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Brachiopod spines as microfossils

ABSTRACT: In microfossil assemblages found in Late Palaeozoic formations of Poland there occur abundant calcareous tubes which have been identified as spines of brachiopods. They show a diversity of shape and size, which may reflect their various adaptative functions. These spines belong to brachiopods of the superfamilies Productacea of Strophalosiacea. Abundant accumulations of brachiopod spines can be used as correlation beds and indicators of the sedimentary conditions.

INTRODUCTION

Abundant calcareous tubes have been found in limestones, marls and shales making up Late Palaeozoic formations of Poland. They are usually up to a few millimetres in length (sporadically more than 1 cm) and from 0,1 to 0.5 mm in thickness. They accompany other microfossils, such as foraminifera, ostracodes, conodonts, skeletal elements of echinoderms (*e.g.* holothurian sclerites), sponge spicules, etc. The tubes can be isolated from the rock by breaking and washing the samples (marls and shales), or by dissolution in acetic acid (limestones).

The calcareous tubes in question have been identified as spines of brachiopods. This is apparent from their close similarity to the spines occurring as outgrowths from the well-preserved shells of brachiopods, for example, in the Lower Carboniferous limestones at Czatkowice near Krzeszowice (Cracow Upland, Southern Poland), or in the Middle Devonian marls at Grzegorzewice near Nowa Słupia (Holy Cross Mts, Central Poland). Characteristic in the micropalaeontological materials is also the presence of fragments of spines attached to fragments of brachiopod shells.

The quantitative content of spines in microfossil assemblages is variable. They are commonly an accessory constituent, but sometimes they are very abundant, forming even mass accumulations, or are the principal component of an assemblage.

Calcareous tubes similar to those discussed were initially defined by Neumann, Pożaryska & Vachard (1975) as an incertae sedis genus *Magnella*, and given the specific name of *Magnella reitlingerae* Neumann & *al.* Later they were recognized as brachiopod spines but cited generic name was retained (Vachard & Tellez-Giron 1978). Such tubes may be very abundant, being one of the principal constituents of a microfacies, or occur sporadically as single specimens. They were reported from the Lower Devonian limestones of southern France, the Middle and Upper Devonian limestones of northern France and Poland, the Lower Carboniferous limestones of Belgium and Mexico, from the Upper Carboniferous of Spain, and from the Lower and Upper Permian sediments of Iran and Afghanistan (Neumann, Pożaryska & Vachard 1975; Vachard & Tellez-Giron 1978).

Tubular brachiopod spines are commonly found among microfossils isolated from rock samples by washing and dissolution. They have not however been described in textbooks on micropalaeontology giving, for example, descriptions of various fragments of macrofossils (*e.g.* echinoderms).

THE INVESTIGATED MATERIAL

The brachiopod spines were found in the Devonian, Carboniferous and Permian limestones and marls in various regions of Poland, *e.g.* in the following localities (Pl. 1, Figs 1—36):

Middle Devonian (Givetian) marls and limestones in the Grzegorzowice-Skały profile, Holy Cross Mts (Pl. 1, Figs 3—5);

Upper Givetian limestones and marly limestones at Chęciny, Holy Cross Mts (Pl. 1, Figs 6—8);

Givetian limestones at Siewierz, Upper Silesia (Pl. 1, Figs 1—2);

Upper Devonian (Frasnian) marls at Dębnik near Krzeszowice (Pl. 1, Fig. 10);

Upper Devonian (Famennian) marls at Kadzielnia near Kielce (Pl. 1, Figs 11—12);

Lower Carboniferous marls and limestones in Western Pomerania (Pl. 1, Figs 13—14);

Lower Carboniferous (Tournaisian) limestones in the Racławka valley near Krzeszowice (Pl. 1, Figs 16—18);

Lower Carboniferous (Lower Viséan) limestones at Czatkowice near Krzeszowice (Pl. 1, Figs 19—20);

Lower Carboniferous (Middle Viséan) marls in the Czernka valley near Krzeszowice ("Czerwona Ścianka" outrop) (Pl. 1, Figs 21—28);

Lower Carboniferous (Viséan) shales at Ptaszkowa Góra near Wałbrzych (Pl. 1, Fig. 29);

Lower Carboniferous (Upper Viséan) shales at Bolesław near Olkusz (Pl. 1, Figs 30—31);

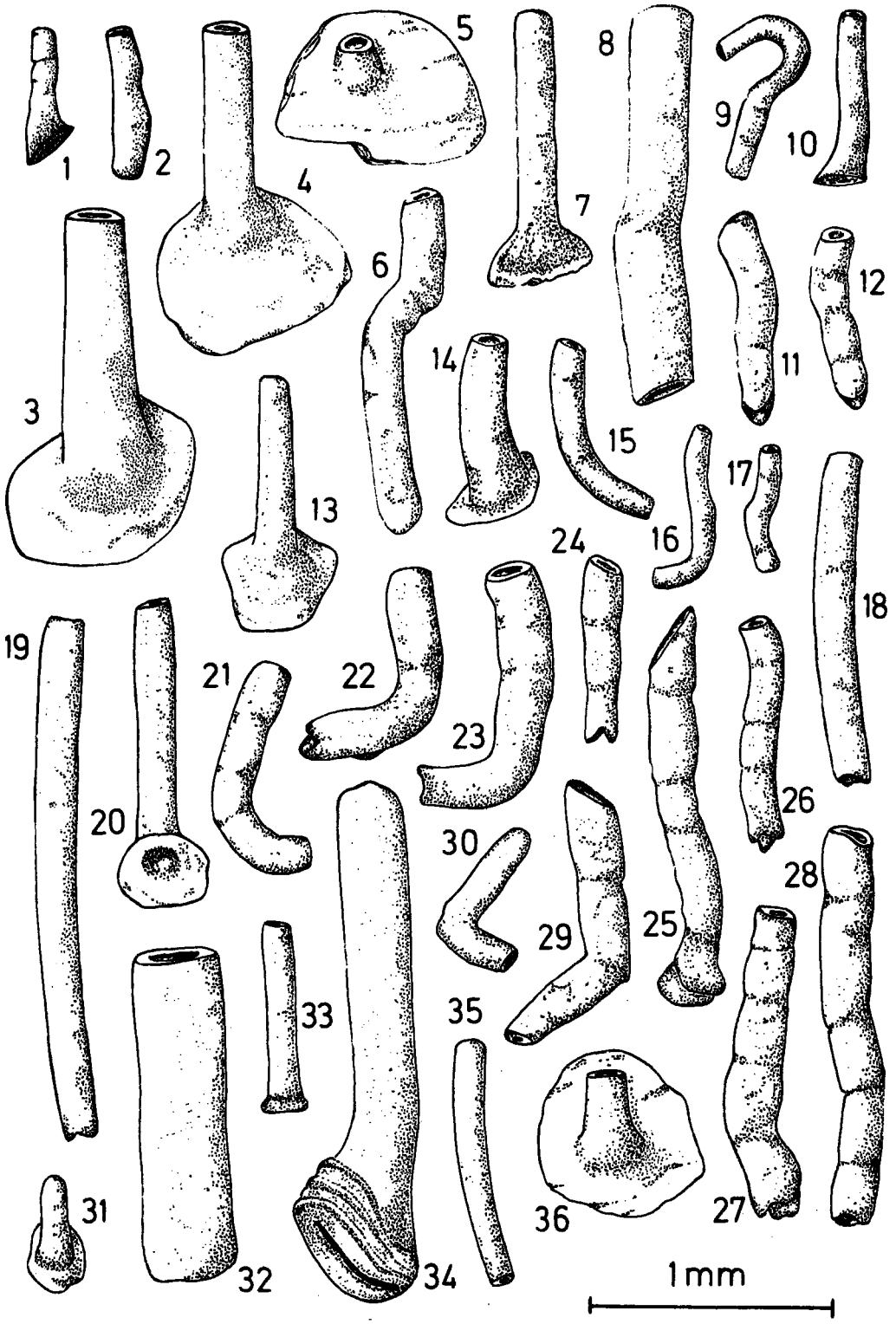
Lower Namurian shales at Jaworzno, Upper Silesia (Pl. 1, Fig. 15);

Lower Westphalian shales at Łączna near Lublin (Pl. 1, Fig. 34);

Lower Zechstein limestones at Gałęzice near Chęciny (Pl. 1, Fig. 32);

Lower Zechstein limestones at Kajetanów near Kielce (Pl. 1, Fig. 36);

Lower Zechstein limestones at Lubin, Lower Silesia (Pl. 1, Figs 33, 35).



1—36 — Brachiopod spines from various Palaeozoic formations of Poland; explanation in text

sporadically they also noted in the Mesozoic Spiriferida (Coven & Rudwick 1970) and Rhynchonellida (Rudwick 1965, 1970).

Tubular spines grew in various positions from the shell and performed a variety of functions. In this respect, seven types of spines can be distinguished (Text-fig. 1).

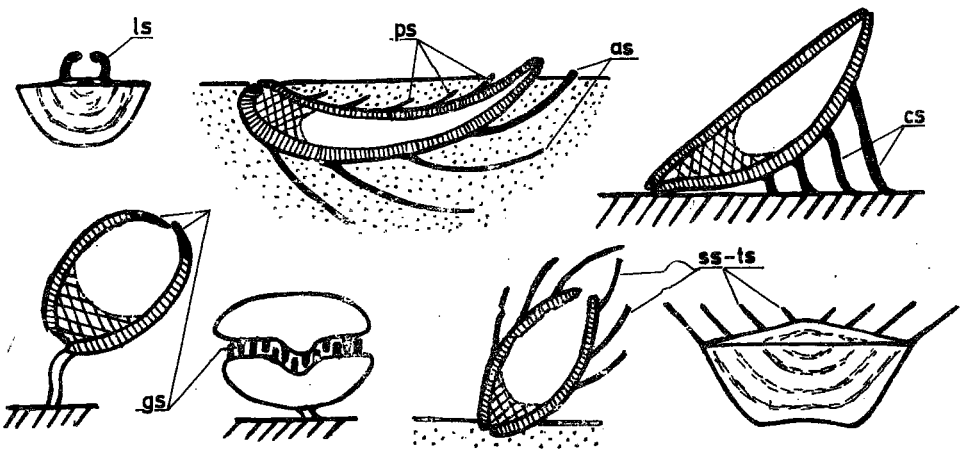


Fig. 1. Adaptative functions of brachiopod spines and their position on shells: **ls** — clasping spines, **as** — anchoring spines, **ps** — camouflage spines, **cs** — attaching spines, **gs** — grille spines, **ss** — sensory spines, **ts** — steering spines

(1) Spines adapted to attach the juvenile individuals to algae or projecting fragments of skeletons and shells of other animals (clasping spines). They are small, short and slender, arcuate or hooked, growing from the ventral valve at the posterior edge near the apex (*ls* in Text-fig. 1). They were noted, for example, in the genera *Plicatifera* (see Brunton 1966) and *Waagenoconcha* (see Grant 1966).

(2) Spines adapted to stabilise the shells of adult (also juvenile) individuals in a soft sediment (anchoring spines). They vary in size, sometimes attaining a length of a few centimetres, *i. e.* a length greater than that of whole shell, and have a thickness of more than 1 mm. These spines can be straight or arcuate, sometimes irregularly curved or bent at an obtuse or even right angle (*as* in Text-fig. 1). They are attached to the shell with the proximal end and when broken off, their base can be observed. As they grow, they taper gradually and occasionally show the presence of well- or poorly-marked narrowings. The number of spines varies over a wide range, from several dozen to several hundred, from one genus or species to another. Spines of this type are characteristic of brachiopods with concavoconvex shells, which have developed the infaunal mode of life (quasi infauna). They appear in many Late Palaeozoic genera, *e. g. Waagenoconcha, Marginifera, Productella, Avonia, Cancrinella, Antiquatonia* (see Licharev 1960; Muir-Wood & Cooper 1960; Grant 1966, 1968; Rudwick 1970). It is the commonest type of spines occurring in the fossil state, preserved both on shells found in the life position and as loose fragments in micropalaeontological materials subjected to washing. It is feasible that the branched spines of the Ordovician brachiopods ?*Spiphonotreta* sp. performed the same function (*cf.* Biernat 1971).

(3) Spines providing the shells of adult individuals with attachment to a hard substrate or to other shells (attaching spines). They are usually straight and fairly

stout, bent at the distal end, often assuming shapes adapted to the place of attachment (*cs* in Text-fig. 1). They have been reported from the Palaeozoic Strophalosiacea (*e. g.* the genus *Chonosteges;* see Muir-Wood & Cooper 1960). Fragments of these spines are hardly distinguishable from the previous type.

(4) Spines adapted to conceal the shell buried at a shallow depth in the sediment (camouflage spines) and to protect it from epifauna settling on shells (protecting spines). They grow from the dorsal valve, mostly of productaceans, and are small, short and thin (*ps* in Text-fig. 1). They primary function was to retain a thin layer of sediment on the lying shell *e. g.* in *Waagenoconcha;* see Grant 1966). This type is presumably represented in the micropalaeontological material by small fragments of thin tubes.

(5) Spines projecting in a single row from the posterior edge of the shell in some Chonetacea. They are short and thin, projecting backwards from the edge (Licharev 1960, Rudwick 1970) or perpendicularly to the edge (Garcia-Alcade & Racheboeuf 1975). Such spines served either as receptors of external stimuli (sensory spines, *ss* in Text-fig. 1) or as a stabilising element during rapid movements of the individual caused by the snapping reaction (steering spines of Rudwick 1970; *ts* in Text-fig. 1). Loose spines of this type have never been reported from Silurian sediments, while in Late Palaeozoic sediments they are indistinguishable from the types described above.

(6) Spines growing from the anterior edge of the shell as its extension, adapted to sense external stimuli (sensory spines). They are slender, gently arcuate (*ss* in Text-fig. 1) and occur in some Mesozoic Rhynchonellacea (Rudwick 1965, 1970). No loose fragments of these spines have yet been found in the fossil state.

(7) Short, thin spines projecting at regular intervals from both valve edges (*gs* in Text-fig. 1) and forming a grille to protect the individuals from predactors and filter the sea-water (grille spines). Such spines have evolved in the Strophalosiacea and Rhynchonellacea (Muir-Wood & Cooper 1960, Rudwick 1970) but they have not yet been recognized or noted in micropalaeontological materials.

Brachiopod spines and fragments of spines found in the washed and dissolved samples of limestones, marls and shales mostly represent type *2* (anchoring spines). Since some of them are hook-shaped, they can be assigned to type *1* (clasping spines). It is difficult to distinguish and identify the other types of spines.

The accumulations of tubular spines of brachiopods can be used for the correlation of strata in the neighbouring profiles, and for the determination of the sedimentary conditions. In the Lower Carboniferous marls in the area of Krzeszowice, brachiopod spines show uneven distribution. They are very abundant in a few marl inserts within the limestones with *Gigantoproductus giganteus* (Sowerby), for example, at Czerna. A feature deserving note is that spines have a similar thickness (0.15—0.22 mm) and show typical narrowings (Pl. 1, Figs 21—28). The spines isolated from Lower Viséan and Tournaisian limestones derived from the neighbouring valleys have somewhat different chraracteristics (Pl. 1, Figs 16—20). The spines found in the Middle Devonian marls and limestones from the Grzegorzowice-Skały profile, Holy Cross Mts, are somewhat thicker (0.2 — 0.3 mm) and have smooth walls.

Owing to the fact that the described calcareous tubes were identified as brachiopod spines, and that it was possible to differentiate them on the basis of their morphological features, they can be treated as microfossils like skeletal elements of echinoderms, sponge spicules and other microremains of macrofossils. Their content in fossil assemblages and the frequency of their occurrence provide evidence, indirect as it is, of the presence of certain genera and species of brachiopods, yet it is impossible to identify the taxa on the basis of the morphological features of spines alone. On view of their considerable diversity it seems pointless to retain the name *Magnella* (especially *Magnella reitlingerae* Neumann & *al.)*, introducted for these microfossils.

Abundant accumulations of brachiopod spines can form as a result of waving and currents which cause flotation and are responsible for the secondary enrichment of the sediment in fragments of calcareous tubes. Such accumulations can be used not only for the direct correlation of strata but also provide a key to the dynamics of sedimentary environments. Studies of this kind were carried out on the basis of the presence and the frequency of spines defined as *Magnella*, found in various carbonate microfacies of Late Palaeozoic rocks (Vachard & Tellez-Giron 1978).

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KOLCE RAMIENIONOGÓW JAKO MIKROSKAMIENIAŁOŚCI

(Streszczenie)

W zespołach mikroskamieniałości znajdowanych w różnych formacjach geologicznych późnego paleozoiku na obszarze Polski występują wapienne rurki, które zostały zidentyfikowane jako kolce ramienionogów. Wykazują one zróżnicowanie wielkości i kształtu, co może odpowiadać ich różnym funkcjom adaptacyjnym (*patrz* fig. 1). Opisane kolce (*patrz* pl. 1, fig. 1—36) wiążą się z występowaniem przedstawicieli nadrodzin Productacea lub Strophalosiacea. Obfite nagromadzenia kolców ramienionogów mogą być wykorzystywane dla korelacji warstw oraz dla określania warunków depozycji osadów.
