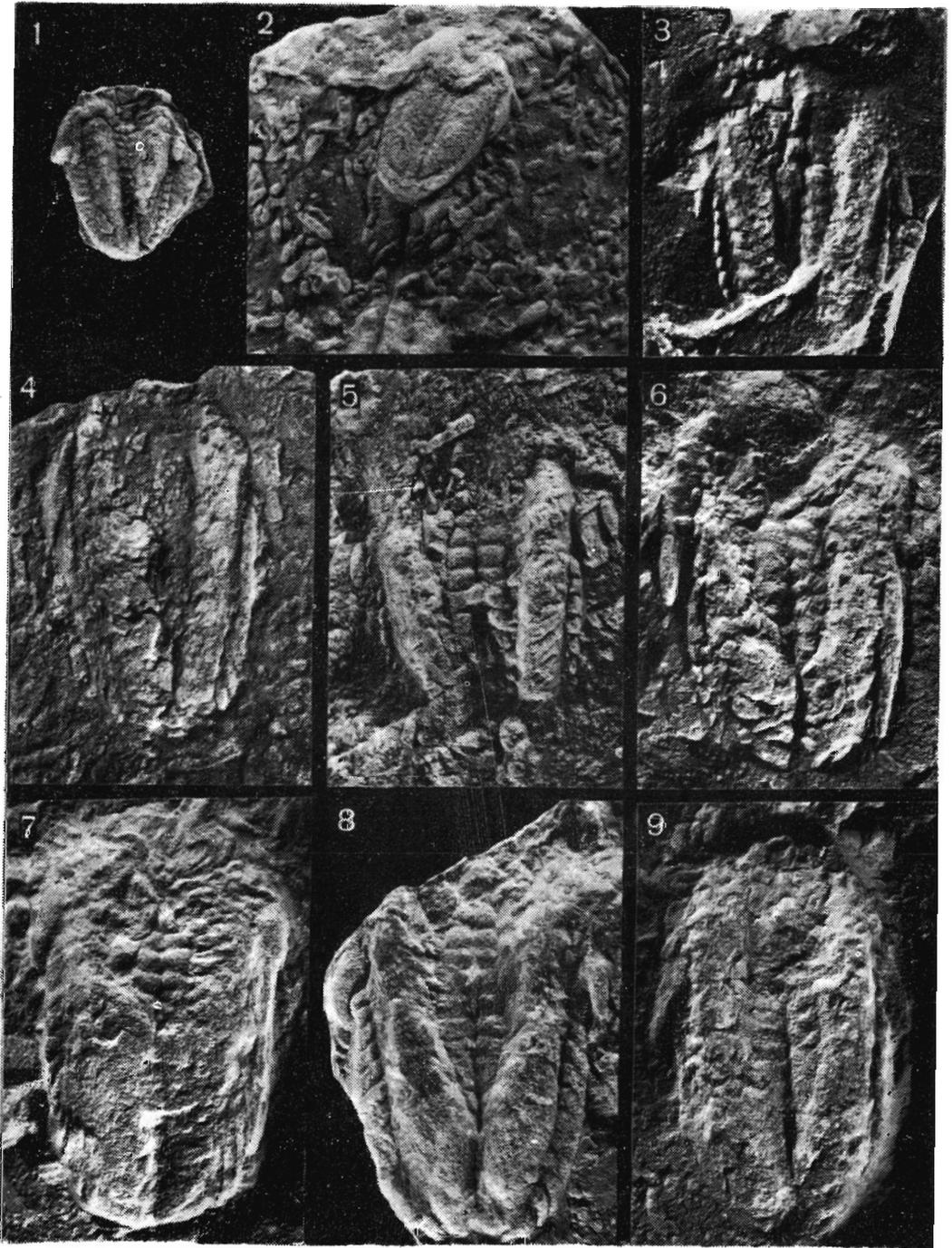
All the trace-fossils bearing horizons within the sequence are here regarded as one *ichnotope* (cf. Radwański & Roniewicz 1970 and their discussion with Martinsson's, 1965, *thanatotope*) taking into account an identity of the trace fossils and of environmental conditions expressed by identic sedimentary structures through the whole sequence discussed. In such a meaning, this ichnotope obviously corresponds to many successive communities of the trace-making trilobites, what may be acceptable since even in a single trace-bearing horizon it is undeterminable to recognize to how many communities the traces belong (cf. e.g. Pl. 1). In consequence, the ichnotope is to be understood as all the places in which, during the sedimentation of the discussed sequence, the trilobites left their traces.

Within the Wielka Wiśniówka ichnotope, various trace fossils occur in a rather great abundance, covering densely the undersides of some layers (Pl. 1). The traces attributable to trilobites predominate here, a majority of which consists of crawling traces, *Cruziana semiplicata* Salter, and singular imprints of legs, the latter probably left by the trilobites swimming over the bottom and accidentally touching or grazing it. The rusophyci either occur separately here, or indistinctly group in places without any instructive evidence of the reason (cf. Pl. 1). In some horizons, the rusophyci are predominant and other traces may be even lacking. The best preserved rusophyci (Pls 2—6) usually come from such latter places, in which the surface of the layer out of the traces is generally smooth or covered by single leg imprints (the best examples: Pl. 3, Figs 1, 4, 6—7; Pl. 4, Figs 2, 4; Pl. 5, Figs 1—4; Pl. 6, Fig. 1b).

All the other traces, occurring within the ichnotope, and attributable to trilobites, aglaspids, polychaetes and sea anemones are not being recalled here as discussed in details previously (Radwański & Roniewicz 1963, 1967; Orłowski, Radwański & Roniewicz 1970).



General view of the ichnotope; lettered (a, b, c) are the rusophyci, *Rusophycus polonicus* Orł., Radw. & Ron. (the arrows point to the front of the trace), variously preserved what depended on various behaviour of the animals during their resting — a quiet resting with a stronger digging of the left side (downward side in the figure), b leaving of the rest place by using of legs and starting into the water, c stronger shuffling into the soft bottom. Besides, fragments of crawling traces, *Cruziana semiplicata* Salter, and single imprints of legs are visible. Nat. size



Syntypes of the ichnospecies *Rusophycus polonicus* Orł., Radw. & Ron., nat. size;
explanation in the text



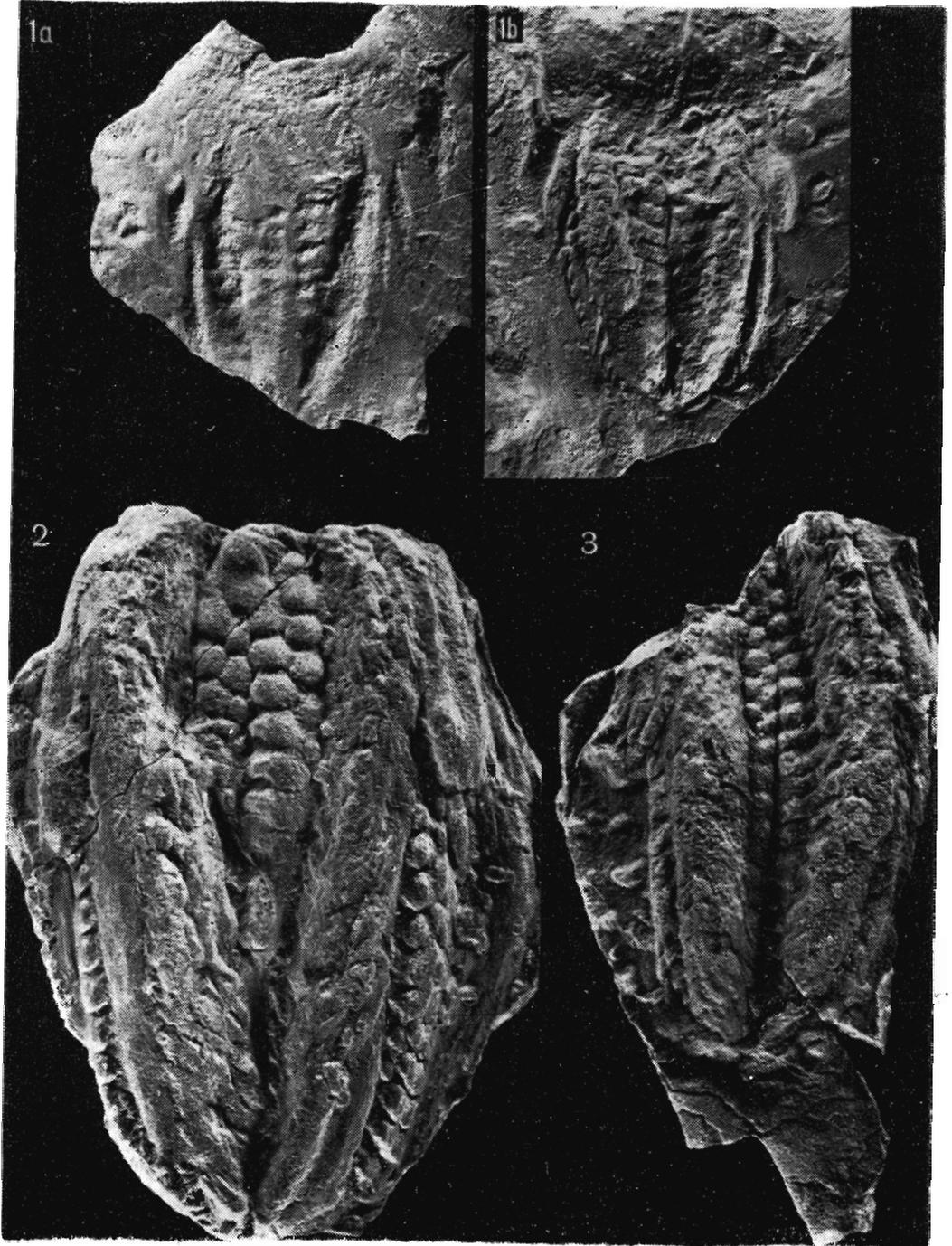
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1a — True rest place left by a trilobite on the sea bottom (topside of a thin, quartzitic siltstone layer).

1b — Counterpart of the trace presented in the preceding figure, i.e. the rusophycus (hieroglyph), *Rusophycus polonicus* Orł., Radw. & Ron.

2-3 — Untypically developed rusophyci, *Rusophycus polonicus* Orł., Radw. & Ron.; explanation in the text.

All figures of natural size

The age of the whole trace-bearing complex at the Wielka Wiśniówka quarry is Upper Cambrian, precisely the Olenus Beds (Orłowski 1968; Orłowski, Radwański & Roniewicz 1970).

THE RUSOPHYCI

The discussed rusophyci exhibit an extensive variability both of their dimensions, general sculpture and subordinate details, as well as of mode of preservation, which resulted both from the behaviour of the trace-making trilobites and from the consistency of the sea bottom. The presented rusophyci (Pls 1—6) are chosen in such a manner that the forms submitted to the latter factor are excluded (the only exception is that presented in Pl. 5, Fig. 4 as the form being of the largest size).

The most attractive feature of all the presented rusophyci is their bearing of various morphological details, corresponding to various parts of the trilobite body, what makes the Wielka Wiśniówka population of these trace fossils a well known basis for studying the nature of rusophyci and for comparisons and taxonomic discussions (cf. Crimes 1970a, b, Seilacher 1970). Since the date of first presenting of these details (Radwański & Roniewicz 1963) it was but Crimes (1970a, b) who has found nearly identical forms in the Upper Cambrian of North Wales¹.

TAXONOMY OF THE RUSOPHYCI

At the first time, when the rusophyci from Wielka Wiśniówka were presented (Radwański & Roniewicz 1960, Pl. 29, Fig. 1), they were generally called *Rusophycus* and the details visible in photo were not explained. In a separate paper on the Wielka Wiśniówka ichnocoenose, all the rusophyci (Radwański & Roniewicz 1963, Pl. 2, Figs 1—8) were determined as *Rusophycus* sp. since their new discovered details did not enable to distinguish the previously known taxons (ichnospecies) of the genus *Rusophycus* Hall, and, on the other hand, they threw a new light on the problem of ichnogenetic variability. Namely, most of the discussed details were sufficient to create new „formal” taxons at the ichnospecific rank, although a full series of variously shaped individuals showed that such a decision should be of none importance. A variability of the discussed traces has evidently been induced by a various behaviour of the animals.

¹ Some similar, details-bearing rusophyci have also recently been illustrated by Osgood (1970) from the Upper Ordovician (Cincinnatian) of Ohio; these forms, being a revised and redescribed ichnospecies, *Rusophycus carleyi* (James 1885), are much greater (up to 25 cm in length) and differ apparently from those discussed of Upper Cambrian age (cf. also Seilacher 1970).

in some places maybe of this same individual, and by the bottom conditions.

At the beginning of the 60's, it seemed that the erection of new ichnological taxons would follow Seilacher's (1953) suggestions of an ecological basis for distinguishing the ichnotaxons. Nevertheless, a few papers presented at the Conference in Liverpool, comprised and offered new taxons based mostly on the morphological criteria. In the Conference's paper, the writers (Orłowski, Radwański & Roniewicz 1970) followed this latter trend and suggested to call all the discussed rusophyci as „*Rusophycus polonicus*” and not to designate them formally (using the name inbetween inverted comas as a proposal) as a new ichnospecies at that moment. The writers believed that the discussion at the Conference should solve the problems and state the principles of erecting new ichnological names. Unfortunately, during the Conference no definite decisions were undertaken in this matter; as a result the principles of ichnological nomenclature are still open to discussion and only in some instances they are in a general agreement with international nomenclature in zoology (cf. Crimes & Harper 1970).

Nevertheless, it happened that Seilacher (1970) in his prominent paper on the trilobite traces, published in the Conference Volume erected for the discussed rusophyci from Wielka Wiśniówka a new, formal ichnotaxon *Cruziana polonica* Seilacher pointing to the writers' figures (Radwański & Roniewicz 1963, Pl. 2, Figs 1—8) as type specimens and the only forms in the synonymy of this ichnospecies. Regardless of the discussion on the ichnogenic separateness of *Rusophycus* and *Cruziana*, which should not be rejected², it occurred that the ichnospecies *polonicus* had been introduced into the bibliography. If a morphological criterion is taken into account at the erecting of new ichnological names, as adopted by Seilacher (1970), it will be evident that the ichnotaxon *polonicus* has been introduced twice in the Conference Volume and independently by various authors who based on this same material! Who is in result the author of the taxon? If one follows the Editors' (Crimes & Harper 1970) wish to be, when possible, in agreement with zoological nomenclature, the present writers should be the authors of the taxon, as its name has been used by us prior (Orłowski, Radwański & Roniewicz, *Trace fossils*, p. 356) to that by Seilacher (*Trace fossils*, p. 473), and International Code of Zoological Nomenclature decides in this matter in the chapter on the priority — in Art. 24 (a). Maybe, the present writers' opinion on their priority is arbitrary a little; in such a case the International Commission

² The writers fully accept the results of a brief discussion given in this matter by Osgood (1970, p. 303); separateness of the discussed ichnogenera was also employed in previous papers (Radwański & Roniewicz 1960, 1963; Orłowski, Radwański & Roniewicz 1970).

on Zoological Nomenclature should take this at their judgement (if should like to take the trace fossils under discussion!).

The present writers' final opinion on the discussed taxon consists in a statement that all the presented rusophyci (Pls 1—6) are conspecific in ichnological sense and represent a typical series, *i.e.* these are the syntypes of the ichnospecies *Rusophycus polonicus* Orł., Radw. & Ron., 1970, and show its ichnospecific variability.

RUSOPHYCI AND THEIR VARIABILITY

The rusophyci of the Wielka Wiśniówka ichnopopulation exhibit a few stable features which are to be regarded as characteristics of theirs³.

The most important feature is the presence of a median furrow stretching along the midline (*sag.*) of all the segments of the thorax (cf. Pl. 2, Figs 5, 8—9; Pl. 4, Figs 1—4; Pl. 6, Fig. 3). The furrow is narrow, straight and distinctly deep. On both sides of the furrow there are imprints of the segments (cf. Pl. 2, Figs 1, 5—6; Pl. 3, Figs 4—5, 7; Pl. 4, Figs 1—4; Pl. 5, Figs 2—3), 8 to 12 of them being the best recognizable.

In the anterior part of the trace, the imprints of the genal spines are lying more or less parallel to the axis (*exsag.*). Some of the specimens (Pl. 3, Fig. 6; Pl. 4, Fig. 4) bear in their anterior part a small, oval swell facing to the median furrow; it might have probably been impressed by hypostoma.

Along the segmented part of the trace, there occur symmetrical, broad and convex areas corresponding to the furrows made by telepodites (endopodites). These areas are covered by imprints of particular telepodites (endopodites), usually oriented backwardly (cf. Pl. 2, Fig. 3; Pl. 4, Fig. 2; Pl. 6, Fig. 2). Outside these areas, in many specimens there also occur small beaded imprints (cf. Pl. 2, Figs 3, 8; Pl. 3, Fig. 4; Pl. 4, Figs 2—4; Pl. 6, Figs 1b, 2—3) which may be interpreted as those left by pretarsus of the telepodites (endopodites) as well as either by distal segment of the pre-epipodites (exopodites) or by outer part of the pleurae. Taking into account that these imprints are elongated out- and backward, the most probable supposition is of their formation by distal segment of the pre-epipodites (exopodites).

³ Some of the rusophyci figured in the present paper (Pls 2—5) and explained in this chapter have previously been published (cf. Radwański & Roniewicz 1960, 1963; Orłowski, Radwański & Roniewicz 1970) as follows:

Pl. 2, Fig. 1 = Radwański & Roniewicz, 1963, Pl. 2, Fig. 2

Pl. 2, Fig. 9 = Radwański & Roniewicz, 1960, Pl. 29, Fig. 1, and 1963, Pl. 2, Fig. 5

Pl. 3, Fig. 6 = Radwański & Roniewicz, 1963, Pl. 2, Fig. 6

Pl. 4, Fig. 4 = Radwański & Roniewicz, 1963, Pl. 2, Fig. 8, and Orłowski, Radwański & Roniewicz, 1970, Pl. 3b

Pl. 5, Fig. 3 = Radwański & Roniewicz, 1963, Pl. 2, Fig. 7, and Orłowski, Radwański & Roniewicz, 1970, Pl. 3c.

A few specimens (*e.g.* Pl. 6, Figs 2—3) bear some untypical features of the segmented part of the trace which most probably have been caused by a temporary local change of the animal's position during its rest.

General feature of most of the specimens is a stronger impression of the posterior part of the animal. It therefore appears that the trace-making trilobites were of the opisthocline type (*cf.* Seilacher 1970).

Other differentiation in the shape and outline of the discussed specimens resulted from various behaviour of the trace-makers, consistency of the bottom and hydrodynamic conditions in the environment. Various behaviour of the trilobites may be easily recognized by the fact that some traces were made very superficially in the bottom (*e.g.* Pl. 2, Figs 3—4; Pl. 4, Fig. 2; Pl. 6, Fig. 1b), whereas the others moderately deeply (*e.g.* Pl. 3, Figs 1—3, 6; Pl. 5, Fig. 3). A sideways motion of the resting trilobite was induced from the trace previously presented (Orłowski, Radwański & Roniewicz 1970, Pl. 3e). Other examples of a different manner of resting or leaving of the rest place by the trilobites are given by the traces presented in Pl. 1. The three specimens presented in the latter figure show a very indistinct rheotaxy (*cf.* Seilacher 1955), and are in fact the only, poor example of this phenomenon in all the ichnotope-bearing sequence under study.

In some places the rusophyci gather in pairs, one specimen by another one (*cf.* Pl. 3, Fig. 8), what may be a result of a change of the rest place by a forward „jump”, or of their love-making, the latter being not a phantasy but a possibility recently supposed by an analysis of the trace fossils, *viz.* trail marks of the xiphosurids (King 1965).

THE TRACE-MAKERS

As the trace-maker of all the discussed rusophyci, the species *Olenus rarus* Orłowski was to be suggested (Orłowski, Radwański & Roniewicz 1970). Maybe that also other species of this genus or other olenids, being the most common forms in the Upper Cambrian seas (*cf.* Henningsmoen 1957) were leaving undistinguishable traces since the trace-making parts of the trilobites' body, mostly the biramous appendages, were very similar in various trilobites broadly differentiated in systematics and geological age (*cf.* Harrington 1959).

Generally it may be assumed that the rusophyci of the *Rusophycus polonicus* type are the result of life activity of the trilobites of the family Olenidae. Regarding the fact that this family was dominating among the trilobite faunas in the Upper Cambrian (*cf.* Henningsmoen 1957), it

is clear that such rusophyci have so far been recorded only in the Upper Cambrian deposits, being therefore of some stratigraphical importance (cf. Crimes 1970a, b, Seilacher 1970).

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**HIEROGLIFY ORGANICZNE *RUSOPHYCUS*
POLONICUS Z GÓRNEGO KAMBRU WIELKIEJ WIŚNIOŹKI
I ICH ZMIENNOŚĆ**

(Streszczenie)

Przedmiotem pracy są zagadnienia związane z taksonomią „gatunku” hieroglifu organicznego *Rusophycus polonicus*, ustanowionego przez autorów uprzednio (Orłowski, Radwański & Roniewicz 1970), a reprezentującego odlewy miejsc spoczynku trylobitów na dnie morskim. W nawiązaniu do poprzednich prac dotyczących zespołu rozmaitych śladów organicznych z górnego kambru Wielkiej Wiśniówki w Górach Świętokrzyskich (Radwański & Roniewicz 1960, 1963; Orłowski, Radwański & Roniewicz 1970) rozpatrzono zmienność tego „gatunku” wynikającą ze sposobu tworzenia poszczególnych śladów przez trylobity (por. pl. 1—6), oraz jego odrębność w stosunku do innych analogicznych form (por. Crimes 1970a, b; Seilacher 1970).

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