



## Astrorhizae-like structures on epitheca of rugose corals from the Carboniferous of Laos

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**Stellate patterns, called astrorhizae, occurring in some Paleozoic stromatoporoids are by most authors regarded as integral elements of these enigmatic fossils. The finding of stellate structures on epithecae of rugose corals from the Lower Carboniferous of Central Laos seems to support, however, the idea that astrorhizae in Paleozoic stromatoporoids may represent traces of foreign organisms.**

### Introduction

The term 'astrorhiza' was coined by Carter (1880) for stellate patterns occurring on skeletons of some stromatoporoids. He interpreted astrorhizae as structures homologous with hydrorhizae (stellate systems of stolons) of the modern hydrozoan *Hydractinia echinata*. In the opinion of other authors, prone to accept stromatoporoids as sponges (e.g., Rosen 1867; Stearn 1975), astrorhizae may represent traces of poriferan exhalant canals. Most stromatoporoid experts accepted either the hydrozoan or the poriferan interpretation. However, Kaźmierczak (1969) disagreed with Carter's (1880) and other paleontologists' opinion and proposed that astrorhizae represent traces of a foreign organism. According to Kaźmierczak & Kempe (1990), stromatoporoid astrorhizae were left by holdfasts (rhizoids) of various macroscopic algae growing on living stromatoporoids. This interpretation has been strengthened by the discovery of stellate trace fossils found on skeletons of various Paleozoic invertebrates, described as *Clionolithes reptans* Clarke, 1908, which closely resemble stromatoporoid astrorhizae (Jordan 1969). Jordan found them particularly abundant on epitheca of the Devonian rugose coral *Calceola sandalina* (Linné).

In 1998, a collection of rugose corals and brachiopods from the Lower Carboniferous strata in Central Laos was made available by the Geological Division for Cooperation with Foreign Countries (INTERGEO). The collection comprised 5 slabs of brown siltstone rich in brachiopods, crinoids and solitary rugosans. The epitheca of the rugose corals contained numerous stellate trace fossils, very similar to stromatoporoid astrorhizae. This report presents a summary of observations on the morphology and mode of distribution of these structures. These data should prove useful in resolving the nature of Palaeozoic stromatoporoid in that they offer additional support for the concept that astrorhizae are not integral parts of stromatoporoid skeletons but rather traces of foreign organisms that occasionally settled on them, as proposed by Kaźmierczak (1969, 1976, 1981) and Kaźmierczak & Kempe (1990).

The paper was prepared at the Laboratory of Paleontology and Stratigraphy, Research Institute of Geology and Mineral Resources, Thanh Xuan, Ha Noi, Vietnam. The described material (originally stored in Ha Noi, abbreviated TL) now is housed in the Institute of Paleobiology of the Polish Academy of Sciences in Warsaw (abbreviated ZPAL)

## Setting

The described material was collected from the middle part of the Bualapha Formation. The Formation has an average thickness of 350 m and consists mostly of clastics (conglomerates, coarse and fine-grained quartzitic sandstone, siltstone and shales) rich in brachiopods and rugose corals with numerous stellate structures on epitheca. The early Carboniferous age (?early Viséan) of the Bualapha Formation is indicated by brachiopods: *Schuchertella globosa* Tolmachov, *Megachonetes papilionacea* (Phillips), and *Chonetes* cf. *carboniferus* Kayser. The Bualapha Formation lies discordantly on Devonian sediments and is overlain by middle Carboniferous limestones.

The collecting site is located 4.2 km northwest of Lak-20 Town, on the road from Lak-20 Town to Phonkham Town, Khamkhet district, Bolikhamxay province (Central Laos). Longitude: 104°50', latitude: 18". Grid of Muong Khamkeut sheet (E.48–66) = 93.8–15.6.

## Descriptions

### Specimen ZPAL V.30/1(TL 3361/1c)

Fig. 1A, B.

Ceratoid rugose coral 4.5 mm in length; 5 mm in diameter. There are 5 internal moulds of astrorhizae located on the epitheca of the proximal part of the corallite. The isolated stellate structure (fig. 2b) is circular in shape, 0.5 mm in diameter, composed of 7 horizontal furrows. Horizontal furrows 1.2–1.5 mm in length, 0.15–0.25 mm in diameter, spread radially from a center. There are 2–3 branching furrows, 0.65–0.75 mm in length, 0.10–0.15 mm in diameter, dividing from every horizontal furrows. The four remaining stellate structures are arranged on the same side of the epitheca. These stellate systems are connected to each other by horizontal furrows with 2–2.5 mm spaces between their centers. All horizontal furrows of the stellate systems have approximately the same size, averaging 1–1.2 mm in length, 0.15–0.2 mm in diameter. Branching furrows are 0.35–0.65 mm in length, 0.10–0.15 mm in diameter. Most branching furrows connect to each other in a zigzag manner, making a network structure.

**Remarks.** — These stellate structures resemble astrorhizae of *Plectostroma scaniense* Mori, 1970 from the upper Ludlovian Hamra Beds of Gotland (Mori 1970: pl. X: 6; see also Fig. 2 herein), and of *Syringostroma perfectum* Lecompte, 1951 from the Eifelian of Belgium (Lecompte 1951: p. 199, pl. XXX: 1–2). The resemblance is underscored by radially spreading horizontal furrows and the size of macrostructural elements.

### Specimen ZPAL V.30/2(TL 3361/1d)

Fig. 1C.

Ceratoid corallite 18 mm in length, 5 mm in diameter, with 3 isolated stellate structures on its epitheca. The astrorhizal systems are arranged in row with spaces of 3.5–4 mm between centers. These astrorhizal system is fan-shaped, 4 mm in diameter with 3–4 horizontal furrows. Horizontal furrows 1.2–2 mm in length, 0.20–0.25 mm in diameter, spreading radially from a center. Branching furrows 0.5–0.75 mm in length, 0.15–0.20 mm in diameter, extend from horizontal furrows.

**Remarks.** — These stellate structures resemble in arrangement and size the horizontal furrows of astrorhizal systems of *Stromatoporella spisa* Lecompte, 1951 from the Givetian of Belgium (Lecompte 1951: p. 187, pl. XXVII: 1a).

### Specimen ZPAL V.30/3(TL 3361)

Fig. 1D.

Internal cast of a cerioid corallite, 10 mm in length, 7 mm in diameter, with one stellate structure perforating its epitheca. The structure consists of three horizontal canals and many branching

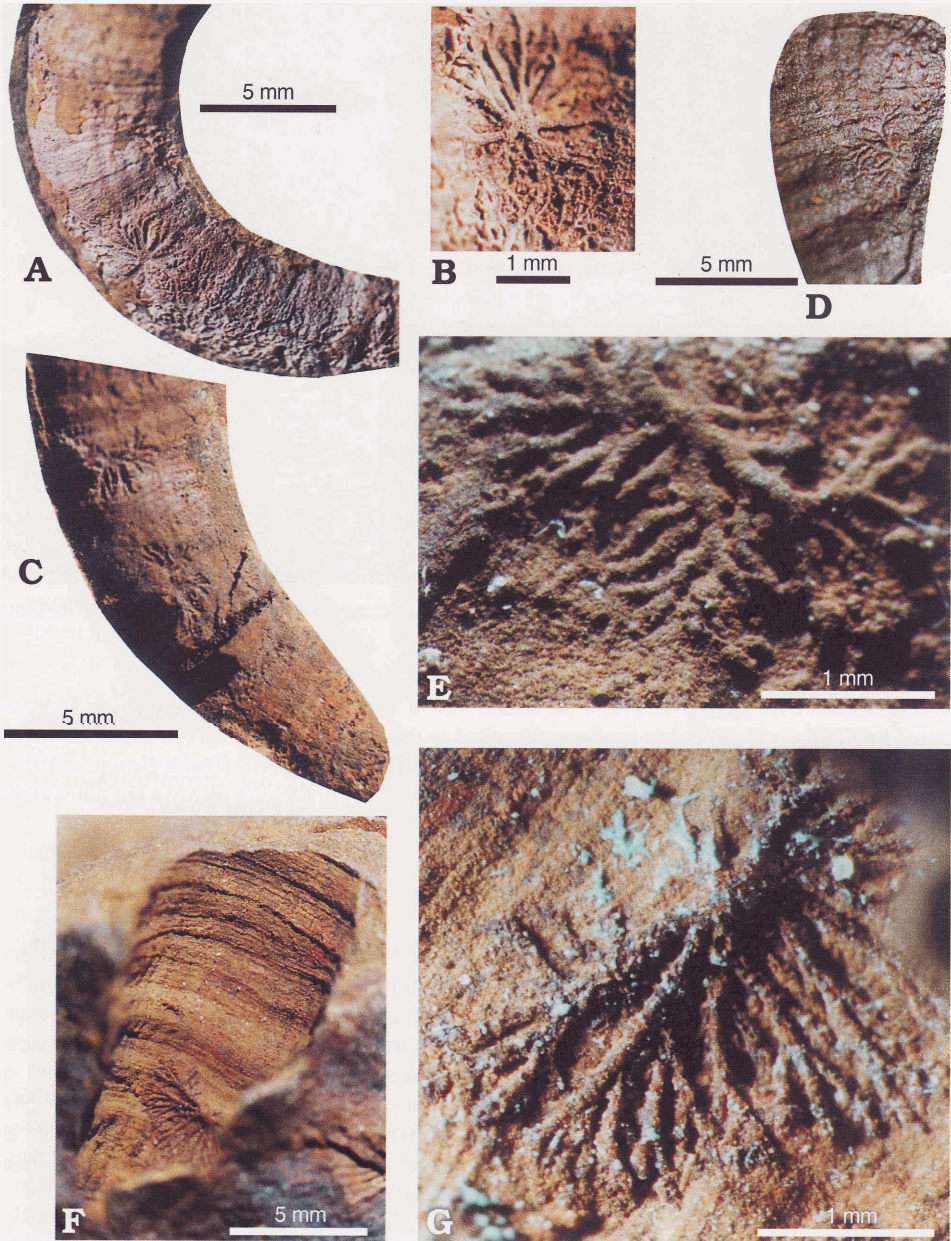


Fig. 1. Examples of stellate structure resembling stromatoporoid astrorhizae on epitheca of solitary rugose corals from the Lower Carboniferous of Central Laos. Catalog numbers of illustrated specimens: A, B, ZPAL V.30/1(TL 3361/1c); C, ZPAL V.30/2(TL 3361/111); D, ZPAL V.30/3(TL 3361); E, ZPAL V.30/4(TL 3361/1b); F, G, ZPAL V.30/5(TL 3361/1a).

canals. Horizontal canals spreading from a center are 2–2.5 mm long, 0.2–0.25 mm in diameter; they divide at their ends into 3–4 branching canals. Branching canals 0.45–0.75 mm in length, 0.15–0.2 mm in diameter.

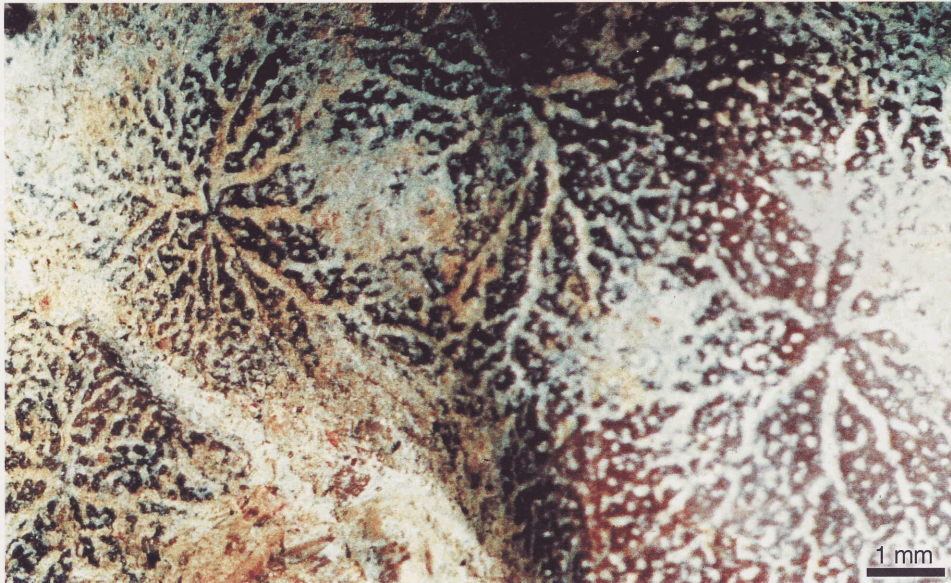


Fig. 2. Astrophoroid grooves on growth surface of a Ludlovian stromatoporoid *Plectostromascaniense* Mori from Hamra Beds, Gotland (ZPAL V.30/6).

**Remarks.** — The stellate structure described above with horizontal and branching furrows spreading radially on one side is almost identical to the astrophoroid system of *Parallelostroma laminatum* Dong, 1984 from the Upper Silurian of Inner Mongolia (Dong De-yuan 1984: pp. 68–69, pl. VII: 2b). Also the diameters of horizontal and branching furrows are not widely different from those of *P. laminatum*.

#### Specimen ZPAL V.30/4(TL 3361/lb)

Fig. 1E.

Part of a solitary corallite 8 x 5 mm in size, containing 5 internal molds of astrophoroid-like structures. One of them is illustrated by an isolated stellate structure, semicircular in shape, 3 mm in diameter, with 7 horizontal furrows coming out from a center. The center is 0.45 mm in diameter. The longest horizontal furrow 1.5 mm in length; 0.4 mm in diameter, with 4 branching furrows, 0.45–0.7 mm in length; 0.15–0.2 mm in diameter. The shorter horizontal furrows 1–1.2 mm in length and 0.25–0.35 mm in diameter with branching furrows 0.4–0.65 mm in length and 0.15–0.2 mm in diameter. The other four stellate structures on this specimen are concentrated in one area with their branching horizontal furrows piling up against each other. The size of their horizontal and branching furrows corresponds to that of an isolated stellate structure.

**Remarks.** — These stellate structures closely resemble astrophoroid systems of *Trupetostroma porosum* Lecompte, 1952 from the Lower Frasnian of Belgium (Lecompte 1952: p. 237, pl. XLIII: 1), which are characterized by rare horizontal furrows spreading on one side and by similar dimensions of macrostructural elements.

#### Specimen ZPAL V.30/5(TL 3361/la)

Fig. 1F, G.

The solitary corallite is ceratoid in shape; 1.3 cm in length, 5 mm in diameter. The stellate structure is located at proximal part of corallite, semicircular in shape, 3 mm in diameter. It is internal

mold composed of a stellate system of 5 horizontal furrows that spread radially from a center. The center is 0.5 mm in diameter. The horizontal furrows: 1–1.2 mm in length, 0.1–0.15 mm in diameter. The branching furrows spread radially from the horizontal furrows: 0.5–0.6 mm in length, 0.05–0.075 mm in diameter.

**Remarks.** — This is a stellate structure with horizontal furrows spreading radially and closely resembling astrorhizal system of *Stromatoporella pertabulata* Lecompte, 1951 from the Middle Frasnian of Belgium (Lecompte 1951: p. 170, pl. XXII: 1–2).

## Conclusions

- All stellate structures found on epitheca of rugose corals from the Lower Carboniferous of Central Laos display basic characteristics of astrorhizal systems in skeletons of stromatoporoids, i.e., they are horizontal furrows spreading radially from a center. The dimensions of the studied structures fall within the ranges of astrorhizae of Paleozoic stromatoporoids.
- Two types of stellate structures occurring on epitheca of rugose corals can be distinguished: (a) those with horizontal furrows spreading on one side [as seen in specimens ZPAL V.30/5(TL 3361/1a), ZPAL V.30/1(TL 3361/1c), ZPAL V.30/2(TL 3361/1d)], and (b) those with horizontal furrows spreading radially [for example in specimens ZPAL V.30/4(TL 3361/1b)].
- The stellate systems from epitheca of rugose corals from the Lower Carboniferous of Central Laos are very similar to the epibiotic trace fossils *Clionolithes reptans* Clark, 1908 interpreted by Jordan (1969) as structures analogous to stromatoporoid astrorhizae. The finding of stellate structures on epitheca of rugose corals from the Lower Carboniferous in Laos supports Kaźmierczak's (1969) hypothesis that astrorhizae in stromatoporoids are traces of foreign organisms.
- Although at present it is impossible to state with any certainty what kind of foreign organism produced the stellate patterns occurring on the epitheca of the rugose corals, rhizoids of various non-calcified algae are at the moment the best candidates.

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