The ichnofossil Rejkovicichnus necrofilus ichnogen. et ichnosp. nov. and body fossils in its filling (Middle Cambrian, Czech Republic)

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Abstract. The newly established ichnofossil *Rejkovicichnus necrofilus* ichnogen. et ichnosp. nov. from the Middle Cambrian of the Barrandian area is interpreted as an complex feeding-fecal structure. It is characteristic by large, often non-randomly oriented bioclasts in its fill.

Abstrakt. Nově stanovená ichnofosilie *Rejkovicichnus necrofilus* ichnogen. et ichnosp. nov. ze středního kambria Barrandienu je interpretována jako složitá potravně-fekální struktura, význačná výskytem velkých, často usměrněných bioklastů ve výplni.

Key words: Trace fossils, Cambrian, Barrandian area, Systematic ichnology.

Introduction

The locality Potůček (about 1000 m W of the railway station in Rejkovice) provided interesting finds of trace fossils. The locality exposed the lower part of the Jince Formation (*Eccaparadoxides pusillus* Zone, *Litavkaspis rejkovicensis* Subzone, see biostratigraphical scale published by Fatka and Kordule 1992). For detailed description of this locality and its palaeontological content we refer to papers of Fatka and Kordule (1992) and Kordule (1996). Layers of violet to greyish-green shales alternate here with less frequent beds of very fine-grained sandstones to sandy siltstones. All the exposed succession of strata provided more-or-less equably numerous finds of large ichnofossils unique both by their morphology and presumed ethological sense. The aim of this contribution is to describe and interpret them.

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Systematic ichnology

Rejkovicichnus ichnogen. nov.

Diagnosis: Large endichnial structures, showing - if fully developed - the form of straight to moderately curved „walls". Their fill contains large amount of disarticulated parts of body fossils. Other structure or orientation of bioclasts may be none, or the wall may be dissected to horizontal trough-like bodies analogical to the ichnogenus *Teichichnus* Seilacher. Bioclasts in the fill of these „troughs" may be oriented randomly, or they may form a meniscate structure analogical, e.g., to *Taenidium* Heer.

Type ichnospecies: *Rejkovicichnus necrofilus* ichnosp. nov.

Rejkovicichnus necrofilus ichnosp. nov.

Pl. I, Fig. 1-7; Text-Fig. 1-5

Holotype: Specimen figured on Pl. I, Fig. 1 and 3 (Collection of the Czech Geological Survey, Prague).

Type horizon: Middle Cambrian, Jince Formation (*Eccaparadoxides pusillus* Zone, *Litavkaspis rejkovicensis* Subzone).

Type locality: Potůček.

Material: About 60 specimens from the type locality only.

Description: See diagnosis of the ichnogenus. The endichnial traces are preserved as full reliefs, showing a morphollogicaly continuous spectrum of forms; each one can be logically derived from other forms. Character of fill, dimensions and a horizontal direction of the action of the tracemaker can be regarded as unifying elements. The most common form (about 60% of collected specimens) are long (more than 20 cm), 5 - 25 mm wide and up to 6 cm high vertical walls contrasting from the surrounding rock by its filling. The fill contains great amount of body fossils of trilobites and echinoderms. The trilobites *Litavkaspis rejkovicensis* (complete specimens, some enrolled, and numerous parts of disarticulated carapaces), *Eccaparadoxides pusillus* and *Conocoryphe cirina* (disarticulated), and isolated plates of ctenocystoid and trochocystoid echinoderms are observable in the fill; numerous further body fossils are probably present here but they cannot be distinguished because of their fragmentary character. The colour and the grain size of fillings may be both the same and different from the surrounding rock.

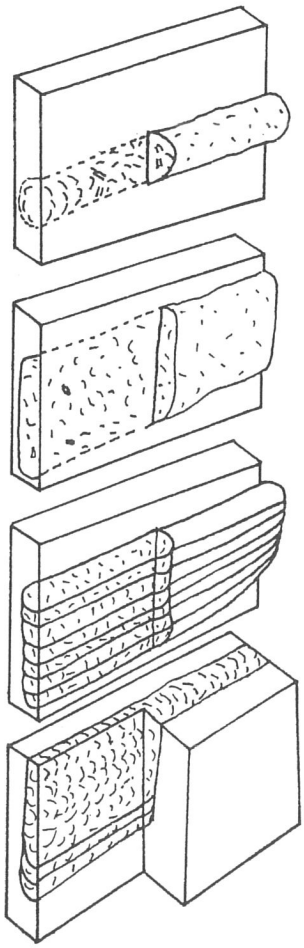

Fig. 1. *Rejkovicichnus necrofilus* and body fossils in its filling. Schematic drawing of various types of morphology and ways of preservation.

In some cases, heigth of the described walls may only moderately exceed the trace width. Simple tunnels without wall linings, showing the body fossil content in the fill as described above (about 40% of finds) can be regarded as an initial form of *Rejkovicichnus*. These tunnels are oval to circular in outline.

About 60% of the collected specimens (both the „tunnels" and the „walls") has a random orientation of minor bioclasts (or the orientation shows as random in a routine macroscopical study, without using a statistical analysis) and also their matrix shows no visible structure. Large, elongate bioclasts (as pleurae of trilobites) are ortiented mostly perpendicularly to the trace axis. Ten or even more collected specimens are evidently dissected to horizontal, virtually pilled-up „troughs", well-visible in vertical sections of rock samples (analogy to *Teichichnus*). These troughs are most frequently several millimetres thick, and they are separated by more or less conspicuous divisional planes in the matrix. Therefore, presence of troughs is not given by an orientation of bioclasts. About one third of the known specimens show a suggestion of meniscate (arcuate) structure in the filling of the tunnel of individual troughs (this structure is therefore visible on rock fractures or sections corresponding to bedding). The meniscate structure is demonstrated (on the contarty to trough-like structure) by the orientation of the bioclasts, mostly several millimetres long particles of trilobite carapaces.

Morphology of lateral margins of the trace (and partly even a way of ending of the structure downwards and upwards) remains somewhat uncertain because of a fragmentary preservation of most collected samples. One of the trough-like specimens is bordered along its upper margin by a conspicuous tunnel oval in a cross-section (also it is an analogy to *Teichichnus*). The lateral ending of the trace is not known from both the ends of the specimen not once. In two cases, a gradual lowering of the structures is visible, but in one side of the traces only. Other specimens are ended by a rock fracture or by an irregular „truncation", often probably of a bioturbation origin.

Remarks: As the morphology of the trace is concerned, *Rejkovicichnus* shows the closest relations to the ichnogenus *Teichichnus* Seilacher, 1955. The „troughy" specimens of *Rejkovicichnus* without meniscate fill differ from *Teichichnus* only by the presence of large bioclasts in the fill. *Teichichnus* shows a homogeneous fill after numerous published descriptions (e.g., Seilacher 1955, Häntzschel 1975, Frey and Howard 1985 and 1990, Bjerstedt 1987, Fillion and Pickerill 1990); small bioclasts only were observed by Pickerill and Forbes (1979). The main feature differing the trace *Rejkovicichnus* from *Teichichnus* is the meniscate filling of individual troughs. The meniscate fill is close to that of *Ancorichnus* Heinberg and *Taenidium* Heer (see Howard and Frey /1984/ and D'Alessandro and Bromley /1987/); these traces, however, show a character of simple individual tunnels. These tunnels are also represented in our material, but as one of the extreme varieties of the morphological spectrum. There are some other traces showing a great amount of bioclasts in its mass, e.g., *Diopatrichnus* Kern, 1978. In the case of this trace, however, the bioclasts served as a material for wall lining of tunnels; it is not, in any case, an analogy of *Rejkovicichnus*. Also numerous coprolites may contain larger bioclasts, but they have their own specific morphology and properties (Hunt et al. 1994).

Interpretation and ethological sense: Because of a continual spectrum of the collected specimens (both as the shape and the character of the fill is concerned), we judge that the visibility or the indistinctness of the inner structure do not show a substantial difference in an origin of such traces; more probably, these differences of the fill are a result of random factors, which influenced if the trough-like structure or orientation of bioclasts were fossilized or not. Among these factors, we can presume a cohesity of the just bioturbated substrate, variations in a rate of the activity of the tracemaker, size and shape of the bioclasts, early diagenetic pressure, or a subsequent re-bioturbation of the fill. Therefore, we do not explain the „troughy walls" and the „not-dissected walls" by different activities of the tracemaker; similarly, we do not believe that the presence or the absence of meniscate orientation show an ethological difference.

Undoubtedly, the individual „troughs" or horizontal lamination of the „walls" point to a manyfold movement of the tracemaker (or a certain organ of the tracemaker) along the same trajectory, but in somewhat upper part of the substrate. The meniscate fill is characteristic for the traces filled with the material that passed by a distinctive tract (*Ancorichnus*, *Taenidium*). Therefore, the tracemaker had stay at the place for some time. Composition of bioclasts specifies a nutrition sources of the tracemaker - disarticulated parts of the Middle Cambrian shelly fauna prevail.

In contrast to *Teichichnus* (its troughs represent individual feeding probes), the troughs and tunnels of *Rejkovicichnus* may be interpreted rather as isolated „fecal acts".

Benthic organisms use, besides a predation and scavengery, most often the two following strategies of obtaining the food: sediment feeding and filtration of water/detritus suspension. In our opinion, *Rejkovicichnus* may be explained as a product of extreme modifications of both the last-named strategies. Both the possibilities are figured on Fig. 3 and 4.

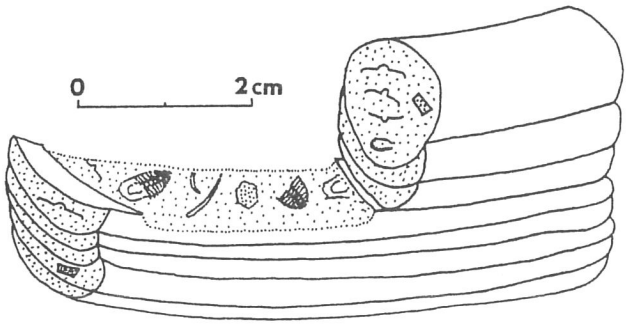

Fig. 2. *Rejkovicichnus necrofilus* ichnogen. et ichnosp. nov. Schematic drawing of the trace made after the holotype.

The high density of bioclasts in the fill is important. If it resulted from catching of the coarsest particles of detritus on the bottom and nearly above, the explanation presented on Fig. 3 is correct. The tracemakers might have been partially covered with the substrate. For the consumption of a mass containing the sharp bioclasts, it might have been advantageous to eat a certain share of the substrate that „wraped" the sharp particles. Deposition of the fecal material to the substrate in the form of the „tunnels" or the „walls" might have been important for all the population of tracemakers (that was probably very dense), because it prevented a mixing of digested particles with usable food sources.

On the contrary, a non-selecting substrate feeding (Fig. 4) cannot concentrate substantially the bioclasts in the fecal material. Nevertheless, we consider even this way of origin of *Rejkovicichnus* to be possible, because the locality Potůček yielded thin layers and concretional clusters of bioclasts of the comparable size and density as seen in the fill of the traces. Origin of these formations is unclear, probably mechanogenic. If the tracemaker would consumed selectively these lenses and clusters only, its fecal material should show the character as known in the fill of *Rejkovicichnus*. Explanation of manyfold movement on the same trajectory is, however, more complicated in this case. Moreover, origin of the described laminae and concretions with bioclats may be of an opposite principle: they might origin by a destruction of the described traces.

Other remarks: *Rejkovicichnus* seems to occur in a limited area and time interval. Therefore, a life strategy represented by this trace did not hold out with a competition of other strategies or it was joined with too specific conditions. Nevertheless, various localities of the central Bohemian Middle Cambrian of the younger Paradoxides gracilis Zone yielded rare finds of traces showing a concentration of large bioclasts (mostly the echinoderm plates, less frequently parts of trilobites) in the fill. In these cases, the tunnel-shaped forms with randomly oriented bioclasts are concerned only, and they can be classified as *Planolites* Nicholson. Nevertheless we do not refuse a certain affinity of this form to *Rejkovicichnus*.

The Potůček locality yielded sporadically also finds of tunnels up to 1 cm in diameter, filled with a material without bioclasts. We presume that they are a result of an activity different to that forming the *Rejkovicichnus* traces. We classify them as *Planolites* ichnosp.

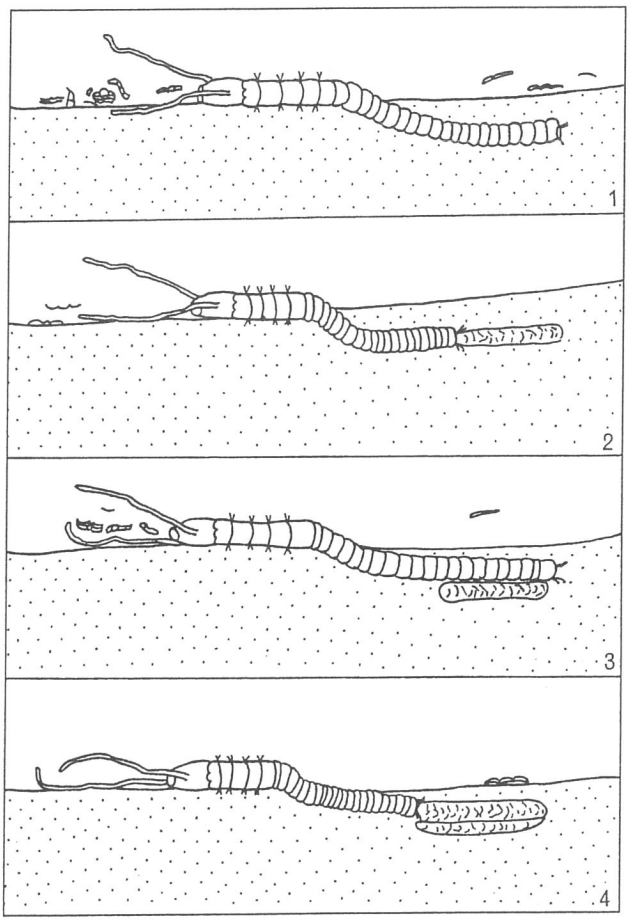

Fig. 3. Origin of *Rejkovicichnus necrofilus* if we presume that the tracemaker obtained the food from a coarse detritus suspension.

Occurrence of complete specimens of trilobite *Litavkaspis rejkovicensis* on the fill of some traces is an unusual phenomenon. Because these trilobite specimens fall outside the spectrum of bioclasts in the *Rejkovicichnus* fill by their larger dimensions and by a completness of preservation, we presume that the trilobites buried into the trace fill by their own activity; the aim of the activity was to find digestible particles. Usually se-

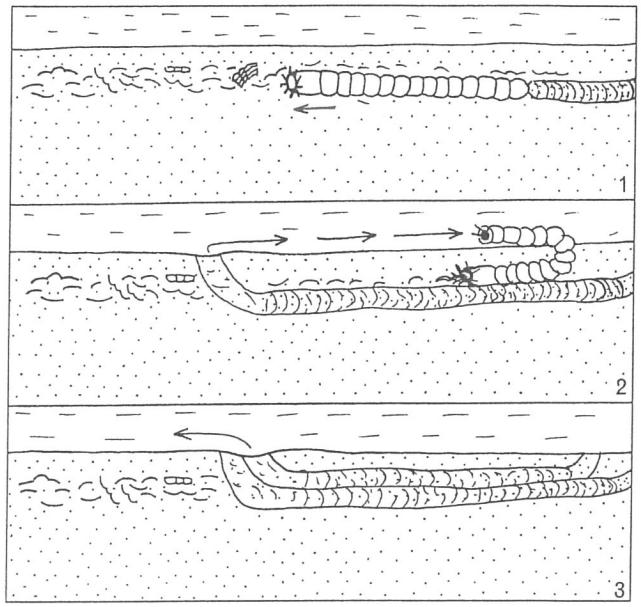

Fig. 4. Origin of *Rejkovicichnus necrofilus* if we presume that the trace-maker obtained the food by feeding on the sediment.

veral complete specimens in one trace are present. More probably we would attribute it to manifestations of an episodic sedimentation, i.e. to a mechanic burying of the specimens which were not able to escape. Biological causes („poisoning" owing to a putrefaction of an organic mass or to a bacterial toxins) are very speculative. Undoubtedly, these finds document that the complete specimens of trilobites may be fossilized in fills of ichnofossils. This fact should be taken into consideration when the finds of rows of benthic fauna in pelitic rocks are interpreted. Such conspicuous rows were described from the Bohemian Ordovician (Prantl 1948, Havlíček 1967, Havlíček et al. 1993). They were interpreded as agglutined tubes of worms (Prantl 1948), or as a result of epiplanktonic life on algae (Havlíček 1967, Havlíček et al. 1993). In our opinion, the possibility, that some of these finds are joined with fillings of traces, exists.

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Explanation of the plate

All the figured specimens come from the Middle Cambrian, the Potůček locality in the Jince area. They are housed in the collection of the Czech Geological Survey, Prague. *Photos by R. Mikuláš*

Pl. I.

1-7: *Rejkovicichnus necrofilus* ichnogen. et ichnosp. nov. 1,3: a „trough-like" specimen; 1 - view of the structure from downwards to upwards. Surface of the basal „troughs" (on the middle part) and margins of upper „troughs" (on the left) are obserable; 3 - rock fracture of the same specimen, corresponding to bedding of the siltstone, 15 mm above the basal „trough". The meniscate character of filling is not developed; x1.0. 2: rock fracture of a „wall-like" specimen with no orientation of bioclasts; complete carapaces of *Litavkaspis rejkovicensis* are present; x 1.0. 4 - specimen with very small randomly oriented bioclasts; x 1.4. 5 - crossing of a „wall-like" specimen with a „tunnel-like" one; x 0.6. 6 - specimen with a meniscate orientation of bioclasts; x 1.2. 7 - oblique rock fracture showing well-visible „troughs" of the fill of *Rejkovicichnus*; x 1.2.

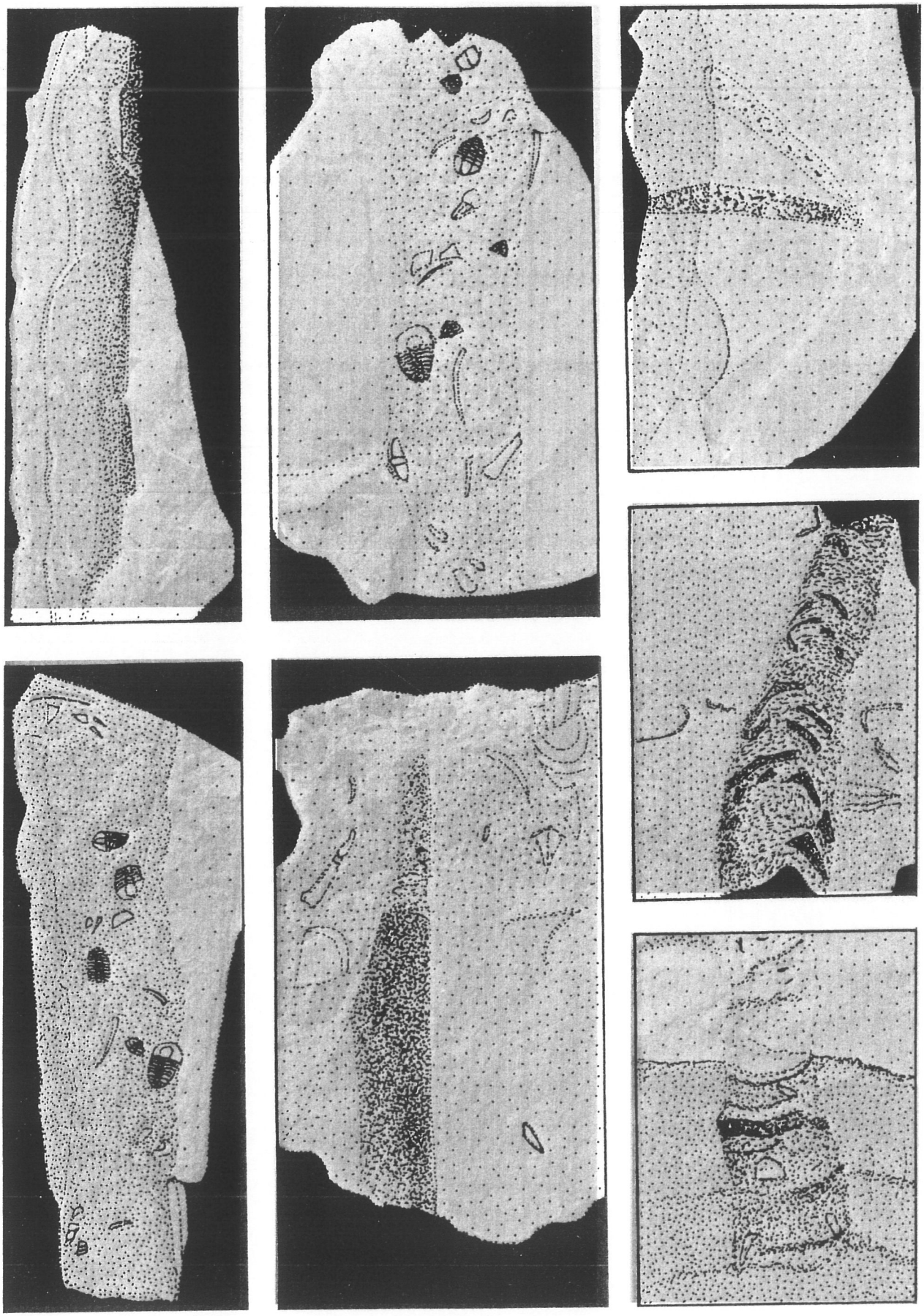
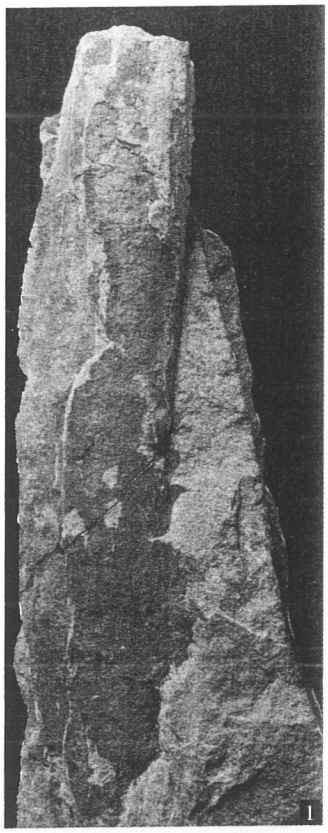


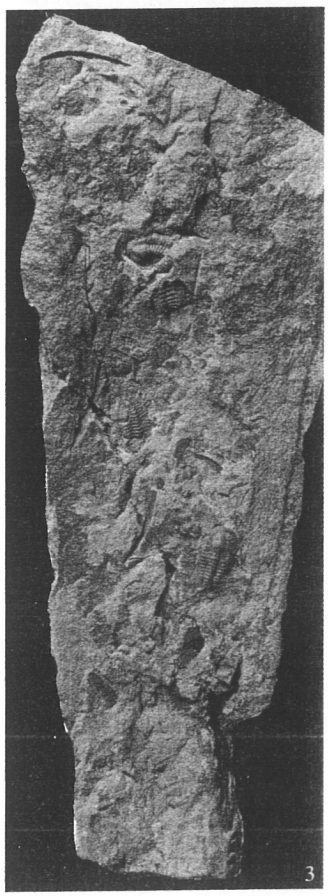
Fig. 5 Interpretative drawings of the specimens figured on Pl. I (see the explanation of the Plate I).













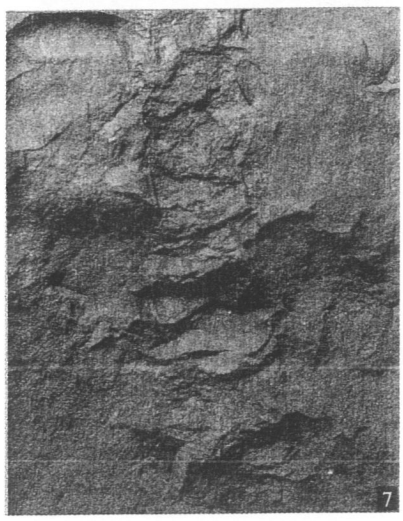


Plate I