

## Palaeozoic ichnofossils in phyllites near Železný Brod, northern Bohemia

### Paleozoické ichnofosilie z pokrývačských fylitů od Železného Brodu, severní Čechy (Czech summary)

(9 text-figs., 8 plates)

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The epizonally metamorphosed roofing phyllites at Železný Brod, constituents of the Krkonoše-Jizerské hory Metamorphic Complex (West Sudetes Unit of the Bohemian Massif), yielded Palaeozoic ichnofossils probably of Ordovician age. Typical are large stellate forms (*Teichichnus* *stellatus*) and branched traces *Phycodes palmatus*. Other traces belong to the ichnogenera *Bifungites*, *Dictyodora*, *Lorenzina*, *Megagraptus*?, *Planolites*, *Spirodesmos*, *Spirophycus*, *Taphrhelminthopsis* and to some forms designated informally. The ichnoassemblage shows a deep-water character with relationships to the flysch facies.

**Key words:** Ichnofossils, probably Ordovician, metamorphic rocks, phyllites, Bohemian Massif, West Sudetes Unit

### Introduction

The complex sedimentary, tectonic and metamorphic history of the Bohemian Massif bears many unresolved problems, particularly in relation to the metamorphic units. This may be exemplified by the West Sudetes or Lugicum area, in the northern part of the Bohemian Massif, where the stratigraphy and effects of orogenic processes are under permanent discussion.

On the territory of the Czech Republic, the metamorphic units of the West Sudetes region have yielded determinable fossils only in the Ještěd Mts., close to the south-western limit of the area, and at a few other localities near Železný Brod and Poniklá, situated to the east, namely south of the Jizerské hory Mts. (review of recent discoveries in Chlupáč 1993).

The area around Železný Brod has the most promise for solving stratigraphic problems, because the grade of metamorphism is low (mostly the chlorite zone), and individual stratigraphic units are well exposed in deep-cut valleys and old quarries. Regretably, body fossils are extremely rare even here being limited to the limestone member of uncertain age (the unique discovery of the phyllocarid crustacean *Silesicaris nasuta* Gürich and problematic remains formerly regarded as graptolites).

In this situation, the discoveries of locally common ichnofossils in the roofing phyllites near Železný Brod are surprising. They represent an unique example of organic evidence in metamorphic rocks of the Czech part of the West Sudetes region and they are noteworthy also from the viewpoint of preservation of ichnofossils in metamorphic rocks.

The reference material is deposited in collections of the National Museum, Prague.

Note to text-figures. The full lines indicate distinct outlines of ichnofossils, the interrupted lines unsharp limits due to metamorphic processes, dotted lines indicate secondary damages, margins of rock samples etc. The ar-

rows indicate the preference orientation of mineral particles (metamorphic lineation), dark parts the exposed fill of burrows.

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### The roofing phyllites near Železný Brod and the localities of ichnofossils

The roofing phyllites crop out in uncertain stratigraphic and tectonic position in the northern and north-eastern vicinity of the town of Železný Brod in northern Bohemia. They are exposed in many abandoned quarries in which they were intensely quarried since the 19th century as a roofing material.

The stratigraphic assignment of the phyllites is problematical: Kodým - Svoboda (1948) and Svoboda - Chaloupský (1966) regarded the roofing phyllites as the

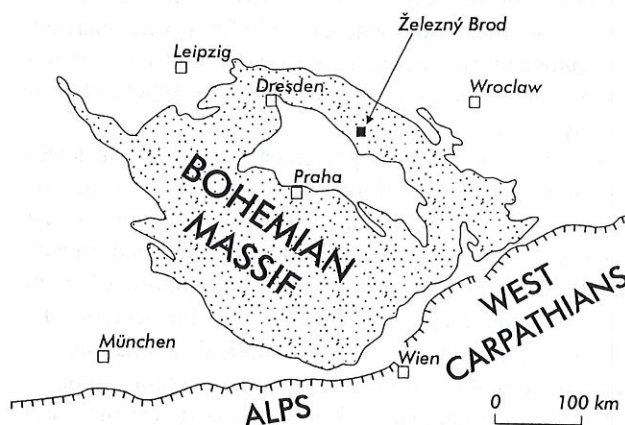
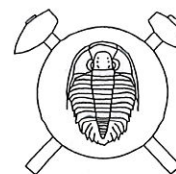


Fig. 1. Geographic position of the studied area within the central Europe





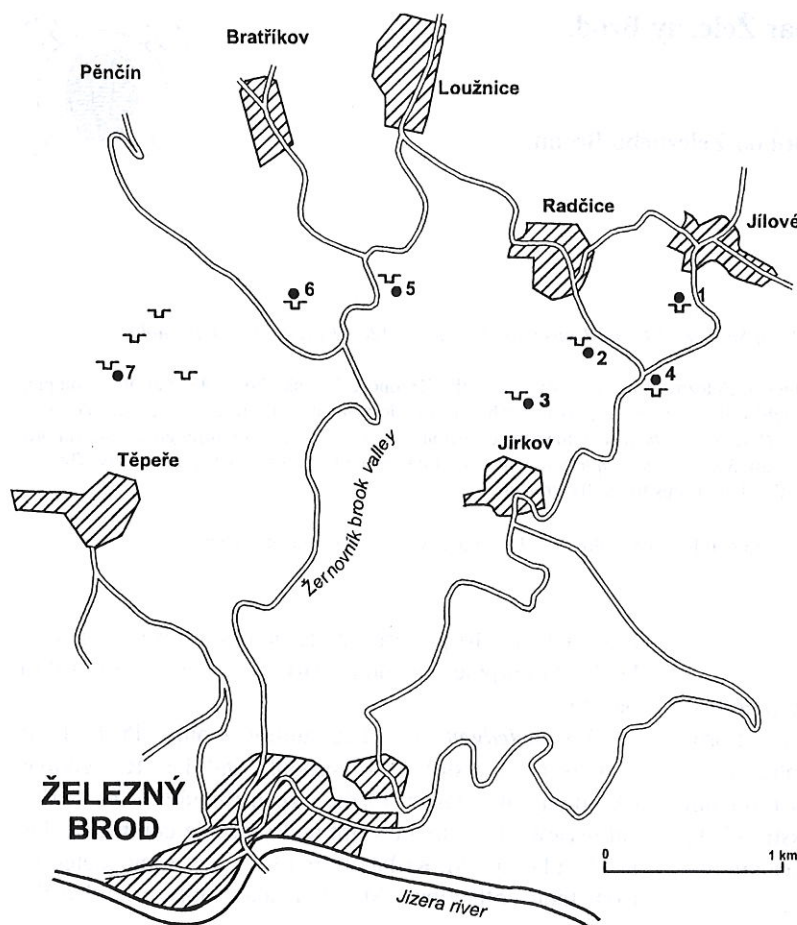


Fig. 2. Position of ichnofossil localities in the Železný Brod area

1 - Tlukačka Quarry; 2 - Samčice Quarry; 3 - Kobližtice Quarry; 4 - Světlův Quarry; 5 - Liebig Quarry; 6 - quarry S of Bratřikov; 7 - quarries near Těpeře

oldest member of the metamorphic complex of presumed Cambrian or early Ordovician age. However, Chaloupský (in Chaloupský et al. 1989 etc.) considered them to be in a reverse position, i.e. in the uppermost part of his Radčice Group of presumed Proterozoic to early Palaeozoic age.

The ichnofossils were found at several localities, but the great majority of them derived from the quarry called Tlukačka, situated SW of the village of Jílové, close to the highway to Jirkov (situation in Text-fig. 2). Other, uncommon discoveries come from the old quarries in the vicinity of Jirkov, namely the Kobližtice and Samčice Quarries N of Jirkov and from the Liebig Quarry in the valley of the Žernovský brook NW of Jirkov. However, ichnofossils occurred at other places where the phyllites were quarried, as documented by specimens preserved on phyllite planes used for decoration e.g. in the village of Těpeře NW of Železný Brod.

The host rock is the light green to grey-green gently glistening and thinly foliated phyllite known as the "Železný Brod roofing slate". It shows a distinct linear preference orientation of mineral particles and mostly smooth foliation surfaces on which the ichnofossils constitute the main major unevennesses. The thin sections and polished cross-sections exhibit a marked lamination, namely an alternation of mica-rich (sericite, chlorite), originally claystone laminae with thin quartz-rich and coarser, originally siltstone layers. The characteristic mineral association consists of quartz, muscovite, albite, chlorite

and chloritoid, accessories are represented by apatite, tourmaline and ore-minerals. The metamorphic grade corresponds to the greenschists facies with a high content of  $\text{Al}_2\text{O}_3$  and high  $\text{K}_2\text{O}/\text{Na}_2\text{O}$  ratio (Fediuk 1962, 1984; Chaloupský - Chlupáč 1984).

The primary sedimentary rock may be interpreted as a shale with alternation of thin claystone and siltstone laminae, and probable tuffaceous admixture.

### Preservation of ichnofossils

The ichnofossils are preserved either at the contact between the primary siltstone and claystone laminae, or inside them. The trace filling is mostly distinguished by coarser aggregates of quartz and chlorite which chemical composition shows, if compared with the host rock, a higher content of  $\text{SiO}_2$ ,  $\text{P}_2\text{O}_5$  and  $\text{CaO}$ , and lower contents of  $\text{Al}_2\text{O}_3$ , which all point to primary coarser silt or sand filling (Chaloupský - Chlupáč 1984). Generally, the filling of most burrows appears as harder and more competent than the host rock.

The ichnofossils are common in some layers at the locality near Jílové and distinct thin layers representing metamorphic shadows preserve several ichnotaxa on one plane. The metamorphic processes had a negative influence on the preservation of ichnofossils. The metamorphic rearrangement of mineral particles and foliation of phyllites does not usually allow us to distinguish whether the ich-

nofossils are epi- or intrastratal. A marked lineation and pressure deformation resulted commonly in effacement of some parts of the ichnofossils so that uncertainties on primary structures exist, for example the limits of traces are unsharp. The intensity of metamorphic pressure deformation may be best documented in star-like ichnofossils in which the branches parallel with the lineation are prolonged and those of transverse direction are markedly shortened and broadened. In spite of all these negative features, the shape of some ichnofossils is surprisingly well preserved, even in details of curvatures (comp. *Dictyodora*, *Spirodesmos*, some *Phycodes*), though we are here concerned rather with exceptions.

### Systematic ichnology

Ichnogenus *Teichichnus* Seilacher, 1955

Type ichnospecies: *Teichichnus rectus* Seilacher, 1955.

"*Teichichnus*" *stellatus* Baldwin, 1975

Pl. I, figs. 1, 2; Pl. II, figs. 1, 2; Pl. IV, fig. 1; Pl. V, fig. 1; Text-figs. 3, 4

Material: 15 specimens preserved on foliation planes of phyllites.

**Description.** Large star-like ichnofossils (diameter 140 to around 700 mm) consisting of 5 to 9 branches radiating from the flat or only slightly elevated centre. The branches are mostly rectilinear, only exceptionally curved (L30556, lesser curved branches in L31810), slightly and gradually tapering distally. The length of branches exceeds in the largest specimens 400 mm, termination is mostly blunt or less distinct due to metamorphic deformation.

The trace is preserved either as flattened tunnels of a low elliptical cross-section, forming a low relief on foliation planes of phyllites, or as completely flat bands differing from the nearby rock only in colour. Combination of both modes of preservation, however, are common even in the same specimens (examples in L30556, L30547, L30568).

The fill of the trace consists usually of coarser and more competent material, generally richer in SiO<sub>2</sub>, if compared with the host rock. Traces preserved only as bands of different colour show enrichment in chlorite and dark pigments.

Most specimens are deformed by pressure. The branches conformable with the linear arrangement of mineral

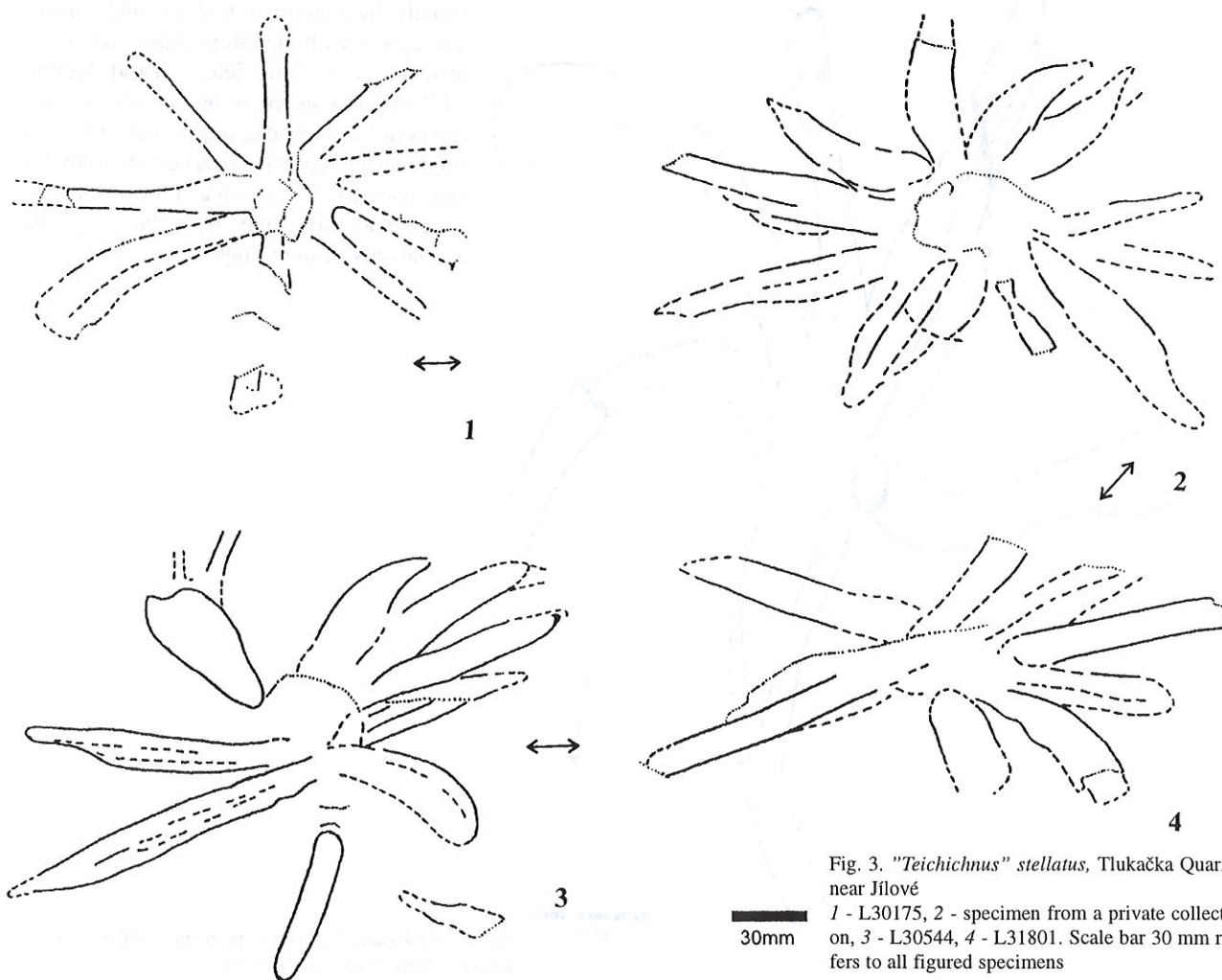


Fig. 3. "*Teichichnus*" *stellatus*, Tlukačka Quarry near Jílové

1 - L30175, 2 - specimen from a private collection, 3 - L30544, 4 - L31801. Scale bar 30 mm refers to all figured specimens



particles are prolonged, whilst the perpendicular ones are markedly secondarily shortened and often also widened. The width of branches is also markedly affected by deformation but a rather small number of only gently abaxially narrowing and newer branching rays is typical.

**Remarks.** The configuration of most specimens agrees with *Teichichnus stellatus* as described by Baldwin (1975). The characteristic internal structure of *Teichichnus*, namely the downwards bent spreite structures arranged within vertically oriented walls, are not perceptible in our specimens, which may be expected in material affected by metamorphism.

The stellate form of "*Teichichnus*" *stellatus*, however, is not compatible with the original (Seilacher 1955) and commonly applied diagnosis of *Teichichnus* as presented e.g. by Häntzschel (1975). In author's view a separate ichnogenus should be established for the "stellate *Teichichnus*".

The first found specimen of our stellate trace was compared by Chaloupský and Chlupáč (1984) with *Glockeria* Książkiewicz (= *Glockerichnus* Pickerill, 1982). *Glockerichnus* differs mainly in more numerous, unequal-

ly developed and often dichotomously branching and denser packed branches lacking the internal structure of *Teichichnus*. However, the main difference between *Glockerichnus* and *Teichichnus*, is in the internal structure which cannot be studied in our specimens and, consequently, the systematic assignment is tentative.

Our material is markedly affected by metamorphic processes and shows different degrees of preservation leading from well preserved specimens with at least partly preserved relief up to less distinct ones marked only as bands differing in colour from the host rock. The central part of the trace is usually flat, a markedly elevated centre of possible concretion character is shown in L30545 (Pl. I, fig. 2) in which a diagenetic origin cannot be excluded.

The specimen L30556 (Pl. V, fig. 1; Text-fig. 4) is exceptional in a marked bending of the branches. This may be accentuated by compaction of the primary downward bent wall-like *Teichichnus* structures, therefore being of secondary origin. The curved branches otherwise resemble the ichnogenus *Bifasciculus* Volk, 1960, whose branches, however, are numerous, densely packed and smaller.

**Occurrence.** "*T.*" *stellatus* was first described by Baldwin (1975) from the Lower Ordovician of the Asturias Province, NW Spain. The lithology of the host rock, namely the combination of silt- and mudstones, agrees with the inferred pre-metamorphic character of the Železný Brod Phyllite. "*T.*" *stellatus* seems to be not rare in some layers at the Tlukačka quarry near Jílové. A single specimen was observed on a phyllite plate used for decoration at Těpeře (this specimen evidently comes from the old phyllite quarry N of the village).

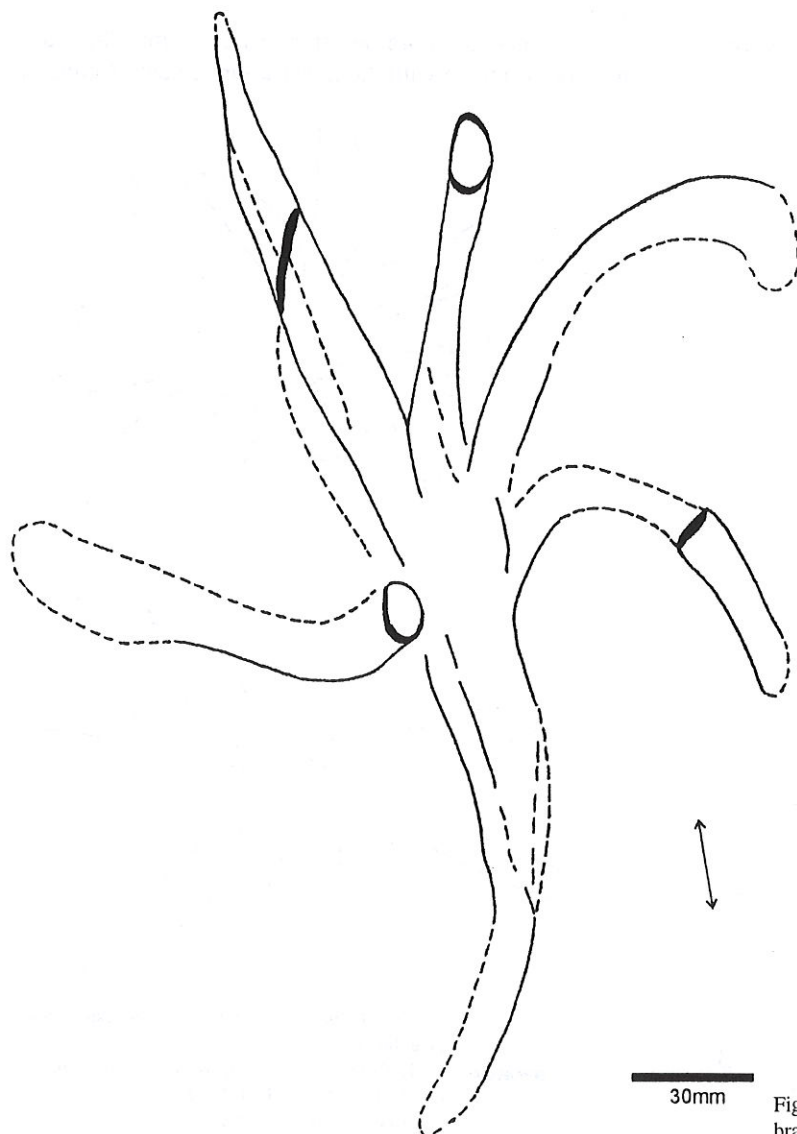


Fig. 4. "*Teichichnus*" *stellatus*, specimen 30556 with curved branches. Tlukačka Quarry near Jílové



Ichnogenus *Phycodes* Richter, 1850

Type ichnospecies: *Phycodes circinatus* Richter, 1853.

*Phycodes palmatus* (Hall, 1852)

Pl. III, figs. 1, 3-6; Text-figs. 5, 6, 8.3,5

Material: 11 specimens preserved (some with counterparts) on foliation planes of phyllites, mostly with gently convex relief.

Description. Large palmate traces consisting of branches radiating from a single initial burrow (L30549, L30553, Text-fig. 5.1, 2), or from an ill-defined centre.

The initial burrow, if developed, shows a lesser expressed relief than the radiating branches but its width is markedly greater than that of the branches. 4-9 (exceptionally up to 13 or 14) radiating branches are not distinctly different proximally, but in their continuation from the centre they become well delimited laterally with subparallel sides and only gently tapering distally. The transverse width of branches ranges between 4 to 9 mm, the exceptional width of up to 18 mm (30553) may be caused by flattening of two neighbouring branches. Distal tips of branches are narrowed and bluntly rounded but the termination is commonly obscured by deformation. Angles between neighbouring branches are typically low, commonly not exceeding 20 degrees. The length of individual branches varies in collected specimens between 30 and 150 mm, the maximum

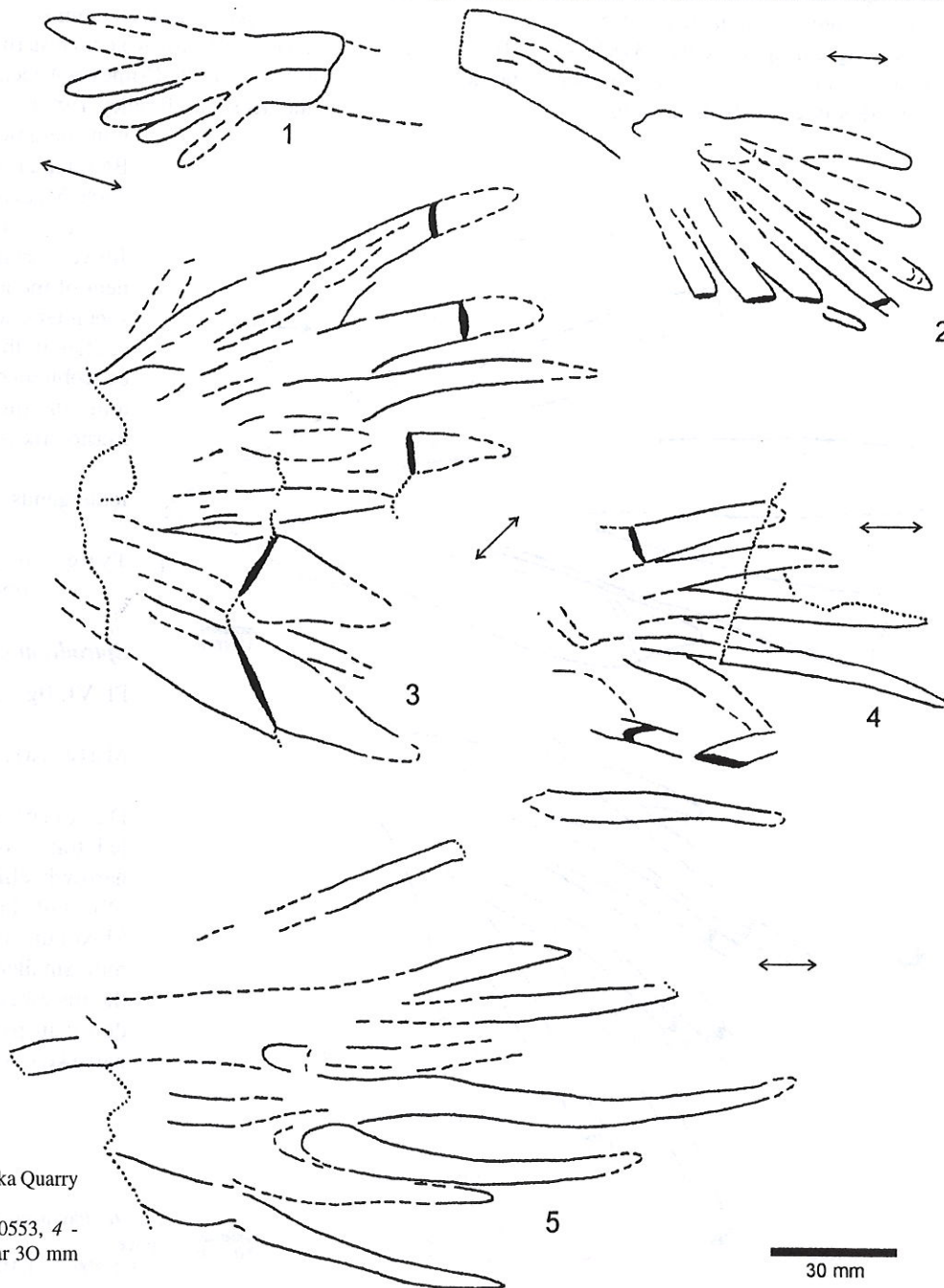


Fig. 5. *Phycodes palmatus*, Tlukačka Quarry near Jílové  
1 - L30549, 2 - L30547, 3 - L30553, 4 - L30554, 5 - L30552. The scale bar 30 mm refers to all figured specimens

length being attained in the middle branches of the palmate burrow system. The preserved relief of the whole trace indicates that the radiating branches were filled by more competent material than the initial burrow.

**Remarks.** The palmate structure consisting of simply radiating branches corresponds to common features of the widely distributed trace *P. palmatus* as first reported by Hall (1852). The preservation in phyllites strongly affected by compaction makes the limits of the trace commonly less distinct, particularly in the proximal part. However, the original cylindrical cross-section of the radiating branches and their fill with harder material withstanding metamorphism and deformation are evident. The mode of preservation of the distal tips of branches does not exclude their slight upwards curvature in the last mm of their course as indicated by Seilacher (1955).

Among our specimens, L31816 (Text-fig. 8.5) deserves a special attention, as its number of branches (13 to 14) markedly exceeds the average.

*P. palmatus* was originally described under the ichnogenetic name *Buthotrephis* Hall, 1847, which was also used for this ichnospecies by some subsequent authors (e.g. Osgood 1970, Clausen et Vilhjálmsson 1986). As pointed out by Fillion and Pickerill (1990), *Buthotrephis* cannot be considered for nomenclatorial reasons as valid and the assignment to *Phycodes* is justified.

On the other hand, *Phycodes* in its present sense is a strongly heterogeneous unit which includes traces markedly differing from the type ichnospecies *P. circinatus* Richter (comp. Han et Pickerill 1994). This is particularly the case of *P. coronatum* Crimes et Anderson, 1985 and *P. pedum* Seilacher, 1955, which show a quite different ground plan, way of branching etc. These should be separated as separate ichnogenera.

*P. palmatus* is a common trace-fossil occurring in diverse facies of Phanerozoic time starting with the Lower Cambrian (Osgood 1970, Crimes et Anderson 1985) and reaching up to the Miocene (Bradley 1981). It was described also from the non-metamorphic Ordovician of the Barrandian area (Vlček 1902, Fritsch 1908, Mikuláš 1993, 1995).

**Occurrence.** In the phyllites at Jílové, forming a characteristic component of the ichnoassemblage. Individual specimens were found also at other localities in the vicinity of Jirkov (quarries Kobližtice, Samčice, Světlův Quarry) and in the Liebig quarry in the Žernovník brook valley NW of Jirkov.

Ichnogenus *Spirodesmos* Andrée, 1920

1 Type species: *Spirodesmos interruptus* Andrée, 1920.

*Spirodesmos spiralis* (Geinitz, 1867)

Pl. VI, fig. 2; Text-fig. 7.2

**Material:** the sole specimen L30550.

**Description.** A slender, spirally coiled trace consisting of two whorls of narrowly elliptical outline. Surface smooth, not interrupted into segments. Maximum diameter of the trace is 77 mm, smaller diameter 21 mm, width of the trace-band around 1 mm (gently widened in parts of maximum curvature, narrowed in parts of the minimum one).

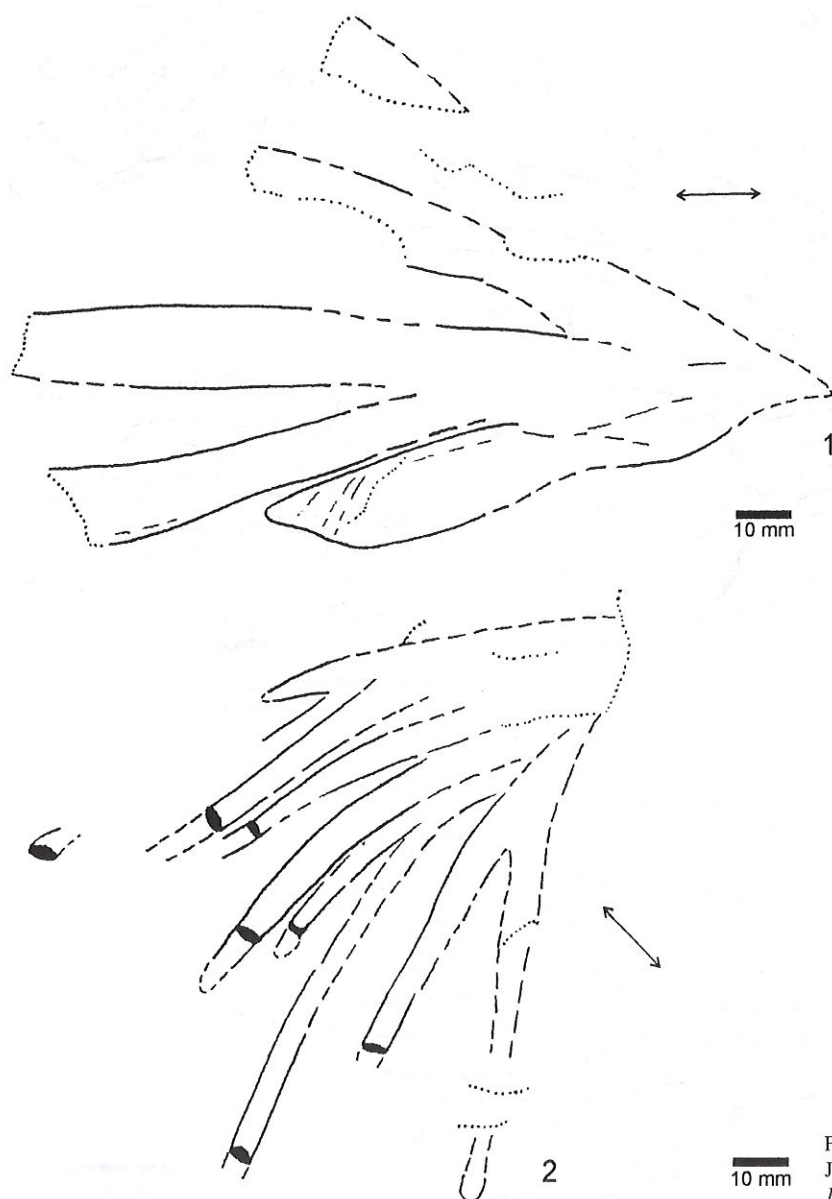


Fig. 6. *Phycodes palmatus*, Tlukačka Quarry near Jílové  
1 - L31809, 2 - L31802



**Remarks.** The simple spiral shape indicates *Spirodesmos*, the slender form and uninterrupted trace-band are consistent with *S. spiralis*, as revised by Pfeiffer (1968). The narrowly elliptical outline of our specimen differs from the typical specimens of *Spirodesmos spiralis* but the effects of metamorphism may be responsible for this feature.

*S. spiralis* was first described from the Lower Carboniferous (Viséan) of Thuringia, Germany. A form very similar in coiling and dimensions to the neotype of *S. spiralis* (comp. Pfeiffer, 1968, Pl. 3, fig. 6) was reported by Pickerill (1980, fig. 2d) from the Lower or Middle Ordovician of New Brunswick, Canada.

**Occurrence.** Rare in phyllites at Jílové (Tlukačka Quarry).

**Ichnogenus** *Spirophycus* Häntzschel, 1962

**Type ichnospecies:** *Muensteria bicornis* Heer, 1877.

#### *Spirophycus* ichnosp.

Pl. VI, figs. 1, 3; Text-figs. 7.1,3

**Material:** two specimens (L30550, L30551).

**Description.** Fairly large spiral-shaped trace which forms a less regular double spiral structure with characteristic level crossing. The trace is preserved as an uninterrupted band differing from the host rock either by a harder fill, or darker colour indicating differences in mineral composition of the fill. Maximum diameter of the whorl is 117 mm, the width of the trace-band ranges between 1.5 to 3.5 mm (affected by pressure deformations).

**Remarks.** The spiral or double spiral form of the trace agrees with *Spirophycus*, though its type ichnospecies is thicker and shows a sculptured surface. The dimensions are analogous as e.g. in *Spirodesmos archimedeus* Huckriede, 1952 but the number of whorls is markedly smaller, the spiral course lesser regular with a typical level crossing which is otherwise characteristic for *Gordia*. *Spirophycus* was interpreted by Seilacher (1962) as a predepositional trail. This seems to be not plausible for our specimens which exhibit a fill different from the host rock.

**Occurrence.** Rare in the phyllites at Jílové (Tlukačka Quarry), the most characteristic specimen L30550 is preserved on the same bedding plane with *Spirodesmos spiralis*.

**Ichnogenus** *Taphrhelminthopsis* Sacco, 1888

**Type species:** *T. auricularis* Sacco, 1888.

#### *Taphrhelminthopsis* ichnosp.

Pl. III, fig. 2

**Material:** One specimen (L30555).

**Description.** A minor part of a bilobed trace forming two meandering curves passing into a circle with overlap. The bilobed character is indicated partly by a distinct longitudinal median furrow, partly by a darker coloured band. The total diameter of the trace is 55 mm, width of the trace-band ranges between 4 and 9 mm (affected by deformation).

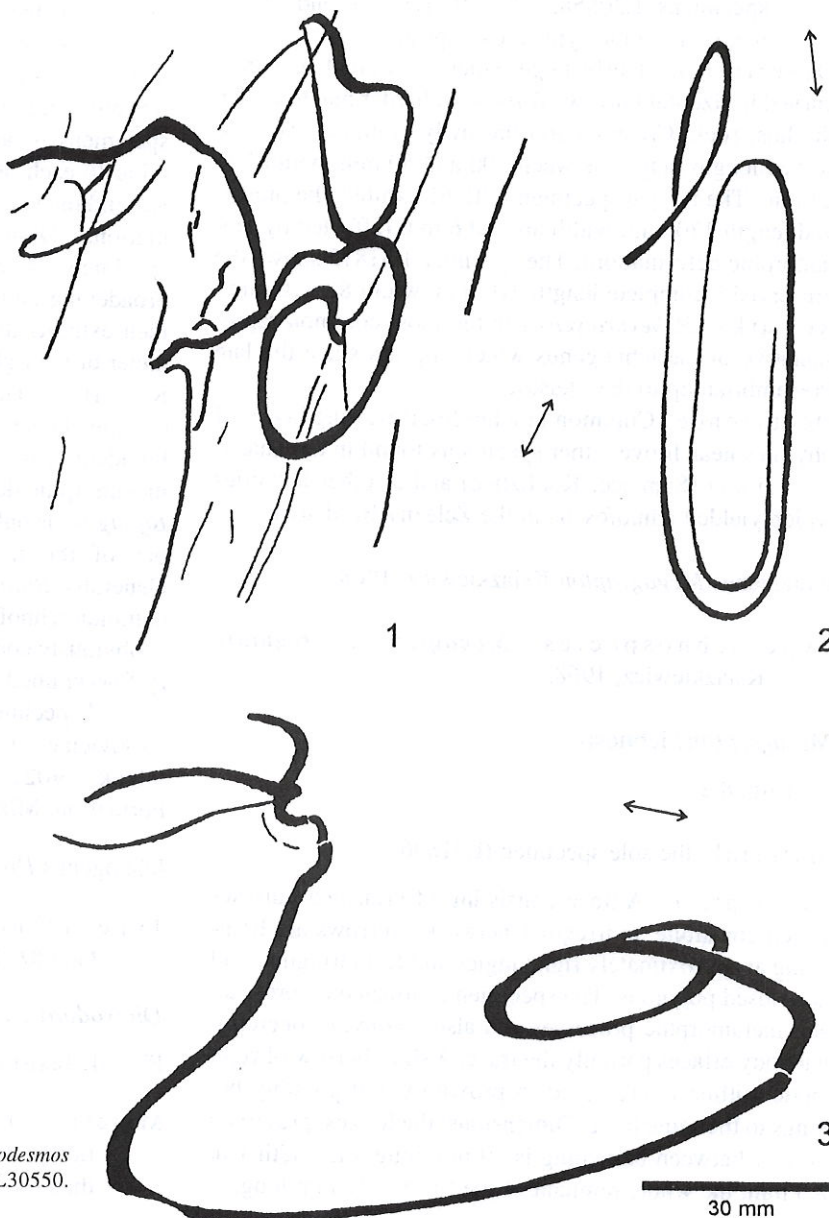


Fig. 7. 1 - *Spirophycus* ichnosp., L30551; 2 - *Spirodesmos spiralis*, L30551; 3 - *Spirophycus* ichnosp., L30550. Tlukačka Quarry near Jílové



**Remarks.** The bilobate character of the trace is similar to *Didymaulichnus* Young, 1972 and *Aulichnites* Fenton et Fenton, 1937. The assignment to *Taphrhelminthopsis* is supported by strong curvatures and crossing (overlapping) of the trail which is characteristic for early forms of the ichnogenus (comp. Crimes et al. 1992). *Taphrhelminthopsis* is known from strata of Lower Cambrian to Holocene ages.

**Occurrence.** Rare in phyllites at Jílové.

**Ichnogenus** *Planolites* Nicholson, 1873

**Type ichnospecies:** *Planolites vulgaris* Nicholson et Hinde, 1875.

***Planolites beverleyensis* (Billings, 1862)**

Pl. V, fig. 2

**Material:** From a large number of observed traces, the specimens L30558, L30559, L30561 and 31812 were selected as typical examples.

**Description.** Fairly large, smooth, straight or gently curved horizontal burrows filled with harder material than the host rock. Cross-section narrowly elliptical. The observed length ranges between 200 and 50 mm, width 5 to 23 mm. The typical specimen L30561 exhibits the preserved length 170 mm, width around 6 mm (affected by metamorphic deformation). The specimen L31812 shows the preserved incomplete length 210 mm, width 8 to 10 mm. **Remarks.** *P. beverleyensis* is the most common representative of the ichnogenus which appears since the late Precambrian up to the Pleistocene.

**Occurrence.** Common in ichnofossil-bearing layers of phyllites near Jílové, other specimens found in the quarries at Jirkov (Samčice, Kobližtice) and at other localities which yielded ichnofossils in the Železný Brod area.

**Ichnogenus** *Megagraption* Książkiewicz, 1968

**Type ichnospecies:** *Megagraption irregulare* Książkiewicz, 1968.

***Megagraption?* ichnosp.**

Text-fig. 8.2

**Material:** the sole specimen (L31806).

**Description.** A trace consisting of branched burrows which constitute an irregular network. Burrows are branching at approximately right angles and form irregular and not closed polygons. The specimen is affected by pressure and metamorphic processes and also a convex concretionary body effaces partially the trace. A short burrow of right angle outline is preserved in proximity and possibly belongs to the same trace. Dimensions: the longest preserved burrow between branching is 19 mm long, the width 1 to 2.3 mm, the whole remnant of the trace is 47 mm long.

**Remarks.** *Megagraption* was first described from the Eocene flysch sediments of Carpathians (Książkiewicz 1968, 1977) and since that time it was found as a typical member of the deep water trace assemblages starting with the Ordovician (Crimes et al. 1992).

**Ichnogenus** *Bifungites* Desio, 1940

**Type ichnospecies:** *Bifungites fezzanensis* Desio, 1940.

***Bifungites* ichnosp.**

Pl. VI, fig. 4; Text-fig. 8.1

**Material:** Two approached specimens L31808 preserved on the same foliation plane with *Phycodes palmatus* but divided from it during preparation.

**Description.** Two rather small specimens are strongly approached and almost in contact. The characteristic dumb-bell shape of the trace is only incompletely developed: the horizontal and straight shaft is markedly broadened on one side only, the broadening of the other end being only slightly indicated. The broadened ends of both specimens are almost spherical in outline and markedly similar to each other. They show subcircular median grooves and unevennesses evidently affected by pressure deformations. Dimensions: the total length of the larger specimen is 42 mm, the maximum diameter of the bulbous broadening on the right end is 15 mm. The smaller specimen exhibits the total length 30 mm, the maximum diameter of the right broadened part is 13 mm.

**Remarks.** The dumb-bell shape of the trace, though incompletely developed, points to *Bifungites*, the unequal broadening of the both ends being evidently caused by metamorphic deformations. The rarity of finds points that *Bifungites* is only uncommon and rather exceptional member of the ichnoassemblage found in the phyllites. Generally, *Bifungites* is otherwise a widely distributed and common ichnofossil known since the Lower Cambrian. It is obviously concentrated in siltstones, silty shales and very fine-grained sandstones (Gutschick et Lamborn 1975). Typical specimens derive also from the non-metamorphic Ordovician of the Barrandian area (Letná Formation: Vlček 1902, Fritsch 1908, Mikuláš 1993, Kosov Formation: Mikuláš 1992).

**Ichnogenus** *Dictyodora* Weiss, 1884

**Type ichnospecies:** *Dictyophyton? liebeanum* Geinitz, 1867.

***Dictyodora* cf. *zimmermanni* Hundt, 1913**

Pl. VII; Text-fig. 9

**Material:** Three specimens preserved on phyllite foliation planes which show slighter developed lineation than the nearby layers.



**Description.** Only incomplete parts of a complex burrow system are preserved. They are delicate irregularly meandering thin burrows constituting a part of complex irregularly spiral system. In our case, only horizontal sections through the vertical walls of burrows are preserved as thin, often parabolically bent structures filled with darker material than the host rock is. The vertical dimension of the trace is completely obscured by metamorphism. The

widened basal burrow was not directly observed in connection with the horizontal sections of the walls but it cannot be excluded that some traces referred to *Spirophycus* (namely L30551) may represent basal burrows of *Dictyodora*. Dimensions: the width of individual burrows ranges between 1 to 2 mm, the diameter of preserved parts of the complex burrow systems exceeds 100 mm.

**Remarks.** *Dictyodora* is a characteristic ichnofossil of

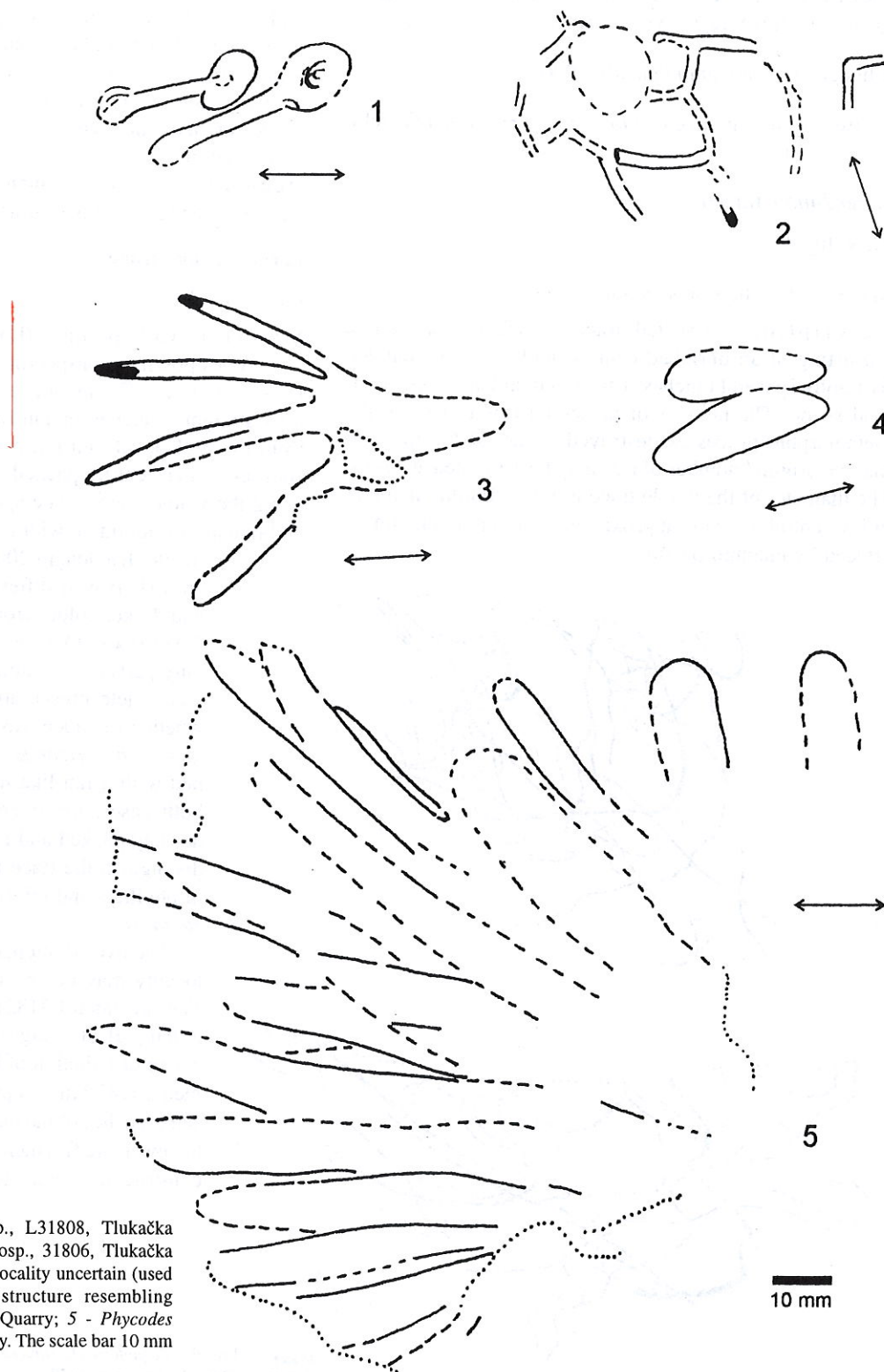


Fig. 8. 1 - *Bifungites* ichnosp., L31808, Tlukačka Quarry; 2 - *Megagraption?* ichnosp., 31806, Tlukačka Quarry; 3 - *Phycodes palmatus*, locality uncertain (used as decoration material); 4 - structure resembling *Rusophycus*, L30550, Tlukačka Quarry; 5 - *Phycodes palmatus*, L31816, Světlův Quarry. The scale bar 10 mm refers to all figured specimens

lower energy and deep water fine-grained sediments of the Palaeozoic. The less regular meander pattern and the absence of secondary sinuosity within the meanders agree with *Dictyodora zimmermanni* as discussed by Benton (1982) and described from the Upper Ordovician Hauptquarzit of Thuringia. As the height of the burrow walls cannot be studied due to deformation, the specimens are designated in the open nomenclature.

**Occurrence.** All specimens derive from the Tlukačka Quarry at Jílové, layers with "*Teichichnus*" *stellatus*.

**Ichnogenus** *Lorenzinia* Gabelli, 1900

**Type ichnospecies:** *Lorenzinia apenninica* Gabelli, 1900.

***Lorenzinia* ichnosp.**

Pl. V, fig. 3

**Material:** The sole specimen L31813.

**Description.** Rosetted trace of subcircular outline consisting of an unribbed central field (areola) encircled by tightly spaced branches (ribs) of equal length and identical shape. The number of preserved ribs is 10, but the metamorphic processes destroyed a part of the trace so that the original number of ribs may be estimated at 12-14. The diameter of the whole trace is 110-120 mm, diameter of the central areola is approximately 30 mm (exact limits effaced by metamorphism).

**Remarks.** The presence of the central empty areola surrounded by regularly arranged ribs indicate *Lorenzinia*. The features distinguishing our specimen are the relatively great dimensions, small diameter of the areola, which is equal to about 1/4 of the whole trace diameter, and a lesser number of ribs (typical specimens from the flysch sediments of Carpathians as described by Książkiewicz (1970, 1977) and other authors from different areas show 16 or more ribs). Our specimen is preserved in phyllite with strong lineation. It is hardly visible on the dry surface of the phyllite slab, but its structures are easily seen on a wet surface or submerged in water.

*Lorenzinia* is known from strata starting with the Lower Ordovician (Crimes et al. 1992) and is typical of flysch sediments.

**Occurrence.** The specimen derives from the Liebig Quarry in the valley of the Žernovík brook NW of Jirkov.

### Large fan-like trace

Pl. IV, fig. 3

**Material:** One specimen (L31814) and two additional ones possibly conspecific.

**Description.** The incomplete trace consists of numerous straight branches in fan-like arrangement radiating from the broken off and not preserved centre. The branches are rather densely packed and attain the same width along the whole course. The specimen L31814 preserves 14 branches of dominant width around 10 mm, maximum incomplete length 200 mm. The fill of the branches (burrows) differs in mineral composition and darker colour from the host rock.

**Remarks.** Our specimens evidently represent only parts of a complex burrow system. Due to incomplete preservation, it cannot be decided whether the trace was stellate and referable to a giant *Glockerichnus*, or whether we are concerned with a fan-like trace of *Phycodes* type. In both cases, the trace is unusually large. The densely packed and numerous branches clearly distinguish the trace from stellate traces found in phyllites and referred here to "*Teichichnus*" *stellatus*.

The two additional specimens from the same locality may belong to the same type of trace. The specimen L31821 can be interpreted as the initial part of a large fan-like trace, close to the centre of radiation of branches. The other specimen L31820 may represent, on the contrary, distal branches of the burrow. The both specimens, however, are fragmentary and do not allow to reconstruct the complete form of the trace.

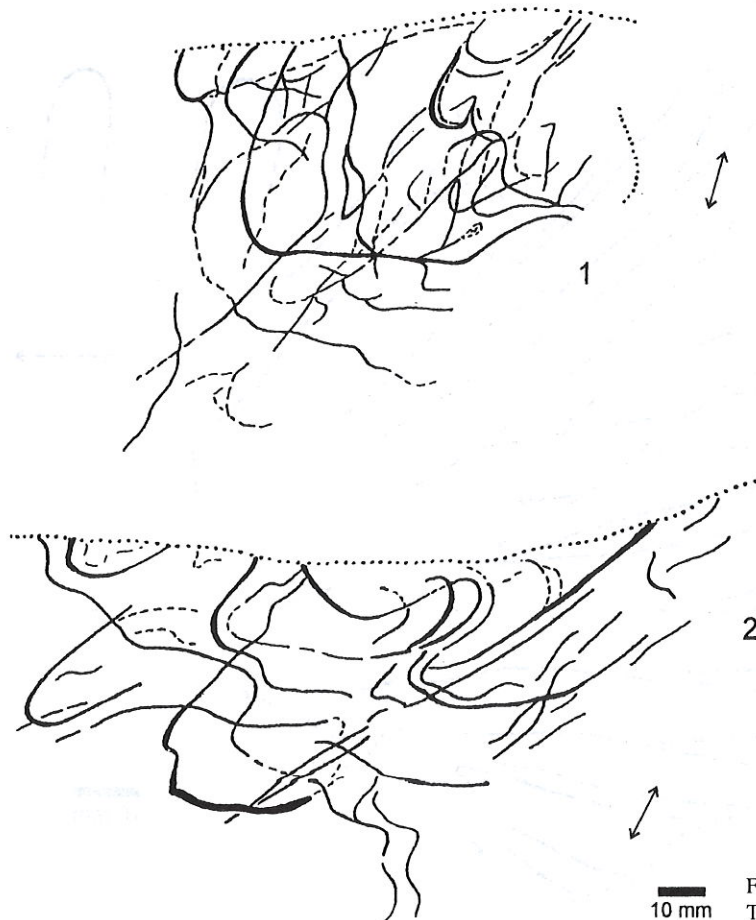


Fig. 9. *Dictyodora* cf. *zimmermanni*, 1 - L31805, 2 - 31804. Tlukačka Quarry near Jílové



Occurrence. In grey-green phyllite of the Kobližtice Quarry N of Jirkov (the largest specimen was found by M. Kříha during a joint excursion with the author).

### Other traces and structures of doubtful organic origin

Straight or less frequently branching traces, preserved as convex bands or linear structures differing from the host rock by their competence or colour pointing to a different mineral composition, commonly occur in the roofing phyllites near Železný Brod. Although the branched burrows (Pl. I, fig. 3; Pl. IV, fig. 2) are evidently of organic origin, the organic nature of straight structures is questionable.

Other, even more problematical structures, are distinguished by suboval outline, gently convex relief (more competent than the surrounding rock), and a median furrow or depression. This furrow subdivides these bodies into two or three subparallel lobes with smooth surface (Pl. VIII, figs. 1, 2; Text-fig. 8.4). Although the configuration of these structures resembles the ichnogenus *Rusophycus* Hall, 1852, their inorganic origin cannot be excluded (concretional bodies affected by deformation).

Another type of problematical structures are circular or oval ring-like "burrows" conform with the foliation planes of phyllites and filled with a more competent material than the host rock (Pl. VIII, fig. 4). They resemble the ichnogenus *Circulichnis* Vyalov, 1971, but also in this case the inorganic origin may be suspected.

### Ichnofacies and environment of the ichnofossil assemblage

The ichnofossil assemblage in the roofing phyllites at Železný Brod is diverse. Owing to the fact that only a few ichnofossils were not totally obliterated by metamorphic processes, the primary content of ichnofossils and the ichnodiversity was probably relatively high.

Regarding the ichnofacies characteristics, as introduced by Seilacher (1964) and later summarized e.g. by Frey and Seilacher (1980), Frey and Pemberton (1984) and Bromley and Asgaard (1991), the occurrence of spiral (*Spirodesmos*), star-like (*Lorenzina*, "*Teichichnus*" *stellatus*) and delicate meandering (*Dictyodora*) traces would point to an oxygenated low energy deep sea environment of the *Nereites* ichnofacies characteristic for flysch and similar deposits. The presence of *Phycodes*, *Taphrhelminthopsis*, *Planolites* as typical "facies crossing" ichnotaxa does not contradict this assignment.

The sole ichnogenus generally regarded as a shallow-water element is *Bifungites*, though it is an expressively rare and exceptional member of the ichnoassemblage found in phyllites.

The absence of vertical burrows and dominance of shallowly burrowing or grazing traces indicate a low energy regime and soft character of the bottom sediments.

### The age of the ichnoassemblage

The age and stratigraphical position of the Železný Brod Phyllites are not known, but the ichnofossils may provide a clue. The individual ichnogenes and the general character of the ichnoassemblage exclude a Proterozoic age for the phyllites.

The occurrence of *Spirodesmos*, *Dictyodora*, *Lorenzina* and "*Teichichnus*" *stellatus* suggest that the phyllites are not older than Ordovician. Assuming the colonisation of the deep seas by different taxa of ichnofossils as discussed by Crimes, Garcia Hidalgo and Poire (1992), we may conclude that the ichnofossil assemblage of the Železný Brod Phyllites is most probably of Ordovician age.

Submitted November 12, 1996

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### Paleozoické ichnofosilie z pokrývačských fylitů od Železného Brodu, severní Čechy

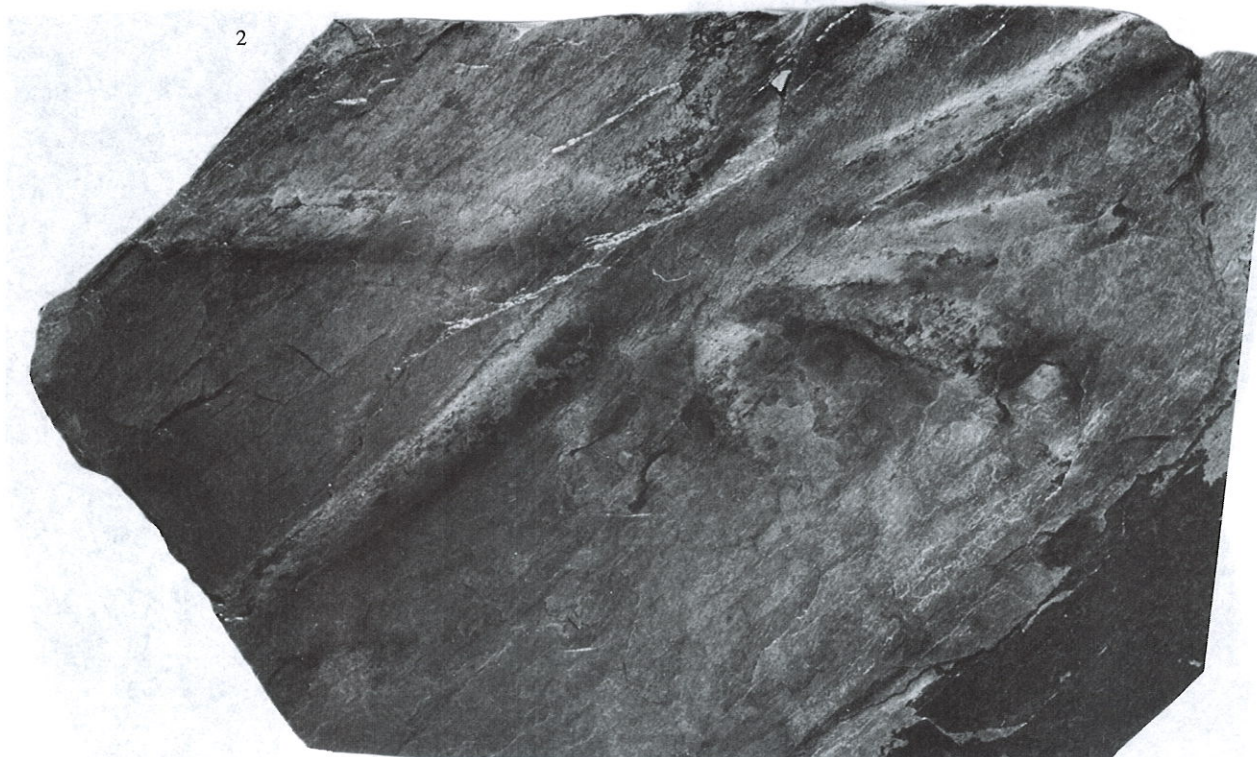
V pokrývačských fylitech, které jsou v okolí Železného Brodu součástí krkonošsko-jizerského metamorfovaného komplexu, byly nalezeny paleozoické ichnofosilie nejspíše ordovického stáří. Typické jsou velké hvězdčité stopy "*Teichichnus*" *stellatus* Baldwin a dlanitě větvené stopy *Phycodes palmatus* (Hall). Další ichnofosilie patří rodům *Bifungites*, *Dictyodora*, *Lorenzina*, *Megagraptus*?, *Planolites*, *Spirodesmos*, *Spirophycus*, *Taphrohelminthopsis* a některým dalším formám označeným neformálně. Společenstvo ichnofosilií má hlubokovodní charakter se vztahy k flyšovým faciím.





1, 2. Two giant specimens of stellate ichnofossil "*Teichichnus*" *stellatus* from the phyllites: 1 - L30557, preserved incomplete diameter 53 cm, 2 - L30545, preserved diameter 58 cm; 3 - bifurcate trace L31802, length 15 cm.  
All from the Tlukačka Quarry near Jílové

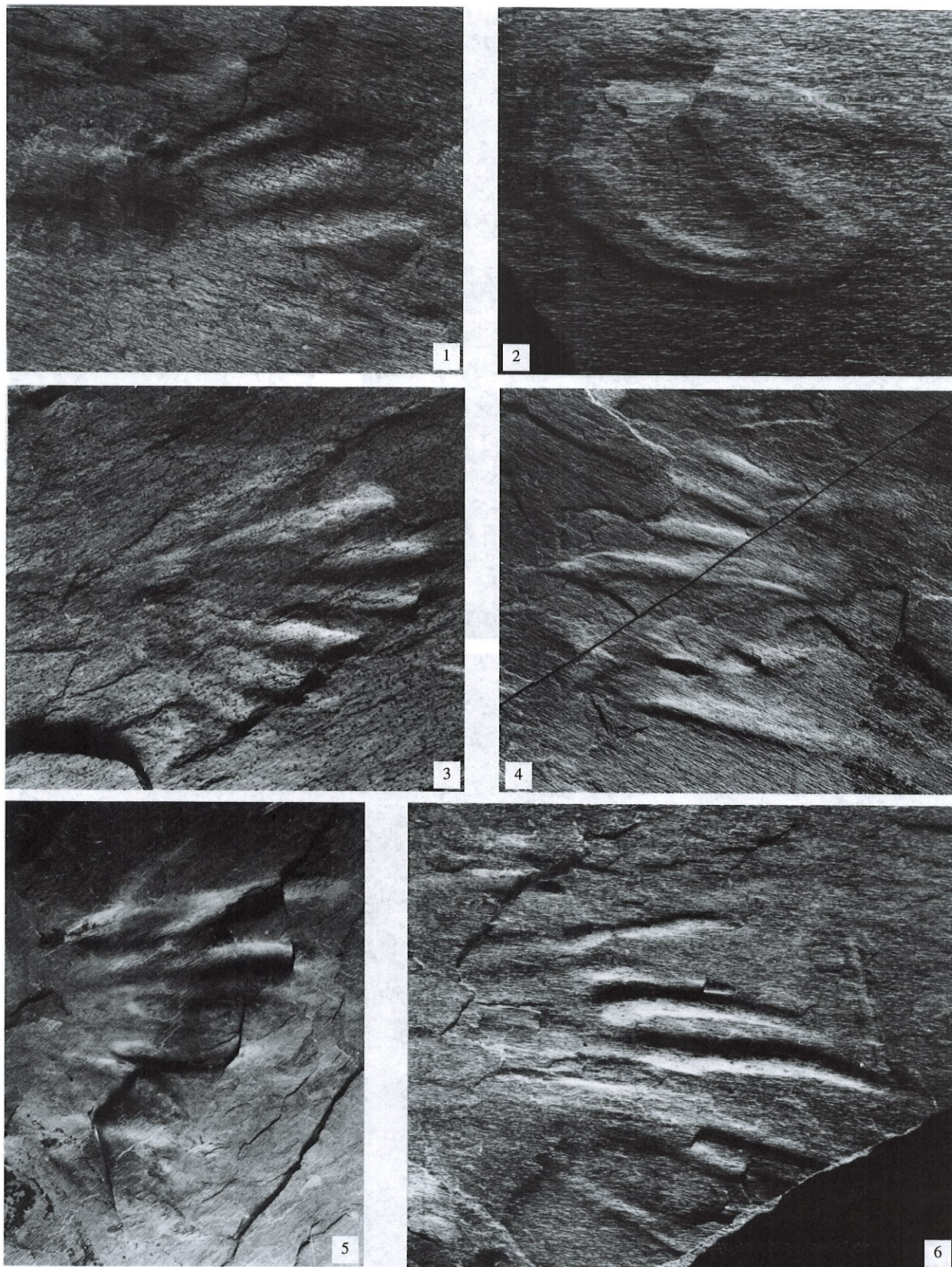




1, 2. *Teichichnus* "stellatus": 1 - L30544,  $\times 0.6$ , 2 - L31801,  $\times 0.6$ .  
Tlukačka Quarry near Jilové



## I. Chlupáč: Palaeozoic ichnofossils in phyllites near Železný Brod, northern Bohemia (Pl. III)



1, 3-6 - *Phycodes palmatus*:

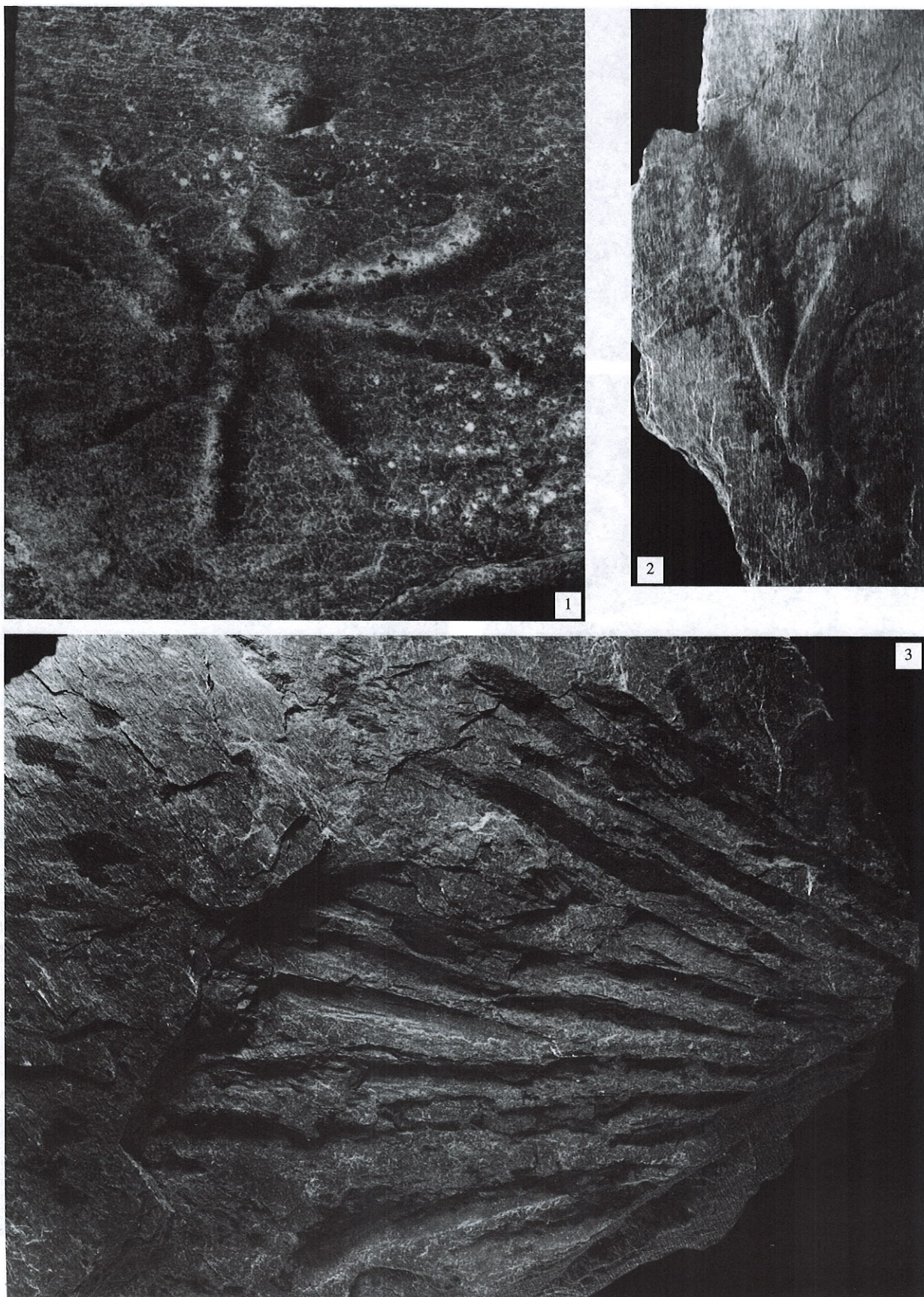
1 - L30549, natural size, 3 - L30547, slightly enlarged, 4 - L30554, x0.5, 5 - L30553, x0.4, 6 - L30552, x0.7;

2 - *Taphrhelminthopsis* ichnosp., L30555, slightly enlarged.

Tlukačka Quarry near Jílové



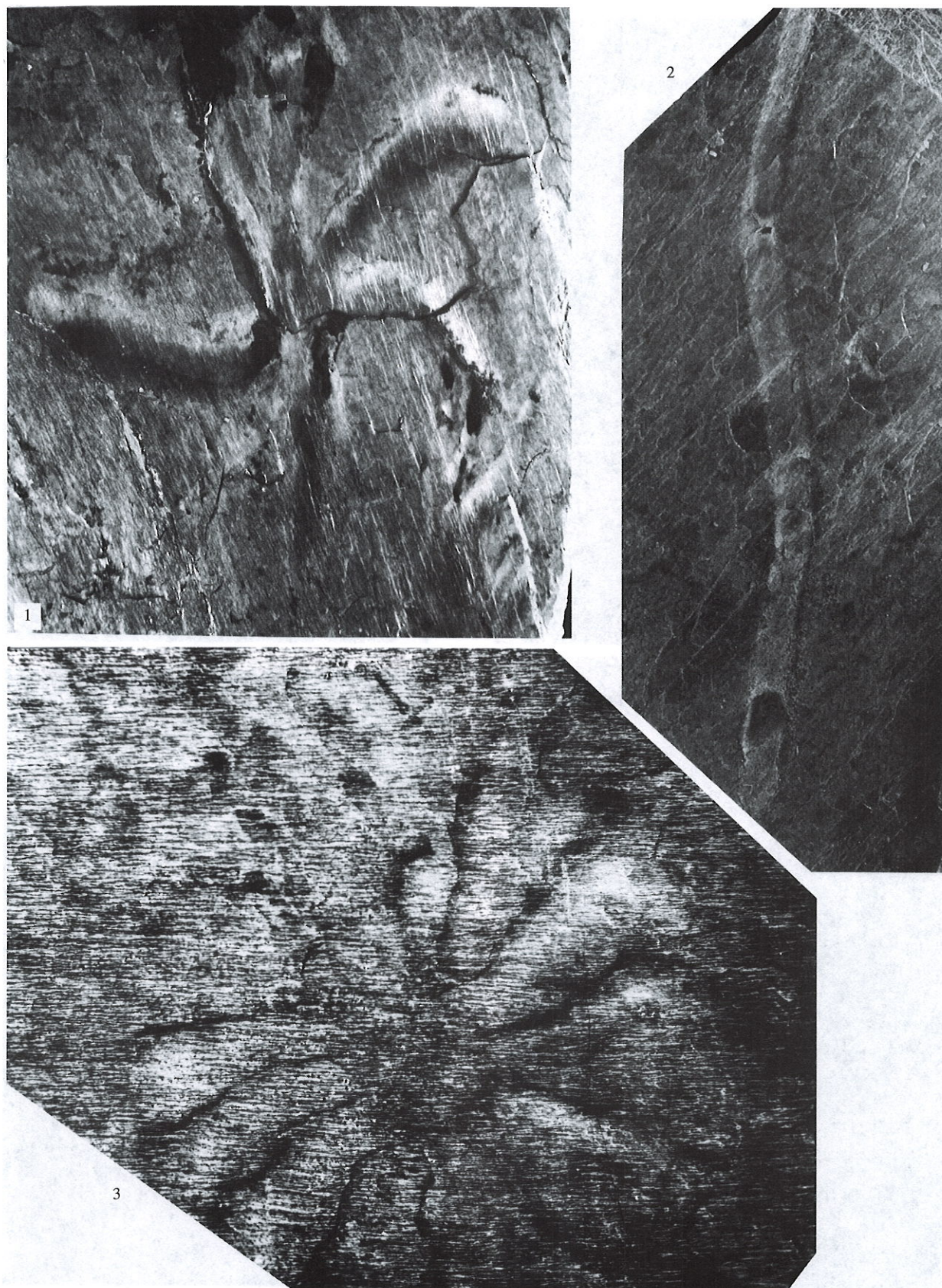
## I. Chlupáč: Palaeozoic ichnofossils in phyllites near Železný Brod, northern Bohemia (Pl. IV)



1 - "*Teichichnus*" *stellatus*, L3O175, x0.6; 2 - bifurcate trace L31803, natural size; 3 - large fan-like trace L31814, x0.5.  
 Tlukačka Quarry near Jílové (1, 2), Kobližtice Quarry near Jirkov (3)



## I. Chlupáč: Palaeozoic ichnofossils in phyllites near Železný Brod, northern Bohemia (Pl. V)



1 - "*Teichichnus*" *stellatus*, unusual specimen with markedly curved branches, L30556, x0.4;

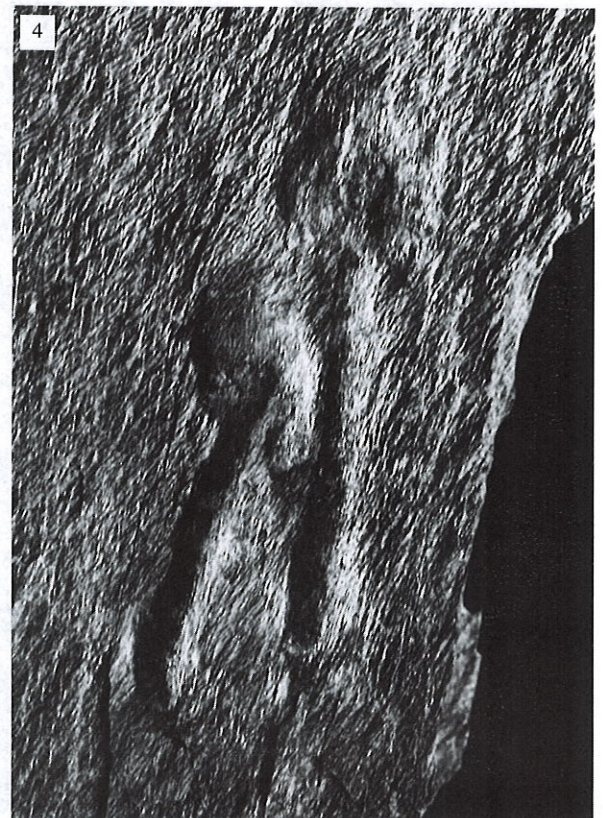
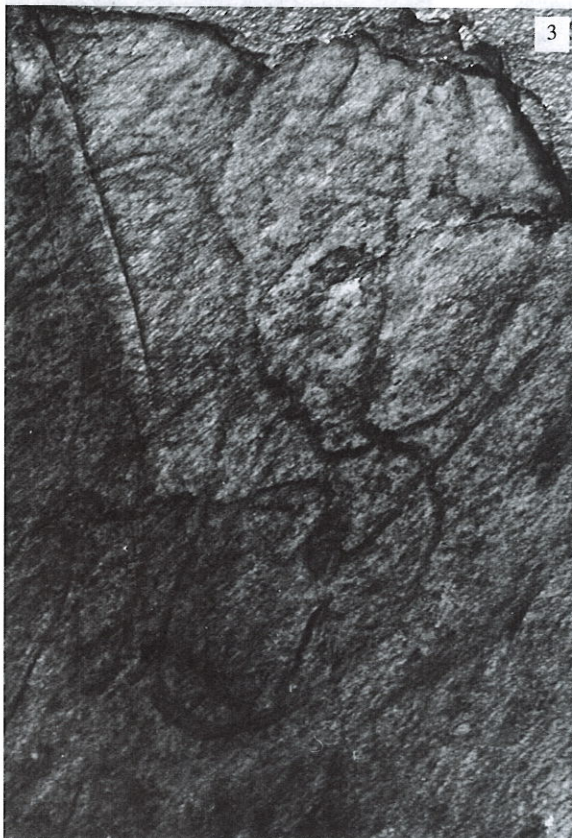
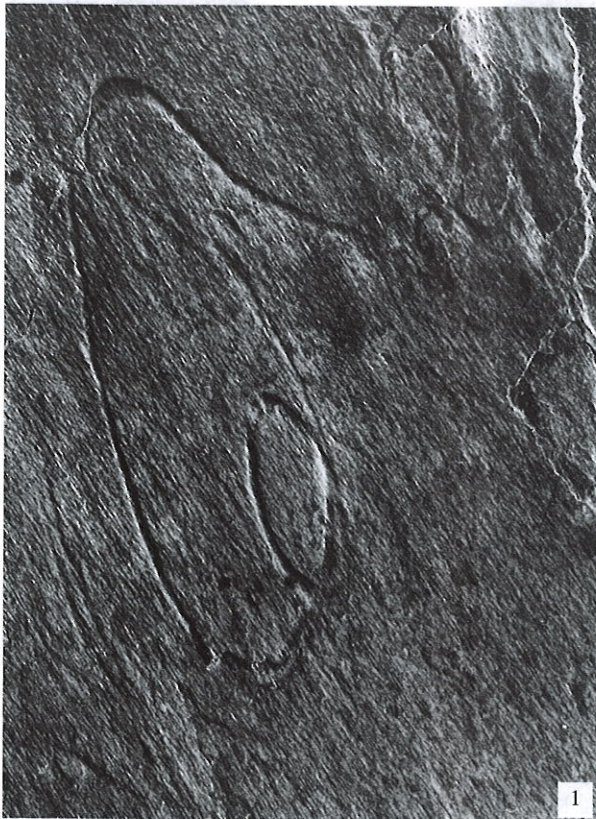
2 - *Planolites* *beverleyensis*, L31812, x0.9;

3 - *Lorenzina* *ichnosp.*, L31813, x0.8.

Tlukačka Quarry near Jílové (1, 2), Liebig Quarry in the Žernovský brook Valley (3)



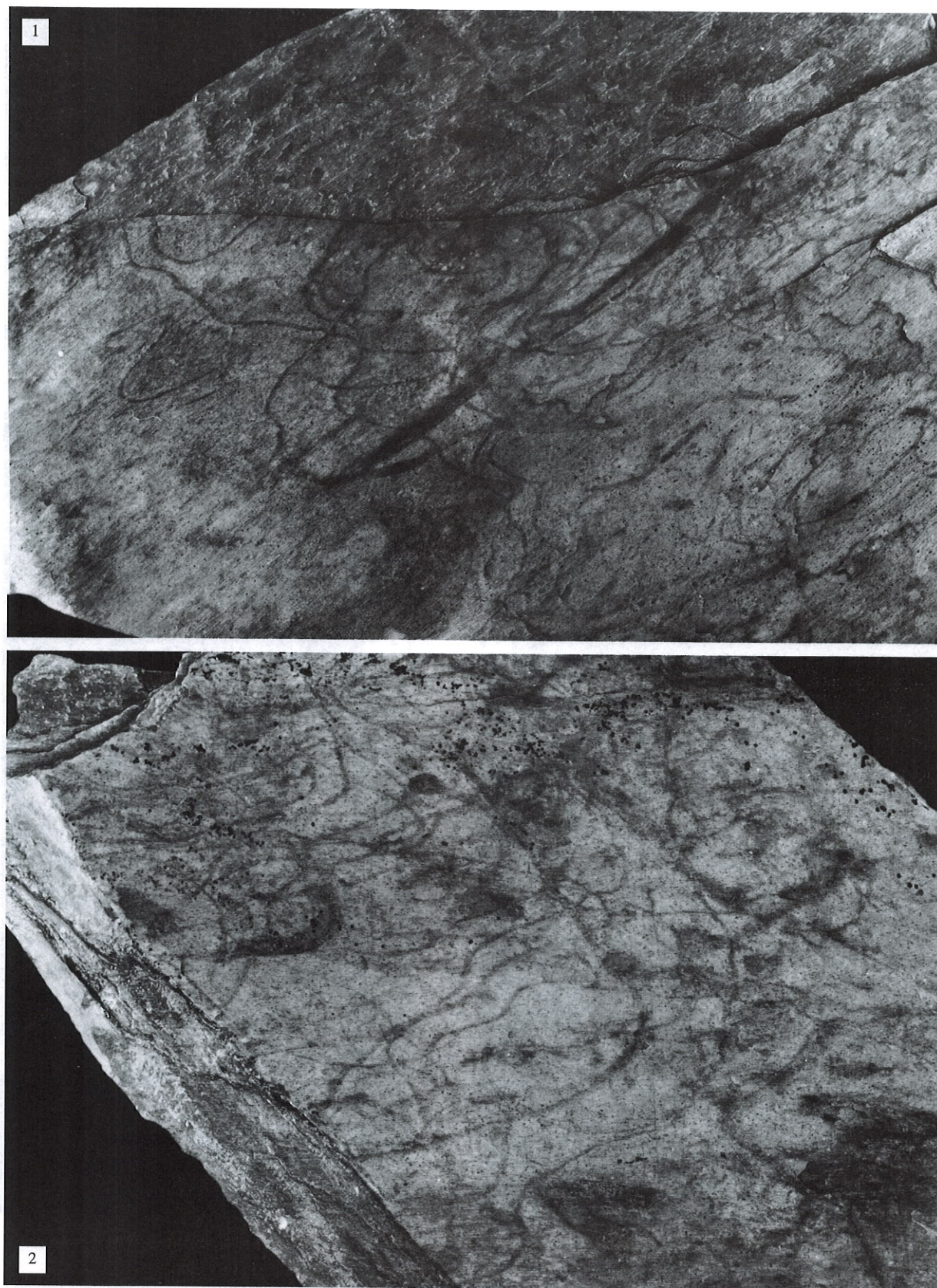
## I. Chlupáč: Palaeozoic ichnofossils in phyllites near Železný Brod, northern Bohemia (Pl. VI)



1 - *Spirophycus* ichnosp., L30550, x0.7; 2 - *Spirodesmos spiralis*, L30550, x0.7; 3 - *Spirophycus* ichnosp., L30551, x1.2; 4 - *Bifungites* ichnosp., L31808, x2.

Tlukačka Quarry near Jílové

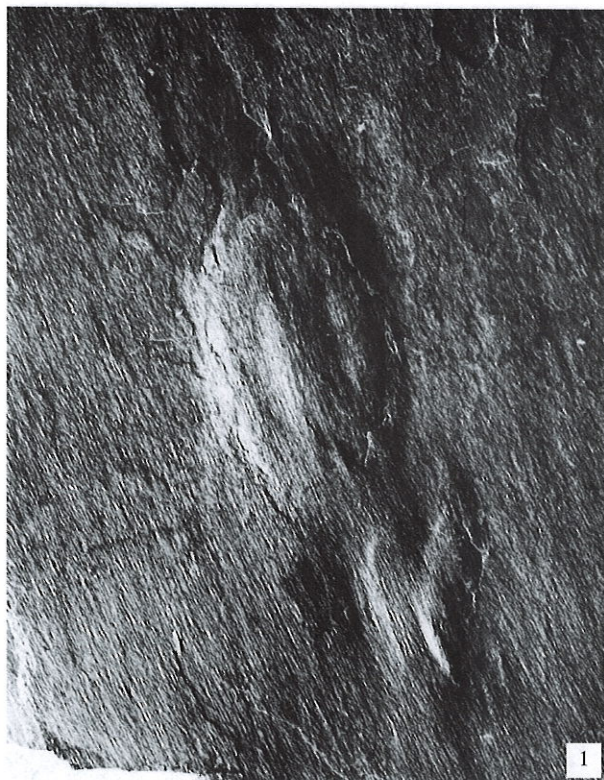




*Dictyodora* cf. *zimmermanni*: 1 - L31804, x0.9, 2 - L31805, natural size. Tlukačka Quarry near Jílové



## I. Chlupáč: Palaeozoic ichnofossils in phyllites near Železný Brod, northern Bohemia (Pl. VIII)



Doubtful ichnofossils or inorganic structures

1, 2 - structures resembling *Rusophycus*, x0.8 (1), natural size (2);

3 - horseshoe-shaped trace, L31822, x0.9; 4 - structure resembling *Circulichnis*, L31817, natural size.

Tlukačka Quarry near Jílové