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UPPER PRECAMBRIAN AND CAMBRIAN PALAEONTOLOGY OF THE EAST-EUROPEAN PLATFORM

CONTRIBUTION OF THE SOVIET-POLISH WORKING GROUP ON THE PRECAMBRIAN-CAMBRIAN BOUNDARY PROBLEM

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Tyrasotaenia, represented by light yellow, fine, flexible *T. podolica* and dark brown compact *T. tungusica* (Pl. XLIV, Fig. 6).

Cambrian (Baltic) vendotaenids have been so far studied only from the Moldavian section and, partly, from the Platonov Formation along the River Sukhaya Tunguska, the Siberian Platform. They are represented by the genus *Tyrasotaenia* (the species *T. tungusica* together with a few *T. podolica*) in the very base of the Cambrian.

The material available (Moldavia, the Chock-Maidan borehole, the Feropontyevo Formation of the Upper Vendian — the Tigech Formation of the Lower Cambrian) suggests that the Precambrian-Cambrian boundary is associated with a gradual replacement of *T. podolica* with *T. tungusica*, the two species being concurrent within one member, 10 m thick.

In the lithologically uniform member of black shales, (the Chock-Maidan borehole), the Precambrian-Cambrian boundary is traced at the depth of 1237—1242 m by the mass occurrence of sabelliditids from the genus *Sokoloviina* Kirjanov. The distribution of *Tyrasotaenia* near this boundary is as follows: depth 1245—1248 m, distinct prevalence of *T. podolica* with very few *T. tungusica*; depth 1243—1246 m, *T. tungusica* more common than *T. podolica*; depth 1235—1237 m, *T. tungusica* vastly more common than *T. podolica;* depth 1232—1235 m, *T. podolica* becomes extinct, *T. tungusica* persists alone.

In the Platonov Formation along the River Sukhaya Tunguska, the analogues of the Nemakit-Daldyn horizon yield well-preserved *T. tungusica* together with numerous sabelliditids. The Nemakit-Daldyn horizon of the Siberian Platform is regarded as being still the top of the Precambrian, while in the East-European Platform deposits containing very similar organic remains are assigned to the base of the Cambrian. Therefore, the particular case of the age of *T. tungusica* will remain open until the more general problem of the Precambrian-Cambrian boundary has been solved.

In conclusion it may be said that the first attempt to use vendotaenids in Precambrian stratigraphy allowed the discrimination of three floras superseding one another.

I. The Redkino flora: *Eoholynia* Gnilovskaya, *Caudina* gen. nov., *Helminthoidichnites* Walcott, *Orbissiana* Sokolov, *Leiothrichoides* Hermann.

II. The Upper Valdai flora: *Vendotaenia* Gnilovskaya, *Aataenia* Gnilovskaya, *Leiothrichoides* Hermann, *Sarmenta* gen. nov., *Primoflagella* gen. nov.

III. The Late Valdai-Early Baltic flora: *Tyrasotaenia podolica* Gnilovskaya, *T. tungusica* sp. nov.

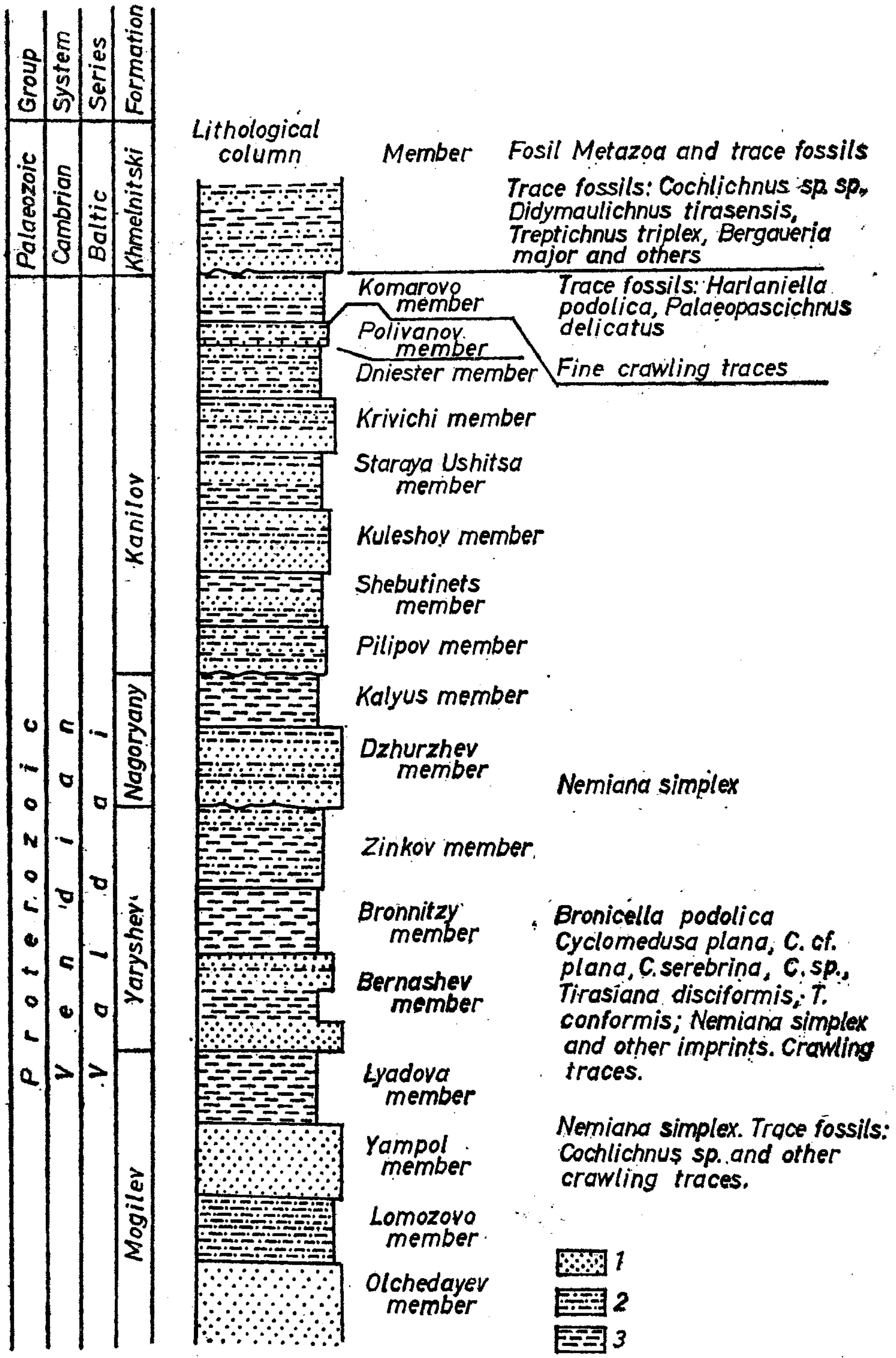
SOFT-BODIED METAZOA AND ANIMAL TRACE FOSSILS IN THE VENDIAN AND EARLY CAMBRIAN

The last decade has seen the discovery of abundant remains of soft-bodied multicellular organisms, preserved as moulds and impressions in the Vendian terrigenous rocks of the East-European Platform. Each year brings numerous new finds (Zaika-Novatsky 1965; Zaika-Novatsky *et al.* 1968; Zaika-Novatsky, Palij 1968, 1974; Keller *et al.* 1974; Keller, Fedonkin 1976; Fedonkin 1978, 1980, 1981; Palij, 1969, 1976; Rozanov *et al.* 1969, Sokolov 1965, 1967, 1971, 1972, 1976). There are two occurrences which are both best known and particularly rich in fossils. One is located in the Podolian Dniester Region and the other in the North of the Arkhangelsk Region, along the White Sea coast (the Onega Peninsula). The largest locality of Vendian non-skeletal fauna was discovered in 1977 in the extended outcrops of the Valdai Series on the Zimnii Shore of the White Sea (Fedonkin 1978, 1980, 1981). Over the last years thousands of specimens of soft-bodied metazoans (about 60 species) and trace fossils (about 20 forms) have been collected from the localities of the Onega Peninsula and the Zimnii Shore.

PODOLIAN DNIESTER REGION

Since the middle of the nineteen sixties the study has continued of problematic organic remains associated with the analysis of the key section of Upper Precambrian and Lower Cambrian deposits in the Podolian Dniester Region. Even the first investigations either produced new evidence of the presence in the Precambrian of the area of peculiar ancient animal forms (Zaika-Novatsky 1965) or allowed a fresh interpretation of familiar data (Zaika-Novatsky, Palij 1968). Further purposeful studies have demonstrated that the Vendian contains an assemblage of soft-bodied multicellular fossil animals (Metazoa), having some elements similar to the Ediacara fossils of South Australia (Zaika-Novatsky *et al.* 1968). These new finds have been described in Palij (1969), Zaika--Novatsky (1974) and Palij (1976). Imprints of soft-bodied metazoans occur in the Lower Valdai sediments of the Podolian Dniester Region from the Yampol beds of the Mogilev Formation to the Dzhurzhev member of the Nagoryany Formation, that is, within the interval roughly corresponding to the Redkino Formation of central and northern parts of the East-European Platform.

Of considerable interest also are trace fossils observed in the Vendian and Lower Cambrian of the Dniester Region. Such fossils from different horizons of the section display some peculiar characters which are especially pronounced at the boundary of the Valdai and Baltic series. This boundary features not only sharply distinct morphological forms of trace fossils but also their greater diversity, abundance and distribution. It is these differences that Seilacher (1956) discusses as evidence of sharp evolutionary changes on the Precambrian-Cambrian boundary. Our data agree with this viewpoint. Some authors say that many characteristic features of trace fossils and their very presence in a given deposit are largely due to facies conditions. Thus, there is a danger of an erroneous interpretation of those features. The section of the Podolian Dniester Region, however, lacks any marked facies change in the course of transition from the Valdai to the Baltic series. Lithologically, the boundary between those deposits is, in fact, arbitrary. Therefore, we have significant grounds to maintain that the changes in the pattern of trace fossil assemblages from the Upper Precambrian to the Lower Cambrian of this region are associated with a great evolutionary breakthrough in the history of the animal kingdom and have considerable stratigraphic importance.



Text-Fig. 2. Generalized geological section of the Upper Precambrian and Lower Cambrian of Podolian Dniester Region;

1 — sandstones; *2* — siltstones; *3* — argillites

There follows a description of the Valdai and Baltic deposits in the Podolian Dniester Region with reference to metazoan remains and trace fossils (Text-Fig. 2).

VALDAI SERIES

Lower Valdai (Redkino) Horizon

M o g i l e v F o r m a t i o n. The rocks of the lower part of the formation, the Olchedayev and Lomozovo members, are essentially of continental origin. In 1979 Fedonkin discovered in the Lomozovo beds of the Mogilev Formation an association of Precambrian Metazoa, the most ancient in the region. This association contains about 30 species including some forms identical to those known from the Vendian of the White Sea region and from the Precambrian Pound Quartzite of Ediacara (South Australia), such as Cyclomedusa, Medusinites, Conomedusites, Dickinsonia, Pteridinium, Tribrachidium etc. Therefore at least in some regions of Podolia the level of Lomozovo beds is represented by normal marine deposits. They first appear in the Yampol member which comprises the most ancient marine sediments of the Vendian in the Podolian Dniester Region. Here, faunal remains are represented by *Nemiana simplex* Palij (Zaika-Novatsky, Palij 1974; Palij 1976) in the form of disc-shaped moulds on the lower surface of sandstone beds. As a rule, moulds (Pl. XLIX, Figs 1, 5) occur in accumulations, some fairly large, more rarely in small groups or singly. Their size varies from 2 to 60 mm, the degree of convexity ranges from quite flat to a height of 10 mm above the specimen surface. The discs do not constitute closed phacoid bodies but make a whole with the overlying rock. Here and there they display reniform processes.

There are many opinions concerning the nature of such fossils. Some authors point out their similarity to the shape of raindrop imprints (Krasovsky 1916); others suggest that these are traces of air bubbles appearing due to the waves surging towards the flat sandy shore (Lungersgausen 1939) or that they might have formed as a result of drops falling from under the overhanging bench (Stashchuk 1958). Voznesensky (1956) described them as trace fossils (burrows) of ancient chordates or crustaceans. Kaptarenko's (1928) most fundamental study made it possible to refute all hypotheses of inorganic origin of the above imprints. She suggested that they belong to primitive medusae similar to *Medusina* Walcott.

Some features betray similarity of *Nemiana simplex* moulds to the trace fossils *Bergaueria* (Prantl 1945 *et al.*) which are believed to be Lebensspuren (burrows) of actinia-like organisms. But there is a number of arguments against attributing *Nemiana* to trace fossils. They lack a cylindrical part which is well-pronounced in *Bergaueria*. Their moulds often display signs of deformation: wrinkles, folds, general deformity of shape (Pl. XLIX, Fig. 6), which could be intrinsic in the animal soft body itself, but not in the traces it left. And finally, the *Nemiana* moulds may deform each other, but even when most tightly packed, they never show any signs of mutual destruction, which would be inevitable had they been the burrowing traces formed mechanically.

Thus, the most reasonable assumption is to refer the imprints of *Nemiana* simplex to very primitive soft-bodied animals. The pattern of those imprints is suggestive of their benthic and sedentary nature. *Nemiana simplex* had a sack-like body open to the top and devoid of tentacles. It inhabited a muddy substrate, which can be deduced from the fact that the surfaces bearing *Nemiana* imprints are confined to argillaceous partings in sandstones. The burial features together with the facies characteristic of the Yampol member show that those organisms required chiefly the following environmental conditions: normal salinity and aeration, shallow water, lack of strong currents. *Nemiana simplex* may have belonged to those ancient soft-bodied polypoids which had occupied the same ecological niche as did the coral polyps from later geological periods.

The occurrences of *Nemiana simplex* imprints are numerous in the Yampol member along the left bank of the Dniester River and its tributaries, the Nemiya, Lyadova, Zhvan and Kalyus. It is noteworthy that they are more often confined to areas of local basement uplifts which were associated with more shallow water conditions of the marine palaeobasin, providing most favourable habitats for those organisms.

A form somewhat similar to *Nemiana simplex* is figured in Sprigg (1947) under the name of "zooidal float". Coming from the Ediacara Pound Quartzite, it is larger than *Nemiana* imprints — up to 15 mm in diameter. However, Sprigg's paper has no description of this fossil. Neither is it mentioned in any later publications of the Ediacara fauna.

The Yampol member also yields trace fossils (Zaika-Novatsky 1971). The present paper (Pl. LIV, Fig. 6) figures a sinusoidal trace of *Cochlichnus* immediately adjacent to the imprints of *Nemiana simplex*. In general, trace fossils are scarce in the Yampol sandstone.

Y a r y s h e v F o r m a t i o n. Imprints of soft-bodied fauna and bioglyphs are known mainly from the Bernashev member, the lower subdivision of the formation. Their occurrences are located in the environs of the town of Mogilev-Podolski, in the village of Serebriya on the left brank of the Dniester River and in the village of Ataki, Dondyushany District, Moldavian SSR. The fossils occur in the upper part of the Bernashev member which consists of alternate thin intercalations of greenish-grey siltstones, mudstones, and fine sandstones with thicker sandstone bands and lenses in the top.

Well-known is the finding in these sediments of *Cyclomedusa plana* Glaessner (Zaika-Novatsky, Velikanov, Koval 1968), the first representative of the Ediacara fauna to be recorded from the East-European Platform. Its identification was confirmed by Prof. M. Glaessner during his visit to the USSR in 1975. A few imprints found here later have also been recognized as *Cyclomedusa*. Some of them (Pl. XLVIII, Figs 2—3) probably belong to the same species, *C. plana;* others were either assigned to *C. serebrina* Palij (Pl. XLVIII, Fig. 4) or identified only at the generic level.

These sediments also abound in *Nemiana simplex* imprints. Additionally, they contain fossils taphonomically close to, but morphologically different from, *Nemiana*. They were distinguished as the genus *Tirasiana* (Zaika-Novatsky, Palij 1974; Palij 1976). *Tirasiana* has a more distinct mould surface sculpture probably due to a more complex structure of its sack-like body than that in *Nemiana*. *Tirasiana* moulds are stepped discs with a round nodule in the middle. According to the complexity of the stepped structure, two species are distinguished, *Tirasiana disciformis* (Pl. XLIX, Figs 3—4) and *T. coniformis* (Pl. XLIX, Fig. 2).

One can suggest that the concentrically-stepped sculpture of *Tirasiana* was due to annular muscles which allowed it, having no skeleton, to preserve a fairly steady body shape and, possibly, to change this according to the environment. This would require a body consisting of at least two layers of cells separated by a mesoglaea. Assuming such a possibility, not only the genus *Tirasiana* but also *Nemiana* (related to it) could be assigned to the coelenterates. Their taxonomic position within the phylum can hardly be defined with precision, since characters are lacking which would prove their affinity with the known representatives of Hydrozoa, Scyphozoa or Anthozoa.

Among other imprints that could be classed with trace fossils of soft-bodied fauna, the Bernashev member displays small discoidal moulds with an extending worm-like body (Pl. LI, Fig. 1). The insufficient material prevented us from describing them with full application of nomenclature.

Trace fossils are quite common in the Bernashev member occurring in the same localities as do the imprints of *Nemiana*, *Tirasiana* and *Cyclomedusa*. These are mostly trails of smaller and larger worm-like animals (Pl. LIII, Figs 2, 4, 5; Pl. LIV, Figs 1, 2). As a rule, they are confined to thin bands of argillaceous sediment which must have contained enough organogenic detritus to feed the mud-eaters. The pattern of these traces shows no system. Of greater interest is the trace fossil from Zhovinsky's collection in the form of a regular chain of small hollows (Tkachuk, Zhovinsky 1972; p. 24, photograph 2). Such traces can be connected with small mud-eaters' feeding. One of the specimens (Pl. LI, Fig. 3) resembles a filled-in burrow.

The overlying Bronnitsy member of the Yaryshev Formation has a unique composition (silicified ash tuff) and is monotonous in structure. The member yields no trace fossils. Zaika-Novatsky (1965) and Palij (1976) described small (2—5 mm in diameter) imprints of *Bronicella podolica*, which are probably of animal origin (Pl. XLVIII, Fig. 1, 5, 6). The imprints were observed in the Bronnitsy member along the Rivers Kalyus and Lyadova. They are similar in shape to *Beltanelliformis brunsae* Menner (Keller *et al.* 1974) from Redkino deposits of the nothern East-European Platform. Their major difference from *Beltanelliformis* is in the nature and pattern of small wrinkles on the surface as well as in a smaller size. The lack on the surface of imprints of organic plant remains, which are usually well-preserved in the rocks of the Valdai series in the Podolian Dniester Region, is an argument against the idea of *Bronicella podolica* being of plant origin. One imprint is distinctive in having a honeycomb structure in its central part (Pl. XLVIII, Fig. 6), which may correspond to a reproductive stage of the problematic *Bronicella* organisms.

N a g o r y a n y F o r m a t i o n. The lower part of the formation, the Dzhurzhev member, yields *Nemiana simplex* imprints abundantly in the area where the Lyadova, Karayets and Zhvan Rivers flow into the Dniester. The Dzhurzhev member with its intercaltions of sandy and clayey rocks differs from the Kalyus member of the top of the formation which comprises dark phosphorite-bearing, often bituminous, argillites having a high content of organic material. There are signs of reducing conditions in the near-bottom waters of the Kalyus basin. This is why the occurrence of faunal remains and trace fossils in the Kalyus deposits is scarcely probable.

Upper Valdai (Kotlin) Horizon

The Kanilov Formation of the Podolian Dniester Region is of Upper Valdai age. No faunal imprints have been found there. This may be accounted for by less developed, as compared with the lower part of the section, sublittoral and neritic sediments. Some authors (Davitashvili 1969) believe that, in connection with the development of predatory activity and biotic factors of living and dead body disintegration in the water or on the bottom of the basins, "the preservation of fossils of Ediacara type became impossible even before the onset of the Cambrian". On the other hand, there are numerous occurrences of medusoid forms and worms from Phanerozoic deposits (Moore 1956; Stasińska 1960; Miroshnikov, Kravtsov 1965 et al.).

The upper subdivion of the Kanilov Formation, the Komarovo member near the village of Molodovo on the right bank of the Dniester River, contains abundant trace fossils of small benthic animals. Remarkable among them are minute sinuous traces on argillaceous surfaces similar to those from the Bernashev member but thinner and more depressed into the sediment. Of considerable interest also are traces of *Harlaniella podolica* described by Sokolov (1972); they consist of grooves (ridges on the undersurface of the bed) with minute oblique striation (Pl. L, Fig. 1—3). According to Sokolov, those are annelid traces. Kirjanov (1968) suggested that they belonged to coprolites. But this suggestion seems to be hardly probable since such traces occur only in semirelief; they would rather be associated with feeding (grazing on the sediment). Mamayev (1970, p. 68) has described a similar trace fossil form, from Vendian sandstones of the South Transurals.

The third form of trace fossils from the Komarovo member should also be referred to feeding traces. These are regular rows of small grooves on the top of the sediment described under the name of *Palaeopascichnus delicatus* (Palij 1976). They (Pl. L, Figs 4—7) are most probably feeding traces, the behaviour of the animals that left these traces displays a certain pattern associated with utilizing, in the course of the movement, the largest possible surface of nourishing sediment. Similar trace fossils have been reported from the Pound Quartzite, South Australia (Glaessner 1969).

Lower Cambrian, Baltic Series

Exposures and boreholes of the Podolian Dniester Region display the lower part of the Baltic series of the south-western edge of the East-European Platform which is known as the Khmelnitski (Rovno) Formation. As to the faunal remains, the Khmelnitski Formation contains different sabelliditid species: *Sabellidites cambriensis* Jan., *S.* ex. gr. *cambriensis* Jan., *Paleolina* sp., *Sokoloviina costata* Kirjanov (Kirjanov

1971). It also yields diverse and abundant trace fossils which chiefly occur in the lowest part of the formation composed of dark-grey siltstones intercalated by argillites, calcareous sandstones and glauconitic-quartzitic sandstones in the base. Observed in the outcrops of the area of the Ternava River inflow into the Dniester these trace fossils constitute a distinctive character of the Khmelnitski Formation and the Baltic series as a whole, distinguishing them from the underlying Vendian sediments.

The specificity and diversity of the trace fossils allow the investigator not only to discriminate morphologically distinct varieties ("genera" and "species") but also to associate them conclusively enough with particular forms of behaviour of Early Cambrian benthic animals, in other words, to assign them to ethological groups accepted in the ichnologic classification (Seilacher 1953a, b; Vyalov, 1966).

The group of feeding traces (Fodinichnia) would include such forms as *Treptichnus*, highly typical of the Khmelnitski Formation (Pl. LI, Figs 4—6, 7; Pl. LII, Fig. 5). The traces of that genus, with elements having a distinct longitudinal tripartite structure, have been distinguished as the species *T. triplex* (Palij 1976). The tripartite configuration of *T. triplex* moulds (Pl. LI, Figs 4—6) is evidence of a fairly complex structure of the animal body, while the pattern of trace elements indicates rather a high degree of organization in their behaviour. Such forms of behaviour as involve traces of this type are extremely characteristic of Phanerozoic benthic animals, from Cambrian (Seilacher 1956; Robinson 1969; Banks 1970) to Recent ones. (Deep-sea photography, 1967, p. 260). One can also class with Fodinichnia quite a few other traces from the Khmelnitski Formation: discontinuous linear trails (Pl. LII, Fig. 6) showing no obvious systematic pattern, dotted burrows, traces of linear movement with regular burrowing into the sediment (Pl. LII, Fig. 4).

Some trace fossil forms from the Khmelnitski Formation are assigned to the group of crawling traces (Repichnia). These are bilobate crawling trails known as *Didymaulichnus tirasensis* (Palij 1974) that belong to bilaterally symmetrical animals (Pl. LII, Figs 1, 2), sinuous traces of the genus *Cochlichnus* (Pl. LIV, Figs 3, 4, 7) and a number of forms less distinct morphologically.

Bilobate crawling traces are common in the Phanerozoic. Glaessner (1969) described forms from the Lower Cambrian of the Arumbera Formation, Central Australia, which are similar to those discussed above. A complete analogy with the Australian forms was discovered by Young (1974) in bilobate traces from the Miette series, British Columbia (Canada) identified as Precambrian. Traces similar to *Didymaulichnus* were observed by Lendzion (1972) in sub-Holmia sediments of the Radzyń borehole, East Poland.

Phanerozoic and, in particular, Palaeozoic deposits also yield *Cochlichnus*, though some varieties of those trace fossils, as is shown by the Podolian material, are also to be found in the Vendian. Their most typical form from the Khmelnitski Formation (Pl. LIV, Figs 3, 4) is close to *Cochlichnus serpens* from the Lower Cambrian of New South Wales, Australia (Webby 1970).

Other *Repichnia* from the Khmelnitski Formation, though too scanty, contribute in some way to our knowledge of abundance, diversity, level of organization and patterns of behaviour in the Early Cambrian benthic animals.

Deep meandering crawling traces on the sandstone surface (Pl. LIII, Fig. 1) are bounded with ridges which suggest that the animal crawled fairly deeply in the substrate. The activity and abundance of crawling worm-like animals can be also deduced from the specimen shown in Plate LIII—LV.

A trace fragment shown in Plate LIII, Fig. 7, belongs to a bilaterally symmetrical animal; the furrow in the middle was probably produced by some protrusion on the animal's body (a kind of keel), while the side furrows were traces of the body's lateral parts.

Two distinct parallel grooves known as *Bilinichnus* sp. (Pl. VIII, Fig. 6) show great resemblance to crawling traces of Recent fresh-water gastropods *Planorbarius corneus* L. They appear as a result of the lateral parts of the mollusc's foot being sunk into the bottom sediment deeper than its central part so that in the course of motion each lateral element leaves behind a narrow furrow.

Plate LV shows an interesting peculiarity of crawling traces, that is some oblique lateral components resembling the traces usually ascribed to gastropods. Lateral stripes are believed to be due to the contraction of mollusc's foot.

Identified as typically Palaeozoic are also the trace fossils *Bergaueria* which are quite common in the outcrops of the Khmelnitski Formation (Pl. LV, Figs 2—6). They are described under the specific name of *B. major* (Palij 1976) and ascribed to the group of dwelling traces (Domichnia). As was mentioned above, they are regarded as belonging to sea-anemone type animals capable of burrowing fairly deeply into the bottom sediments (judging by the size of *Bergaueria major* the burrowing depth might reach 9 cm). Representatives of the genus *Bergaueria* including not only *B. major* but also three more species have been recorded in the Lower Cambrian of Canada and Spain, in the Lower-Middle Cambrian of the USA, in the Upper Cambrian of Poland, in the Middle Ordovician of Czechoslovakia and in the Lower Palaeozoic (Cambrian and Ordovician) of the USA (Alpert 1973).

Thus, most of the characters of the Khmelnitski Formation trace fossils are of a distinct Palaeozoic pattern typical of the Baltic fauna.

THE ONEGA PENINSULA

In 1972, Stepanov brought several imprints of Precambrian soft-bodied fauna collected on the Onega Peninsula near the village of Syuzma, Arkhangelsk Region. In 1973, Keller organized a field trip to the area with a view to making a more extensive study of the locality and collecting more fauna. Among the participants were Keller, Stepanov, and Chumakov. This trip resulted in a collection of fossils that was described by Keller. It contained imprints of *P. nenoxa* Keller and hydromedusae (?) (Keller at al. 1974). Thus, a discovery was made of one of the most exciting occurrences of Precambrian soft-bodied animals within the boundaries of the USSR, probably, no less representative than the famous Ediacara fauna in Australia.

In 1974, this region was further investigated by Chumakov and Fedonkin. They took samples for radiometric and palaeomagnetic dating and gathered a small collection of trace fossils from the beds bearing imprints of metazoans. In 1975, Fedonkin carried on those studies chiefly of the outcrops along the bank of the River Syuzma. More imprints of soft-bodied organisms were found, such as *Dickinsonia costata, Albumares brunsae, Onega stepanovi, Vendomia menneri, Pteridinium nenoxa* (Keller, Fedonkin 1976), and metazoan Lebensspuren (Fedonkin 1976).

In 1976, the same outcrop yielded a large collection of metazoan imprints, some of which are described in this chapter. These are *Beltanelliformis brunsae* Menner, *Spriggina borealis* Fedonkin sp. nov., *Palaeoplatoda segmentata* Fedonkin gen et sp. nov., *Archangelia valdaica* Fedonkin gen. et sp. nov., etc. The bulk of the new collection, however, contained, alongside medusoid forms (over 100 specimens), imprints of organisms ascribed to the genus *Pteridinium*. Being beyond the scope of the present paper, this material requires further studies.

In the south-western part of the Onega Peninsula, the Summer (Letnii) Shore of the White Sea together with the banks of the River Syuzma displays exposures of flat-lying dense greenish-grey clays having thin lenses of light greenish-grey dense flat-bedded siltstones, sometimes calcareous. The siltstones of one such exposure outcropping on the seashore yielded an imprint *Pteridinium nenoxa* (Keller *et al.* 1974).

Of greatest interest are two long outcrops about 12 m high on the right bank of the River Syuzma, 5 km upstream from the river's mouth. Their total length is 900 m. The upper outcrop contains flat-bedded greenish-grey clays similar to those of the coastal exposures, while the lower outcrop is subdivided into two by a tectonic disturbance. The nature of the outcrop suggests the upthrusting of more ancients beds with a vertical fault movement of at least 15 m. Exposed downstream above the fault are clays with siltstone intercalations similar to the clays in other outcrops along the river and the seashore. As to the rocks exposed downstream below the fault, they are brownish-grey clays with intercalations of grey fine-grained sandstones and siltstones, often clayey and poorly cemented. The siltstones of this stratigraphically lower member located downstream from the fault have yielded most of the soft-bodied organisms and some trace fossils. In greenish-grey clays intercalated with siltstones (the upper member), imprints and moulds of soft-bodied organisms are less common (fragments of *Pteridinium* and medusoid forms), while trace fossils occur much more frequently.

An acritarch assemblage discovered in greenish-grey clays is represented, according to Volkova's identification, by *Leiosphaeridia* of two types, A. and B. Type B, having a denser vesicle and being prevalent in the assemblage, usually occurs in the upper part of the Valdai series of the East-European Platform. Microphytolites, found in dolomitized marls, intercalating the beds of greenish-grey clays in small outcrops some 0.5 to 2 km from the mouth of the Syuzma, are represented, according to Z. Zhuravleva's identification, by *Nubercularites antis* Z. Zhur., and *N. varians* Z. Zhur., which are common in the Nemakit-Daldyn horizon of Siberia.

There is no agreement as to the age of the clayey beds on the River Syuzma. Zoricheva (1963) believes that the clayey beds exposed in the

Nenoksa borehole belong to the Kotlin deposits. This conclusion is corroborated by Volkova who indicates that the acritarchs from the clayey beds of the Syuzma allow for correlation with the very top of the Valdai series (Kotlin Formation) (Keller *et al.* 1974).

Aksenov and Igolkina (1969) consider the clayey beds of the Nenoksa borehole and of the River Syuzma to be analogues of the Redkino Formation, believing that the Kotlin Formation is observed only in the boreholes of Arkhangelsk.

Up to the present, the following fossils from the beds of the Valdai series cropping out of the surface on the Onega Peninsula have been described: *Pteridinium simplex* Gürich, *P. cf. simplex* Gürich, *P. nenoxa* Keller, *Vendomia menneri* Keller, *Dickinsonia costata* Sprigg, *Albumares brunsae* Fedonkin, *Onega stepanovi* Fedonkin, *Spriggina borealis* Fedonkin sp. nov., *Inkrylovia lata* Fedonkin gen. et sp. nov., *Archangelia valdaica* Fedonkin gen. et sp. nov., *Palaeoplatoda segmentata* Fedonkin gen. et sp. nov., *Beltanelliformis brunsae* Menner and *Cyclomedusa minuta* Fedonkin sp. nov. The species *Pteridinium nenoxa* described by Keller (Keller *et al.* 1974) was later ascribed by Sokolov to a presumably new genus *Onegia* Sokolov (1976).

Of the above forms, two species: *Pteridinium simplex* and *Dickinsonia costata* are known from the Ediacara assemblage, Australia. Common also are the genera *Spriggina* and *Cyclomedusa*. All this suggests that the sediments bearing the fauna described in the East-European Platform and in Australia are of the same age.

Earlier, some of the boreholes in the northern part of the East-European Platform yielded fossils from the same horizon, namely, *Vendia sokolovi* Keller from the Yarensk borehole (Rosanov *et al.* 1969), and *Charnia* ex. gr. *masoni* Ford from the Nizhnyaya Pesha borehole, south of the Cheshskaya Guba (Sokolov 1976). Finding of the latter made it possible to correlate the Charnia-bearing occurrence in England with the above horizon.

The Valdai series to which the Onega Peninsula localities belong was encountered in the boreholes of Nenoksa, Arkhangelsk and Nizhnaya Toima (Kamenny Priluk) on the River Severnaya Dvina. According to Igolkina, the Valdai series in the Nizhnaya Toima boreholes is overlain with a small number of thin-layered argillaceous rocks bearing sabelliditids and acritarchs. Volkova's identification shows that acritarchs are represented by numerous *Leiosphaeridia*, type B, widespread both in the Valdai and in the Baltic series together with individual *Pterospermopsimorpha* sp., *Cymatisphaera* sp., *Micrhystridium tornatum* Volk. and *Granomarginata* cf. *squamacea* Volk. (depth 758.8 m), in other words, by all species associated with the Baltic series of the Lower Cambrian. These facts demonstrate that the metazoan remains from the Valdai series of the Onega Peninsula occur much below the most ancient Cambrian strata.

The above is also confirmed by the assemblage of trace fossils from the Valdai series of the Onega Peninsula. Lacking here are forms characteristic of the most ancient Cambrian terrigenous rocks. The lack of Domichnia (dwelling structures) in that part of the Valdai series is again evidence in favour of its Precambrian age. Confined to the lower member with numerous metazoan imprints are crawling traces (Repichnia) and resting traces (Cubichnia) of fairly large organisms as well as, more rarely, feeding traces (Fodinichnia) in the shape of circular burrows or strings of rounded faecal pellets up to 8 mm in diameter. This lower member yielded such trace fossils as *Planolites* sp., *Neonereites* sp., *Suzmites volutatus* Fedonkin, *Vendichnus vendicus* Fedonkin gen. et sp. nov. and some others.

The upper member of grey-green or sometimes bluish clays with intercalations and lenses of dense siltstones contains a significantly different trace fossil assemblage; it is predominated by Fodinichnia (feeding traces), Pascichnia (grazing traces) and, more rarely, Repichnia (crawling traces). The traces occurring in the upper member are of smaller size and feature no Cubichnia (resting traces). From this member, such trace fossils as *Neonereites uniserialis* Seilacher, *N. biserialis* Seilacher, *Nenoxites curvus* Fedonkin, *Palaeopascichnus delicatus* Palij, *Planolites* sp., *Bilinichnus simplex* Fedonkin et Palij gen. et sp. nov. and some others have been recognized.

Thus, the animal trace fossils that have been found in the Valdai series of the northern East-European Platform cover four out of five groups in Seilacher's ethological classification (1964): traces of crawling, resting, feeding and grazing. No structures have been observed so far which could be referred to dwelling burrows (Domichnia).

A comparison of trace fossils and the fauna known from imprints in the Valdai series of the Onega Peninsula shows that except in very few cases it is impossible to assign the trace fossils to a given faunal taxon. Such "incongruity" of trace fossils with fauna is quite common not only in Pre-Cambrian but also in Phanerozoic ichno- and biocoenoses, for trace fossils usually belong to infauna (traces made below the sediment surface have a much better chance of preservation than surfacial traces), while body fossils represent either vagile benthos or nectonic and planktonic fauna. Besides, the infauna is usually associated with soft-bodied forms that can be preserved extremely rarely.

Among trace fossils that, not without a doubt, could be correlated with the Valdai fauna known from imprints one can point out *Suzmites volutatus* possibly related in some way with *Pteridinium nenoxa* (Fedonkin 1976).

Trace fossils from the Valdai series of the Onega Peninsula are evidence of a high organization of Precambrian benthos. The Vendian metazoans moved in the sediments due to peristalsis of the entire body in much the samy way as do Recent annelids, nemertineans and sipunculids, letting the sediment pass through the gut (Pl. LXII, Figs 1—4, 6). In the near surface layers and on the surface, Vendian benthic organisms moved by means of peristaltic waves passing along their ventral side just as is characteristic of living planarians, chitons, and gastropods (Pl. LX, Figs 1, 2; Pl. LXI, Fig. 1); more rarely, they moved with the help of wavy bends of the body (Pl. LXI, Fig. 4) or with the use of appendages.

Characteristic features of grazing traces, both meanders (Pl. LXI, Fig. 1) and sequences of thin ridges (Pl. LXI, Figs 2, 3), are suggestive of the presence in Precambrian detritophags of certain behavioural feeding patterns based on a maximum utilization of sediment in the course of motion. One can see that in the Precambrian those systems were as if "two-dimensional", for the animals chiefly utilized the sediment of the benthic near-surface zone (Fedonkin 1977).

What characterizes the ichnocoenosis described is the lack of any traces of motion involving appendages (such traces have not yet been observed in the Precambrian), though trace fossils of the genus *Vendichnus* permit one to suggest that some Vendian animals related to Arthropoda possessed appendages, but had a nectonic way of life.

THE SOUTHERN SLOPE OF THE BALTIC SHIELD AND THE NORTHERN PART OF THE BALTIC BASIN

The representativeness of the material covering this region varies from horizon to horizon. This is due to the Lontova and Talsy horizons having, besides borehole material, a great number of outcrops.

By their mineralogical composition the trace fossils can be subdivided into two groups: one filled with clastic material of silt grade and the other filled with pyrite crystals of various size. Pyritization of feeding trace fossils is likely to be due to the presence in them of organic substances such as mucus, faeces, etc. The same beds often display pyritization of animal remains: sabelliditids, platysolenids, gastropods and hyolithids and of plant remains, vendotaenids in particular.

Discussed below is the vertical distribution of trace fossils and problematica from the Redkino to Rausve horizon inclusive.

REDKINO HORIZON

The most ancient Lebensspuren have been found in the top of the horizon, within a narrow interval of some 4 m (boreholes: Kunevichi, Malashaty, Pasha). Problematic remains are confined to silty clays. They consist of oval to circular pyrite cells resembling *Orbisiana simplex* Sokolov (Sokolov 1970). The cells usually form a two-row string, but sometimes occur in clusters. The cell diameter of different specimens varies from 0.12 to 0.8 mm, being variable also within one organism. Additionally the same interval yielded ramified pyritized traces up to 0.25 mm wide and less than 5 mm long (Pasha-3) borehole, depth 255—262 m together with straight and meandering trails on the surface of clayey beds. It is not impossible that the remains described are the result of algal pyritization.

KOTLIN HORIZON

Here Lebensspuren are scarce, being confined to the top. A problematic form has been found in silty clay. It resembles a flattened ring (positive hyporelief) with a smooth surface (Pl. LXIII, Fig. 4). The specimen's width is 6 mm and the ring diameter — 1.5 to 2 mm (Kunevichi-4 borehole, depth 328.2 m). At the same level (Pasha borehole, depth 144 m), smooth and longitudinally striated ridges 1—2 mm wide (Pl. LXIII, Fig. 3a, b) have been observed on the underside of the siltstone layer. They are 1.5 mm across, with striae spaced at 0.3 mm. Other ridges (Pl. LXIII, Fig. 3c) show a very distinct striation in the form of oblique furrows. The distance between furrows is 0.25 to 0.5 mm. This form is similar to that from the Komarovo Formation of the Podolian Valdai series which Sokolov (1972) called *Harlaniella podolica*.

ROVNO HORIZON

The Rovno horizon sediments are encountered only in eastern regions. The horizon features two parts differing in the combination of particular types of rocks. The lower part having coarser grains is made of alternating sandstones, siltstones and pelitic siltstones. The upper part is composed of siltstone clays intercalated with siltstones. A fairly uniform composition, thickness and structure of the rocks in the horizon throughout the entire area under study points to the fact that Rovno sediments were deposited in a fairly shallow, open marine basin.

At this stratigraphic level, trace fossils are scarce, consisting usually of pyritized straight, curved or, rarely, branched trails. Their width, never exceeding 2 mm, is as a rule less than 0.5 mm. On the underside of siltstone layers, straight or curved ridges 1 to 3 mm wide have been observed. Much rarer are vertical tubular traces having a width of 3 mm. It should be noted that the upper part with finer grains has more abundant trace fossils than the sandstones and siltstones of the lower part of the horizon.

LONTOVA HORIZON

The Lontova horizon consists of four members. The basal member occupies the whole northern periphery of the East-European platform. At the time of its formation, sedimentation took place in a shallow water environment, which is attested by the presence of sandy and even gravelly material, phosphoritized and clayey pebbles, oblique layering, ripple marks and mud cracks.

In the eastern part of the area under study (Leningrad Region, western and central North Estonia), the member is chiefly composed of clays having numerous though thin intercalations of siltstones and sandstones. Several types of Lebensspuren have been recognized here:

1. Pyritized traces, straight, curved or meandering (Pl. LXIII, Fig. 7), sometimes branched (Pl. LXIII, Fig. 6A), 0.5 to 2, rarely 3 mm wide. On the clay surface occur clusters of problematic ovate pyritized imprints with a diameter of 1 to 2 mm. Much less common are cylindrical forms made of distinct crystal pyritic aggregates 0.5 to 3 mm wide, lying horizontally or obliquely to the layer.

2. Traces filled with siltstone. There are ridges, chiefly straight or curved, more rarely branched and looped, usually horizontal, less frequently oblique, 1 to 4 mm wide, related to *Planolites*. They are common at the underside of siltstone layer, less common on its upper surface. The system of ridges (Pl. LXIII, Fig. 5) that was recorded on the underside belong, in our opinion, to *Phycodes pedum* Seilacher. This form, extremely typical of Lower Cambrian deposits, has been described from

the Lower Cambrian of Pakistan, Australia, and Norway (Seilacher 1955; Glaessner 1960; Banks 1970).

Westwards, the proportion of clayey rocks decreases, intercalations of siltstones and sandstones occur more frequently with sandstones predominating on the islands. This is also the direction of a considerable reduction in the abundance and diversity of fossils, both pyritized and filled with siltstone.

Most diversified trace fossils have been recognized in the upper part of the Lontova horizon which occur in north-western Estonia. This is composed of intercalating clays and siltstones the surface of which displays mud cracks and ripple marks, while the siltstone surface also contains pebbles of phosphatized rocks. All this suggests that the top of the Lontova horizon formed under shallow water conditions. Pyritized traces are fairly few, whereas subhorizontal *Planolites*, 1 to 15 mm wide and filled with siltstone, are abundant.

TALSY HORIZON

The Talsy horizon in the north-west of the region is not uniform lithologically. There are three lithological units of formation rank. The most ancient deposits situated in the extreme West of the region are represented by coarse-grained siltstones with inclusions, at some levels, of a pelitic siltstone member. The bottom part of the member displays scarce horizontal, straight or curved, ridges filled with siltstone material on the underside of the siltstone layer together with vertical burrows 2 to 3, rarely more than 10 mm wide. More common in the upper part of the member are vertical burrows with a width of 2 to 3 mm and isolated tubercles having a diameter of 2—3 mm.

This member or the Lontova horizon is overlain by the Lükati Formation chiefly composed of alternate clays and siltstones. Eastwards, the proportion of clays in the formation increases. There are common conglomerate beds at the base of the formation. Numerous ripple marks and mud cracks on the bedding surface are evidence of an extremely shallow water environment at the time of the Talsy sedimentation. Trace fossils are abundant and varied. Transverse ridges are filled with diversified material: siltstone which is often enriched with dark green glauconite grains. The ridges often contain remains of *Volborthella* and trilobite fragments.

The Lükati Formation also bears numerous *Planolites* and peculiar resting traces (positive hyporelief), 5 to 7 mm long, that are oriented almost entirely in one direction (Pl. LXVIII, Fig. 1). These traces are similar to *Sagittichnus* Seilacher occurring in the Lower Triassic of Central Europe (Hantzschel 1962, Figs 133—5).

Different trilobite traces are widespread here, namely *Rusophycus* (Pl. LXVI, Fig. 1), *Cruziana*, and *Diplichnites*, the forms close to *Rhizocorallium* and *Halopoa* being much less common.

The Lükati Formation is overlain by a siltstone bed of the Tiskre Formation separated from the layers below by an intercalation of *Mikwitzia* conglomerate. No trace fossils have been found in the basal layers of the Tiskre Formation. The lack of ichnofossils is due to the deposition of those sediments under highly turbulent shoal water conditions. This is also proved by the frequent recognition of pebbles in the siltstones and their occurrence as big lenses.

The basal layers are chiefly composed of horizontally layered coarse grained siltstones with an admixture of clay particles and, to a lesser degree, sand grains. Clayey layers are 5 to 10 mm thick. The sandstones on the top of the bed have ripple marks which suggest that the waters of the basin were rather shallow and highly active at the time of rock formation. Trace fossils found in sandstones comprise U-shaped burrows — *Diplocraterion* (Pl. LXVI, Fig. 4) and straight tubes — *Skolithos* (Pl. LXV, Fig. 1). These vertical burrows have been identified by Öpik as *Diplocraterion parallelum, D. helmerseni,* and *Skolithos linearis* (Öpik 1929, 1933). In some cases, thin clayey intercalations display vertical burrows, 3 to 5 mm wide, and ridges lying parallel to the bedding surface and having a width of 2 to 4 mm.

VERGALE-RAUSVE HORIZONS

In western Estonia and on its islands the lower part of the Vergale horizon contains a siltstone complex differing from the underlying deposits in that it has several intercalations of pelitic siltstones. It displays a horizontal stratification that becomes oblique in some parts of the basal beds. The scarce vertical and straight traces of worm-like organisms at the underside of the beds are 2 to 3 mm wide and filled with siltstone.

The siltstone bed is overlain with more clayey siltstones composed of two beds. The first is made of alternate silty clays and siltstone, and embraces the western islands of Estonia. The second, occupying the western continental part of Estonia, represents chiefly the coastal zone of sedimentation and consists mainly of siltstones. Prevalent is a horizontal lens-like type of layering, oblique layering being quite rare. The siltstone sediments of the western islands of Estonia are reworked by mud-digging organisms forming a texture of "kraksten" kind. The continental part is characterized by an almost complete lack of trace fossils, with straight or curved ridges filled with siltstone and vertical burrows up to 13 mm wide occurring rarely. The former probably represents a fairly shallow exoneritic marine zone. Flat clayey pebbles and a conglomerate-like accumulation are suggestive of a considerable turbulence of the water mass during sedimentation.

In spite of the fact that a systematic study of trace fossils from the Upper Precambrian and Early Cambrian has only jus been started, there is still room for drawing some conclusions.

The earliest animal traces have been recognized at the Redkino level in Podolian sections, in the Kunevichi, Malashaty and Pasha boreholes of the Baltic Region as well as in the beds of the Valdai Series on the Onega Peninsula. But there is preliminary evidence concerning the occurrence of undoubted traces in the earlier Upper Riphean beds. Vendian trace fossils permit one to suggest that this was the time when many groups of animals either appeared or turned to a benthic way of life. Most of these animals are not known from the remains of soft-

-bodied organisms, but their traces are indicative of a fairly advanced organization similar to that of Annelida, Arthropoda and Mollusca (Gastropoda?).

The Vendian saw the appearance of new ways of locomotion and behavioral patterns in the course of feeding of Metazoa (Fedonkin 1976) that had been unknown in the earlier eras. Characteristic of the Vendian and the Precambrian in general is the absence of deep burrows and their small diameter as well as the negligible role or complete lack of Domichnia (domicile structures) in the ichnologic spectrum.

All in all, the Vendian ichnocoenosis is specific enough for trace fossils to be used in the recognition and correlation of Vendian sediments. Ichnologically, the Valdai series includes forms common to various regions of the East-European Platform, analogues of the Vendian in the Urals and Siberia, of the Ediacarian in Australia and other regions of the world where Upper Precambrian trace fossils have been studied. Given below is a list of animal trace fossils of the Valdai series in the East-European Platform *.

Harlaniella podolica Sokolov
Palaeopascichnus delicatus Palij
Cochlinus sp.
Suzmites volutatus Fedonkin
Neonereites uniserialis Seilacher
Neonereites biserialis Seilacher
Nenoxites curvus Fedonkin
Planolites cf. *serpens* (Webby, 1970)
Planolites sp.
Bilinichnus simplex Fedonkin and Palij
Vendichnus vendicus Fedonkin
and other forms

The palaeoichnologic character of the Baltic Series is more distinct and prominent. The oldest Cambrian layers display a sharp increase in the abundance, diversity and complexity of trace fossils with a much greater biological utilization of the sediment as compared to Precambrian beds. These differences can be suggested as a criterion for tracing the Precambrian-Cambrian boundary.

Such a sharp difference between the Vendian and Cambrian ichnocoenoses is probably due to the beginning of a more active occupation by Cambrian animals of sediments as a new ecological niche. The appearance of hard parts of the body (skeleton) opened up great prospects for faster locomotion over the surface and inside the sediment. There is every possibility that the rapid occupation of sediment in the Cambrian was accounted for by some stress on the organisms of certain ecological (biotic or abiotic) factors. Under the circumstances, the sediment thickness played the part of a buffer lessening the effect of the stress. An increased predation and interspecific competition could be those abiotic factors which influenced the way of life and behaviour of the invertebrates in the Cambrian sea. This can be indirectly proved by the greater role of Cambrian Domichnia (dwelling burrows) and the more complex behavioural feeding patterns suggesting a more rational utilization of feeding resources of the area.

Lower Cambrian deposits contain the following trace fossils:

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* The list of Vendian trace fossils can be completed now by the forms described from the Valdai Series of the Zimnii Shore (Fedonkin, 1980a), namely, ***Vimenites bacillaris*** Fedonkin, *Neonereites renarius* Fedonkin, ***Intrites punctatum*** Fedonkin and ***Aulichnites*** sp.

Rovno and Lontova Horizons

Didymaulichnus tirasensis Palij
Treptichnus triplex Palij
Bergaueria major Palij
Cochlichnus sp.
Treptichnus sp.
Phycodes pedum Seilacher
Planolites sp.

Talsy Horizon

Skolithos linearis Haldenmann
Rhizocorallium sp.
Holopoa sp.
Sagittichnus sp.
Cruziana sp.
Rusophycus sp.
Diplichnites sp.
Dimorphychnus sp.
Diplocraterion sp.
Gordia sp.
Treptichnus sp.
Planolites striatus (Hall)
Planolites virgatus (Hall)

The above lists show that the Precambrian-Cambrian boundary features a sharp change in ichnocoenoses. Such traces as *Treptichnus, Didymaulichnus, Phycodes,* and *Bergaueria* are of universal distribution in the Lower Cambrian sediments, while in the Precambrian they have not been recognized so far. The traces of the above genera may be considered to be index fossils for the Lower Palaeozoic.

One can fix a distinct beginning of post-Tommotian sediments in the East-European Platform by trace fossils. This boundary is distinguished by the appearance of a trilobite trace association, *Cruziana, Rusophycus, Diplichnites* etc. Widely distributed in those sediments are U-shaped burrows of *Diplocraterion* type associated with simple vertical tubes of *Skolithos linearis*. Whether *S. linearis* occurs below is not yet clear.

For the last decade the paleontological inventory of the Valdai series has been considerably enlarged due to the finds of soft-bodied metazoan remains. We give below a general list of forms specific to the Valdai series of the East-European Platform.

Bronicella podolica (Zaika-Novatsky)
Nemiana simplex Palij
Cyclomedusa cf. *plana* Glaessner
Cyclomedusa serebrina Palij
Cyclomedusa minuta Fedonkin, sp. nov.
Albumares brunsae Fedonkin
Onega stepanovi Fedonkin
Beltanelliformis brunsae Menner
Archangelia valdaica Fedonkin, gen. et sp. nov.
Pteridinium simplex Gürich
Tirasiana disciformis Palij
Tirasiana coniformis Palij
Vendia sokolovi Keller
Vendomia menneri Keller
Dickinsonia costata Sprigg
Palaeoplatoda segmentata Fedonkin, gen. et sp. nov.
Spriggina borealis Fedonkin, sp. nov.
Charnia ex. gr. *masoni* Ford
Inkrylovia lata Fedonkin, gen. et sp. nov.

New forms of Vendian Coelenterata described recently from the outcrops of the Valdai Series of the Zimnii Shore (the White Sea) should be added to this list: *Nimbia occlusa* Fedonkin, *Pinegia stellaris* Fedonkin, *Veprina undosa* Fedonkin, *Paliella patelliformis* Fedonkin, *Pomoria sorolliformis* Fedonkin, *Bonata septata* Fedonkin, *Protodipleurosoma rugulosum* Fedonkin, *Ramellina pennata* Fedonkin, *Armillifers parva* Fedonkin (Fedonkin, 1980b).

Only four from among the forms listed above disclose similarity between the Vendian assemblage of soft-bodied organisms and the Ediacara fauna. They are *Cyclomedusa, Dickinsonia, Pteridinium*, and *Sprig-gina*. This indicates that so far the Vendian and Ediacara faunas have shown more differences than points in common.

TAXONOMIC DESCRIPTION OF BODY FOSSILS (IMPRINTS)

Phylum: Coelenterata
Coelenterata incertae sedis
Genus: *Bronicella* Zaika-Novatsky, 1968

Bronicella podolica (Zaika-Novatsky), 1965

Pl. XLVIII: 1, 5, 6

Beltanella podolica: Zaika-Novatsky, 1965, p. 98
Bronicella podolica: Zaika-Novatsky, Palij, 1968, p. 132, pl. 1, figs 3a, b; Zaika--Novatsky, 1971, p. 160, text-fig. 24a-e; Palij, 1976, p. 69, pl. XXI, figs 1—2.

Description. Small (2 to 5 mm) circular imprints of convex (hyporelief) or flattened shape with a hardened enamel-like surface either smooth or (in deformed specimens) sculptured with very thin wrinkles and folds.

Distribution. Imprints occur in the Bronnitsy member of the Yaryshev Formation of the Vendian in Podolia.

Genus: *Cyclomedusa* Sprigg, 1947

Cyclomedusa cf. plana Glaessner et Wade, 1966

Pl. XLVIII: 2—3

Description. Circular flat moulds 70 to 72 mm in diameter. Their surface subdivided into three concentric zones, inner, middle and outer. The inner zone is a rounded tubercle with thin concentric folds, the middle zone being smooth and slightly sculptured by punctuated grooves and strings of small impressions. Separated from smooth outer zone by a groove or a ridge.

Distribution. Imprints come from the Bernashev member of the Yaryshev Formation in the environs of the town of Mogilev-Podolski.

Cyclomedusa serebrina Palij, 1969

Pl. XLVIII: 4

Cyclomedusa serebrina: Palij, 1969, p. 111, figs 1—3.

Description. Circular or ovate imprints 40 to 45 mm in diameter, having a depression (negative epirelief) in the centre of a smooth field with a diameter of 3 to 5 mm. The imprint's peripheral part is a margin formed by partly overlapping concentric folds.

Distribution. Imprints come from the Bernashev member of Yaryshev Formation in the environs of Mogilev-Podolski.

Cyclomedusa minuta Fedonkin, sp. nov.

Pl. LVIII: 4

Holotype. No 4464/112; Valdai series, upper part; Onega Peninsula, right bank of the Syuzma River, 5.5 km upstream from the mouth.

Description. Small medusa preserved in the shape of flattened mould with a slightly impressed central tubercle and regular concentric ridges of about the same width around it.

Dimensions, mm:

Umbrella diameter	7
Central tubercle width	1
Concentric ridge width	0.4—0.6

Comparison. Out of all species of *Cyclomedusa* known from the literature the form described has a structure most resembling that of *C. davidi* Sprigg (Wade, 1972) but differing from it in being more regularly concentric and flat. But the specimen of *C. minuta* also differs from regularly concentric *C. radiata* Sprigg (Wade, 1972) in lacking fine radial furrows and having a much smaller size.

Distribution. Valdai series, upper part, Onega Peninsula, right bank of the river Syuzma, 5.6 km upstream from its mouth.

Genus: *Nemiana* Palij, 1976

Nemiana simplex Palij, 1976

Pl. XLIV: 1, 5, 6

Nemiana simplex: Palij, 1976, p. 70, pl. XXI, fig. 5; pl. XXII, figs 1—3.

Description. Circular, usually convex moulds 2 to 60 mm in diameter on bedding undersides forming a whole with them. Edges of mould surface slightly intraverted, its cross-section displaying a flat bag-like shape. There are some traces of deformation, such as wrinkles, impressions, furrows, distortion of general form and (scarce) bud-like processes.

Distribution. Moulds are distributed in the Yampol, Bernashev and Dzhurzhev members of the Vendian, Podolian Dniester Region.

Genus: *Tirasiana* Palij, 1976

Tirasiana disciformis Palij, 1976

Pl. XLIX: 3, 4

Tirasiana disciformis: Palij, 1976, p. 71, pl. XXII, fig. 4; plate XXIII, figs 1—2.

Description. Convex rounded moulds on the underside of bedding in the form of two superimposed discs. In the centre of the second, smaller, disc there is a round tubercle. Diameters of main disc, second disc and tubercle are 10 to 27 mm, 5 to 17 mm and 2 to 4 mm, respectively.

Distribution. Moulds are known from the Bernashev member; the village of Ataki, Dondyushan District, Moldavian SSR.

Tirasiana coniformis Palij, 1976

Pl. XLIX: 2

Description. Rounded, convex to tapered moulds on the undersurface of bedding with a stepped sculpture of the surface in the form of three superimposed discs each smaller than the one below, and a round tubercle in the centre. Diameters of moulds (chief disc) and central tubercle 27 to 35 mm and 2 to 6 mm, respectively, height of moulds 5 to 11 mm.

Distribution. Moulds come from the Bernashev member; environs of Mogilev-Podolski: the villages of Ataki and Serebiya. One specimen has been found by Yu. Bekker in the Chernokamensk Formation of Sylvitsa (Asha) series of the western slope of the Urals (identified by the author).

Tirasiana sp.

Pl. XLIX: 7

Description. Fairly strongly flattened mould (with height never exceeding 2 mm); diameter of chief disc 27 mm, that of the second disc 16 mm. The central part of impression deformed so that there is no way to establish whether it was just a central tubercle or a third disc. Surface of second disc shows two diametrically opposed rounded tubercles 2.5 mm in diameter.

Distribution. The mould together with its negative relief have been recognized in the upper part of the Bernashev member; the village of Ataki.

Discoidal mould with an adjacent worm-like body

Pl. LI: 1

Description. Moulds in the shape of small discs 6 to 11 mm in diameter, 1 to 2 mm thick, with a tubercle in the centre having a diameter of 3 to 4 mm, located on the undersurface of green-gray siltstone layer (in the middle of the bottom part and in the lower left corner of the picture). Adjacent to disc from the side opposite the tubercle is a three-dimensional worm-like body, slightly flattened, 15 to 28 mm long, 3 to 5 mm thick. There are nips suggesting its subdivision into 3 to 5 segments. In contrast to *Nemiana* and *Tirasiana*, the mould described can be fully separated from the rock.

Distribution. Recognized in the Bernashev member; the village of Ataki.

Genus: *Beltanelliformis* Menner, 1974

Beltanelliformis brunsae Menner, 1974

Pl. LVIII: 5; Pl. LIX: 5

Medusoid organism related to *Beltanella gilesi* Sprigg: Stratigraphy of the USSR. Upper Precambrian (in Russian), pl. 18, figs 8, 8a, 1962.
Beltanelliformis brunsae Menner: Kirsanov, 1968, p. 90, text-fig. 1; Keller *et al.*, 1974, pl. I, fig. 10.
Beltanelloides sorichevae: Sokolov, 1973, p. 313, fig. 5, No 1—5; Sokolov, 1976, p. 138, text-fig. A.

Description. Convex or slightly flattened moulds (positive hyporelief), circular in cross-section or slightly deformed, with thin concentric wrinkles chiefly along the periphery and a smooth almost flat central part. Wrinkles which are not regularly concentric can merge or branch. They are not always preserved, being rare or completely lacking in small forms less than 5 mm in diameter. Some of larger specimens with a diameter up to 20 mm have small depressions near the centre. This character may be of great taxonomic significance, therefore we have tentatively assigned specimens with similar depressions to *B. brunsae* until more material is obtained.

Distribution. Valdai series, Onega Peninsula. Mass occurrence.

Class: Scyphozoa
Genus: *Albumares* Fedonkin, 1976

Albumares brunsae Fedonkin, 1976

Pl. LVIII: 1

Albumares brunsae: Fedonkin, in: Keller, Fedonkin, 1976; p. 39, pl. I, figs 1—2.

Description. Small medusae with a semi-spherical flattened umbrella having a triradiate symmetry. Three oval lobes preserved in the form of ridges radiate from the center of umbrella. They begin as small thickenings growing thinner towards the peripheral part and terminating in small tubercles at their end. The body of medusa was probably very thin and tender, since the impressions have preserved a system of thin radial dichotomous ridges, which are traces of its gastrovascular system. In each of the three sectors of medusa's body, separated by oval lobes, three channels diverge from the central part, dichotomizing four times towards the edge of umbrella. There are no traces of ring channel or gonads. Along the umbrella adge, the disc displays numerous short, fine tentacles altogether totalling no more than one hundred.

Dimensions, mm:

Diameter of umbrella	13
Length of oral lobes	5
Thickness of tentacles along the edge of umbrella	0.15

Remarks. Triradiate symmetry is fairly rare in coelenterates appearing rather as an exception (Beklemishev 1952). Nevertheless, the shape and structure of *Albumares*, a complex gastrovascular system in particular, which is unusual in Hydrozoa and much more typical for Scyphosoa, allows a suggestion that *Albumares* belongs to scyphomedusae.

Distribution. Valdai series, River Syuzma, Arkhangelsk Region.

Phylum: Plathelminthes
Genus: *Palaeoplatoda* Fedonkin, gen. nov.

Type species: *Palaeoplatoda segmentata* Fedonkin, sp. nov.

Diagnosis. Flat leaf-like body, undulated along the periphery due to deformation, laterally narrowed in the central part. Ventrally, the body is covered with fine transverse ridges converging on the median zone and slightly curved in one direction.

Comparison. New genus and its type species resemble the genus *Dickinsonia*, especially *D. elongata*, in their body shape and fine segmentation but differ from them in having a narrowed central part and a special kind of curvature in finer segments.

Composition. Monotypic.

Distribution. The same as in the type species.

Palaeoplatoda segmentata Fedonkin, sp. nov.

Pl. LIX: 2—4

Holotype: GIN USSR Ac. Sc., No 4463/101; Valdai Series; Arkhangelsk Region, right bank of the River Syuzma, 5 km upstream from its mouth.

Description. Lateral parts of extended body, void of appendages, usually convex. Segmentation due to thin transverse ridges observed on only one (ventral?) side of the body; on the other (dorsal) side such segmentation either hardly distinct or obliterated. Uneven edges undulated due to deformation indicative of their being very tender during the organism's life.

Dimensions, mm:

Length of body	over 70
Width of body	30
Width of median ridge	2
Width of segments	0.6

Remarks. Leaf-like or ribbon-like body of the species described points to its similarity with Recent turbellarians, especially those from the order Polycladida and Tricladida (Dogel 1975). Additionally, they have similar morphological characters and size. Segmentation in the form of transverse ridges, however, resembles the metamery in some polymeric annelids. These facts may be an indication that we are dealing with a type of organism which is transitional from flat worms to annelids. But some turbellarians crawling by peristaltic movements that involve the side of the body facing the substrate have similar transverse ridges (myopodia); such is the case of *Rhynchodemus bilineatus* (Triclada Terricola) according to Beklemishev (1952). All the above allows us to assign, for the present, the form described to the Plathelmintes, though there may appear some additional material refuting this point of view.

Distribution. Nine specimens in different state of preservation found in the lower bed along the River Syuzma, 5 km upstream from its mouth.

Genus: *Dickinsonia* Sprigg, 1947

Dickinsonia costata Sprigg, 1947

Pl. LVII: 2, 4, 6

For synonymy see Keller, Fedonkin, 1976.

Description. Flat ovoid bilaterally symmetrical body, distinctly segmented, with length almost equal to width. Some imprints display a longitudinal median furrow. Body subdivided into long narrow segments slightly flared towards their outer ends. The closer to the anterior or to the posterior end of the body, the greater the bend of segments towards the respective end, the smaller their size and the angle between them and the median line. One of the imprints shows that on each side of median furrow there are two ridges going all along its length and being the starting point for segments.

Dimensions of the smallest complete imprint *D. costata* (Pl. LVII, Fig. 4): length 15 mm, width 12 mm, number of segments 25. The largest imprint, unfortunately incomplete, has a width of 50 mm, observed length of 40 mm, observed number of segments 30 (Pl. LVII, Fig. 2).

Distribution. Valdai series; River Syuzma, Arkhangelsk Region.

Phylum: Annelida
Genus: *Spriggina* Glaesnner, 1958

Spriggina borealis Fedonkin, sp. nov.

Pl. LIX: 1

Holotype. GIN USSR Ac. Sc., No 4464/110; Valdai series, Arkhangelsk Region, River Syuzma, 5 km upstream from its mouth.

Description. Prostomium horseshoe-shaped, slightly broader than the segmented body in its widest middle part. Segments of middle part are the longest, wide and slightly curved towards the posterior end. Posterior segments short and straight. A shallow median furrow in places narrowed due to small tubercles that initiate the segments.

Dimensions, mm:

Length including prostomium		55
Width of segmented part	up to	20
Width of segments, maximum		2.5
Width of median furrow	up to	1.5
Number of segments observed		19

Comparison. Out of the two species of the genus *Spriggina* (Glaessner 1958; Glaessner, Wade 1966), *S. borealis* is most closely related to *S. floundersi* Glaessner, differing from it in the shape of segments and their smaller number while having a fairly large body size.

Material. One well-preserved specimen and several fragments, possibly of the same species.

Distribution. Valdai series; River Syuzma, 5 km upstream from its mouth.

Genus: *Onega* Fedonkin, 1976

Onega stepanovi Fedonkin, 1976

Pl. LVIII: 2

Onega stepanovi: Fedonkin, in: Keller, Fedonkin, 1976, p. 39, plate 1, figs. 3,-6.

Description. Small animals having an ovate flat body with a distinct outline. Central part of the body contains a distinctly protruding segmented zone, slightly shifted towards the narrower end of body. This zone has the following structure: a non-segmented crescentic portion along the vertical axis of the body is followed by five paired vertical lobes oriented at right angles to the body axis and separated by a wide and deep axial groove. Outer ends of lobes slightly curving towards the wider end of the body. Length of lobes gradually decreasing towards its narrow end.

Dimensions, mm:

Length of body	6
Width of body	3.8
Width of protruding segmented zone	1.9
Length of protruding segmented zone	2.8
Width of lobes	0.3

Remarks. Out of the four imprints recognized on the undersurface of the clayey sandstone bed, two (one of them being the holotype) are of similar size and identical structure. The third imprint, 4 mm long and about 2.5 mm wide, has all three segments hardly discernible due to unsatisfactory preservation. Difference in segment number may result from the ability, so characteristic of arthropods, annelids and other animal groups, to increase number of segments with the increase of body size in a given specimen.

Distribution. Valdai series, Arkhangelsk Region, River Syuzma.

Phylum: Arthropoda (?)
Genus: *Vendomia* Keller, 1976

Vendomia menneri Keller, 1976

Pl. LVII: 5

Vendomia menneri: Keller in: Keller, Fedonkin, 1976, p. 39, pl. 1, fig. 4.

Description. Small ovoid body, over one-third of which is taken up by a broad semicircular head. Median ridge begins in the cephalic part. Paired extended segments emerging from the median ridge display an obvious decrease towards posterior part of the body. This is also the direction in which the angle between segments and median ridge is reduced from 85° down to 45°.

Dimensions, mm:

Length of body	4
Width of body	3
Width of median ridge	0.2
Number of segments	6

Distribution. Valdai series; River Syuzma, Arkhangelsk Region.

Incertae sedis
Genus: *Archangelia* Fedonkin, gen. nov.

Type species: *Archangelia valdaica* Fedonkin, gen. et sp. nov.

Diagnosis. Bilaterally symmetrical animal with an ovate body. The axial zone is a sequence of short wide segments showing a zig-zag line in vertical longitudinally oriented section. Segment size gradually decreases unidirectionally. Lateral parts display transverse, gently inclined undulation.

Archangelica valdaica Fedonkin, sp. nov.

Pl. LVII: 1, 3

Holotype. GIN USSR Ac. Sc., No 4464/50; Valdai series, Arkhangelsk Region. Letnii (Summer) Coast, River Syuzma, 5 km upstream from its mouth.

Description. As seen in top view, elongated ovoid body divided by an axial zone, one-fifth of the total width of the body. Segments observed in the axial zone number 12, but even with the missing part added they would be no more than 15. Segment length (measured along the body axis) decreases faster than their width. The number of gently inclined transverse undulations on lateral parts, probably, corresponds with the number of segments in the axial zone. Observed length of body 45 mm, width 27 mm. Length of segments from 2.5 to 4.5 mm, width from 5 to 7 mm.

Material. One mould and fragments of a countermould (negative relief).

Distribution. Valdai series, River Syuzma.

Genus: *Inkrylovia* Fedonkin, gen. nov.

Type species: *Inkrylovia lata* Fedonkin, gen. et sp. nov.

Diagnosis. Large bag-like bilaterally symmetrical forms, with a regular longitudinal segmentation. Flat unidirectionally curved segments subdivided by fine furrows emerging from a deeper median furrow towards the edges. The ends of bag-like body slightly bifurcated.

Comparison. In its segmentation, the new genus resembles imprints of smoothly segmented (ventral?) parts of *Pteridinium nenoxa* (Keller *et al.* 1974), but segments of *Inkrylovia* are distinguished by a practically uniform length (measured longitudinally) and lack of tapering towards their outer ends.

Inkrylovia lata Fedonkin, sp. nov.

Pl. LVI: 1—4

Holotype. GIN USSR Ac. Sc.; No 4464/147; Valdai series (Vendian): Onega Peninsula, right bank of River Syuzma, 5 km upstream from its mouth.

Description. Wide bag-like body must have been flexible which is indicated by gentle folds formed during its burial.

Body width from 40 to 60 mm. Observed length of a fully preserved specimen (Pl. LVI, Fig. 2) about 70 mm, but the fragments available suggest that it may reach 100 mm. Segment length ranges from 4.5 to 6.5 mm being stable within a given specimen.

Remarks. The body of *Inkrylovia* must have been highly flexible which is attested by accidental gentle folds formed during its burial. One of the moulds has a median furrow that terminates in a triangular hollow which may correspond to the oral opening, none of the specimens, however, shows any sign of viscera. The problem of the taxonomic position of *Inkrylovia* cannot be solved without some additional study. One of the specimens (Pl. LVI, Fig. 4) shows a small leaf-like segmented body emerging from the tip of *Inkrylovia* and having a similar type of segmentation. It is likely to be a daughter specimen that has not detached itself from the parental organism. Another specimen displays a small widening in the terminal part. If these facts are proved by some additional material, one would be justified in suggesting that the form described was a soft-bodied bag-like gemmating organism having a sedentary way of life.

Material. Twelve specimens.

Distribution. Onega Peninsula, right bank of River Syuzma, 5 km upstream from its mouth; Valdai series.

Genus: *Pteridinium* Gürich

Pteridinium nenoxa Keller

see Pl. LVIII: 3

Fodinichia Seilacher, 1953
Fodinichia Seilacher, 1953

Harlaniella podolica Sokolov, 1972

Pl. L: 1—3

Problematic worm-like moulds obliquelly wrinkled (coprolites): Kirjanov, 1968, p. 117, pl. I, fig. 2.
Harlaniella podolica: Sokolov, 1972, pl. II, fig. 4; Palij, 1976, pl. XXIV, fig. 1.

Description. Ridges (positive hyporelief), 1 to 4 mm wide, on the surface of siltstone, covered with dense oblique striation in the form of fine furrows tipped at 45 to 80° to longitudinal axis of trace. The furrows are spaced at 0.5 to 0.8 mm. Ridges have frequent gentle curves often slightly narrowed or widened towards one side. Length of traces up to 10 cm.

Distribution. Ridges come from an exposure of the Komarovo member, Kanilov Formation, in the village of Molodovo, Chernovtsy Region as well as from the top of the Kanilov Formation, borehole at the village of Chovguzov, Khmelnitski Region (upper reaches, River Zbruch).

Genus: *Treptichnus* Miller, 1889

Treptichnus triplex Palij, 1976

Pl. LI: 4—6

Problematic moulds (grazing burrows): Kirjanov (1968), p. 118, pl. VI, figs 2, 3.
Treptichnus triplex: Palij, 1976, p. 74, 75, pl. XXIV, figs 3—5.

Description. Positive hyporelief is a system of ridges arranged at an angle of 20 to 40° to the trace longitudinal axis, alternating to right and left. Ridges of regular width, their outward ends either rounded or tapered with the internal ones overlapped by preceding fragments. In vertical plane ridges slightly curved, the convex part directed downwards. Ridge surface subdivided by two vertical grooves into three segments of equal width.

Distribution. *Treptichnus triplex* occurs in an exposure of the Khmelnitski Formation, Baltic series; right bank of River Dniester opposite the mouth of River Ternava, and also from boreholes in Kamenets-Podolski, the village of Olkhovitsy and the town of Volochisk, Khmelnitski Region.

Treptichnus sp. 1

Pl. LI: 7

Description. Spike-like moulds on the surface of fine-grained quartzose calcareous sandstone (positive hyporelief) with some elements inclined to the system's vertical axis at about 40°. Trace elements triangular in plan view, 22 to 23 mm long, 6 to 9 mm wide at the base. Internal tips of elements screened by preceding moulds. In cross-section, mould surface passing from rectangular, at the base, to circular towards the tip.

Distribution. Outcrop of the Khmelnitski Formation; right bank of River Dniester, opposite the mouth of River Ternava.

Treptichnus sp. 2

Pl. LII: 5

Description. Slightly curved, S-shaped trace consisting of two rows of individual moulds (positive hyporelief). Moulds arranged at 45° to the system's longitudinal axis, the shape of most complete of them resembling in plan view a grain with its tip tapered and base rounded. Particular elements 2 to 3.5 mm long and up to 2 mm wide. Total length of the trace about 4.5 cm. Specimen made of greenish-grey siltstone.

Distribution. Specimen comes from an outcrop of the Khmelnitski Formation, opposite the mouth of River Ternava.

Genus: *Neonereites* Seilacher, 1960

Neonereites uniserialis Seilacher, 1960

Pl. LXII: 1

Description. Small rounded bodies, 0.5 to 5 mm in diameter, closely packed, forming straight or curving strings that sometimes cross the bedding surface. Preserved as positive hyporelief. The study of body size shows that with larger specimens the trace trajectory straightens up, while the bodies themselves acquire an oval shape slightly oblate along the axial line of trace. Individual bodies of peculiar structure: their external pellicle is made of coarser grains than the enclosing rock (fine-grained siltstone), whereas the internal part of pellets consists of fine-grained material which often crumbles out leaving hollows inside pellets.

Remarks. The strings of small bodies described are probably traces of peristaltic crawling of sediment-eaters having a fairly high organization, that passed the sediment through their guts, in other words, they are faecal pellets. Quite common are areas of almost complete utilization of nourishing substrate surface (Pl. LXII, Fig. 3).

Distribution. Mass occurrence. Valdai series; River Syuzma in particular (Onega Peninsula).

Neonereites biserialis Seilacher, 1960

Pl. LXII: 2

Description. Small pellets under 1 mm in diameter, forming double strings in which pellets are arranged obliquely to vertical axis of trace. Some of larger pellets display small hollows on one side that may be due to the animal's pushing off the sediment while moving.

Distribution. Valdai series; right bank of River Syuzma, 6 km upstream from its mouth (Onega Peninsula).

Neonereites sp.

Pl. LXII: 4

Description. Rounded pellets of similar diameter (1 to 1.5 mm) preserved on the base of the siltstone as a uniform layer or in small clusters.

Distribution. Valdai series; right bank of River Syuzma, 6 km upstream from its mouth.

Genus: *Planolites* Nicholson, 1873

Planolites virgatus (Hall, 1847)

Pl. LXVI: 2A

For synonymy see Alpert, 1975.

Description. Subhorizontal, slightly vertically and horizontally curved burrow, lens-shaped in cross-section. Burrow beginning in sandstone layer gently slants into argillaceous sediment to acquire a horizontal direction 15 mm below the bottom of sandstone layer it originated from. Burrow surface uneven, width 15 mm, height 6 to 7 mm.

Remarks. Lens-shaped cross-section of burrow is probably due not so much to vertical diagenetic rock compression but to its original ellipsoidal or lenticular shape, for *Planolites striatus* recognized in the same specimen under *P. virgatus* is of a circular cross-section. The burrow may be a feeding trace of a fairly large worm-like organism (probably *Sipunculida*) that grazed its way through the sediment. Part of material filling the burrow was sucked in from overlying sandy layer while the animal was digging into the argillaceous sediment.

Distribution. Lower Cambrian, Talsy, Vergale and Rausve horizons; Latvia.

Planolites striatus (Hall, 1852)

Pl. LXVI: 2B

For synonymy see Alpert, 1975.

Description. Subhorizontal burrow beginning in sandstone layer rather sharply slants into clay to continue horizontally and in a straight line some 15 mm below the sandstone layer it originated from. Burrow surface displays numerous poorly pronounced longitudinal striae of parallel arrangement. Cross-section circular, 5 mm in diameter.

Remarks. *P. striatus* not unlike *P. virgatus* is a feeding trace. A worm-like animal grazed its way through the sediment passing both mud and sand through its gut and consuming the organic matter from it. Fine longitudinal striation of burrow walls may be the effect of bristles that scratched the walls during the animal's movement.

Distribution. Lower Cambrian, Talsy horizon; Latvia.

Planolites cf. *serpens* (Webby, 1970)

Pl. LXII: 6

Description. Subhorizontal burrows, gently sinuously curving and crossing the bedding plane. Burrows circular in cross-section, having 1 to 2 mm in diameter. Burrow sections visible on undersurface of bedding up to 40 mm long. Burrows preserved as gently curving ridges on the underside of siltstone intercalations (positive hyporelief).

Distribution. *P.* cf. *serpens* are associated with *Neonereites* (specimen 4464/47) in the second argillaceous bed of the Valdai Series; River Syuzma, Onega Peninsula.

Genus: *Phycodes* Seilacher, 1955

Phycodes pedum Seilacher, 1955

Pl. LXIII: 5

Phycodes pedum: Seilacher, 1966, p. 386, figs 4, 5; pl. 23, figs 6, 7; pl. 25, fig. 3; Glaessner, 1969, p. 383, figs C-E.

Description. Branches, 7 to 10 mm wide, arranged obliquely to the circular main burrow with a width of 3 to 3.8 mm. Branching tips tapering towards the main burrow 1.5 to 2.9 mm wide.

Remarks. According to Seilacher (1955), a worm-like animal grazed its way through the sediment, moving forward and filling the tunnel end with faeces. This blocked the movement in the previous direction, so the animal made a small adjacent burrow. With this process successively reproduced, plant-like structures appeared. Identical tunnels were observed by Seilacher (1955, p. 386) in the Lower Cambrian of the Salt Range, Pakistan and by Glaessner (1969, p. 313) from the Lower Cambrian of Central Australia.

Distribution. Lontova horizon; northern Estonia (Jägala borehole).

Domichnia Seilacher, 1953

Genus: *Bergaueria* Prantl, 1945

Bergaueria major Palij, 1976

Pl. LV: 2—6

Bergaueria major Palij: 1976, p. 76, plate XXVIII, figs 1—4.

Description. Cylindrical moulds with a rounded lower part often in the shape of a regular hemisphere. The end blunt, rarely conically rounded. Moulds 17 to 60 mm in diameter, up to 90 mm high. Conical part being often destroyed, many moulds are represented by their rounded lower part alone. They are either solitary or arranged in small groups without touching one another.

Distribution. Numerous moulds of *Bergaueria major* have been found in outcrops of the Khmelnitski Formation, right bank of River Dniester, near the village of Suboch.

Genus: *Diplocraterion* Torell, 1870

Diplocraterion parallelum Torell, 1870

Pl. LXVII: 4

For synonymy see Fürsich, 1974.

Description. Vertical U-shaped burrows with similarly curved Spreiten between vertical components. Distance between tubes 18 to 34 mm, diameter of tubes 2 to 4.5 mm, depth of burrows 47 to 105 mm.

Remarks. According to Fürsich (1974), Spreiten are traces of former burrows which were repeatedly re-dug by the animal in response to environmental changes such as fast sedimentation or erosion, in order to keep away from the bottom at a constant distance optimum for feeding and respiratory requirements.

Distribution. Tiskre Formation, Talsy horizon; right bank of River Narva, near Ivangorod Fortress.

Genus: *Skolithos* Haldemann, 1840

Skolithos linearis Haldemann, 1840

Pl. LXV: 1—3

For synonymy see Alpert, 1974.

Description. Vertical burrows, cylindrical to subcylindrical, straight to somewhat curving, some slightly inclined. Walls of burrows distinguishable. In cross-section, the burrow shows a concentric distribution of material: confined to the edges are white quartz grains, while in the centre there is a patch of dark coloured grains, with lighter quartz grains appearing again in the middle. Place of contact between burrow and enclosing rock often ferruginated.

Diameter of burrows from 1 to 4 mm, predominant size being 2 mm, length up to 50 cm and over. Maximum number of burrows per 1 cm^2 is 8. In some cases sequences of 4 to 6 burrows occur with their walls contacting which, in cross-section, appears like a chain with rounded links.

Remarks. The burrows described were, probably, dwellings of annelids or phoronids (Häntzschel 1962, Alpert 1974), though there are quite a few other interesting interpretations (Häntzschel, 1975). They are common in sandy sediments, serve as an indicator of near-shore shallow water environment, known as *Skolithos* facies of bathimetric zonal scale.

Distribution. Ovishi and Tiskre Formations, Lower Cambrian (Talsy horizon).

Repichnia Seilacher, 1963

Genus: *Gordia* Emmons, 1844

Gordia sp.

Pl. LXIII: 2

Description. Narrow, shallow furrows randomly dispersed over the bedding surface (negative epirelief), straight or curving, some loop-like, intersecting one another. Width of furrows 1 to 1.2 mm, depth under 0.5 mm.

Remarks. These traces must have been formed by small worm-like organisms that, while moving, used to disturb the original structure of the near-surface sedimentary zone thus allowing for the traces to be imprinted there.

Distribution. Ovishi Formation, Lower Cambrian; Latvia.

Genus: *Scolicia* de Quatrefages, 1849

Scolicia sp.

Pl. LXIII: 1

Description. Bilaterally symmetrical, straight, long trail (full relief) which in epirelief appears as a ridge with a longitudinal median furrow and smooth gentle slopes. Cross-section shows the trail "bottom" consisting of two shallow furrows separated by a wide low median ridge. Trail 7 mm wide, 3 mm high, width of median groove 1 to 1.5 mm.

Variability of the trail described shows up in the ability of the ridge with a median furrow, in epirelief, to be transformed into two low, narrow parallel ridges separated by a wide almost flat zone. Such variability may be caused by different methods of moving (for example, changing from creeping along the surface of sediment to burrowing inside it). Internal trails preserved as full relief burrows, similar to the above trace, are assigned to the subgroup Subphyllochorda Gotzinger et Becker, 1932 of the group Scolicia, being interpreted as traces of crawling and, possibly, feeding of fossorial gastropods (Häntzschel 1975).

Distribution. Kibartu horizon, Middle Cambrian; Latvia, Ventspils borehole.

Genus: *Bilinichnus* Fedonkin et Palij, ichnogen. nov.

Typė species. *Bilinichnus simplex* Fedonkin et Palij, ichnogen. ihnosp. nov.

Diagnosis. Two narrow shallow parallel furrows of equal width, forming a gently curving trail.

Composition. Monotypic.

Distribution. As in type species.

Bilinichnus simplex Fedonkin et Palij, ichnosp. nov.

Pl. LX: 1, 2

Holotype. GIN USSR Ac. Sc., No 4464/42; Valdai series, River Syuzma, Onega Peninsula.

Description. Two narrow parallel furrows (negative epirelief), forming a long gently curving trail. Often preserved as narrow parallel furrows on the undersurface of siltstone intercalations (positive hyporelief). Furrows 0.8 to 0.9 mm wide, spaced at 2.5 mm, 0.2—0.3 mm deep.

Remarks. Similar traces are made by small gastropods creeping on wet siltstone substrate, grooves being produced by lateral parts of the foot which plunge deeper into the sediment than does its middle part.

Distribution. Valdai series; River Syuzma, Onega Peninsula.

Bilinichnus sp.

Pl. LIII: 6

The surface of thick fine-grained quartzose sandstone contains a fragment of gently curving trace in the form of two narrow strictly parallel furrows (negative epirelief). Each furrow no more than 1 mm wide, 0.2 to 0.3 mm deep, distance between furrows 4 mm.

The specimen has been recognized in an outcrop of the Khmelnitski Formation; right bank of River Dniester, opposite the mouth of River Ternava.

Trilobate discontinuing linear trails

Pl. LII: 6

Distinct moulds (positive hyporelief) on the surface of fine-grained quartzose calcareous sandstone arranged in two rows. Each mould arcuate in vertical plane, its surface subdivided by vertical furrows into three subequal lobes. Moulds rectangular in cross-section, closely adjoining one another, 8 to 10 mm wide, with particular elements 13 to 35 mm long. One of the sectors (in the centre of the picture) displays a zig-zag mould arrangement not unlike that in *Treptichnus*.

The mould comes from an outcrop of the Khmelnitski Formation, right bank of River Dniester, opposite the mouth of River Ternava.

Trails of bilobate to trilobate structure

Pl. LII: 3

Trace consisting of a number of adjacent moulds (positive hyporelief), each arcuate in vertical plane. Along most of its length, the surface of every mould divided into two by a narrow longitudinal furrow. At the point where the mould begins to sink sharply into the rock, the furrow bifurcates subdividing the mould surface, over some length, into three lobes. The farther it is from the bifurcation point, the wider becomes the middle part and the narrower the side lobes, until they fully disappear. Middle part gives rise to the next mould which, in turn, features a median furrow and so on. Width of moulds 8 to 9 mm, length about 35 mm.

The specimen comes from a borehole near the town of Podvolochisk, Ternopol Region (upper reaches of River Zbruch), from intercalation of light-grey fine-grained sandstones and dark-grey siltstones of Khmelnitski Formation.

Trails of progressive motion with periodic burrowing into the sediment

Pl. LII: 4

Positive hyporelief reveals a slightly curving string of irregularly rounded or oblong-rounded moulds on the surface of dense fine-grained sandstone. Moulds 4 to 6 mm across. One mould of irregular shape attains 10 mm in the direction of its greatest elongation. Height of moulds 1.5 to 2 mm. One of the moulds (top left) is located some 5 mm away from the string. At one of string ends (top), four moulds are interconnected by a ridge 2.5 to 3 mm wide and 0.5 to 0.7 mm long. Ridge surface slightly sculptured with arcuate transverse wrinkles, to produce an effect of being formed by several warts. Distance between wrinkles 1.2 to 1.5 mm.

The specimen has been found in an outcrop of the Khmelnitski Formation, opposite the mouth of River Ternava.

Burrowing traces

Pl. LIII: 3

Next to the sinuous crawling trail, there are two adjacent rounded moulds (positive hyporelief), each 6 mm in diameter and 3 mm high. At a distance of 15 mm from them is an oblong mould 8 mm long, 4 mm wide and 2 mm high. All moulds somewhat damaged, the rounded ones broken off from the right, the oblong ones — from the left. Specimen composed of fine-grained quartzose sandstone.

The specimen has been found in an outcrop of the Khmelnitski Formation, opposite the mouth of River Ternava.

Genus: *Didymaulichnus* Young, 1972

Didymaulichnus tirasensis Palij, 1974

Pl. LII: 1, 2

Didymaulichnus tirasensis: Palij, 1974, p. 502, text-fig. 1—2.

Description. Positive hyporelief shows repeatedly curving intersecting and overlapping ridges 8 to 14 mm wide. In cross-section they are trough-like, some almost cylindrical. Stretching along the smooth surface of ridges are furrows 0.5 to 2.5 mm wide, up to 1.5 mm deep, wedge--like in cross-section, with rounded edges.

Distribution. Trail imprints occur in the outcrop of the Khmelnitski Formation, right bank of Dniester bend, near the village of Suboch.

Filled-in burrow

Pl. LI: 2

Mould (positive hyporelief) making a whole with the specimen surface. Curved over most of its length, forming a closed loop. Loop, intersected by an earlier formed arcuate fragment, overlaps in turn a section of a later origin. Mould 5.5 to 7 mm wide, 1.5 to 2 mm thick, ovate in cross-section. Specimens composed of fine-grained quartzose sandstone, with argillaceous underlying layer.

The specimen comes from an outcrop of the Khmelnitski Formation, opposite the mouth of River Ternava.

Filled-in burrow (?)

Pl. LI: 3

Slightly curving S-shaped mould, 28 mm long, 4 mm wide, distinct on a fragment of fine-grained glauconite argillaceous sandstone. Mould edges sinking into the rock, it cannot be separated from the surface, and the side opposite that observed probably forms a single whole with it. Mould flattened, under 1.5 mm wide.

The mould has been found in laminated sandstones, lower part of the Bernashev member cropping out in a clay pit; Gorky Street, Mogilev-Podolski.

Crawling trails of worm-like animals

Pl. LIII: 2, 4, 5; Pl. LIV: 1—2

Moulds appear in three varieties. The first comprises narrow, unbranching, irregularly dispersed, shallow furrows on the upper surface of layers with corresponding ridges on the undersurface. Furrows 1 to 1.6 mm wide, no more than 0.5 mm deep. Trails form arcuate loop-like irregular curves (Pl. LIII, Figs 2, 4).

The second variety (Pl. LIII, Fig. 5; Pl. LIV, Fig. 1) differs from the first one in greater width (3 to 8 mm) and depth (up to 2 mm). Fragments chiefly straight or gently curving, edges indistinct or rounded. These traces often occur in association with trails of the first variety (Pl. LIV, Fig. 1) intersecting them.

Trails of the above two varieties are distributed in siltstones and sandstones of the upper part of the Bernashev member near Mogilev--Podolski.

The third variety (Pl. LIV, Fig. 2) is represented by narrow, meandering, distinct moulds (positive hyporelief) of small length. They are of smaller width, under 0.8 mm, and more pronounced sculpture than trails of the first variety which is suggestive of a more active penetration of the animals into the sediment.

Moulds of the third variety occur in intercalations of siltstones and argillites, Komarovo member, Kanilov Formation, the village of Molodovo.

Genus: *Cochlichnus* Hitchcock, 1958

Cochlichnus sp. 1

Pl. LIV: 3—4

Description. Sinuous unbranching furrows (negative epirelief) on the surface of argillite. Furrows of constant width, with distinct edges, arcuate in cross-section. Trace longitudinal axis straight, more rarely curving. Sine wave length 7 to 33 mm, amplitude 4 to 10 mm; furrows 1.3 to 2 mm wide, up to 4 mm deep. Trace pattern in places asymmetrical due to the change in amplitude or sine wave length of certain trail sections.

Distribution. Abundant in argillites of Khmelnitski Formation; right bank of River Dniester, opposite the mouth of River Ternava.

Cochlichnus sp. 2

Pl. LIV: 6

Description. The surface of a slab of medium-grained quartz-feldspathic sandstone contains between two groups of moulds of *Nemiana simplex*, an oblong "outgrowth" about 10 cm long, 3.5 to 4 cm wide and 3 to 5 mm high, which is probably the filling of a depression in the bottom of a water basin. Stretching along the middle of the "outgrowth" is a meandering mould (positive hyporelief) 25 mm long. Meanders regular with an amplitude of 1.5 mm and a sine wave length 5 mm, while the mould itself 2 mm wide and about 1 mm high.

Distribution. Yampol member (Vendian, Mogilev Formation) near the village of Ozarnitzy (lower reaches of River Nemiya).

Cochlichnus sp. 3

Pl. LIV: 7

Description. Mould of sinuous trail (positive hyporelief) on fine-grained calcareous sandstone containing glauconite grains. Mould 5 mm wide, about 1 mm high, meanders having an amplitude of 15 mm, sine wave of 55 mm. Cross-section reveals a semi-elliptical shape of mould surface.

Distribution. Specimen observed in an outcrop of the Khmelnitski Formation; right bank of River Dniester, opposite the mouth of River Ternava.

Crawling traces

Pl. LIII: 1; Pl. LIV: 5

Traces of this kind are abundant in rocks of the Khmelnitski Formation. Plate LIII, Fig. 1 shows fairly large, up to 8 mm wide, trails (negative epirelief) on the surface of coarse-grained sandstone. Traces meandering with furrows about 2 mm wide and 1 mm high stretching on both sides of furrows.

Smaller traces occur as irregularly dispersed fragments, width of moulds (positive hyporelief) from 1 to 2.5 mm, height up to 1.5 mm. In cross-section moulds are semicylindrical. There are some longer sinuous fragments. Specimen composed of compact, fine-grained quartzose sandstone with considerable amounts of glauconite.

Moulds shown in Fig. 3, Plate LIV (positive hyporelief) feature constant length and gentle curves. Moulds 2 to 4 mm wide, up to 2 mm high, semicylindrical in cross-section. Specimen composed of fine-grained compact quartzose sandstone with inclusions of argillaceous pebbles.

The above traces observed in an outcrop of the Khmelnitski Formation, opposite the mouth of River Ternava.

Lobate trace

Pl. LIII: 7

On the mould (positive hyporelief) one can clearly differentiate: median crest, wedge-like in cross-section, with gentle slopes, under 1 mm high; side crests higher than the median one (up to 1 mm), separated from it with depressions; external depressions. On the whole, mould somewhat asymmetrical owing to a smaller width of one of external depressions. Total width of trace 15 mm. Negative epirelief should contain respectively a median furrow, two side furrows and rather low outside ridges. Specimen is made of compact yellowish-grey argillite.

Specimen comes from an outcrop of the Khmelnitski Formation; right bank of River Dniester, opposite the mouth of River Ternava.

Complex crawling traces

Pl. LV: 1

Trails figured in the plate are situated on the upper surface of specimen. Trail stretching from top right to bottom left corner of the picture is asymmetrical in cross-section: it consists of a furrow, bordered, on one side, with a massive ridge up to 4 mm wide and up to 2 mm high (Fig. 1, on the right). Groove surface sculptured with oblique furrows (at an angle of about 30° to longitudinal axis), spaced regularly at 4 to 6 mm. The structure of other trails is less pronounced; however, one can trace bilobate ridges as though composed of a string of small depressions and separated by crests also indistinct.

Trail width about 6 mm. Specimen composed of compact, fine-grained quartzose sandstone.

This form has also been found in an outcrop of the Khmelnitski Formation, opposite the mouth of River Ternava.

Genus: *Cruziana* d'Orbigny, 1842

Cruziana ex gr. *fasciculata* Seilacher, 1970

Pl. LXIV: 1

Description. Crawling trace of a trilobite, preserved as a bilaterally symmetrical elongated mould with a deep median furrow and thin transverse ridges associated with burrowing traces of endopodes. Their burrowing trails, under 1 mm wide, make with the median line an angle close to 90° or a little less. Crawling trace 20 mm wide.

Distribution. The specimen described was found by Michniak in the Bukówka quarry (Holy Cross Mts.), lower part of Holmia Zone. It was from these beds that Samsonowicz described *Holmia kierulfi* (Lnrs) and *Holmia* cf. *torelli* (Mbg.), while later Volkova identified the Lukati acritrach assemblage (Michniak in litt.). These beds also yielded *Rusophycus sp.* (Pl. LXIV, Fig. 2).

Cubichnia Seilacher, 1953
Genus: *Rusophycus* Hall, 1852

Rusophycus sp. A

Pl. LXVIII: 3

Description. Trail preserved as a mould (positive hyporelief) of a wide, flat, U-shaped depression with flattened bottom and almost vertical side walls. The mould clearly shows a deep uneven median furrow which breaks off disappearing in the narrower part of the trail. Transverse wrinkles (endopodites burrowing traces), narrow and distinct, are spaced at 0.5—1.5 mm, oblique to the median furrow (70°). Width of trace 40 mm, observed length 50 mm. Resting trace of a large trilobite filled with fine-grained micaceous sandstone in an argillaceous matrix.

Distribution. Venta Formation, Lower Cambrian; Latvia.

Rusophycus sp. B

Pl. LXVI: 1

Description. Two specimens of similar size found in the Kopli quarry near Tallinn, in the bed that has yielded the trilobite *Schmidtiellus mickwitzi* (Schmidt). One of the specimens of *Rusophycus* figured in the picture has traces of trilobite appendages at right angles to the trail axis, while in the other specimen this angle varies from 40 to 80°. Both specimens 56 mm wide. It is possible that these traces were produced by the trilobate *S. mickwitzi*, 50 mm wide, 80 mm long.

Distribution. Talsy horizon, Lükati member; Estonia, Kopli quarry near Tallinn.

Genus: *Vendichnus* Fedonkin, ichnogen. nov.

Type species: *Vendichnus vendicus* Fedonkin, ichnogen. et ichnosp. nov.

Diagnosis. Short bilaterally symmetrical resting trace (lying) subdivided into two by an uneven ridge. On both sides of the ridge, over its full length, there are elongated shallow wing-shaped depressions with transverse ridges and furrows.

Vendichnus vendicus Fedonkin, ichnosp. nov.

Pl. LXII: 5

Holotype. GIN, No 4464/4; Arkhangelsk Region, River Syuzma, 5 km upstream from its mouth; Valdai series.

Description. Traces preserved in positive hyporelief as irregular convex fossils with a median furrow projecting 1.5 to 2 mm above bedding surface. Wide shallow grooves outlining these traces correspond to the external sediment ridges displaced by the animal during excavation. Transverse ridges and striae of variable width. The largest trace 35 mm, the smallest 10 mm long, with the width being 20 and 10 mm respectively.

Remarks. Short transverse striae recognized on both halves of trace are, probably, due to movements of the animal's feet. Traces oriented parallel to the linear current marks which is indicative of the organisms' response to water turbulence (rheotaxis), peculiar to most of the Recent bilaterally symmetrical animals. Features in common that relate the trace described with some trails assigned to trilobates, *Ixalichnus* Callison, 1970 (Häntzschel, 1975) in particular, allow one to suggest that *Vendichnus* was produced by a bilaterally symmetrical animal, representative of nectonic fauna of the Valdai sea. It swam rather than crawled over the bottom, for no crawling traces of similar morphology have been observed.

Distribution. Two specimens have been found in the Valdai series; right bank of River Syuzma, 5 km upstream from its mouth.

Pascichnia Seilacher, 1953
Genus: *Palaeopascichnus* Palij, 1976

Palaeopascichnus delicatus Palij, 1976

Pl. L: 4—7; Pl. LXI: 2—3

Palaeopascichnus delicatus: Palij, 1976, p. 74, pl. XXIV, fig. 2.

Description. A series of small, parallel, in most cases arcuate, tightly packed furrows (negative epirelief) on siltstone surface. In positive hyporelief, there are respective ridges of similar structure. Ends of furrows indistinct, gradually passing into rock surface or blunt. Some furrows are transversely segmented by contractions. Furrows of one series number from 4 to 10 and over.

Distribution. Komarovo member; the village of Molodovo and the top of Kanilov Formation of Volhynia (boreholes in the village of Roznichi, Volhynia Region, and in the village of Grabov, Rovno Region) as well as Valdai series of Onega Peninsula; River Syuzma.

Genus: *Nenoxites* Fedonkin, 1976

Nenoxites curvus Fedonkin, 1976

Pl. LXI: 1

Nenoxites curvus: Fedonkin, 1976, p. 130, Text-Fig. 4.

Description. Sinuous shallow relief trace (negative epirelief), about 5 mm wide, stretching through the bedding surface plane in the form of alternate transverse depressions and protrusions, the size of which is not exactly uniform, but the width does not exceed 1 mm. Depressions and protrusions, many slightly inclined to one side, do not always cross the trace from one end to the other, some of them are either shifted towards the lateral part of trace or located in the middle. Sine amplitude 25 to 30 mm, sine pitch from 35 to 40 mm.

Remarks. The trace described may result most likely from the movement of gastropods associated with peristalsis involving the ventral part of foot. Sinuous movements are highly typical for gastropods when they are engaged in taking in food from the substrate surface.

Distribution. Five specimens in the Valdai series; River Syuzma, Onega Peninsula.

Genus: *Suzmites* Fedonkin, 1976

Suzmites volutatus Fedonkin, 1976

Pl. LX: 3—4

Suzmitus volutatus: Fedonkin, 1976, p. 130, Text-Fig. 1.

Description. A succession of long, narrow, similarly curving parallel ridges of equal width (about 1 mm), separated by stretches of smooth surface. No lateral limit, relief low. Some ridges, lying closer to the "centre of rotation", have a steeper curvature from one end. Width of smooth sections gradually decreases, from 5.5—6 mm at the place where ends of ridges curve more steeply to 4—4.5 mm at the opposite end.

Remarks. Two specimens, coming from a shear normal to the top of bed, yielded imprints of *Pteridinium* in close proximity to trace-bearing plane, with their long axis parallel to bedding surface. Width of intervalla in *Pteridinium* imprint is subequal to that of smooth spaces between narrow, concentrically curving ridges in the trace described, which suggests its being produced by the costate portion of *Pteridinium* body during the animal's sliding over the substrate.

Distribution. Valdai series; River Syuzma, Onega Peninsula.

Genus: *Dimorphichnus* Seilacher, 1955

Dimorphichnus sp.

Pl. LXVI: 3, 4

Description. Trails produced by raking movement of trilobite's feet due to lateral current. Preserved as parallel ridges on the undersurface of siltstone layer (positive hyporelief). Ridges 30 to 35 mm long, arranged in "bunches" of 3 to 4 spaced at 15 mm.

Distribution. Talsy horizon, Kolgaküla quarry (Estonia); Venta horizon, Latvia (D-4 Ventspils borehole, depth 1095 m).

PLATYSOLENITES

Cambrian deposits of the East-European Platform, the Lontova horizon in particular, contain extremely widespread *Platysolenites* which make up the bulk of the microfauna to be found there. Initially, all

Kotlin horizon; 6 — prep. R—2—27—5, ×1000; epibionts on Vendotaenia; Rovno-2-borehole, depth 27 m; Vendian, Povarovo series

Fig. 7. *Sarmenta capitula* Gnilovskaya, gen. et sp. nov.
Prep. Vor—1029—1, ×240; tube-like epibionts on the substrate; Vorobyevo borehole, depth 1029 b; Vendian, Povarovo series, Makaryevo Formation

Plate XLVIII

Figs *1, 5, 6*. *Bronicella podolica* (Zaika-Novatsky)
1 — holotype, KGU* No 1817, ×1.5 (Palij, 1976); *5* — deformed imprint; *6* — imprint having honeycomb structure of its central part; village of Yastrebna; Bronnitsy member

Figs *2, 3*. *Cyclomedusa* cf. *plana* Glaessner et Wade
2 — KGU No 1808, nat. size; village of Serebriya; Bernashev member; *3* — nat. size (Palij, 1976)

Fig. *4*. *Cyclomedusa serebrina* Palij
Nat. size (Palij, 1969)

Plate XLIX

Figs *1, 5, 6*. *Nemiana simplex* Palij
1 — holotype, nat. size (Palij, 1976); *5* — Palaeontological Museum of the Ukr. SSR Ac. Sc.; large mould encircled by smaller ones, ×2/3; village of Ozarintsy; Yampol member; *6* — deformed mould, nat. size (Palij, 1976)

Fig. *2*. *Tirasiana coniformis* Palij
Holotype, nat. size (Palij, 1976)

Figs *3, 4*. *Tirasiana disciformis* Palij
3 — holotype, nat. size (Palij, 1976); *4* — KGU No 1827, moulds of coalesced specimens, nat. size; village of Ataki; Bernashev member

Fig. *7*. *Tirasiana* sp.
IGN of the Ukr. SSR Ac. sc. No 1907/1, positive hyporelief, nat. size; village of Ataki; Bernashev member

Plate L

Figs *1—3*. *Harlaniella podolica* Sokolov
1 — holotype, ×5 (Palij, 1976); *2, 3* — IGN No 1907/6, ×5; village of Chovguzov, Khmelnitski Region; Kanilov Formation (V. Kirjanov's collection)

Figs *4—7*. *Palaeopascichnus delicatus* Palij
4 — holotype, ×5 (Polij, 1976); *5* — IGN No 1907/8, nat. size; village of Molodovo, Komarovo member; *6* — traces on organic film; IGN No 1907/9, ×5; village of Grabov, Rovno Region; Kanilov Formation; *7* — IGN No 1907/10, ×5; village of Roznichi, Volhynia Region; Kanilov Formation

Plate LI

Fig. *1*. Discoidal moulds with an adjacent worm-like body, nat. size (Palij, 1976)

Fig. *2*. Filled in burrow; IGN No 1907/3, nat. size; Khmelnitski Formation; River Dniester

Fig. *3*. Filled in burrow (?) IGN No 1907/4, nat. size; town of Mogilev-Podolski; Bernashev member

Figs *4—6*. *Treptichnus triplex* Palij
4 — holotype, nat size (Palij, 1976); *5* — IGN No 1907/14, nat. size; town of Volochisk, Khmelnitski Region; Khmelnitski Formation; V. Kirjanov's collection; *6* — fragment, nat. size (Palij, 1976)

Fig. *7*. *Treptichnus* sp. 1
IGN No 1907/17, nat. size; River Dniester; Khmelnitski Formation

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* KGU — Kiev State University.

Plate LII

Figs *1—2*. *Didymaulichnus tirasensis* Palij
1 — ×1/3; *2* — × 1/2 (Palij, 1974)

Fig. *3*. Trails of bilobate to trilobate structure; IGN No 1907/25, nat. size; town of Podvolochisk, Ternopol Region; Khmelnitski Formation (V. Kirjanov's collection)

Fig. *4*. Trails of progressive motion with periodic burrowing into the sediment, nat. size (Palij, 1976)

Fig. *5*. *Treptichnus* sp. 2
IGN No 1907/23, ×1.6; River Dniester; Khmelnitski Formation

Fig. *6*. Trilobate discontinuing linear trails, nat. size (Palij, 1976)

Plate LIII

Fig. *1*. Crawling traces; Palaeontological Museum of the Ukr SSR Ac. Sc., nat. size; River Dniester; Khmelnitski Formation

Figs *2*, *4*, *5*. Crawling trails of worm-like animals; IGN No 1907/33-1907/36
2, *4* — nat. size; *5* — ×1/2; village of Ataki; Bernashev member

Fig. *3*. Burrowing traces, nat. size (Palij, 1976)

Fig. *6*. *Bilinichnus* sp.
IGN No 1970/64, nat. size; River Dniester; Khmelnitski Formation

Fig. *7*. Lobate trace; IGN No 1907/63, nat. size; River Dniester; Khmelnitski Formation

Plate LIV

Figs *1—2*. Crawling trails of worm-like animals
1 — IGN No 1907/45, nat. size; village of Ataki; Bernashev member; *2* — IGN No 1907/47; village of Molodovo; Komarovo member

Figs *3*, *4*. *Cochlichnus* sp. 1
IGN No 1907/55/56, nat. size; River Dniester; Khmelnitski Formation

Fig. *5*. Crawling traces; IGN No 1907/62, nat. size; River Dniester; Khmelnitski Formation

Fig. *6*. *Cochlichnus* sp. 2
KGU No 1836, nat. size; River Nemiya; Yampol member

Fig. *7*. *Cochlichnus* sp. 3
Palaeontological Museum of the Ukr. SSR Ac. Sc., nat. size; River Dniester; Khmelnitski Formation

Plate LV

Fig. *1*. Complex crawling traces; IGN No 1907/66, nat. size; River Dniester; Khmelnitski Formation

Figs *2—6*. *Bergaueria major* Palij
IGN Nos 1907/67—1907/70, ×1/2; River Dniester; Khmelnitski Formation

Plate LVI

Figs *1—4*. *Inkrylovia lata* Fedonkin, gen. et sp. nov.
3 — holotype, GIN No 4464/147, nat. size; Valdai series (Vendian); Onega Peninsula, River Syuzma

Plate LVII

Figs *1*, *3*. *Archangelia valdaica* Fedonkin, gen. et sp. nov.
Holotype, GIN No 4464/59, nat. size; Onega Peninsula; Valdai series

Figs *2*, *4*, *6*. *Dickinsonia costata* Sprigg
2, *6* — nat. size; *4* — ×2; GIN No 4464/12, 4464/57B, 4464/17; locality as above

Fig. *5.* *Vendomia menneri* Keller
Holotype, GIN No 4464/57A, ×5; locality as above

Plate LVIII

Fig. *1.* *Albumares brunsae* Fedonkin
Holotype, GIN No 4464/14, ×3.5; Onega Peninsula; Valdai series

Fig. *2.* *Onega stepanovi* Fedonkin
Holotype, GIN No 4464/57, ×9; locality as above

Fig. *3.* *Pteridinium nenoxa* Keller
GIN No 4464/13, ×0.73; locality as above

Fig. *4.* *Cyclomedusa minuta* Fedonkin, sp. nov.
GIN No 4464/112, ×3; locality as above

Fig. *5.* *Beltanelliformis brunsae* Menner
GIN No 4464/115, ×2; locality as above

Plate LIX

Fig. *1.* *Spriggina borealis* Fedonkin, sp. nov.
Holotype, GIN No 4464/110, nat. size; Onega Peninsula; Valdai series

Fig. *2—4.* *Palaeoplatoda segmentata* Fedonkin, gen. et sp. nov.
2, 3 — fragments, GIN No 4464/102—103, ×1.4; locality as above; *4* — holotype, GIN No 4464/101, nat. size

Fig. *5.* *Beltanelliformis brunsae* Menner
GIN No 4464/116, ×2; locality as above

Plate LX

Figs *1, 2.* *Bilinichnus simple* Fedonkin et Palij, gen et sp. nov.
1 — holotype, nat. size; *2* — fragment, ×2; GIN No 4464/42; Onega Peninsula, Valdai series

Figs *3, 4.* *Suzmites volutatus* Fedonkin
3 — holotype, GIN No 4310/18—4, nat. size; locality as above

Plate LXI

Fig. *1.* *Nenoxites curvus* Fedonkin
Holotype, GIN No 4310/202—4, nat. size; Onega Peninsula; Valdai series

Figs *2, 3.* *Palaeopascichnus delicatus* Palij
GIN No 4310/202—6, nat. size; locality as above

Fig. *4.* Crawling trace close to Cochlichnus; GIN No 4464/62, nat. size; locality as above

Fig. *5.* Resting trace of a large worm-like animal; GIN No 4464/48, nat. size; locality as above

Plate LXII

Locality: all specimens come from the Onega Peninsula, Valdai series

Fig. *1.* *Neonereites uniserialis* Seilacher; strings of pellets, ×2; GIN

Fig. *2.* *Neonereites biserialis* Seilacher; spec. No 4464/30, nat. size

Fig. *3.* Clusters of small pellets; spec. No 4464/34, nat. size.

Fig. *4.* *Neonereites* sp.
Nat. size, GIN No 4464/9

Fig. *5.* *Vendichnus vendicus* Fedonkin, ichnogen et ichnosp. nov.
Holotype, GIN No 4464/4, nat. size

Fig. *6.* *Planolites* cf. serpens (Webby, 1970)
GIN No 4464/47, nat. size

Plate LXIII

Fig. *1*. *Scolicia* sp.
GIN No 4473/33, Ventspils D-3 borehole, depth 1014.5 m, nat. size; Kursak Formation, Middle (?) Cambrian; Latvia

Fig. *2*. *Gordia* sp.
GIN No 4472/6; Ventspils D-3 borehole, depth 1129.4 m, nat. size; Ovishi Formation, Lower Cambrian; Latvia

Fig. *3*. Sample with *Planolites* sp. and *Harlaniella* sp. ×1.5; Pasha borehole, depth 144 m, Estonia; Kotlin horizon.

Fig. *4*. Problematic structure in the form of a flattened ring in silty clay; positive hyporelief, ×3; Kunevichi-4 borehole, depth 328.2 m, Estonia; Kotlin horizon

Fig. *5*. *Phycodes pedum* Seilacher
Positive hyporelief, nat. size; Koluvere-12 borehole, depth 285.5 m, Estonia; basal member of the Lontova horizon

Fig. *6*. Curving and branching pyritized trails in clays, ×1.5; Ilumäe (near Tapa), depth 122.9 m, Estonia; basal member of the Lontova horizon

Fig. *7*. Meandring, flat, pyritized trails of crawling in clays, ×1.1; Viru-Jaagupi borehole (near Viru-Roela), depth 253.1 m, Estonia; basal member of the Lontova horizon

Plate LXIV

Fig. *1*. *Cruziana* ex gr. *fasciculata* Seilacher
Nat. size; Holy Cross Mountains, Bukówka quarry Poland; base of the Holmia Zone (R. Michniak's collection and photographs)

Fig. *2*. *Rusophycus* sp.
Nat. size; locality as above (R. Michniak's collection and photographs)

Plate LXV

Figs *1—3*. *Skolithos linearis* Haldemann
1 — Türisalu outcrop, Estonia; Tiskra Formation (Müürisepp's photographs); *2*, *3* — cross sections of Skolithas burrows, ×2; Ventspils D-3 borehole, Latvia; Ovishi Formation; *2* — depth 1105 m; *3* — depth 1135 m (GIN, Nos 4472/7 and 4472/5 respectively)

Plate LXVI

Fig. *1*. *Rusophycus* sp. B
Positive hyporelief, nat. size; Kopli quarry near Tallinn, Estonia; Talsy horizon

Fig. *2* *A* — *Planolites virgatus* (Hall); *B* — *Planolites striatus* (Hall); GIN No 4472/19, nat. size; Ventspils D-3 borehole, depth 1095.7, Latvia; Venta Formation

Figs *3—4*. *Dimorphichnus* sp.
3 — ×0.65; *4* — ×0.35; Kolgaküla quarry, Estonia; Talsy horizon (E. Pirrus' photographs)

Plate LXVII

Fig. *1*. *Halopoa* sp. and *Bifungites* sp. seen in positive epirelief, nat. size; Kopli quarry near Tallinn, Estonia; Talsy horizon.

Fig. *2*. *Rhizocorallium* sp., *Halopoa* sp. and a typical crawling trail with ridges of sediment pressed out on both sides of trail; nat. size; locality and horizon as above.

Fig. *3*. *Rusophycus* sp. A, GIN No 4472/8; positive hyporelief, nat. size; Ventspils D-3 borehole, depth 1094/9 m, Latvia; Ventava Formation

Fig. *4*. *Diplocraterion parallelium* Torell, ×0.6; exposure near the Ivangorod Fortress, Leningrad Region; Tiskra Formation, Talsy horizon

Plate LXVIII

Fig. *1*. *Sagittichnus* sp.

Positive hyporelief, ×0.75; exp. Suhkrumägi near Tallinn, Estonia; Talsy horizon (A. Öpik's collection)

Fig. *2*. Trails of vertical burrows on the surface of sitty clays, ×1.4; Viru-Jaagupi borehole (near Viru-Roela), depth 188.5 m, Estonia; Talsy horizon

Fig. *3*. Burrow resulting from crawling of a large worm-like animal, filled with siltstone, trilobite fragments and aggregates of pyrite crystals, ×0.6; exp. Saviranna (E. Pirrus' photographs), Estonia; Talsy horizon

Fig. *4*. Trails of vertical burrows on siltstone surface, ×0.75; exp. Saviranna near Tallinn, Estonia; Talsy horizon

Fig. *5*. *Planolites* sp.

×1; Kunda quarry (near Essu), Estonia; Talsy horizon

Plate LXIX

Figs *1—5*. *Platysolenites antiquissimus* Eichwald

1 — GIN No 4432/1, sample 18/25; general view, ×3.6; Vishki-25 borehole, depth 717.4 m, Latvia; Lontova horizon; *2* — GIN No 4432/2, sample 353/17, spec. *2, 3, 4, 5* — showing varying distances between costae in different specimens; Baltanava borehole, depth 790.8 m, Latvia; Lontova horizon; *3* — GIN No 4432/3, sample 353/17; fraction of coarse-grained material; Baltanava borehole, depth 790.8 m, Latvia; Lontova horizon; *4* — GIN No 4432/4; fraction of fine-grained material showing specimens circular in cross-section, ×0; Tallinn quarry, Estonia; top of Lontova horizon; *5* — GIN 4432/5 fragments of pseudospiral forms; Tallinn quarry, Estonia; top of Lontova horizon

Plate LXX

Figs *1—5*. *Platysolenites antiquissimus* Eichwald

1 — GIN No 4432/6 sample 353/17, spec. III-4; general view ×18, arrow indicates the location of photographs *2* and *3*, asterisk that of photographs *4* and *5*; Baltanava borehole, depth 790.8 m, Latvia; Lontova horizon; *2* — structure of the internal tube layer showing globules ×800; *3* — cristobalite making the globules ×4.200; *4* — micrograph showing the matrix inside the tube, an internal layer of tube made of cristobalite and an outer layer made of tridymite and quartz ×1800; *5* — tridymite of the outer layer

Plate LXXI

Figs *1—5*. *Platysolenites antiquissimus* Eichwald

1 — GIN No 4432/7, spec. I—1,2; two fragments of pseudospiral specimens; Tallinn quarry, Estonia; top of Lontova horizon; *2, 3* — same specimens, high magnification; *4* — GIN No 4432/8, spec. II—1,4; spec. II—1, sample 353/17; irregularly tubercular shape; Baltanava borehole, depth 790.8 m, Latvia; spec. II—4, Tallinn quarry, Estonia; Lontova horizon; *5* — GIN No 4432/7, sample 353/17, spec. 1—3; irregularly tubercular shape; Baltanava borehole, depth 790.8 m, Latvia, Lontova horizon. Fig. 1×17, Fig. 2×4.2, Figs 4—5×19

Plate LXXII

Figs *1—2*. Samples with sabelliditid remains etched by HF and stored in glycerine

1 — almost free of associated membranous organic material (saprophytic fungi?); borehole Vishki-25, depth 725.4—730.0 m; Lower Cambrian, Eastern Latvia, USSR; *2* — with abundant membranous organic material (saprophytic fungi?) seen as misty places; borehole Ludza-15, depth 775.0—777.0 m; Lower Cambrian; Eastern Latvia, USSR. A—B, approx. ×3

Plate LXXIII

Micromorphology of zooidal tubes in Sabelliditida (Lower Cambrian) and Pogonophora (Recent)

Figs *1—5*. *Sabellidites* sp.

1—2 — SEM micrographs of a tube in *Sabellidites* sp. showing characteristic wrinkles on the surface (*1*) and their details (*2*); *3* — SEM micrograph of a "shaggy" sabelliditid

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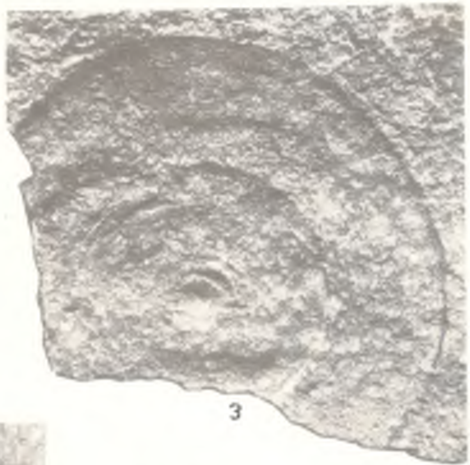

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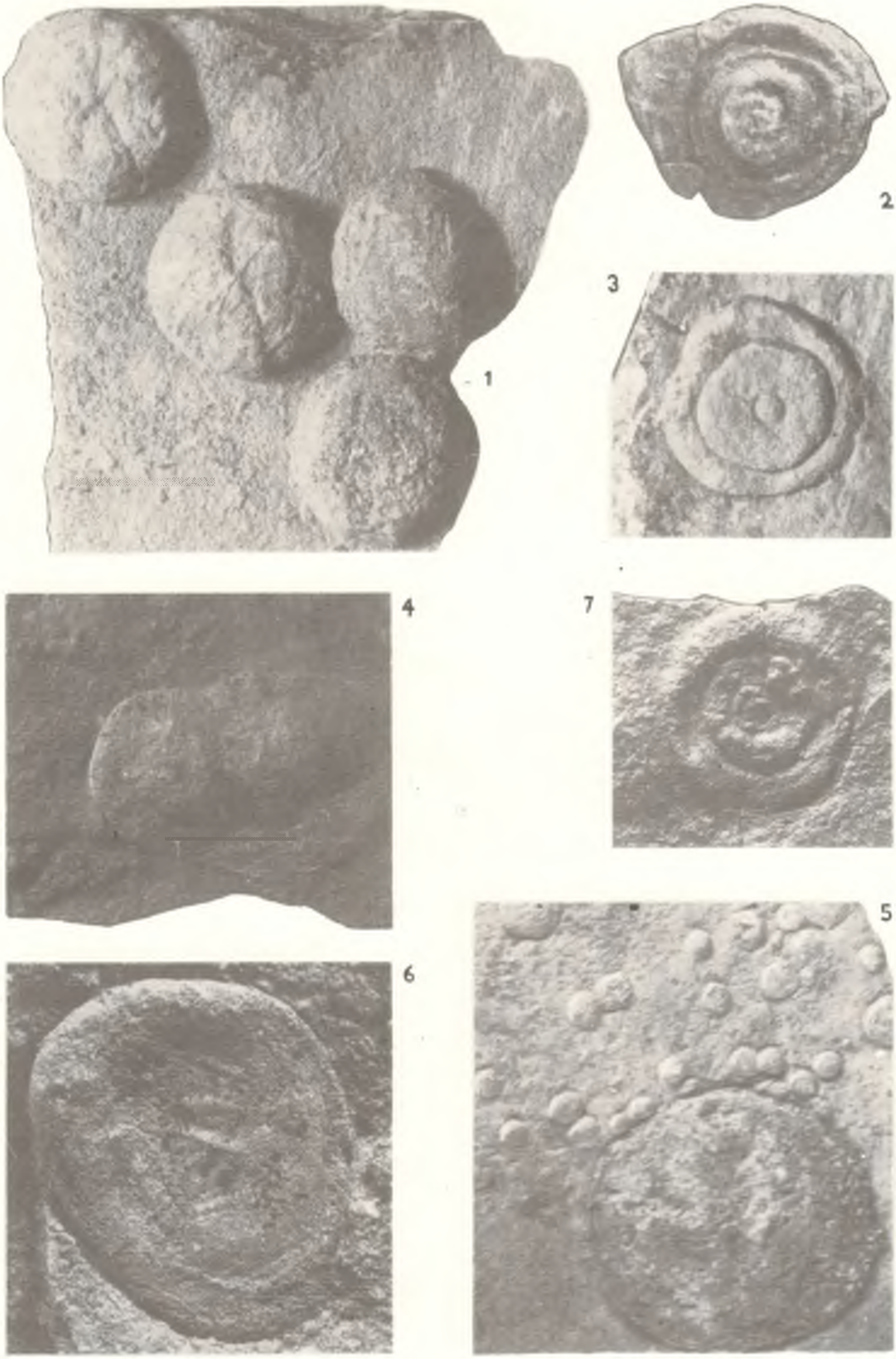
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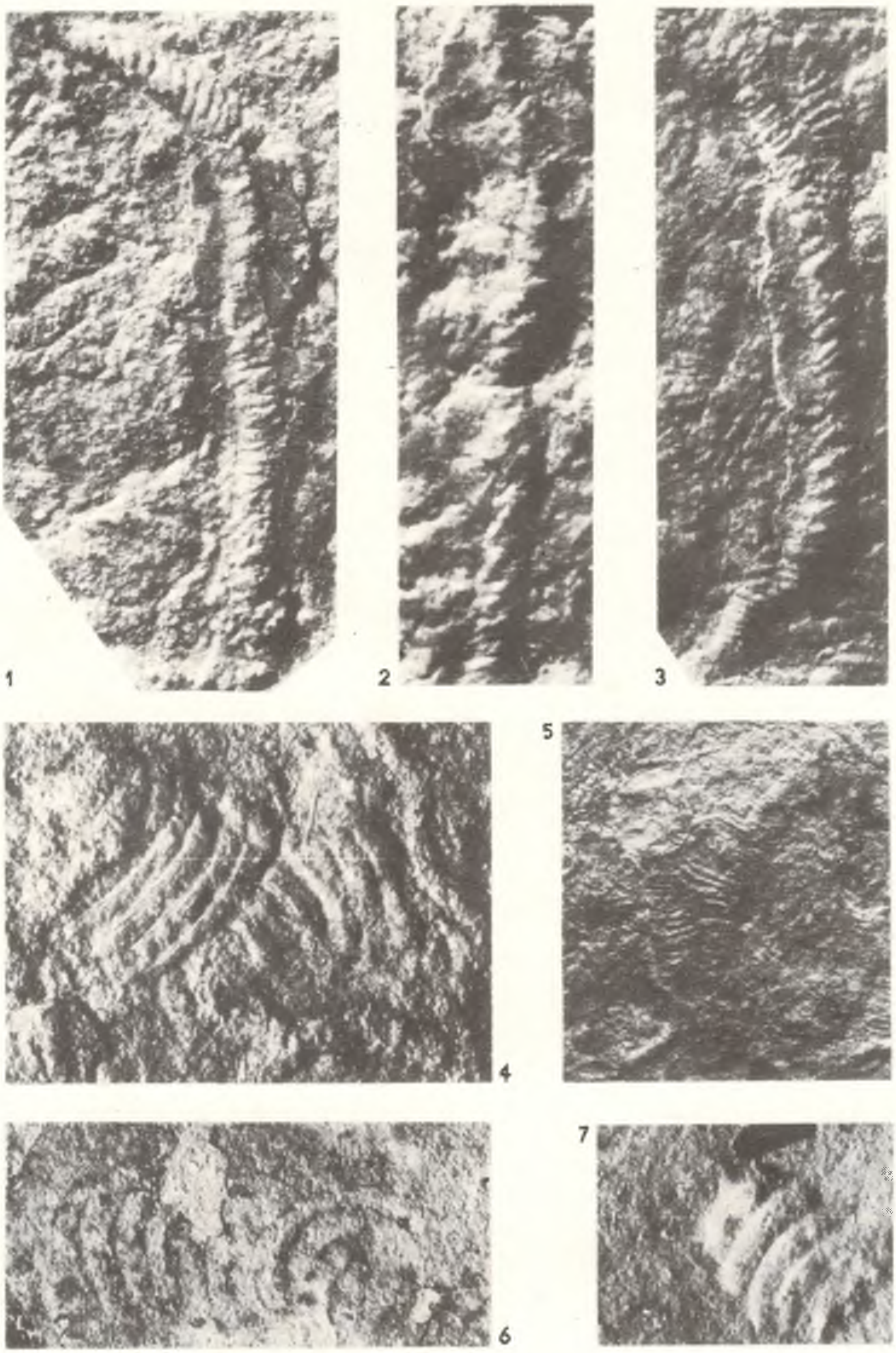


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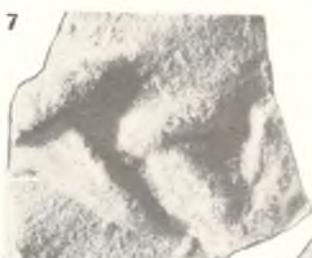


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4a

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PLATE LIV

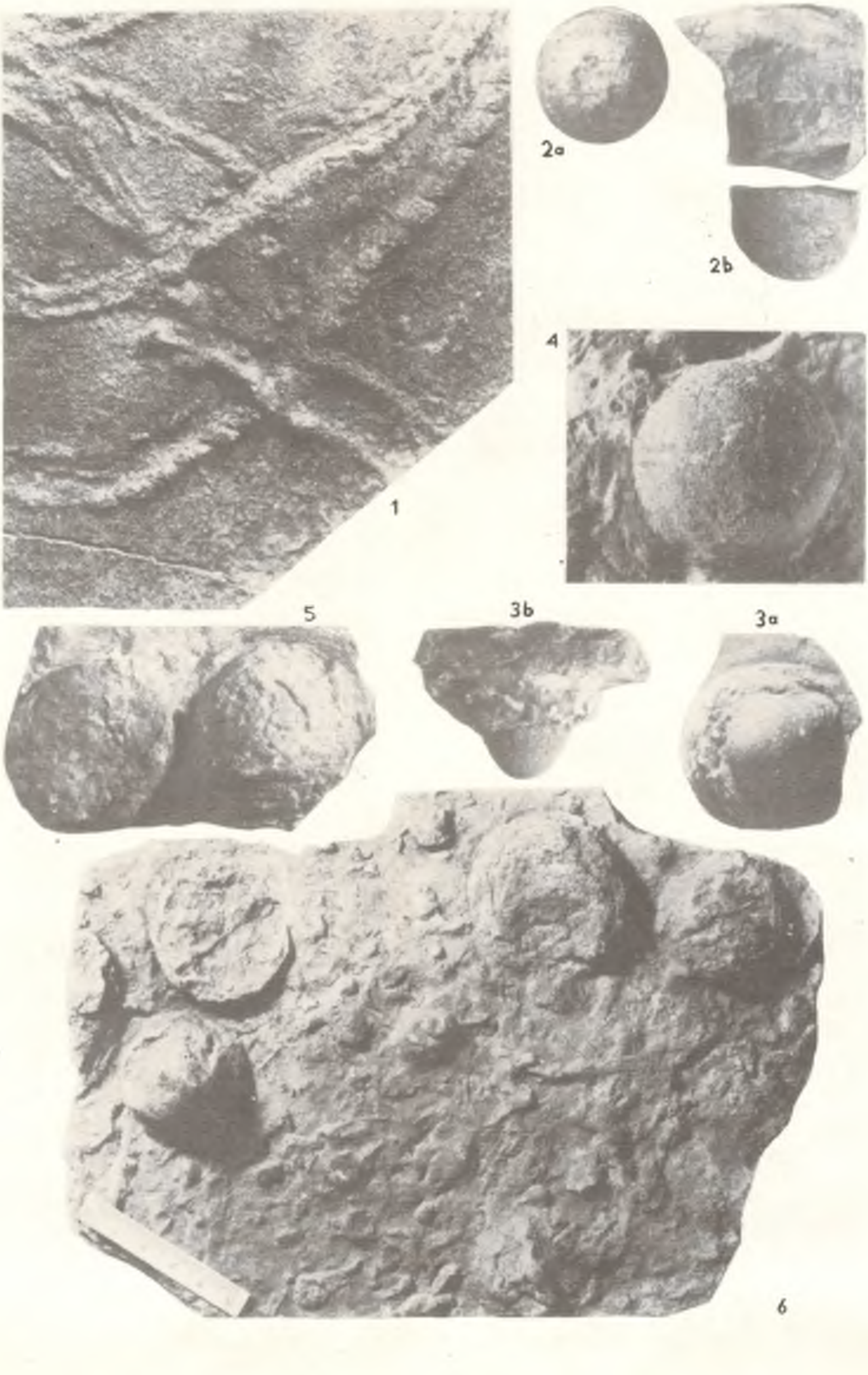
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PLATE LVI


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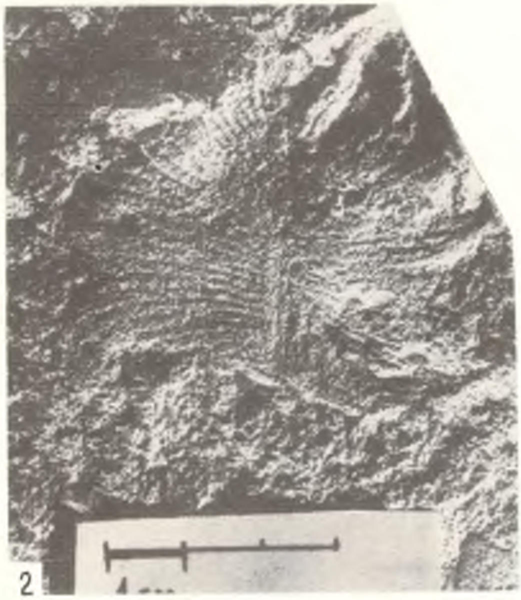
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PLATE LVIII

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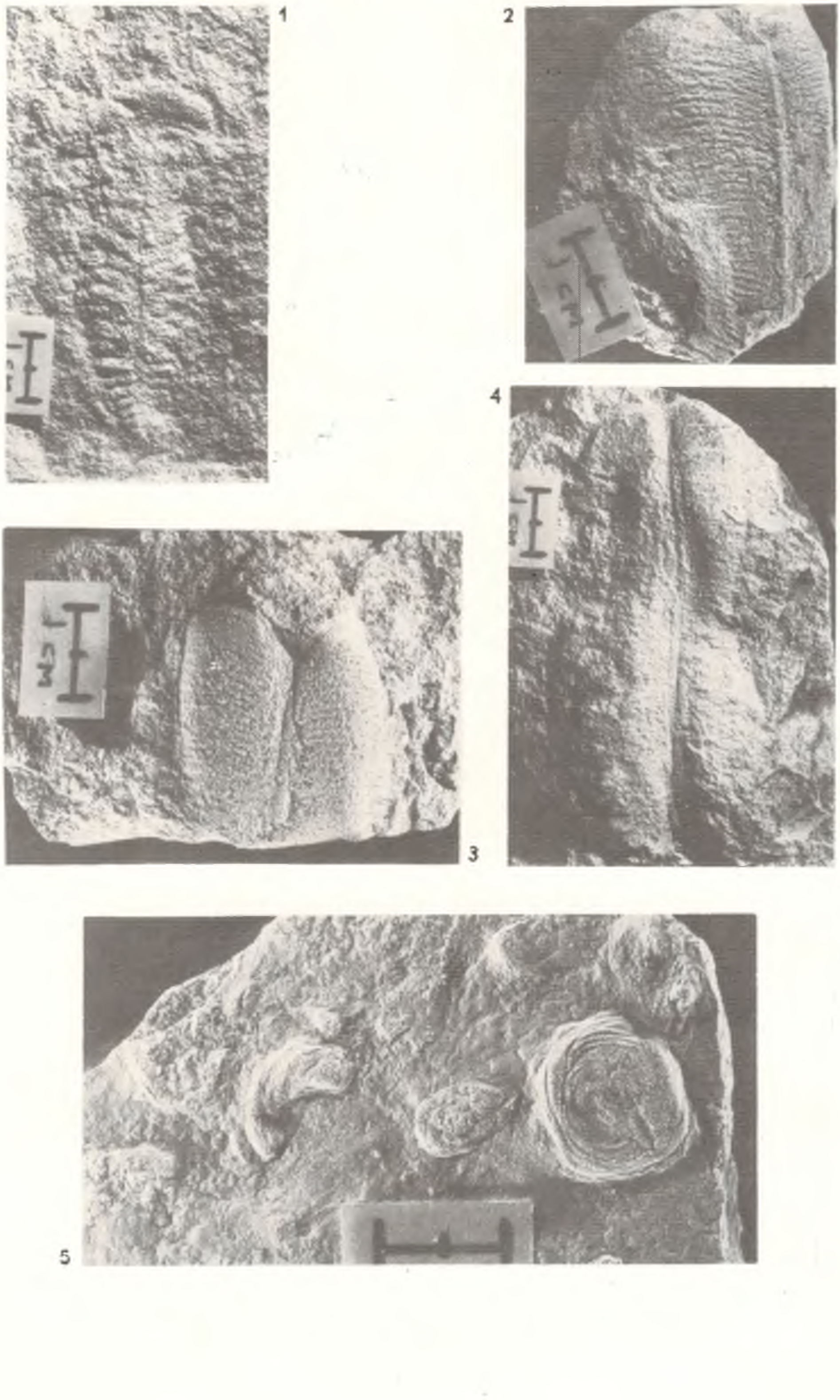
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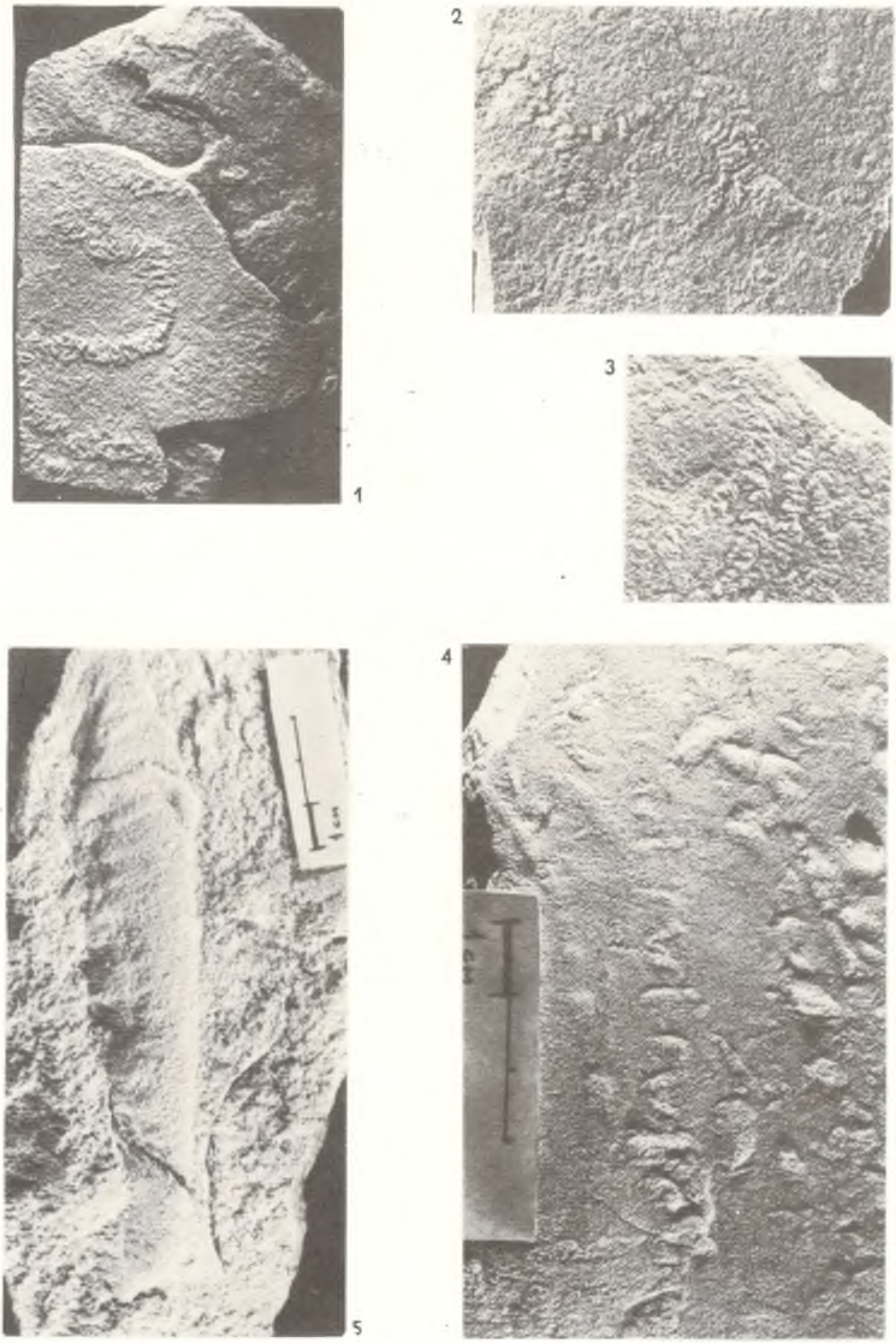
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PLATE LXII

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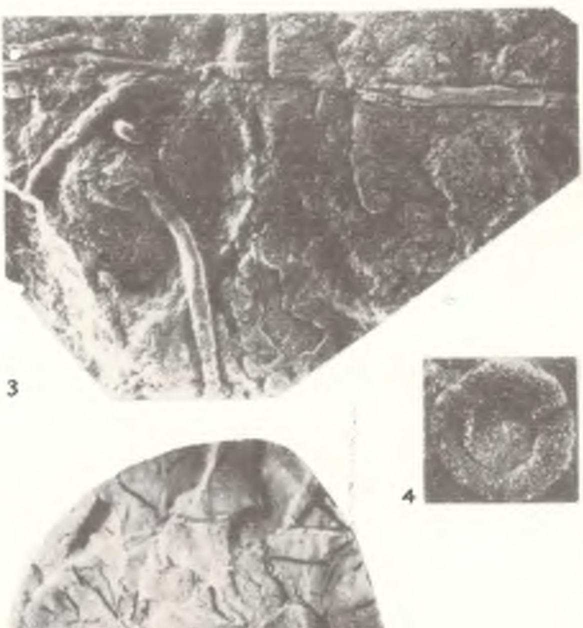
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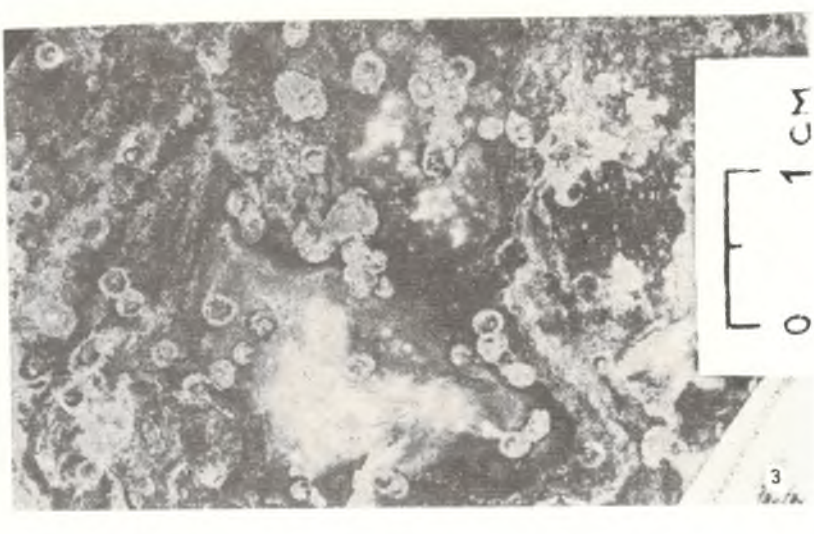
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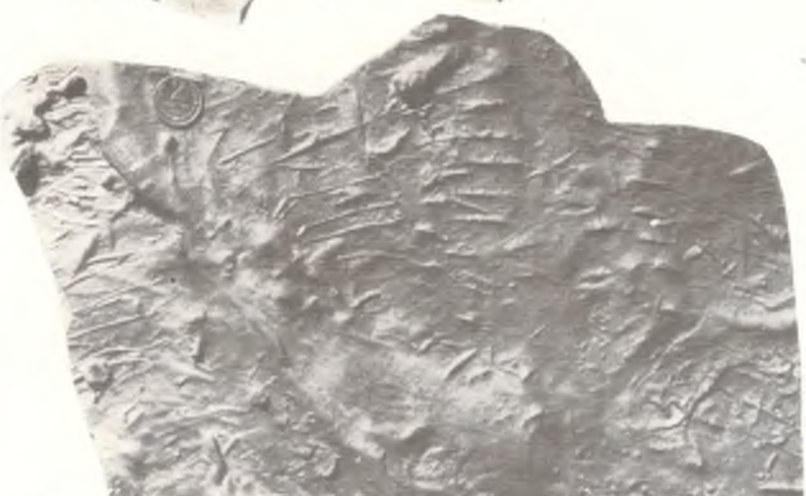

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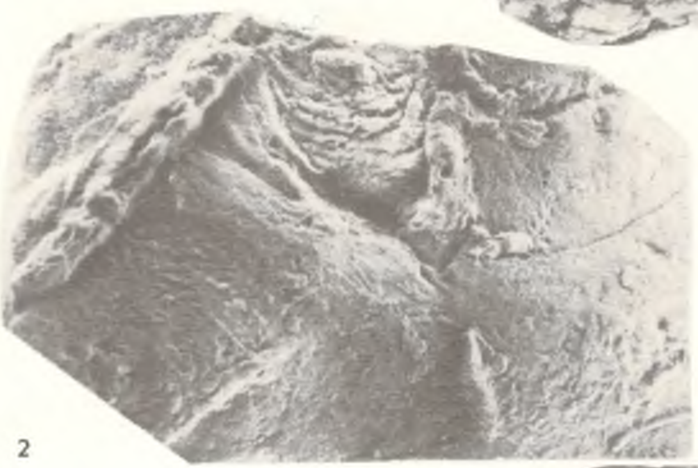

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PLATE LXVIII

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