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## Algae *Calcifolium* in the Lower Carboniferous deposits of the Lublin Upland

**ABSTRACT:** Two species of the algal genus *Calcifolium* have been recorded in the Lower Carboniferous carbonates in boreholes in the Lublin Upland, eastern Poland. Acme zone of one of the species, *Calcifolium okense* Shvetzov & Birina, is recognized for indicative of the deposits of Late Viséan age.

### INTRODUCTION

The phylloid algae (see Pray & Wray 1963) appear as an important group among diversified Early Carboniferous algae, due mostly to their short stratigraphic range, considerable significance for stratigraphy and facies analysis, and sometimes also a rock-building role. The following genera are assigned to this group: *Anchicodium* Johnson, *Archeolito-phyllum* Johnson, *Calcifolium* Shvetzov & Birina, *Eugonophyllum* Konishi & Wray, and *Ivanovia* Khvorova. Systematic position of some of these genera appears highly disputable. This is especially the case with the genus *Calcifolium* investigated in the present paper. In fact, the latter genus was attributed to the codiacean algae by Shvetzov & Birina (1935), whereas Perret & Vachard (1975) regarded it as comparable to the pharetronid calcisponges. Despite this equivocality in the actual systematic position of the genus, its diagnostic features are so clearly determined that it is quite easily recognizable.

The present paper is intended to describe two species of the genus *Calcifolium* unknown thus far from Poland, and to analyse their distribution in a few selected borehole sections in the northeastern Lublin Upland, eastern Poland (see Text-fig. 1).

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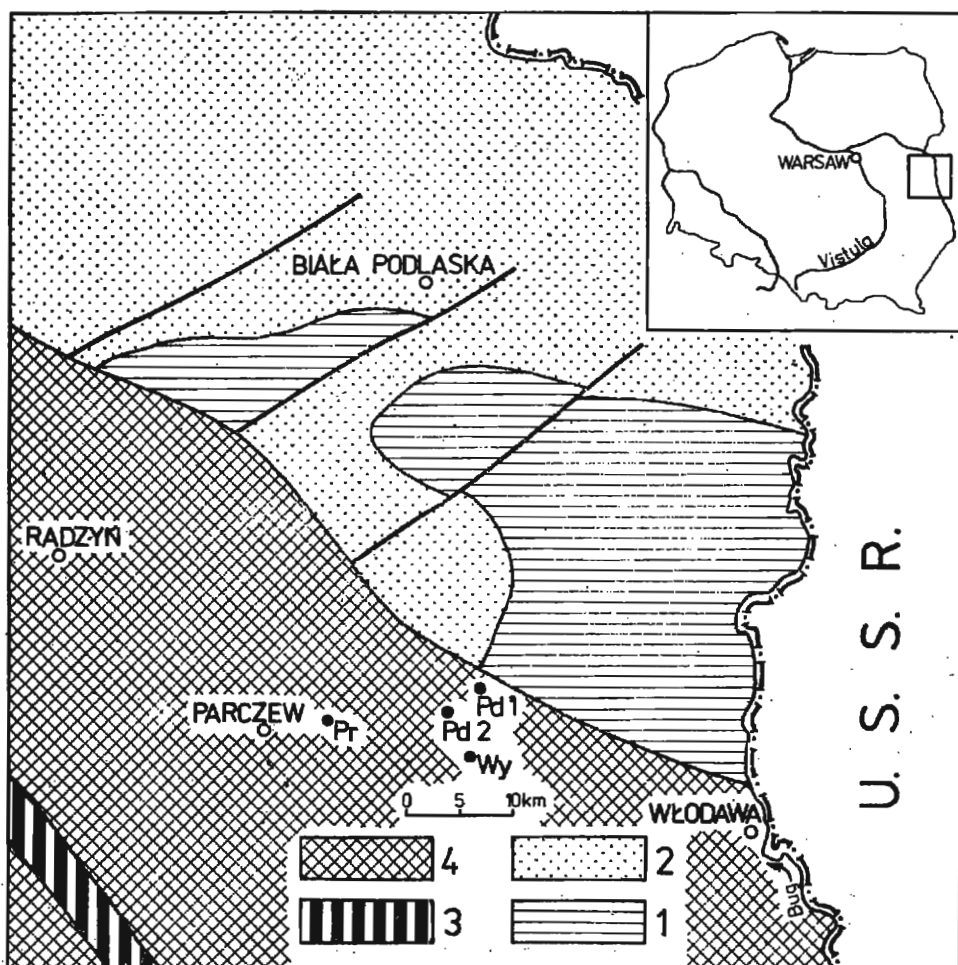


Fig. 1. Geological sketch map of the NE part of the Lublin Upland (without Cainozoic, Mesozoic and Permian formations; after Pożaryski & Radwański 1972); inset shows location of the area in Poland

Investigated boreholes are marked with black spots: Pd 1 Podedwórze IG-1, Pd 2 Podedwórze IG-2, Pr Frzewołka IG-1, Wy Wyhaław IG-1

1 Upper Eocambrian (Wendian); 2 Cambrian, Ordovician and Silurian; 3 Middle and Upper Devonian; 4 Lower and Upper Carboniferous

#### SYSTEMATIC DESCRIPTION

##### Genus *CALCIFOLIUM* Shvetsov & Birina, 1935

Type species: *Calcifolium okense* Shvetsov & Birina, 1935

**Diagnosis:** Thallus composed of tubular calcareous stems provided each with transversal lateral plates. Stem wall with a system of parallel channels of constant diameter branching dichotomously in lateral plates.

**Remarks.** — Thus far, only a single fragment of the surface of *Calcifolium* „leaf” has been illustrated (Maslov 1956, Pl. 9, Fig. 4); while all the other

Illustrations are micrographs of thin sections. Therefore, descriptions of the genus deal mostly with a hypothetical reconstruction of the alga, and interpretations prevail commonly over the actual morphological characteristics. Consequently, the descriptions are largely incompatible with one another.

*Calcifolium okense* Shvetzov & Birina, 1935  
(Pl. 1, Figs 1-4; Pl. 2, Figs 2-4; and Pl. 3, Fig. 3)

1935. *Calcifolium okense* n. sp.; Shvetzov & Birina, p. 20-21, Pl. 4, Figs 11-12 and 14-15 (non Fig. 10).  
 1956. *Calcifolium okense* Shvetzov & Birina; Maslov, p. 63-64, Pl. 8, Figs 1 and 3-7; Pl. 9, Figs 2-5; Pl. 10, Figs 1 and 3-5; Text-figs 7 and 9.  
 1958. *Calcifolium bruntonense* n. sp.; Johnson, p. 153-157, Figs M-31 and Text-fig. 3a-b.  
 1965. *Calcifolium okense* Shvetzov & Birina; Burgess, p. 193, Pl. 21, Figs 1-3.  
 1970. *Calcifolium okense* Shvetzov & Birina; Hallett, p. 876, Pl. 1, Figs 2-4.  
 1975. *Calcifolium okense* Shvetzov & Birina; Mamet & Roux, p. 154-155, Pl. 10, Figs 1-21; Pl. 11, Figs 1-3 and 9.  
 1975. *Calcifolium okense* Shvetzov & Birina; Perret & Vachard, p. 2649-2651, Text-figs BN.  
 1977. *Calcifolium okense* Shvetzov & Birina; Mamet & Roux, p. 244-264, Text-figs 11-12.  
 1977. *Calcifolium okense* Shvetzov & Birina; Perret & Vachard, p. 49-53, Pl. 10, Figs 3-4 and 6; Text-figs 24-26 [cum. syn.].

*Description.* — The investigated specimens show the diagnostic features of the species viz. a single row of pores at the margin of flat thallus (Pl. 3, Fig. 3), and a ring of pores in cross section of stem tube (Pl. 2, Figs 2-4). The dimensions of particular morphological elements are as follows:

|                                |               |
|--------------------------------|---------------|
| inner diameter of stem tube    | 300-500 $\mu$ |
| diameter of stem-wall channels | 10-30 $\mu$   |
| channel spacing                | 20-45 $\mu$   |
| thickness of lateral plates    | 60-100 $\mu$  |
| angle of channel branching     | 10-20°        |

The measurements approximate those given by Maslov (1956) confirmed also by later workers (*see* synonymy).

*Remarks.* — Among the morphological characteristics making up a difference between *Calcifolium bruntonense* and *C. okense*, Johnson (1958) mentioned the larger size of the former species, i.e. its stem-tube diameter ranging up to 1,000  $\mu$ . This disagrees however with Johnson's (1958) illustrations, all of which show actually specimens attributable to *C. okense*. The other diagnostic features proposed for *C. bruntonense* by Johnson (1958), as e.g. nearly parallel channels in lateral plates and specificity of branch arrangement in central stem, seem to be far from objectively recognizable and may actually be largely dependent upon more or less random orientation of thin sections. Therefore, the present author follows Mamet & Roux (1975) in considering *C. bruntonense* as a junior synonym of *C. okense*.

*Occurrence.* — In Poland: uppermost Viséan (V3c) possibly to the lowermost Namurian (Parczew-Włodawa region, Lublin Upland).

*Calcifolium punctatum* Maslov, 1956  
(Pl. 2, Fig. 1 and Pl. 3, Figs 1-2)

1935. *Calcifolium okense* n. sp.; Shvetzov & Birina (*partim*), Pl. 4, Fig. 10.  
 1956. *Calcifolium punctatum* n. sp.; Maslov, p. 49-51, Pl. 8, Fig. 2; Pl. 9, Fig. 1; and Pl. 10, Fig. 2.

1965. *Calcifolium punctatum* Maslov; Burgess, p. 194—195, Pl. 22, Figs 1—5.

1970. *Calcifolium punctatum* Maslov; Hallett, p. 875, Pl. 1, Figs 5—6.

1975. *Calcifolium punctatum* Maslov; Mamet & Roux, p. 165—166, Pl. 11, Figs 4—9.

**Remarks.** — A considerable morphological variability recorded in *Calcifolium punctatum* explains why no reconstruction of this species has thus far been presented. No doubt that the most reliable element of such a reconstruction would be the stem because its cross section (see Pl. 2, Fig. 1; cf. also Mamet & Roux 1975, Pl. 11, Fig. 7; Burgess 1965, Pl. 22, Fig. 4) and dichotomous branching (cf. Pl. 2, Fig. 1 and Pl. 3, Fig. 1) seem to be quite well recognized.

**Occurrence.** — In Poland: uppermost Viséan (V3c) possibly to the lowermost Namurian (Parczew-Włodawa region, Lublin Upland).

#### RECONSTRUCTION OF CALCIFOLIUM AND ITS TAXONOMY

In the original description of *Calcifolium*, the authors of the genus (Shvetsov & Birina 1935) considered it as comparable to the Recent codiacean genus *Udotea*. Maslov (1956) described the both of the investigated species and presented a few distinct reconstructions of the alga; accordingly to him, the most plausible hypothesis is that the central stem encrusted the substrate and gave the origin to lateral plates showing each a system of dichotomously branching channels (the plates themselves could also split each into two layers). The above presented idea is followed by the interpretation (see Text-fig. 2A) given by Mamet & Roux (1977). All the students referred above to assigned *Calcifolium*

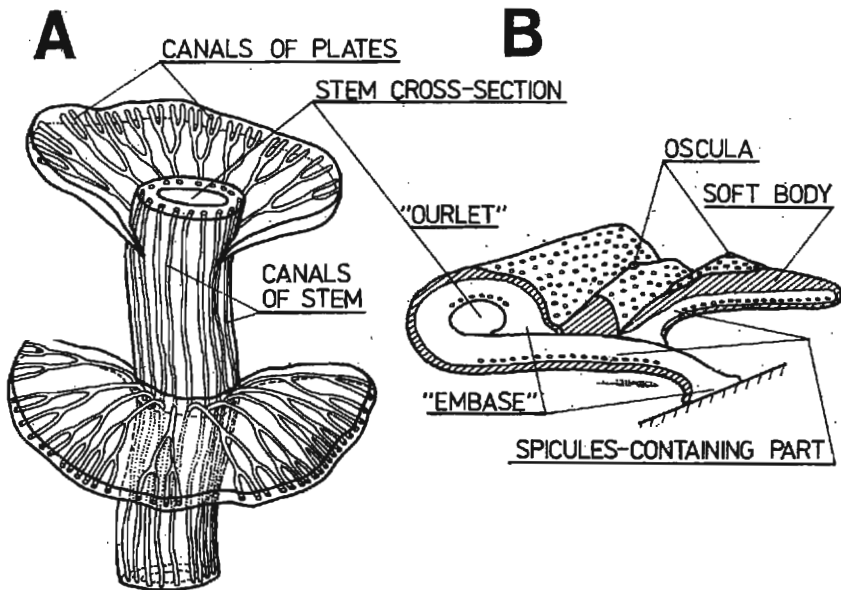
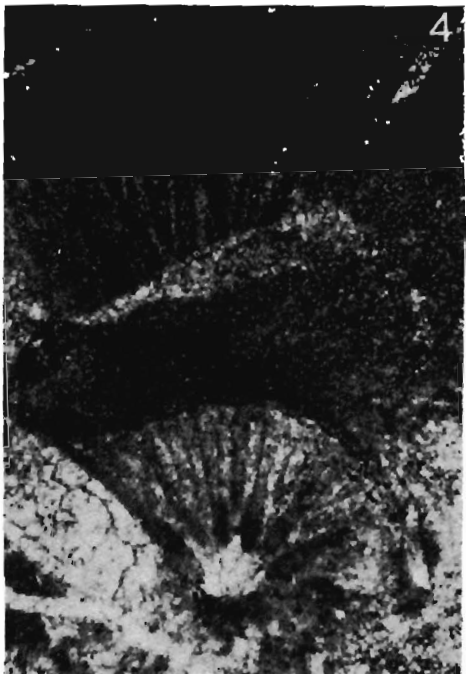
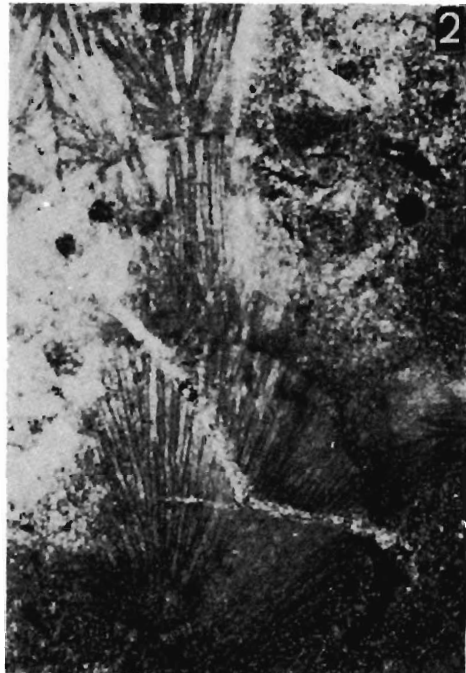
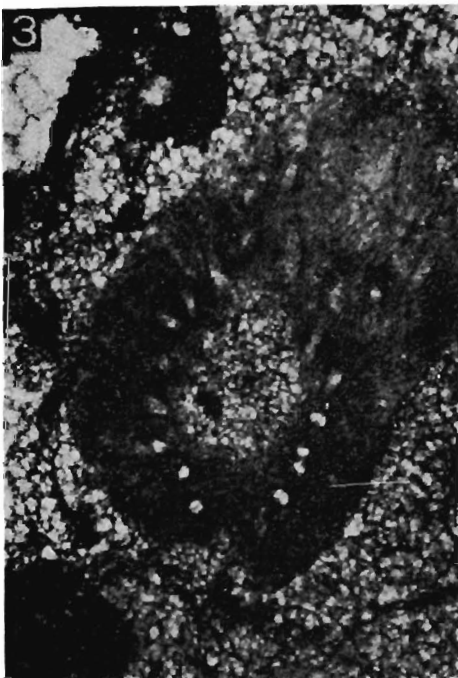
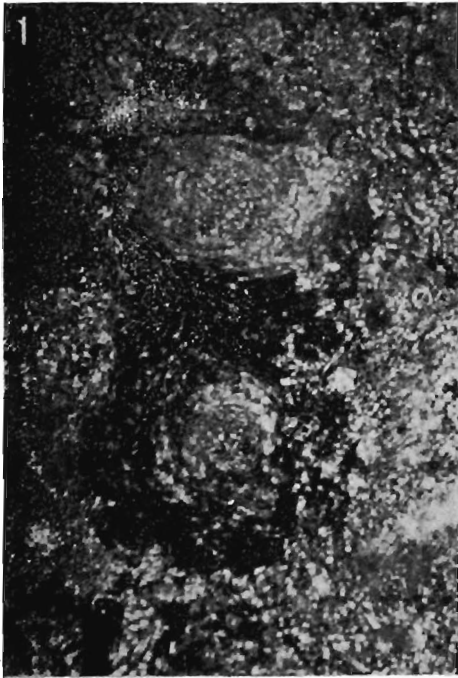


Fig. 2. Reconstruction of *Calcifolium*: A — according to Mamet & Roux (1977), B — according to Perret & Vachard (1977)



- 1 — *Calctofolium okense* Shvetsov & Birina; oblique section of the lateral plate; borehole Rudno (depth 786m), X110
- 2 — *Calctofolium okense* Shvetsov & Birina; tangential section of the lateral plate; Rudno (depth 760 m), X45
- 3 — *Calctofolium okense* Shvetsov & Birina; oblique section of the stem-tube; Rudno (depth 760 m), X60
- 4 — *Calctofolium okense* Shvetsov & Birina; tangential section of the lateral plate and transverse of the stem-tube; Przewłoka (depth 820 m), X80



- 1 — *Calcifolium punctatum* Maslov; transverse section of the stem-tube at the branching part; borehole Przewłoka (depth 818 m),  $\times 50$
- 2 — *Calcifolium okense* Shvetzov & Birina; transverse section of the stem-tube; Podedwórze 2 (depth 587 m),  $\times 100$
- 3 — *Calcifolium okense* Shvetzov & Birina; transverse, slightly oblique section of the stem-tube; Przewłoka (depth 818 m),  $\times 90$
- 4 — *Calcifolium okense* Shvetzov & Birina; transverse section of the stem-tube; Podedwórze 2 (depth 587 m),  $\times 100$

to the codiacean algae because of its general morphological characteristics.

In contrast, Perret & Vachard (1975) attributed *Calcifolium* to the pharetronid calcisponges. Accordingly to this hypothesis, dichotomously branching channels of *Calcifolium* are to be interpreted as equivalent to a sponge water-system; and parts of thallus covered with a row of pores, which is so typical of *C. okense*, are to be considered as equivalent to the pharetronid spicule-bearing cortex. After the appearance of the paper by Mamet & Roux (1975) who demonstrated clearly that the pores were actually cross sections of the dichotomously branching channels (cf. Pl. 1, Figs 2—4), Perret & Vachard (1977) claim that the channels of *Calcifolium* filled up with calcite had originally contained fork-shaped spicules interconnected in form of the system characteristic of the fossils under discussion. By this way, Perret & Vachard (1977) refuted their earlier interpretation recalling existence of a system of water channels. Perret & Vachard (1975, 1977) denied also the existence of central stem in *Calcifolium*, and the circular sections of *Calcifolium* thallus (regarded by other authors as sections through the stem) interpreted as an extreme turn of the thallus outwards ("ourlet") up to its fusion with a plate to form finally a widening ("embase"); circular sections could also arise from oblique orientation of the section plane (see Text-fig. 2B).

None of thus far presented reconstructions can be regarded as sufficiently supported by empirical data. However, the reconstruction given by Perret & Vachard (1977) refers to so many hypotheses that one can hardly recognize it for true. Actually, the specimens illustrated in this paper (Pl. 2, Figs 2—4) as well as in other ones (cf. Mamet & Roux 1975, Pl. 10, Figs. 12 and 18) are suggestive of existence of a stem tube instead of "ourlet"; furthermore, the origin and function of the latter structure remain thus far unrecognized by the authors of the pharetronid interpretation of *Calcifolium*. Disputable is also the assumption that the secondary calcite fill of the channels represents actually spicules forming a cortex.

#### DISTRIBUTION OF CALCIFOLIUM

The investigated specimens of *Calcifolium* were found in the following boreholes located between Radzyń, Parczew, and Włodawa in the Lublin Upland (see Text-fig. 1): Podedwórze IG-1, IG-2, IG-3, IG-4, IG-5, IG-6; Włodawa IG-1, IG-2; Lubiczyn IG-1, Lubień IG-1, Wyhalew IG-1, Rudno IG-1, and Przewłoka IG-1. That area was covered with the Late Visean transgression onto the eroded surface of Proterozoic to Lower Paleozoic rocks (cf. Cebulak & Porzycki 1976). The Visean deposits are represented

by terrigenous coal-bearing rocks interbedded with shallow-water carbonate-clayey rocks (Text-fig. 3). Carbonate beds range from 1 to 12 m in thickness and are represented by organodetrital limestones with variable contents of clay matter. In the lowermost carbonate bed, corals prevail among the fossils, forming here and there reef structures. Higher in the section, corals disappear from the carbonate beds, replaced with abundant crinoid trochites and fragmented brachiopod, bivalve, gastropod, and ostracode shells. All the carbonate beds comprise also a rich foraminiferal assemblage and conodonts. Biostratigraphical analysis.

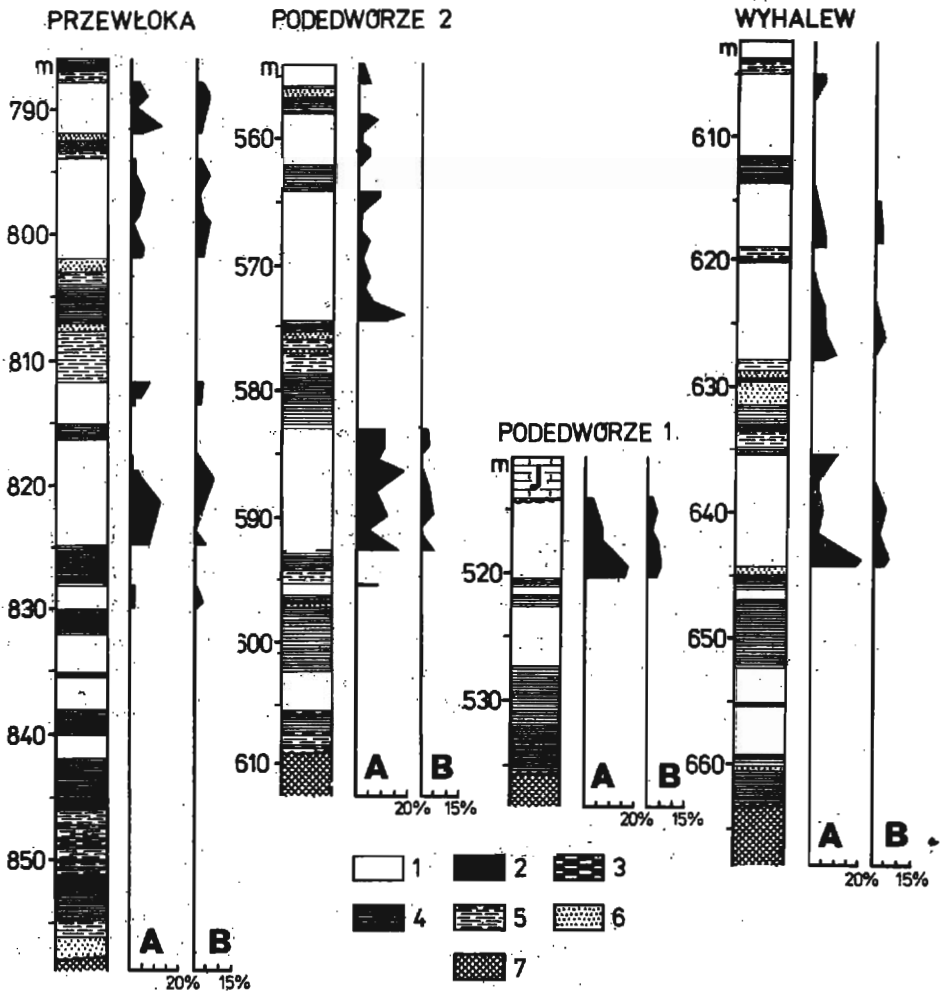


Fig. 3. Frequency of *Calcifolium* in the investigated boreholes: A — *Calcifolium okense* Shvetzov & Birina, B — *Calcifolium punctatum* Maslov

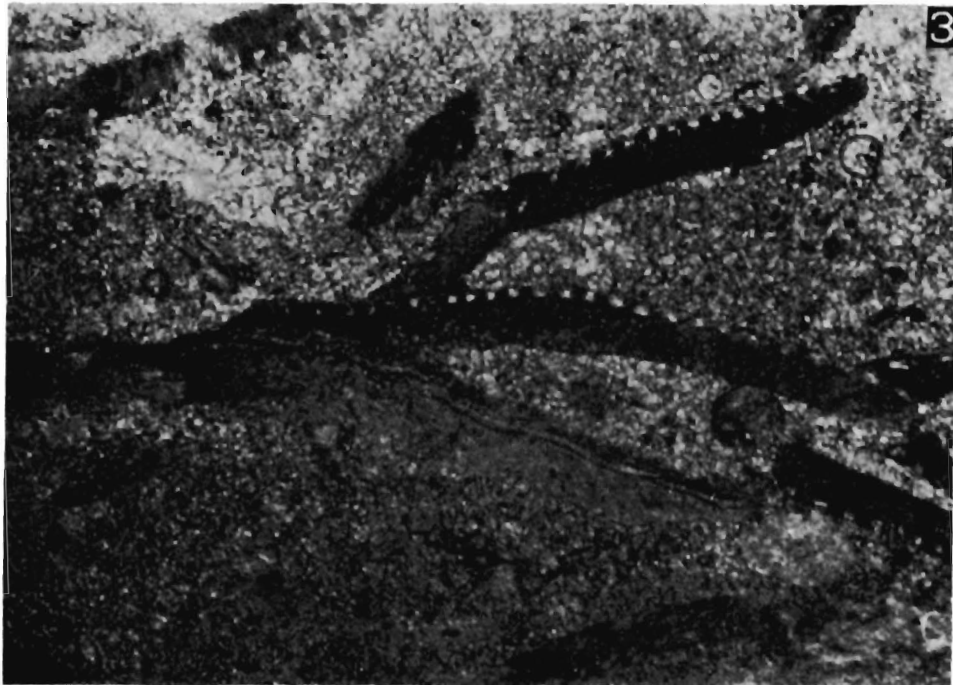
1 Viséan carbonate rocks, 2 coal measures, 3 carbonaceous shales, 4 claystones, 5 mudstones, 6 sandstones, 7 basement (Precambrian and Palaeozoic, older than Viséan; cf. Text-fig. 1), J overlying Upper Jurassic limestones.



of microfauna derived from two boreholes from the investigated area (Podedwórze IG-2 including) permitted assignment of the strata under discussion to the *Paragnathodus nodosus* Zone (= V3c), uppermost Viséan (Skompski & Soboń-Podgórska 1980). Neither microfauna, nor spore assemblage (Jachowicz & Jachowicz 1976), nor macrofauna (Musiał 1976) allow to recognize chronostratigraphic boundaries; on the other hand, one can hardly establish any unequivocal lithostratigraphical scheme which considerably hampers any time correlation of the investigated borehole sections.

A correlation tool is offered by the stratigraphical distribution of *Calcifolium*, in particular the species *C. okense*. Both the species discussed in the present paper appear rapidly and in large amounts in the investigated sections (Text-fig. 3). The proportion of *Calcifolium* in a sample was estimated after the proportion of thin-section area covered with algal thallus. As demonstrated by the diagram of numerical abundance, the environmental conditions most favorable for *C. okense* occurred at the early and the latest stages of formation of the carbonate beds. The amounts of the species range up to 15% of rock volume in samples of the respective carbonate beds. In turn, *C. punctatum* is much less abundant in the samples; it occurs mostly in the lowermost carbonate bed comprising the investigated algae, whereas it becomes very rare higher in the section and gradually disappears. One may consequently claim that the appearance of *C. okense* and the beginning of its flourishing mark a valuable correlation horizon in the Lower Carboniferous in the investigated area.

The genus *Calcifolium* is also well known to show rather short stratigraphical range and hence, it may be useful for chronostratigraphy even though its range varies a little among its students. Johnson (1958) and Hallett (1970) studied the carbonates in the uppermost Yoredale Series, England, and noted that *Calcifolium* ranged from the Middle Limestone to the Main Limestone ( $P_{1c}$  to  $E_1$  in the English goniatite zonal scheme). Hallett (1970) noted also that *C. punctatum* disappears already in the Underset Limestone (the highest carbonate bed assigned to the Viséan), replaced with *C. okense* ranging up to the Namurian. Perret & Vachard (1975, 1977) recorded *C. okense* in the uppermost Viséan to lowermost Namurian (V3b to *N inf*) of the Pyrenees. Finally, Mamet & Roux (1975) analysed the stratigraphical distribution of Carboniferous algae in the West Europe, North Africa, the Ukraine, Moskva region, and the Urals (cf. also Vdovenko 1969, Ivanova 1973, Koulik 1973), and concluded that *C. punctatum* ranges throughout the uppermost Viséan but is absent from the Namurian, while the acme of *C. okense* starts in the uppermost Upper Viséan (V3c sup) and ranges up to the Namurian. Thus far, the genus *Calcifolium* has not been recorded in the Lower Carboniferous of North America in spite of the



- 1 — *Calcifolium punctatum* Maslov; transverse section of a fragment of the thallus with branching; borehole Przewioka (depth 829 m), X70
- 2 — *Calcifolium punctatum* Maslov; transverse section of the fragmented thallus; Przewioka (depth 829 m), X70
- 3 — *Calcifolium okense* Shvetzov & Birina; transverse section of bifurcation of the stem-tube, and of the lateral plates; Przewioka (depth 821 m), X80

common occurrence of other phylloid algae in that area. The stratigraphical distribution of *Calcifolium* in the Lublin Upland fits thus well to those recorded in other regions.

The last problem to be solved is the relationship between distribution of *Calcifolium* and facies. Thus far, the only analysis of the life environment of *Calcifolium* is that one given by Perret & Vachard (1977). The latter authors claim that the organisms under discussion were restricted to inter- and/or back-reef habitats somewhat deeper and more sheltered than a proper reef. Accordingly to Johnson (1958), *Calcifolium* is commonly associated with small-sized corals, crinoids, bryozoans, bivalves, gastropods, and ostracodes. In the investigated borehole sections of the Lower Carboniferous of the Lublin Upland, the lowest carbonate beds comprise several reef structures lacking at all in the overlying *Calcifolium* — bearing strata. This reef facies occurs however merely in a few sections and hence, cannot be responsible for the total absence of *Calcifolium* from the lowermost portion of the Lower Carboniferous carbonates. One may therefore suppose that the appearance of the fossils under discussion marks the lower boundary of the uppermost Viséan.

It is to be concluded that the acme zone of *Calcifolium*, in particular *C. okense*, makes up in the Lublin Upland a reliable, useful, and easily recognizable correlation horizon of the uppermost Viséan (V3c).

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**GLON CALCIFOLIUM W PROFILACH DOLNEGO KARBONU  
LUBELSZCZYZNY**

(Streszczenie)

W utworach węglanowych dolnego karbonu północno-wschodniej Lubelszczyzny (patrz fig. 1) stwierdzono występowanie glonu *Calcifolium*, reprezentowanego przez gatunki *Calcifolium okense* Shvetzov & Birina oraz *Calcifolium punctatum* Maslov. Wątpliwości w odtwarzaniu postaci tego glonu i interpretacji funkcji spełnianych przez jego poszczególne fragmenty (patrz fig. 2 oraz pl. 1—3) sprawiły, że jego pozycja systematyczna jest przedmiotem rozbieżnych poglądów (zaliczanie do Codiaceae wśród Chlorophyceae, oraz sugestie o jego przynależności do gąbek wapiennych). Analiza częstości występowania obu gatunków *Calcifolium* w badanych profilach (patrz fig. 3) wykazała, że poziom rozkwitu *Calcifolium okense* Shvetzov & Birina można uznać za dobry poziom korelacyjny oraz istotny wskaźnik stratygraficzny najwyższego wizeniu (V3c).

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