Ichnos: An International Journal for Plant and Animal Traces

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gich20

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Published online: 17 Dec 2008.

To cite this article: Ivo Chlupáč & Radek Mikuláš (1995) Amanitichnus omittus ichnogen. et ichnosp. nov. from the Middle Cambrian, Barrandian area, Czech Republic, Ichnos: An International Journal for Plant and Animal Traces, 3:4, 273-279, DOI: 10.1080/10420949509386397

To link to this article: http://dx.doi.org/10.1080/10420949509386397

Ichnos, v. 3, pp. 273–279, 1995
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Amanitichnus omittus ichnogen. et ichnosp. nov. from the Middle Cambrian, Barrandian area, Czech Republic

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The newly established ichnofossil *Amanitichnus omittus* ichnogen. et ichnosp. nov. represents a complex burrow system consisting of upward convex conical structures with radiate sculpture, recurring in different stratification levels and connected by a subvertical shaft. The system is interpreted as an intrastratal fodinichnion with some resemblance to epistratal *Oldhamia* and *Glockerichnus*. The ichnofossil occurs in the silty Skryje Shale of Middle Cambrian age and is accompanied by common benthic body fossils and by ichnofossils of the *Cruziana* ichnofacies.

Key Words: Middle Cambrian, ichnofossils, fodinichnia, *Cruziana* ichnofacies, Barrandian area.

INTRODUCTION

Collections at the classic paleontological locality of Buchava near Skryje, lead the senior author to discover a new ichnofossil. His material was later supplemented by collections made by the junior author. The present report describes and interprets the new ichnofossil.

The reference material is deposited in the collections of the National Museum, Prague (inventory numbers prefixed by L).

GEOLOGICAL SETTING AND ACCOMPANYING FOSSILS

The locality at Buchava is situated in Cambrian strata of the Skryje-Týřovice area, about 3 km SW of the village of Skryje, at the roadway to Podmokly (the northwestern flank of the Barrandian, locality No. 16 in the Guidebook of Chlupáč (1993).

The fossiliferous strata belong to the Skryje Shale, the equivalent of the lower part of the Middle Cambrian Jince Formation (Havlíček, 1971; Havlíček in Chlupáč et al., 1992). The Skryje Shale comprises dark grey and grey-green to grey-brown siltstones and subordinate sandy clayey shales and impure carbonate concentrated in diffusely delimited lenses and laminae.

Fossils are generally common and crowded in some layers and lenses. The most common components of the assemblage are trilobites *Skrejaspis spinosa* (Jahn), *Eccaparadoxides pusillus* (Barr.), brachiopods *Bohemiella romingeri* (Barr.), carpoids *Trochocystites bohemicus* Barr. and *Ceratocystis perneri* Jaeckel (disarticulated skeletons), accompanied by numerous less common species of diverse groups. The locality is famous for its hyolithids, among which the giant *Maxillites maximus* (Barr.) is most spectacular (see Marek, 1975). *Teichichnus*, *Phycodes*, *Palaeophycus striatus* and *Thalassinoides* are common and collectively are indicative of the shallow water *Cruziana* ichnofacies.

Our new ichnofossil *Amanitichnus omittus* ichnogen. et ichnosp. nov. occurs in the sequence of the Skryje Shale overlying the main hyolite-rich layers and exposed in old quarries on the southern side of the highroad SE of the solitary farm Podmokelský mlýn (for location see Fig. 1). The specimens of *Amanitichnus* were mostly collected in

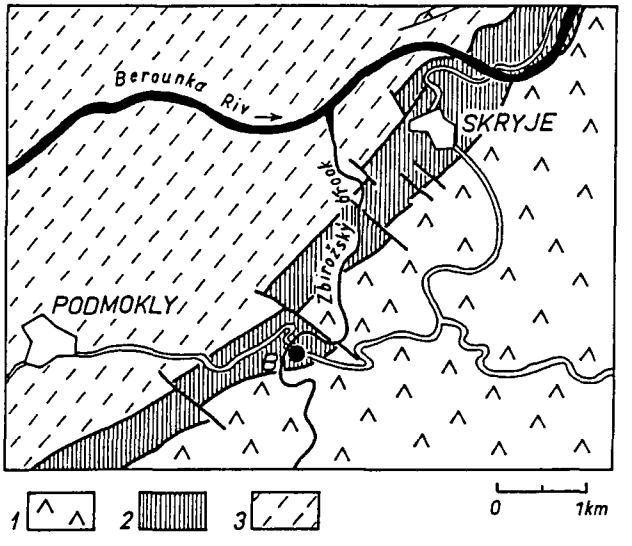

Fig. 1. Geological sketch map of the Skryje area. **(1)** Upper Cambrian volcanic rocks. **(2)** Middle Cambrian marine sediments. **(3)** Proterozoic sedimentary and volcanic rocks—the Kralupy–Zbraslav Group. **(B)** Locality Buchava.

debris left by fossil collectors. The primary orientation of ichnofossils was inferred from lithologic features (sharp lower limits of coarser laminae, cross lamination) and accompanying ichnofossils.

SYSTEMATIC ICHNOLOGY

Amanitichnus ichnogen. nov.

Diagnosis: Intrastratal ichnofossils consisting of one or several low and upward convex conical structures, commonly recurring in different levels within the same bed either in vertical superposition, or gently shifted laterally. The conical structures are covered with fine radial ridges and grooves, commonly slightly curved and/or anastomosing, particularly close to the outer margin of the cone. The outline of individual cones is subcircular or oval, the diameter equals several centimeters. The vertical or oblique distance between recurring cones ranges from a few mm up to several cm. The conical structures are connected by a narrow central shaft with a homogeneous fill.

Amanitichnus omittus ichnosp. nov.

Figures 2–6

Holotype: Specimen figured on Figs. 2C, 3A, 3B (L 30679).

Type horizon: Skryje Shale (Middle Cambrian).

Type locality: Buchava near Skryje.

Material: 22 specimens, commonly several conical structures within the same slab of rock (over 30 conical structures observed).

Diagnosis: As for ichnogenus.

Description: The complex ichnofossil consists of horizontally oriented, low conical bodies, of typical diameter between 20–30 mm, but possibly even larger—according to some fragmentary specimens, up to 40 mm. The cones are typically upwardly convex and form low elevations with rounded or flattened apices. Apical angles are low and broad, commonly around 150–160° (130° minimum value), but even completely flat discoidal bodies were observed (Fig. 4C). The apices of the cones are rounded, obviously terminated by one or more (up to three) low bulbous elevations. The mouth of the subvertical shaft connecting individual conical structures is more or less centrally located (Figs. 2D, 2E, 2F, 5A, 5B).

The outer outline of the cone is subcircular, or, more commonly, oval or ellipsoidal. The apex is usually gently eccentric in position, the eccentricity in superimposed cones of the same trace system is commonly similar. The outer margins of the cones are usually not sharply delimited and are less regular.

The radial ribs are one of the most characteristic features of the trace. The ribs radiate from the apex and densely cover the surface of the cone (commonly 3 to 5 ribs per 2 mm). The ribs are generally not strictly rectilinear but less regular and commonly gently curved, particularly close to the outer margin of the cone. The imprint of the ribs is unequal, they die out for some distance and reappear; less frequently they are anastomosing and apparently crossing. Indices of systematic curving of ribs near the outer margin (to produce a spiralled effect) were observed (e.g., in the holotype).

The specimen L 30684 (Figs. 2A, 3C, 3D) shows that the inner composition of the cone wall is complex and consists of several thin layers or laminae, each with radiate ribs not strictly identical. The distance between individual lamina of the same cone is minimal (tenths of mm) and during compaction individual layers were apparently overprinted resulting in a more common but false branching of the ribs. The apices of cones usually lack ribbing. The larger number of bulbous apical elevations (Figs. 2G, 4E) suggests that each layer of the same cone might have separate, and not strictly identical elevations.

Individual cones show less regular concentric structures which do not interrupt the radial ribs. They are evidently caused, or at least accentuated by, vertical pressure deformation of the trace during compaction.

Vertical or oblique connection of individual cones within the same trace system is presumed according to the specimens L 30690 and L 30682 (Fig. 5A, 5B) which exhibit an essentially subvertical, central shaft. The fill of the shaft consists, in L 30690 (Fig. 5A), of fine-grained material differing from the surrounding rock by a higher proportion of clayey substance that is darker in color. The fill of the shaft in L 30682 (Fig. 5B) is enriched in brown carbonate but no difference in grain size was observed.

The observed vertical distance between cones is 6 to 25 mm, but even larger values were observed during field work at the type locality.

Remarks: *Amanitichnus* represents a complex burrow system. Assignment to medusoid-like body fossils is not plausible due to the presence of the vertical shaft connecting the cones (this shaft is comparable with the central shaft of *Lennea* or *Gyrophyllites*, a.o.). Individual conical components may be compared with *Guilielmites* Geinitz whose organic origin is questionable. Häntzschel (1962) characterized it as "ellipsoidal bodies, 1 or 2 cm in diameter, originally thought to be seeds; most authors consider them to be inorganic (concretions or similar diagenetic structures); Purvost (1930) interpreted them as burrows of lamellibranchs" and figured them as ellipsoidal patterns with dense and prominent radial sculpture. Similar forms were reported by Pek (1986) from the Lower Carboniferous Culm deposits of Moravia-Silesia and they occur also in the Ordovician of Bohemia (in the Vinice Formation—

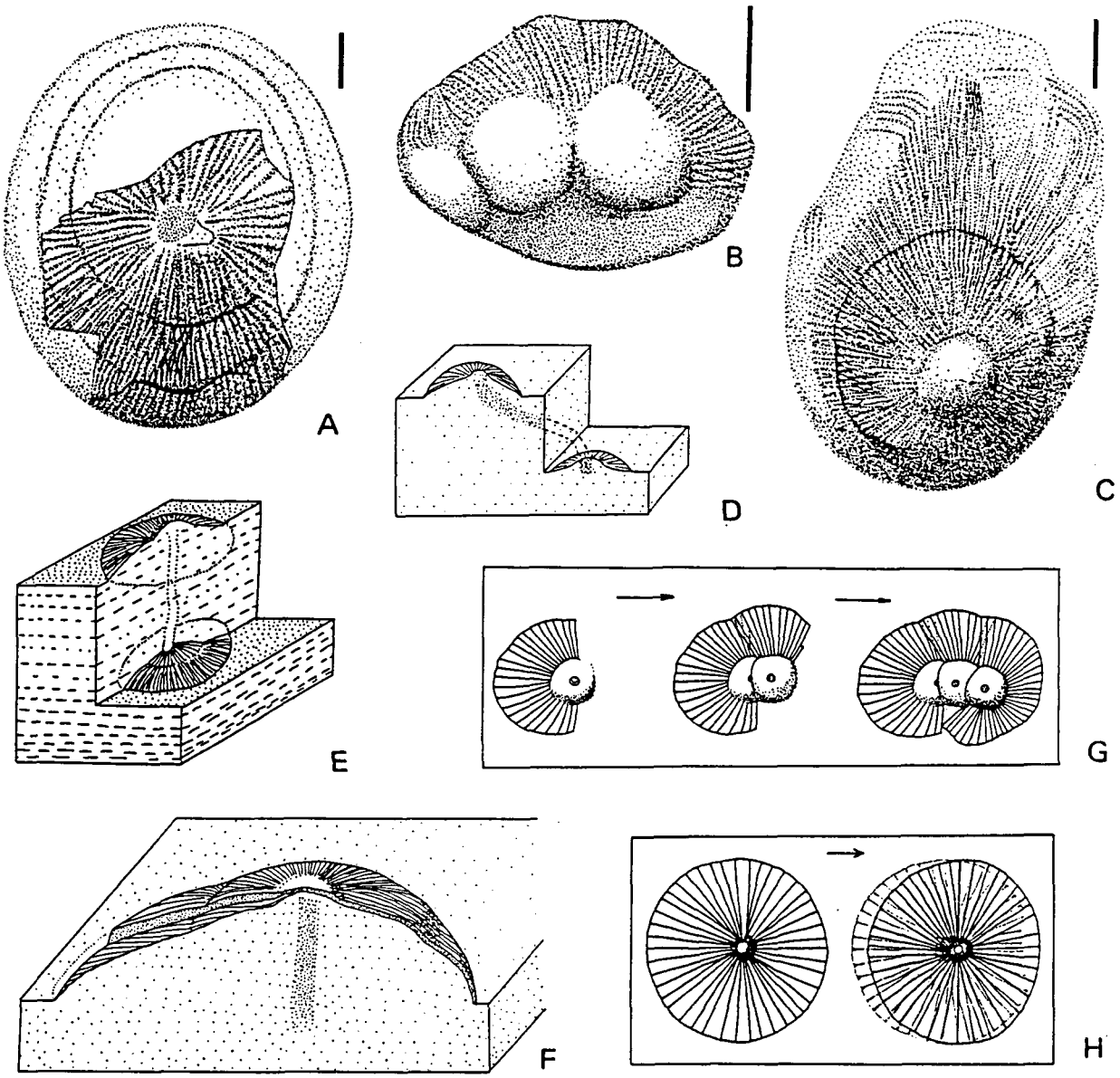

Fig. 2. *Amanitichnus omittus* ichnogen. et ichnosp. nov. **(A–C)** Schematic drawings made from specimens L 30684⁻, L 30680 a, and L 30679 (holotype). Bar scale = 5 mm. **(D–F)** Schematic vertical sections and block-diagrams showing the position of individual cones within the specimen, and the lamination of some cones. **(G–H)** Presumed movements of the tracemaker during the burrowing, and subsequent morphological manifestations.

according to oral communication with Dr. L. Marek, and in the Kosov Formation—collections of the junior author). All these bodies are three-dimensional and not lamellar, possibly of concretional nature. *Amanitichnus* may also have in its apex concretional structures but these are in all cases markedly smaller than the whole lamellar structure of the cone.

An inorganic origin for *Amanitichnus* is not plausible. The radial sculpture, consisting of non rectilinear and commonly curved ridges and lamellar structures with upward oriented apices of individual cones markedly differs from inorganic structures which may be interpreted as casts of radial mineral aggregates, concretional bodies or cone-in-cone structures.

Among true ichnofossils, *Oldhamia radiata* Forbes, 1849 exhibits a vague resemblance. Hofmann and Cecile (1981) described *O. radiata* as "stellate to plumose patterns of small club-shaped ridges on bedding planes, patterns 1–2 cm across, composed of rectilinear to gently curving rays of generally subequal length, but slightly

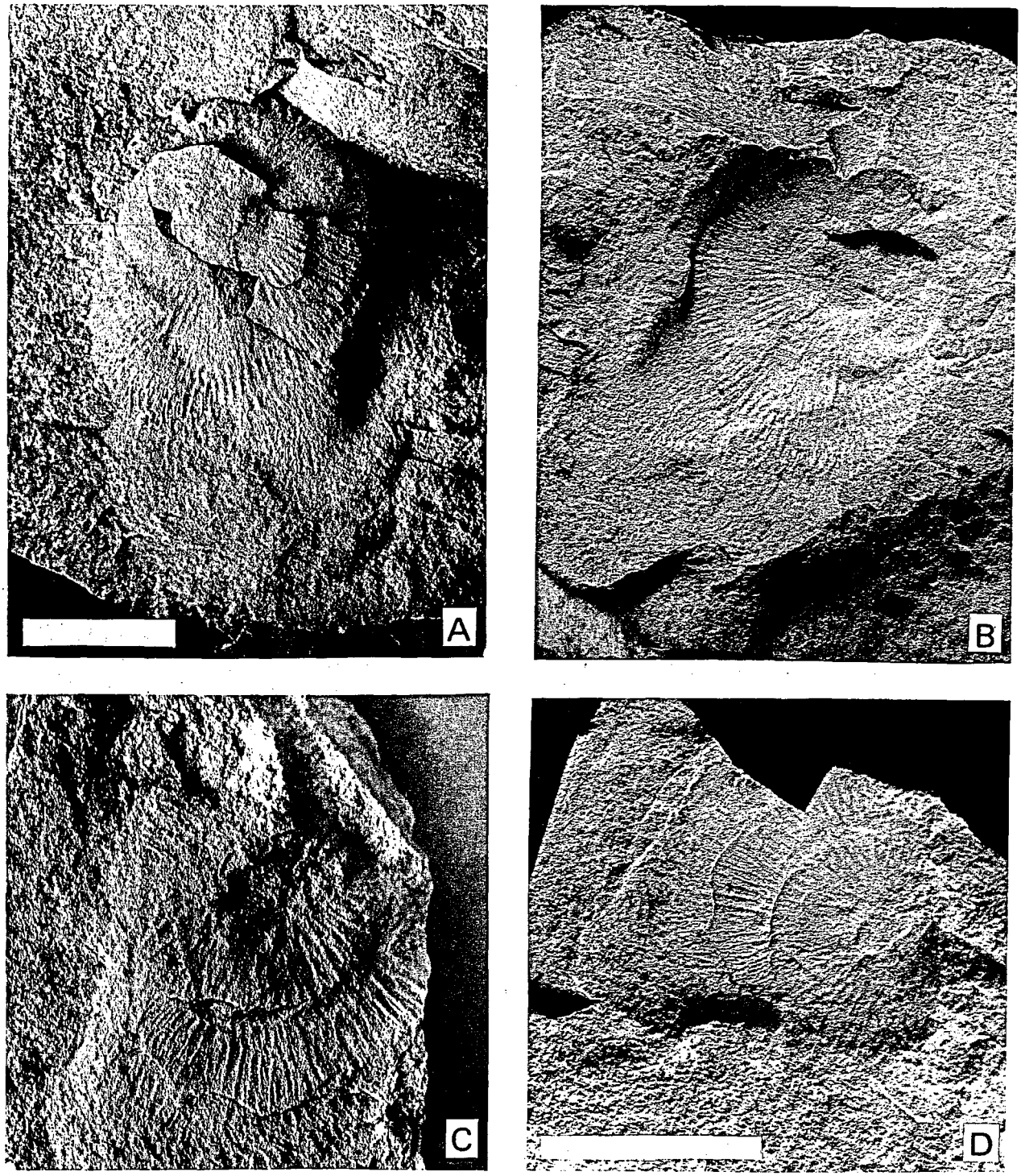

Fig. 3. *Amanitichnus omittus* ichnogen. et ichnosp. nov. **(A)** L 30679; holotype. **(B)** L 30679^{-}; negative of holotype. **(C)** L 30684. **(D)** L 30684^{-}. Bar = 1 cm. Middle Cambrian, the Skryje Shale, Buchava.

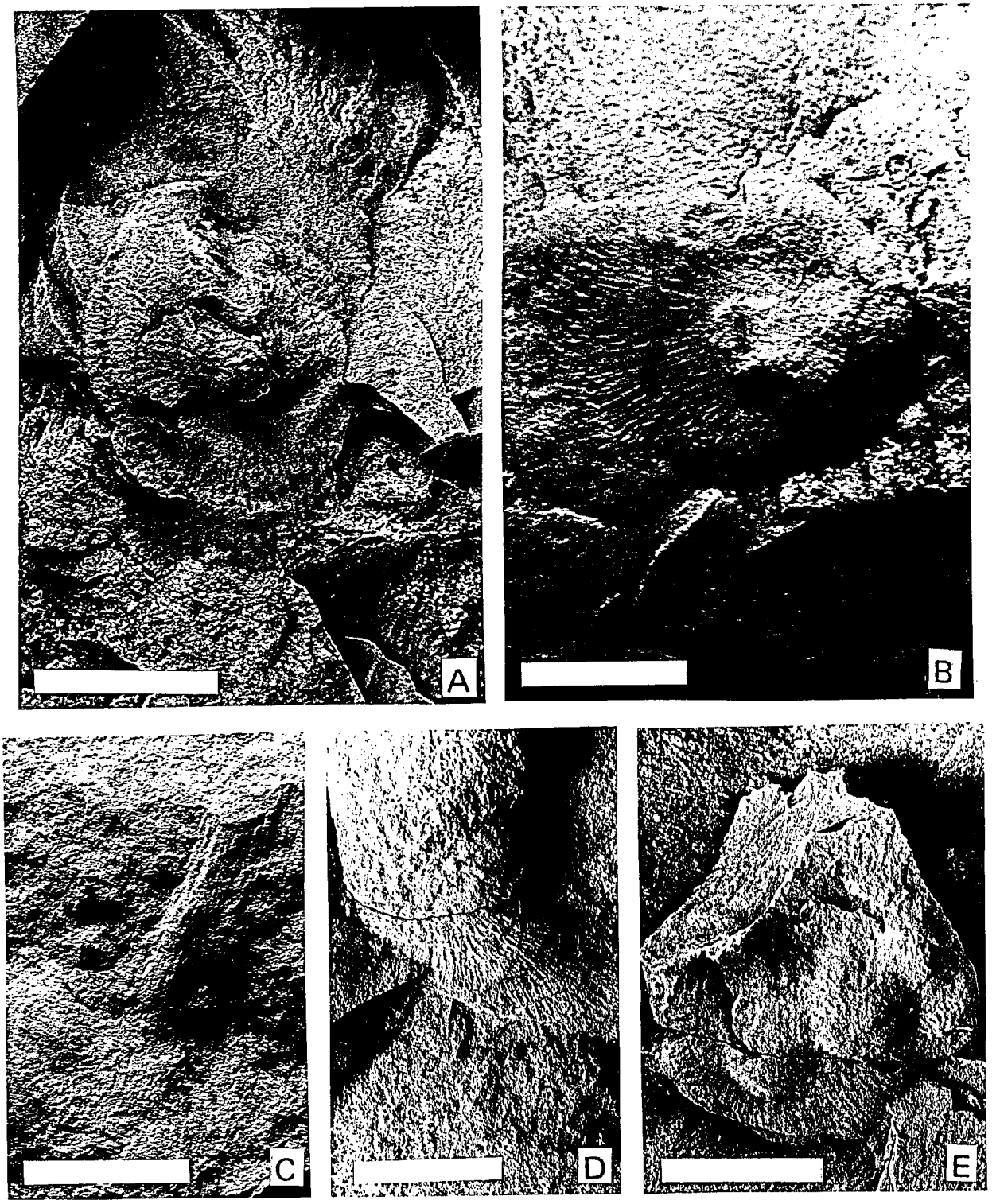

Fig. 4. *Amanitichnus omittus* ichnogen. et ichnosp. nov. **(A)** L 30680 b. **(B)** L 30681. **(C)** L 30683. **(D)** L 30685. **(E)** L 30680 a. Bar = 1 cm. Middle Cambrian, the Skryje Shale, Buchava.

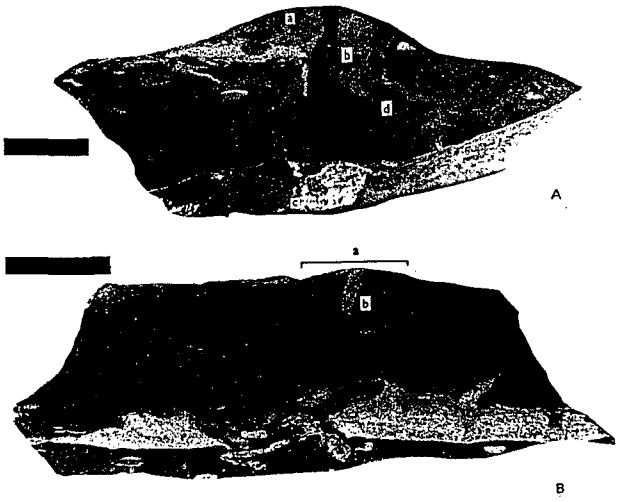

Fig. 5. **(A)** Cross-section of *Amanitichnus* (L 30690) showing the upwards convex upper cone (a) connected by a vertical shaft (b) with the lower cone (c) preserved as a counterpart. The dark subhorizontal cross-section (d) may represent another intrastratal cone or a random trace. **(B)** Cross-section of a partly preserved burrow system of *Amanitichnus* (L 30682) showing the surface of the upper cone (a) and partially preserved subvertical shaft (b) directed from the center downwards. Middle Cambrian, the Skryje Shale, Buchava.

broadening distally, and ending in bluntly rounded termini, rays up to 10 mm long, 0.2–0.8 mm wide, very closely spaced, emanating from a common central burrow, individual stellate patterns often overlapping adjoining ones". *Oldhamia* occurs in the Lower and Middle Cambrian strata of many localities (cf. Crimes et al., 1992). *Oldhamia* is a fine stellate structure which differs markedly from *Amanitichnus* in its completely flat shape, less distinct outer margin and less perfect radial symmetry. *Oldhamia* is an epistratal trace that does not show the complex structure of recurrent and connected cones as is the case in *Amanitichnus*.

Another Lower Cambrian trace fossil *Astropolichnus hispanicus* Crimes, Legg, Marcos and Arboleya shows regular and sparse radial ridges surrounding a central axial cylinder (Pemberton et al., 1987). It differs from *Amanitichnus* in having a smaller number of regular ribs and a wide central unsculptured area.

INTERPRETATION

The intrastratal character of *Amanitichnus*, recurrent parts of the burrow system at different stratification levels, irregularities in course of radial ribbing, the outline and the existence of a vertical shaft connecting the conical structures, collectively suggest that *Amanitichnus* may be classified as a fodinichnion. It is rather an intrastratal analogy of the ichnogenera *Oldhamia* or *Glockerichnus*, not a domichnion comparable to *Astropolichnus*, *Bergaueria* etc.

Irregularities in ribbing might be caused by slight movements of the burrower in a horizontal or oblique direction (Figs. 2G, 2H). Individual ribs could represent feeding probes packed very close together and forming conical components of the burrow system.

The presumed burrower could be a worm-like animal which was able to move within the narrow central shaft connecting the upward convex conical parts of the system. The fine radial feeding probes might have originated by special organs (e.g., tentacles) either gradually, or abruptly (Figs. 6A, 6B).

The upward convex central components of the burrow system might have became centers of concentration of minerals, namely carbonates, during diagenesis. In this sense, a relation to the production of concretional bodies seems to be apparent. A similar relation between ichnofossils and concretions was documented for example in the Šárka and Dobrotivá formations of the Bohemian Ordovician (Mikuláš, 1991).

Amanitichnus is a member of a rather richly diverse ichnofossil assemblage of the *Cruziana* Ichnofacies (sensu Seilacher, 1967; Frey and Pemberton, 1984; Frey et al., 1990). Commonly associated benthic forms with a dominance of trilobites, brachiopods and echinoderms suggest, together with the lithology (fine-grained clastic with carbonate admixture), a rather shallow water environment of medium energy, suitable for life on the bottom surface and beneath it.

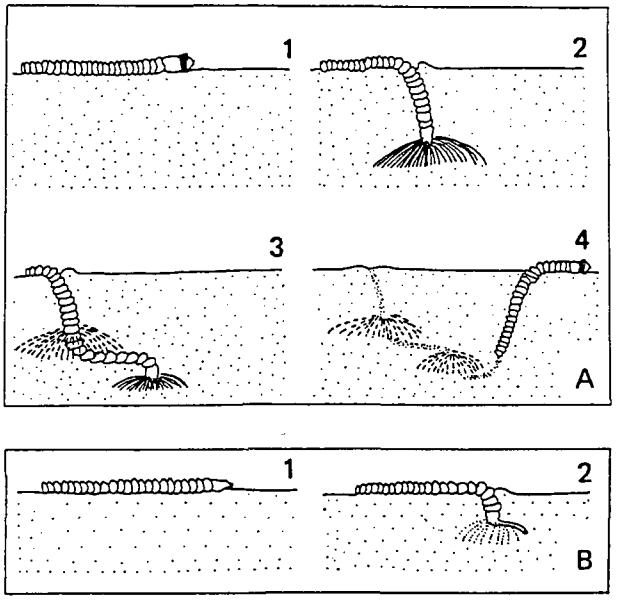

Fig. 6. Speculative tracemaker of *Amanitichnus omittus* during the burrowing. **(A)** Feeding probe originating abruptly. **(B)** Feeding probes originating gradually. Natural size.

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