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Early Frasnian bioherms in the Holy Cross Mts

ABSTRACT: The Frasnian bioherms exposed along the southern limb of the Gałęzice syncline in the Holy Cross Mts, Central Poland, occur in the highest part of the stromatoporoid-coral sequence, and their facies equivalent are chiefly the coral biostromes of the Upper Sitkówka Beds. In spite of small bathymetric differences between bioherms and biostromes, they contrast in ecology of the contained invertebrates, especially in brachiopod assemblages. The bioherms have developed in the belt on a gentle southern slope of the early Frasnian shallow-water carbonate bank of the Kielce region in the central part of the Holy Cross Mts.

INTRODUCTION

A large part of the trangressive Devonian succession in the Holy Cross Mts represents a thick complex of stromatoporoid-coral limestones which is largely referred to the Givetian and Frasnian though the position of the Givetian/Frasnian boundary within this complex remains an open question.

A bulk of the stromatoporoid-coral limestones is built of stratified limestones, but some bioherms have also been found in several localities Pajchlowa & Stasińska 1965, Szulczewski 1971), and a few additional examples are described in the present paper.

All the recognized bioherms occur within the uppermost part of the stromatoporoid-coral sequence, and they are undoubtly Frasnian in age.

The purpose of the paper is to summarize the essential bioherm features, to infer their paleogeographic position against the regional facies ackground and establish their exact stratigraphic position within the Frasnian stage. Discussed is also the significance of brachiopods in the

bioherm ecology, the chapter on which has been supplemented by G. Racki.

DISTRIBUTION AND FEATURES OF THE BIOHERMS

In the Holy Cross Mts the occurrence of the bioherms is limited only to the two areas: the southern limb of the Kielce syncline (Kadzielnia chain of Frasnian limestones), and the southern limb of the Gałęzice syncline (Kowala vicinity).
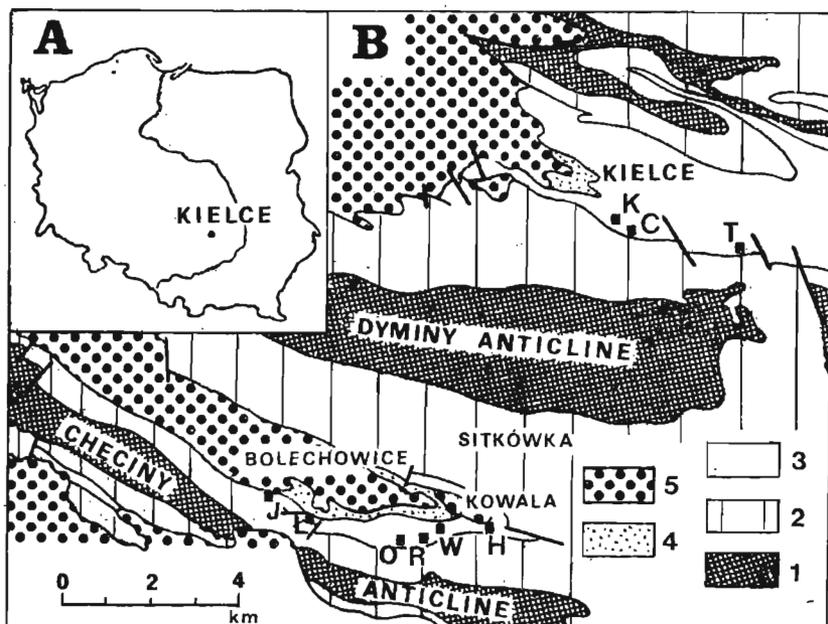

Fig. 1. Location of the discussed exposures in Poland (A), and in the western part of the Holy Cross Mts (B); taken after Szulczewski (1971, Text-fig. 1; simplified)

1 Cambrian, Ordovician and Silurian, 2 Lower and Middle Devonian, 3 Upper Devonian, 4 Lower Carboniferous, 5 post-Variscan cover

J — Jaźwica Quarry environs, Ł — Łgawa Hill, O — Kowala road cut, R — Kowala railroad cut, W — Wola Quarry, H — Kowala Hill, K — Kadzielnia Quarry, C — Cmentarna Hill, T — Wietrznia Quarries

Within the Kadzielnia chain, small bioherms were described from the Kadzielnia Quarry (Pajchlowa & Stasińska 1965), and two large biohermal bodies of unstratified limestone have also been exposed in the Wietrznia Quarries, both of them being now completely quarried out.

In the Gałęzice syncline, a small bioherm was reported from the Frasnian sequence (set *C*) at the Kowala railroad cut (Szulczewski 1968, 1971).

A similar bioherm, embedded within stratified biostromal limestones equivalent to the sets *A-C* of Szulczewski (1971), have also been temporarily visible in the nearby Wola Quarry at its upper exploitational level (*I*) of the southern wall (Text-figs 2—3; Pl. 1, Fig. 1); this buildup was definitely destroyed in 1976.

All the above bioherms are (or were) the unbedded massive lenticular bodies composed of light-colored limestones, and laterally passing into distinctly bedded limestones decreased in their thickness. Each bioherm has been exposed along one section only, and therefore its three-dimensional shape and size are not exactly known. In the sections available, all but one bioherms attain no more than a few meters in their height, and their upper surface displays a low relief only.

The only exception is a fairly large bioherm partly exposed at the Kadzielnia Quarry. Formerly, a discussion existed as to the presence of bioherms in this well known outcrop. Already Sobolev (1909) inferred existence of lenses and stocks in the Kadzielnia chain. Pajchlowa & Stasińska (1965) descibed small bioherms from here, but afterwards Kaźmierczak (1971) postulated a biostromal character of all stromatoporoid--coral limestones exposed in that quarry.
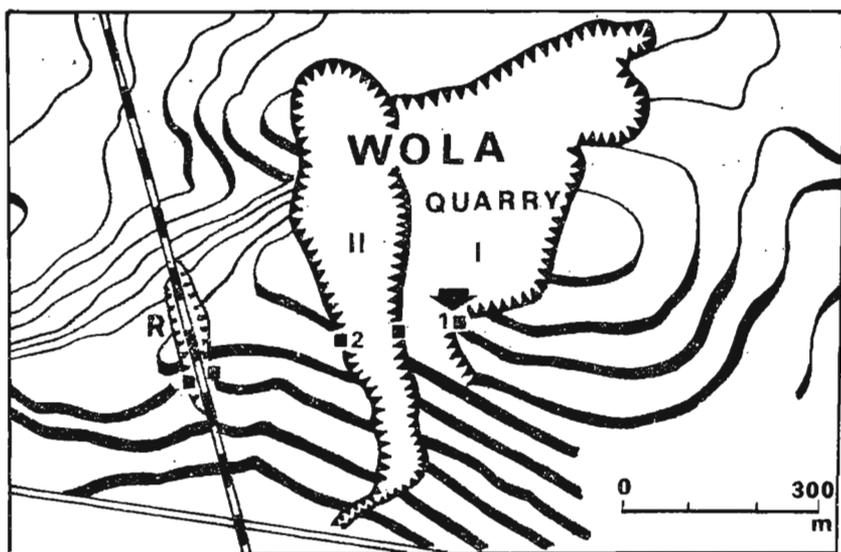

Fig. 2. Location sketch map of Wola Quarry

Quadrangled are bioherm sites: **1** — illustrated in Text-fig. 3 and Pl. 1, Fig. 1 (*arrowed*), **2** — in Pl. 1, Fig. 2; **I** — upper exploitational level, **II** — lower exploitational level; **R** — Kowala railroad cut

Detailed stratigraphic researches undertaken in the last decade show (Szulczewski 1971; Szulczewski & Brykczyński, *in preparation*) that stromatoporoid-coral limestones at the Kadzielnia Quarry form a large buildup (above 50 m thick) overlain by the Famennian marly sequence, and with its slopes covered with intervening Frasnian flanking beds, younger than the buildup itself. This buildup laterally passes into the bedded-type of stromatoporoid-coral limestones which are slightily bent upwardly in the buildup immediate proximity. Small bioherms reported by Pajchlowa & Stasińska (1965) occur within a poorly bedded part of stromatoporoid-coral limestones and virtually they are small satellite bioherms associated with the main bioherm and developed probably on its leeward side.   •

All the bioherms studied display similar main lithological features, as they are composed of light-colored, massive and pure boundstone with micritic matrix. Coarse calcite, commonly forming bedding-parallel shelter voids and stromatactoid structures (Text-figs 3 and 5; *cf.* also Szulczewski 1971), and sometimes alternating with pink to red internal sediment is also typical of the biohermal limestones.

The main builders of the bioherms are sheet-like and tabular stromatoporoids buried in their growth position (Text-fig. 3B). Coral-rich portions, chiefly with laminar *Alveolites*, as well as brachiopods nests, streaks of brachiopod coquinas, and echinoderm-rich arenites are also common. The bioherm builders occur in relatively low concentration, and they are scattered in the relatively high amount of micritic matrix.

The stromatoporoids and corals have not been the subject of special treatment as the bioherm builders, but the hitherto presented accounts (*eg.* Stasińska 1953, Kaźmierczak 1971, Różkowska 1979) do not allow to expect any characteristic or persistent assemblage (with possible exception of *Alveolites complanatus* Lecompte) confined to these bioherms. The list of stromatoporoid species reported from the localities in which the bioherms occur are short (Kaźmierczak 1971) and point to low-diversified assemblages. A faunal succession suggested by Pajchlowa & Stasińska (1965) for small bioherms at Kadzielnia have never been recognized in any other bioherm. In contrast to the coelenterates, the brachiopods are relatively abundant and remarkably diversified; their analysis is the subject of the following chapter.

The other groups of the bioherm dwellers are not enough understood, but some of them, eg. the trilobite *Scutellum kielcensis* (Gürich), recorded from Kadzielnia, Łgawa Hill, Kowala railroad cut and Wola Quarry appear to be confined to that very environment.

A characteristic lithology and a fossil content, especially the brachiopods, permit to infer the presence of bioherms in some other localities, although they are not enough exposed to recognize their spatial proper-
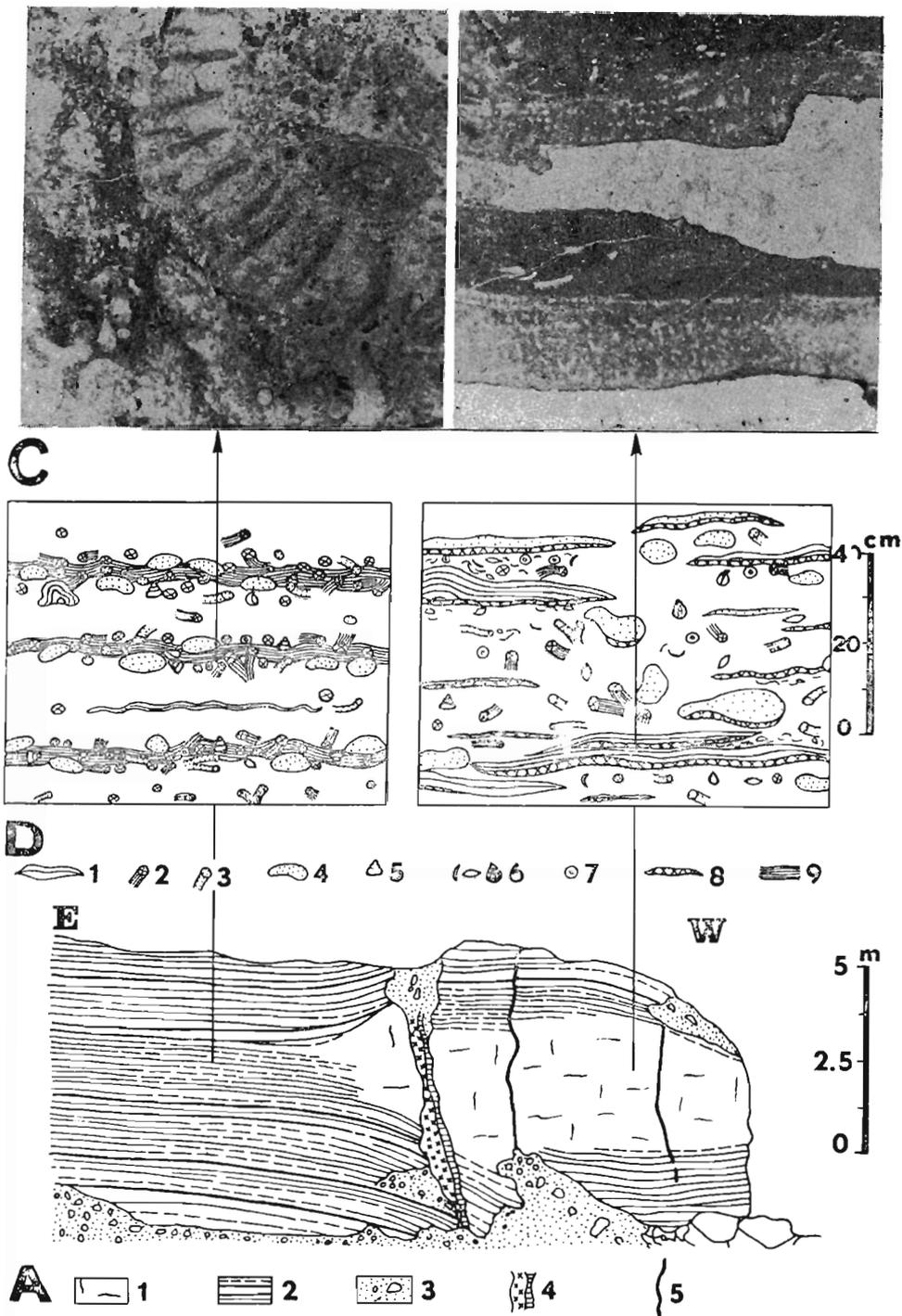
Fig. 3

A — Biohenm exposed in the southern wall of Wola Quarry (*see* Text-fig. 2)
1 biohermal limestones, *2* biostromal limestone, *3* waste, *4* calcite vein, *5* thrusts

B — Schema of faunal distribution in biostromal (*left*) and biohermal (*right*) limestones
1 stromatoporoids, *2* ramose rugosans, *3* ramose tabulates, *4* massive tabulates, *5* gastropods, *6* brachiopods, *7* crinoid columnals, *8* coarse-calcite fillings, *9* marly partings

C — Biostromal and biohermal microfacies; note pelsparitic matrix of bafflestone, and fibrous-calcite filled shelter-cavities (with preceding thin micritic cement crust) in bindstone

ties. Such "biohermal-type limestones" were found in some places within the southern limb of the Gałęzice syncline, at Łgawa Hill (cf. Filonowicz 1973), in the vicinity of the Jaźwica Quarry near Bolechowice (Racki 1981), at Kowala Hill, and at the lower (II) exploitational level of the Wola Quarry (cf. Text-figs 1—2).

BRACHIOPOD ECOLOGY

Biostromal equivalents of bioherms at Kowala yielded a poor bra-chiopod fauna (chiefly atrypids) and a rich gastropod-dominated shelly fauna. It is apparent that the brachiopods were excluded from this habi-tat. It had not been result of abiotic factors only (see Table 1), but chiefly of some biotic influences (competition of high-level suspension--feeders, eating of brachiopod larvae by polypes; vide Ager 1965).

On the contrary, biohermal shelly fauna is very abundant and stron-gly dominated by diversified brachiopod assemblage. At least 16 species of brachiopods known from Kadzielnia (see Gürich 1896, Biernat 1971) have been found in rich collection (about 400 specimens; Pl. 2) from the Gałęzice syncline. The brachiopod faunas from different sites are quite similar and two general ecomorphic groups can be distinguished:

(i) Small (up to 15 mm) forms with weak sulcus, pedunculate in adult stages. This is dominant group of bioherm-dwelling brachiopods, with some species obviously occupying also other habitats (e.g. *Gypidula (Ivdelina) rectangularis* (Torley); cf. Jux 1969). Most numerous (taxonomy such as used by Biernat 1971) are: smooth spireferid *Crurithyris globosa* (Gürich), *Athyris*, as well as some tere-bratulids — *Dielasma* cf. *sacculus* (Martin), and gypidulids. Common atrypids (chiefly small *Spinatrypina* cf. *plicata* Rzhonsnitskaya, ultimatelly also *Spinatry-pina (Exatrypa) planata* Biernat), ribbed and alate sspriferids (some species of *Adolfia*, *Verneuilia kadzielniae* (Gürich), *Cyrtospirifer*), as well some rhynchonel-lids (chiefly alate uncinulid *Fitzroyella alata* Biernat, and *Hypothyridina nana* Nalivkin) were also included to this group. They occur chiefly in coquinas, but also in nest-like clusters (cf. Pl. 2, Fig. 6) or even singularly (Text-fig. 5A-B).

(ii) Large (up to 30—40 mm), globular, sulcate or weakly ornamented forms with strongly reduced pedicle function in adult stages. Such a group was mention-ed from the Devonian reefs of the Ardennes (Lecompte 1970) and Australia (vide Druce 1976). The most typical representative is *Parapugnax brecciae* (Schmidt), but also infrequent *Undispirifer*, *Warrenella euryglossus* (Schnur), and *Desqua-matia (Seratrypa) pectinata* (Schröter) are included here. All of them were found chiefly in monospecific nests (cf. Biernat 1971), but also in coquinas and mixed nests (cf. Text-fig. 5 C; see also Gürich 1896).

Such differentiated brachiopod fauna is known only from biohermal assemblages. A few comparable brachiopod-rich sites in the Frasnian stromatoporoid-coral facies yielded distinctly different faunas, e.g. with many large *Schizophoria* (Cmentarna Hill at Kielce, Text-fig. 1B) or strongly dominated by gypidulids and atrypids (Sitkówka in the Gałę-

Differentiation between bioherms (right)

Lithology	Dark, slightly knobby and irregularly wavy-stratified bafflestones; locally marly intercalations; matrix chiefly micritic, with some bioclasts and pellets	
Rock-forming fossils	Branched tabulates and rugosans, nodular *Alveolites*, tabular and massive stromatoporoids	
Shelly benthos	Gastropod-dominated: poor, with rare brachiopods (chiefly *Spinatrypina*)	
Inferred environment	Deeper-water, quiet; periodic influx of buildup-derived bioclasts, sometimes also argillaceous material; transitionally poor circulation; ?soft bottom	

zice syncline; see Text-fig. 1B; Tudorów in the eastern Holy Cross region). Several forms are restricted to bioherms in the Holy Cross Frasnian, and *Fitzroyella alata, Parapugnax brecciae, Spinatrypina (Exatrypa) planata, Verneuilia kadzielniae* and *Undispirifer* represent such key taxa. Therefore, the bioherm-type brachiopod fauna is called here the *F. alata — P. brecciae* assemblage (Tex-fig. 4).

Great variety of shapes, sizes (with same cases of micromorphism and gigantism), and surface ornamentations (cf. Biernat 1971) certainly reflect heterogeneity of benthic habitat attributed to organic buildups (see Grassle 1973 for review). In the studied assemblage dominate the forms with adaptations supposed for deeper-water habitats (smooth, globular, sometimes sulcate shells with most efficient lophophores; cf. Fürsich & Hurst 1974, Faber & al. 1977). It is suggestive for a response to relatively low food supply to brachiopod microniches due to activity of main bioherm-builders. Micromorphic character of some species (cf. Biernat 1971) is notable also in this context (see Palmer & Fürsich 1981). On the other hand it is evident that this kind of Devonian buildup offers suitable conditions (see Table 1) for prolific brachiopod growth, what seems to be related also with small frequency of high-level suspension-feeders (Text-fig 6). Brachiopod-rich bindstones (type facies 6D of Wilson 1975) were frequently cited from the Devonian carbonate complexes of Europe (e.g. Krebs 1966, 1974; Franke 1973), Canada (e.g. Klovan 1964, Leavitt 1968, Embray & Klovan 1971) and Australia (cf. Playford 1980).

Growth habits of stromatoporoids-coral assemblage point to the soft-bottom conditions (Kaźmierczak 1971). Typical brachiopod adaptations

and biostromes (left) in Kowala sections

Light, pure, massive or undistinctly bedded bindstones, rare calcarenitic streaks and coquinas; matrix pure micritic, sometimes bioclastic; common fibrous calcite-filled cavities (chiefly shelter voids)
Sheetlike and tabular stromatoporoids, laminar *Alveolites*, branched corals
Brachiopod-dominated: abundant and diversified, with variety of other dwellers
Shallower, quiet to intermittently agitated; clear, nutrient- and oxygen-rich water; soft bottom, quickly firming due to early cementation

to live on muddy substrates are however rare (*e.g.* frilled atrypids — Pl. 2, Fig. 3) or lacking among the studied faunas. It seems therefore that they mostly inhabited hard organic substrates and/or lithifitied portions of the bottom.

It is apparent that the above ecomorphic groups occupied different microniches, what is connected also with a different mode of life in adult stages. Autochthonic findings, typical of many biolithites (Ivanova 1958, Makridin 1964), point that smaller forms can live nestly on firm bottom and/or with abundant skeletal grains. The genus *Spinatrypina* is however typical inhabitant of tabulate coral thickets (biotope 6 of Copper 1966). These brachiopods lived in conditions of intermittently agitated waters and their frequently disarticulated shells were collected in local depressions after short transport. The representatives of smooth spiriferids were sometimes found in calcite fillings of shelter voids. Some of them (Text-fig. 5A) certainly represent a residuum due to outwash formations of cavities (see Szulczewski 1971). It is also possible that some others lived in the cryptic interior of voids, as recent reef--dwelling brachiopods (see Logan 1977 for review) and some fossil species (Kobluk & James 1979).

The second group of brachiopods is characterized by patchy distribution suggesting colonial mode of life (cf. Ager 1965) in low-energy habitat. Crowding of populations agrees well with high intraspecific varia-

bility (e.g. within the most typical *Parapugnax brecciae*; of. Biernat 1971) and functional morphology of shell-type. For example, a well developed sulcus (tongue-shaped in *P. brecciae)* gives better separation of inhalant currents of the mantle cavity after loss of pedicle (cf. Makridin 1964, Fürsich & Hurst 1974). This adaptive strategy was very profitable in closely-packed clusters where many specimens had filtered the same water (Watkins 1975).

The *Fitzroyella alata — Parapugnax brecciae* assemblage had been replaced by the *Phlogoiderhynchus polonicus* assemblage (Text-fig. 4) after cessation of bioherm growth in the Frasnian of the Gałęzice syncline area (Biernat & Szulczewski 1975). The latter includes mostly free lying forms: large rhynchonellids, some atrypids, spiriferids (e.g. *Warrenella euryglossus),* productellids and strophomenids, associated with *Styliolina,* small gastropods, rare pelecypods and goniatites.

Rhynchonellid assemblages were typical of Paleozoic (cf. Wilson 1975) and Mesozoic (cf. Ager 1965) flanking (perireef) habitats. Stratigraphic succession of brachiopod faunas in the Holy Cross Frasnian closely resemble that known from Australia (Biernat & Szulczewski 1975). Similar situation existed also in the Rhenish Slate Mts (above Dorperkalk, *see* Copper 1967), and in the Ardennes (above biohermal stage F2d = Arche Member, Middle asymmetricus Zone; Lecompte 1970, Tsien 1974).

The other bioherm-dwelling organisms are represented by e.g. trilobite *Scutellum kielcensis* (Gürich), reported from the Kadzielnia Quarry, Łgawa Hill, and Wola Quarry; the scutellids are typical element of Devonian carbonate buildup biota (Mikulic 1981).

STRATIGRAPHICAL POSITION OF THE BIOHERMS

All the discussed bioherms found are confined to the topmost part of the stromatoporoid-coral sequence, undoubtly Frasnian in age. It concerns also the "biohermal-type" limestones found in all other localities where their geometric properties are not clearly visible. Such a stratigraphic position is based largely on brachiopod and coral assemblages.

The critical exposure which provided a number of fossils giving the key to the establishment of this position is the Kadzielnia Quarry. Biernat (1971) suggested that the association of brachiopods here recorded indicates the tentative correlation with the Belgian *F2a-h* Stage.

Although there is rather only rough correlation between the Kadzielnia biolithite and the units of the former Belgian subdivision, the whole taxa assemblage broadly indicate a horizon low (but not lowermost) in the Frasnian.

A similar and characteristic brachiopod assemblage *Fitzroyella —
Parapugnax brecciae* has been obtained from biohermal limestones in
most other localities, and may serve to give equation of these bioherm
with the Kadzielnia buildup.

As brachiopods and other benthic fossils give no more precise indica-
tion of age, more detailed correlation against the standard stratigraphi-
cal subdivision is forthcoming from the conodonts.

The bioherms itself yielded only sparse conodont fauna, almost com-
pletely devoid of the platform-type elements, especially important for
stratigraphical purpose.

In sharp contrast, the limestones which lie in the immediate roof of
bioherm-bearing stromatoporoid-coral limestones, carry a relatively rich
and distinctive conodont fauna which provide the main tool for deter-
mining the more precise position of the top of the sequence against the
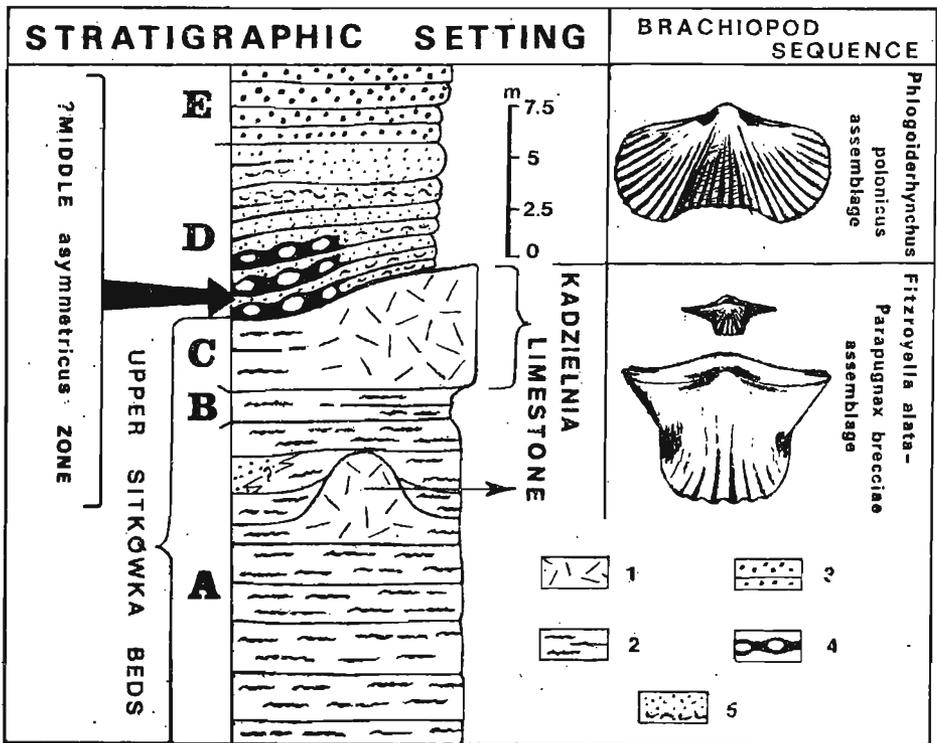standard zonal scheme. This conodont fauna is diagnostic for the Middle

Fig. 4. Stratigraphic position of bioherms in the southern limb of the Gałęzice
syncline (based chiefly on Kowala sections), and succession of brachiopod assem-
blages
1 biohermal limestones, 2 biostromal limestone, 3 detrital limestones, 4 marly-nodular lime-
stones, 5 platy pelitic limestones with coquinas

A-E — lithololologic sets after Szulczewski (1971, 1979)

Polygnathus asymmetricus Zone (evidenced by the presence of *Ancyrodella rotundiloba* and *Palmatolepis punctata*), and has been found within the set *D* (Text-fig. 4), which caps the bioherm exposed in the Kowala railroad cut (*see* Szulczewski 1971).

A lithologic succession reported from this section is laterally persistent and their informal units can be traced in a narrow belt along the strike over the western part of the southern limb of the Gałęzice syncline from the Kowala vicinity in west direction to the Łgawa Hill (Racki 1981). The set *D*, overlying the bioherm-bearing topmost part of the stromatoporoid-coral sequence yields in some other outcrops the conodonts of the same zone. It is additionally a source of the brachiopod species *Phlogoiderhynchus polonicus* (Roemer), another evidence of such a position and valuable for regional correlation (Biernat & Szulczewski 1975).
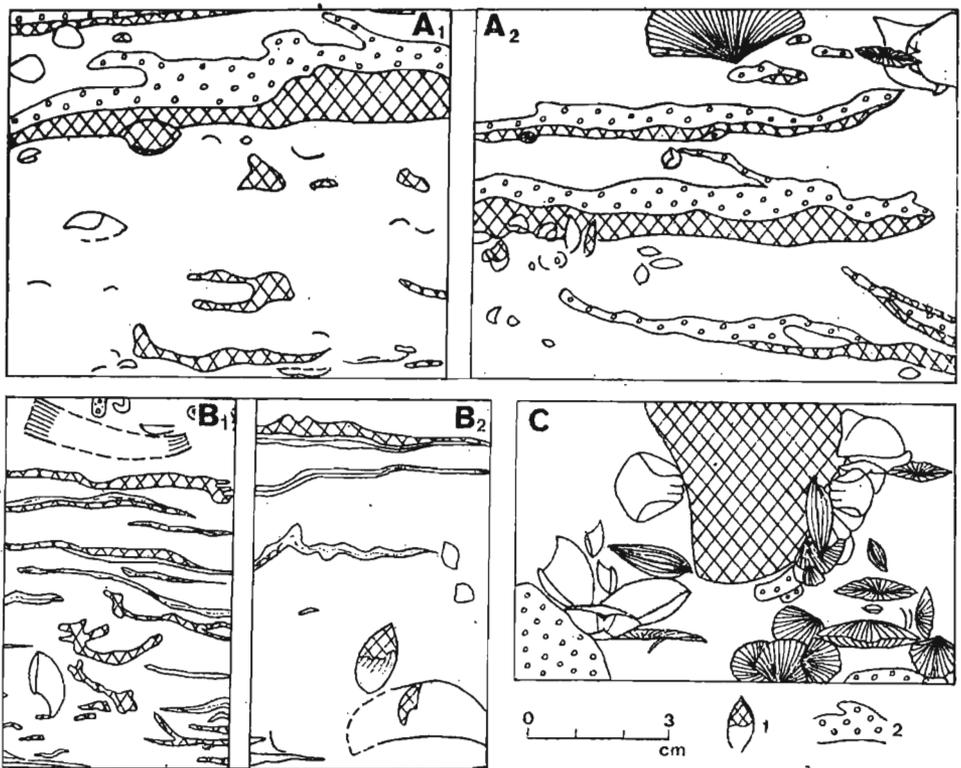

Fig. 5. Typical brachiopod habitats in Kadzielnia Limestone bioherms; note vertical orientations of some spiriferid and atrypid specimens (A_2-B_2), occurrences of shells in coarse-calcite fillings (A_1-A_2), and nest (C) dominated by *Spinatrypina (Exatrypa) planata* Biernat, *Parapugnax brecciae* (Schmidt) and *Verneuilia kadzielniae* (Gürich)

A_1-A_2 — Kowala railroad cut, B_1-B_2 — Jaźwica Quarry environs, C — Kadzielnia Quarry

1 geopetal filling, *2* tabulates; for other explanations see Text-fig. 3B

The biolithite and its lateral equivalent, the stratified limestones, are also extremely poor in conodonts at the Kadzielnia Quarry, but fortunately the overlying beds furnished some dateable conodonts. After a currently proposed model of stratigraphic relationships between the Upper Devonian lithosomes exposed at Kadzielnia (Szulczewski 1979; Szulczewski & Brykczyński, *in prep.*), the stromatoporoid-coral biolithite is covered by ascending post-mound sediments successively lapping on its slope and at last upon its roof. The oldest encroaching unit are the detrital flanking beds which cover the bioherm slope side. This unit yielded in its lowermost available part a conodont fauna characteristic of Middle (or Upper?) Polygnathus asymmetricus Zone. In such a way, the conodonts provide reliable correlation of bioherm tops between Kadzielnia and the Gałęzice syncline.

The stromatoporoid-coral sequence in the Holy Cross Mountains is also a subject of an informal regional subdivision.

Especially, the old name *Kadzielnia Limestone* has long been in common use for the uppermost, Frasnian part of the sequence, containing a large biolithite and a few small satellite bioherms at the stratotype of the unit. In spite of a long usage, this term is devoid of any clear and stable definition, as it was used in many different meanings, sometimes fairly broad, and other times narrow. A lack of rigorous rules in the stratigraphic classification caused that the name has been adopted by some early workers with attention focused largely on time-correlation, despite of facies differences, and with the others with emphasis mainly, or even solely, on facies similarity.

After a current subdivision of the stromatoporoid-coral sequence proposed by Kaźmierczak (1971) it may be subdivided into the *Kadzielnia Beds* and underlying the *Lower and Upper Sitkówka Beds*. The former unit largely corresponds with the Kadzielnia Limestone of earlier authors, especially those which have adopted a rather broad sense meaning of that term. After Kaźmierczak (1971), the unit is restricted to the southern limb of the Kielce syncline and probably corresponds to a brief time-span between the lowermost Frasnian and his "Frasnian γ". After this definition, the Kadzielnia Beds comprise at their stratotype not only biolithite and time-equivalent stratified stromatoporoid-coral limestones, but also detrital flanking beds covering its side.

After original definition each unit is believed to display a lithologic identity, characteristic assemblage of stromatoporoids and corals, and a more or less definite position against the chronostratigraphic scheme, determined on the basis of these groups of fossils. Kaźmierczak (1971) placed the Givetian/Frasnian boundary broadly at the boundary of his Lower and Upper Sitkówka Beds; he did not preclude however possibility that some limestones assigned to the uppermost Sitkówka Beds (e.g. these from the Kowala railroad cut, and Wola Quarry) may be equivalent of the Kadzielnia Beds.

The here presented wide distribution and persistent stratigraphical position of the Frasnian bioherms in the Holy Cross Mts does not seem to fit with the current regional stratigraphical subdivision. Although the name Kadzielnia Limestone has been applied in some different notions, it always comprised an unstratified type of stromatoporoid-coral limestones well known from the critical Kadzielnia Quarry. The bioherms within the Gałęzice syncline display the same

general lithology, characteristic fossil content, and even stratigraphic position as the biohermal type of the Kadzielnia Limestone (or even Beds), never mind which definition of this division is accepted.

The biohermal type of the Kadzielnia Limestones (or Beds) is hence not restricted to the Kadzielnia chain only, i.e. to the southern limb of the Kielce syncline, but it also occurs within the southern limb of the
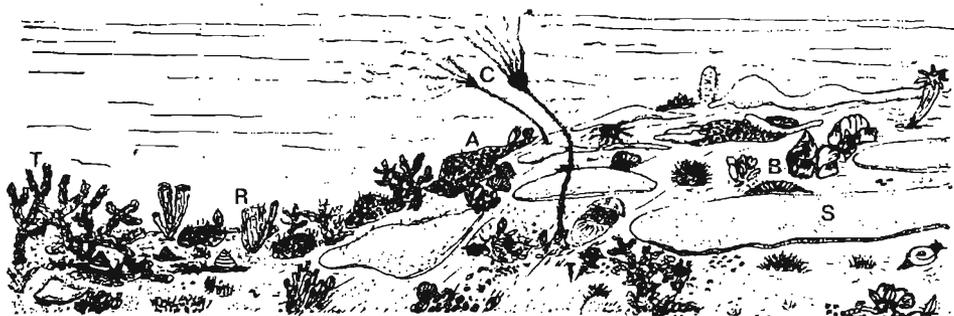

Fig. 6. Idealized reconstruction of biohermal and biostromal biota (drawing by W. Bardziński); presented are tabular stromatoporoids (S), *Alveolites* (A), ramose tabulates (T), rugosans (R), brachiopods (B) and crinoids (C), as well as gastropods echinoids, sponge, ophiocistoid, trilobite, and tentaculitids

Gałęzice syncline where the Sitkówka Beds were only suggested. In fact, the Kadzielnia-type limestons are here limited to the bioherms which are embedded within the topmost part of the Sitkówka-type limestones (Text-fig. 4), and these two subdivisions, if appropriate, are partly time-equivalent.

PALEOGEOGRAPHICAL REMARKS

The bioherm distribution within the Holy Cross Mts area displays a characteristic pattern, since all of them are confined to the marginal belts fringing the carbonate bank of the Kielce region. The bank has covered a broad part of the central Holy Cross (Kielce) region and was bordered to the north (Łysogóry region) and to the south (Chęciny region) by more deep basins filled mainly with marly sediments (Sobolev 1909; Szulczewski 1971, 1979).

The Kadzielnia and Wietrznia bioherms were situated at the northern margin of the bank, and the here described bioherms of the southern limb of the Gałęzice syncline seem to be scattered along a linear tract at least 5 km long and parallel to the supposed south margin of the bank.

The both belts are separated by the Frasnian "back-reef" facies (Kaźmierczak 1971), characteristic of the bank interior.

Such a model of bioherm distribution is however somewhat tentative, and may be influenced by exposures pattern, since the Upper Devonian sequence has been completely eroded in anticlines. The model proposed advances the concept of a reef-fringed bank suggested previously by Szulczewski (1971).

However, the rock-forming fossils did not make any rigid frame of bioherms even if a considerable amount of stromatoporoids is in a growth position. The domination of tabular and lamellar coelenterates shows that the mud-supported organisms were capable only to encrusting and binding fine lime sediments. A quiet water environment was hence postulated for accumulation of limestones corresponding with all described here carbonate mounds (Kaźmierczak 1971, Szulczewski 1971).

Additional to the organic sediment binding would be an early inorganic cementation of limy matrix as was postulated for many fossil examples (Heckel 1974, Klovan 1974, Mazzullo & Cys 1978). Abundance of fibrous-calcite structures seems to suggest such a mode of an early submarine cementation (cf. Mountjoy & Walls 1977, Walls & al. 1979).

A large biolithite exposed at Kadzielnia Quarry displays of characteristic sequence of flanking and capping beds. After mound-core accumulation it persisted a long time as a topographic high and subsequently was a side of a production of flank beds winnowed probably from its top and removed to the slope and its near by vicinity. The former mound maintained its relatively high relief up to the early Famennian. Such a position is reflected by condensed cephalopod limestones of *do II*, deposited at the summits of the eroded mound.

On the other hand, small and low-relief bioherms did not influenced either sedimentation in their surrounding or postmound deposition. The only exception is coarse intrabiorudite found locally in the bioherm-bearing part of sequence in the Gałęzice syncline at Jaźwica Quarry (cf. Text-fig. 4). Hence, the counterparts of the peripheral Kadzielnia buildup with its flanking and overlying beds has not been virtually recorded from the southern marginal zone of the carbonate bank in the studied area. The absence of such structures would be eventually explained by subsequent erosion of the Devonian deposits along the core of Chęciny anticline. At the southern limb of this anticline there are detrital limestones which take the approximately same position against the conodont zonal scheme as bioherms in the Kowala-Bolechowice sections (cf. Narkiewicz 1973, Biernat & Szulczewski 1975). Their equivalent position is also confirmed by the presence of *Phlogoiderhynchus polonicus* (Roemer) in the overlying marly-shale sequence (Biernat & Szulczewski 1975). All the Frasnian sequence here exposed fill a basin adjacent to the carbonate

bank at its south side. Detrital limestones would be eventually a thin
tip of a detrital wedge deposited at the foot of a gently inclined slope
of the Kielce region bank if a model of the "knoll reef" ramp (Wilson
1975; *cf. also* model *C* of Dolphin & Klovan 1970) is accepted for an
early stage of its development.

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BIOHERMY W FACJI STROMATOPOROIDOWO-KORALOWCOWEJ FRANU GÓR ŚWIĘTOKRZYSKICH


(Streszczenie)

W południowym skrzydle synkliny gałęzickiej stwierdzono występowanie bio-
herm (*patrz* fig. 1—6 oraz pl. 1—2) identycznych pod względem litologii, fauny
i pozycji stratygraficznej z biohermalnym typem wapienia kadzielniańskiego Kielc.
Biohermy te występują zawsze w najwyższej (często stropowej) partii profilu wa-
pieni stromatoporoidowo-koralowcowych i tym samym wapień kadzielniański jest
facjalnym ekwiwalentem przeważnie biostromalnych górnych warstw z Sitkówki
J. Kaźmierczaka (1971). Mimo małych różnic batymetrycznych między biohermami
i biostromami zaznacza się silny kontrast ekologiczny ich biotopów, widoczny szcze-
gólnie w zespołach ramienionogowych. Biohermy wyróżniają się liczną i urozmai-
coną fauną ramienionogową z wieloma gatunkami znanymi tylko z tego typu facji
Biohermy te wchodziły w skład południowej bariery rozwiniętej na łagodnym
stoku płytkowodnej ławicy węglanowej regionu kieleckiego.
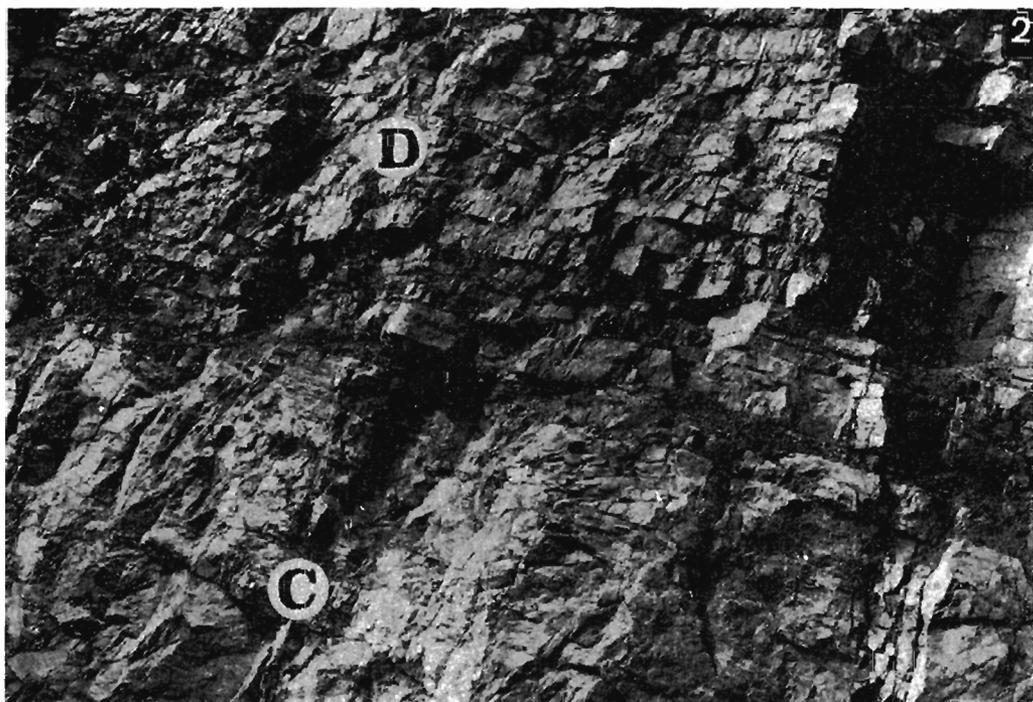
1 — Bioherm exposed in the southern wall of Wola Quarry; note depositional dip
of the capping beds and their local wedging out (cf. Text-fig. 3A)
2 — Topmost part of the biohermal (C) and overlying limestones (D) exposed in
the western wall of Wola Quarry cf. (Text-fig. 4).
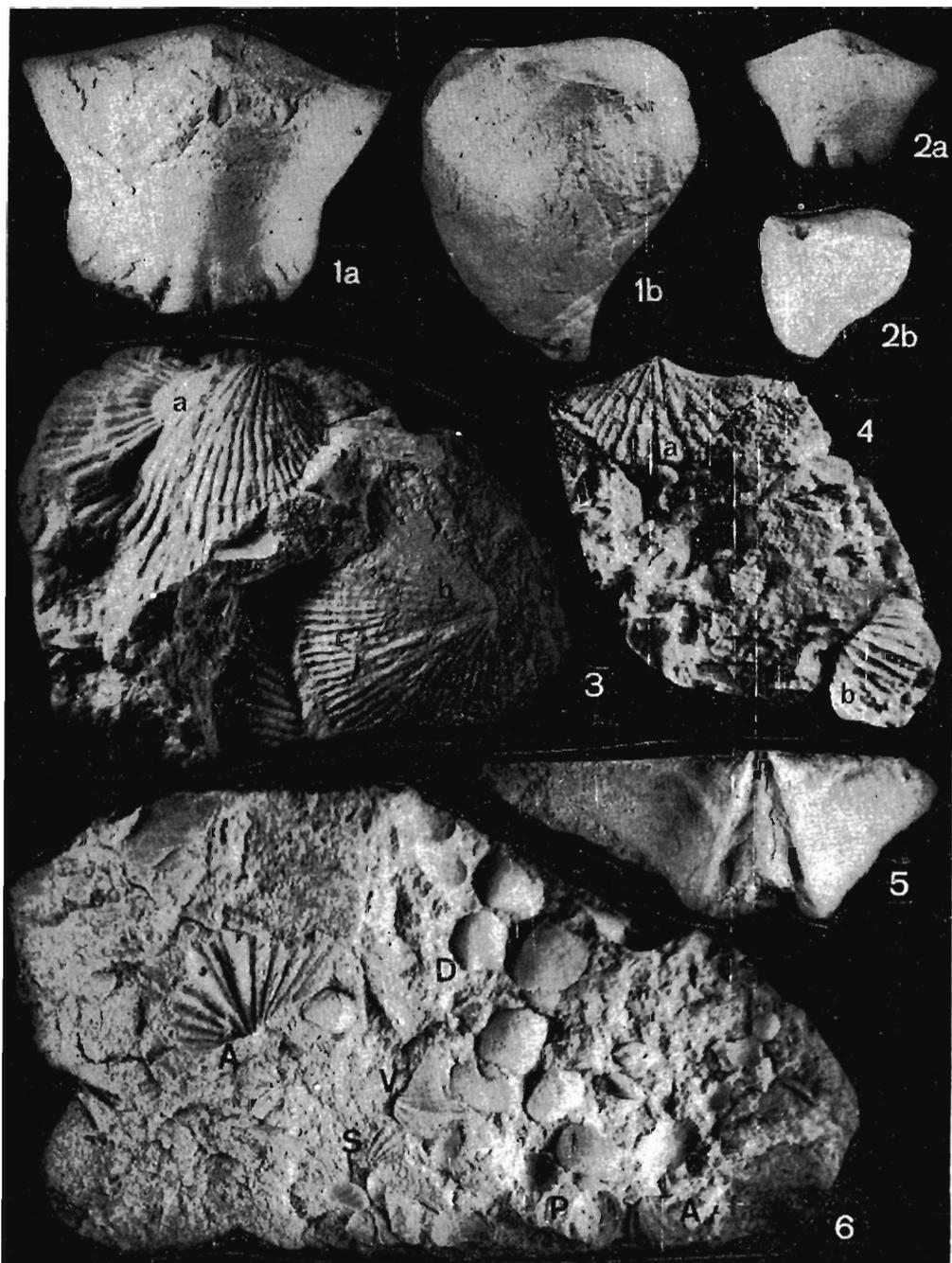
Brachiopod fauna of the Kadzielnia Limestone bioherms from the Gałęzice syncline
1-2 — *Parapugnax breccine* (Schmidt): dorsal (*1a* and *2a*) and side (*1b* and *2b*) views;; 3 —
frilled atrypids: ventral (*a*) and dorsal (*b*) views; 4 — *Fitzroyella alata* Biernat: ventral (*a*)
and anterior (*b*) views; 5 — *Verneulia kadzielniae* (Gürich): dorsal valve; 6 — nest-like
cluster dominated by *Crurithyris globosa* (Gürich) associated with: A — *Adolfia*, V — *Ver-
neulia kadzielniae* (Gürich), S — *Spinatrypina* cf. *plicata* Rzhonsnitskaya, D — *Dielasma
sacculus* (Martin)

All specimens from Łgawa Hill, except these illustrated in Fig. 1 (Kowala railroad cut)
and Fig. 4 (Jaźwica Quarry environs); all taken × 1.5, except Fig. 4 taken × 2