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The Alpine microfacies with *Glomospira densa* (Pantić) in the Muschelkalk of Poland and some related paleogeographical and geotectonic problems

ABSTRACT: The Alpine foraminiferal microfacies with *Glomospira densa* (Pantić) has been found in the Triassic epicontinental (German) basin in Lower Silesia and Central Poland. Since in Poland this species was found not only in the Illyrian but also Pelsonian, the zone of Glomospira densa (both *sensu* Salaj 1969a and *sensu* Zaninetti & *al.* 1972), so far restricted to the Illyrian only, becomes thus extended. This horizon occurs not only in the higher part of the Anisian of the Tethys, but also in the deposits of the same age found at least in the eastern part of the German epicontinental basin. The problem of the paleogeography of the Muschelkalk basin and its connection with the geosynclinal area as seen in the light of the theory of plate tectonics are also taken into consideration.

INTRODUCTION

A typical microfacies with *Glomospira densa* (Pantić) has been found in the Lower Muschelkalk of the Radziątków 5 borehole (Głazek & Trammer 1972) in Central Poland. At the same time, the presence of *Glomospira densa* in a relatively extensive stratigraphic interval (*cf.* Fig. 2) was stated during studies on the Muschelkalk in Lower Silesia (*cf.* Zawidzka 1970, 1971, 1972).

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RADZIĄTKÓW 5 BOREHOLE

Description of the microfacies

The oil-prospecting borehole has been drilled at Jeżów, Piotrków Trybunalski District (*cf.* 27 in Fig. 3), where a microfacies with abundant *Glomospira densa* (Pantić) was found at a depth 2,556.2 m, that is, 10 m below the top of deposits assigned to the Lower Muschelkalk (Fig. 1). The lower boundary of the Lower Muschelkalk formation was settled about 150 m below (2,701 m).

The microfacies under study was found within a thin, 10 cm, detrital layer inbetween micritic limestones. This is a micritic-sparitic foraminiferal limestone (Pl. 2, Figs 8—9), containing the following foraminifers which occur in abundance:

Glomospira densa (Pantić) — vide Pl. 1, Figs 1, 3*a*, 5, 6*a*, 7*a*;
Glomospira cf. *densa* (Pantić) — vide Pl. 1, Figs 2*b*, 6*b*; Pl. 2, Fig. 5*b*;
Glomospirella grandis (Salaj) — vide Pl. 1, Figs 2*a*, 3*b*, 7*b*; Pl. 2, Fig. 2;
Glomospirella cf. *grandis* (Salaj) — vide Pl. 1, Fig. 4;

and less frequent [1]:

Glomospira sinensis Ho — vide Pl. 2, Fig. 1;
Glomospira articulosa Plummer — vide Pl. 1, Fig. 6*c*, and Pl. 2, Fig. 5*a*;
Glomospira gordialis (Jones & Parker);
Glomospira regularis Lipina — vide Pl. 2, Fig. 4;
Glomospirella sp. — vide Pl. 2, Fig. 3;
Hemigordius sp.;
Agathammina sp.

These foraminifers are preserved on the whole completely and their micritized tests are not crushed. The chambers of tests are filled with a fine-grained sparite. In addition, there are trochites of crinoids, vertebrae of ophiuroids (Pl. 2, Fig. 7; *cf.* Głazek & Radwański 1968), fragmentary shells of thin-shell pelecypods and, sporadically found, shells of small gastropods and associations of the spores (Pl. 2, Fig. 6) *Globochaete alpina* Lombard. The matrix is mostly micritic. Formed at the expense of micrite, sparite surrounds the tests of foraminifers and occurs as irregular spots against the micritic background.

Stratigraphic position

No macrofauna of biostratigraphic importance has been found in the Muschelkalk core sectors of the profile of the borehole. On the other hand, index conodonts were contained in some of the Muschelkalk samples from the Radziątków 5 borehole, which allows one to determine

[1] The forms named here have been determined on the basis of descriptions and illustration given by various authors, mostly by Ho (1959). However, the concurrence of such a great number of sympatric species, in particular of the genus *Glomospira* Rzehak, seems improbable from the ecological viewpoint. We may suppose that in certain cases they were distinguished overhastily (*cf.* Pantić 1965, p. 190) on the basis of taxonomically unimportant differences resulting from a variety of sections visible in microscope or from not very essential morphological differences representing individual variability and varying stages of the ontogenetic development.

the age of the layer containing *Glomospira densa*. Thus, the following conodonts occur within the range of the Upper Muschelkalk at a depth 2,446.6 to 2,447.6 m (*cf.* Fig. 1):

Gondolella haslachensis Tatge
G. mombergensis media Kozur
Hindeodella (Metaprioniodus) suevica (Tatge)
Prioniodina muelleri (Tatge)

The first three make up an assemblage typical of the lower part of the conodont zone *4* from the Upper Muschelkalk of Germany (Kozur 1968) and Poland (Trammer 1972b). The lower part of zone *4* corresponds to the Upper Fassanian (Kozur & Mostler 1972).

The following species of conodonts occur lower, at a depth 2,451.2 to 2,451.5 m (*cf.* Fig. 1):

Gondolella mombergensis mombergensis Tatge
G. mombergensis media Kozur
G. prava Kozur
Prioniodina muelleri (Tatge)

The two first, with a distinct percentage predominance of *G. mombergensis mombergensis* over *G. mombergensis media,* indicate the uppermost part of the conodont zone *2* (Kozur 1968, Trammer 1972b). According to Kozur & Mostler (1972), the upper part of zone *2* corresponds to the uppermost Illyrian *sensu* Kozur 1972 (the boundary between the Illyrian and the Fassanian equals that between the *trinodosus* and *avisianus* zones).

The form *Gondolella navicula* Huckriede, found at a depth 2,556.2 m in the same layer as the microfacies with *G. densa,* is known from the Pelsonian through the end of the Norian (Huckriede 1958, Mosher 1968).

About 34 m below, *Gondolella navicula* Huckriede and *Neospathodus kockeli* (Tatge), the latter an index species of the Pelsonian (Kozur 1971, Kozur & Mostler 1972) were found at a depth 2,590.5 m (*cf.* Fig. 1).

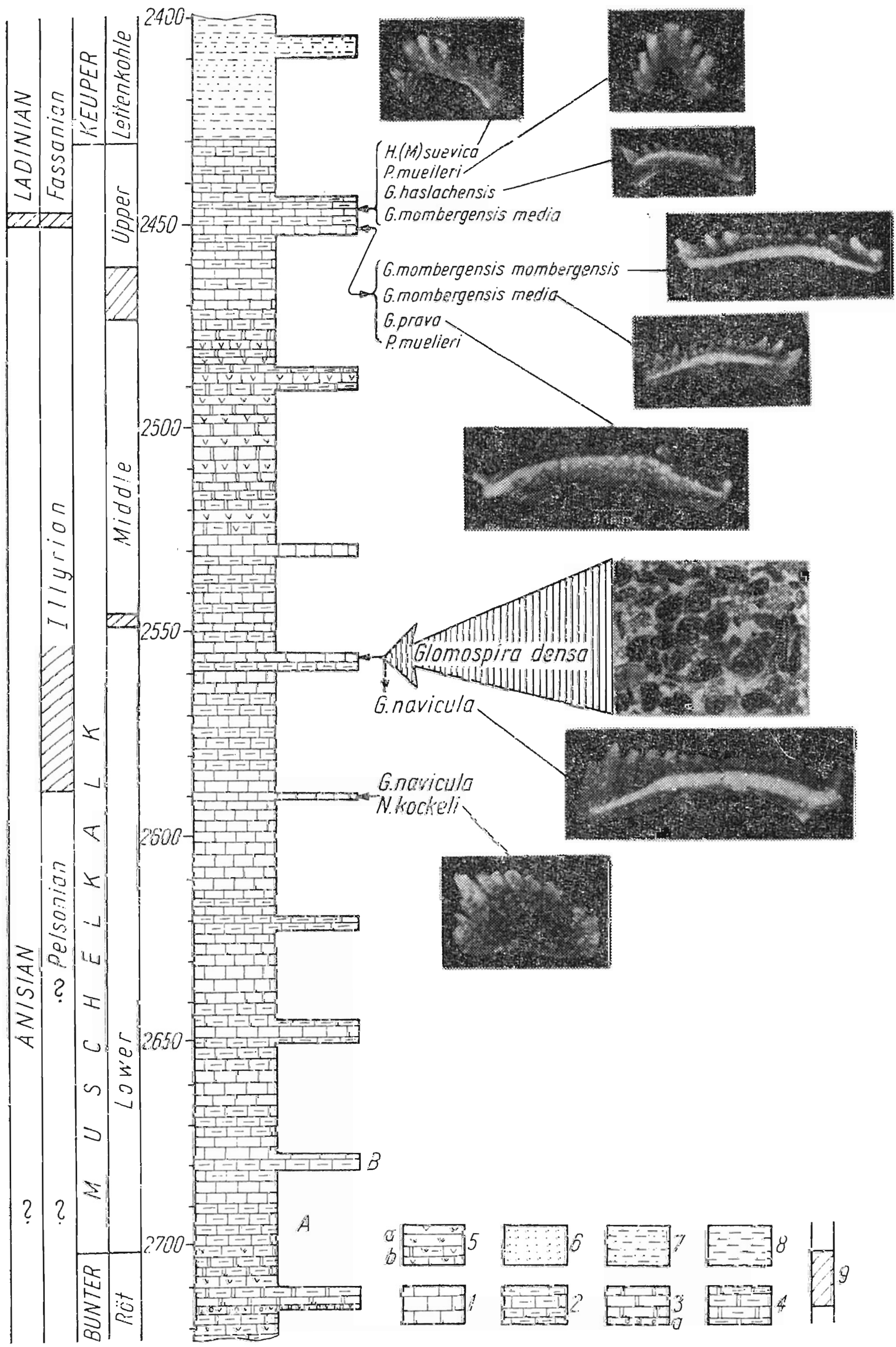
On the basis of the facts described, we can state that the microfacies with *Glomospira densa* occurs in the borehole under study within the Lower Illyrian or uppermost Pelsonian.

LOWER SILESIA

Description of the microfacies

The occurrence of *Glomospira densa* (Pantić) in several thin sections coming from the entire Górażdże Beds (Fig. 2), have been found in the Strzelce Opolskie profile [2] (*28* in Fig. 3). In addition, the foraminifer in

[2] A detailed description of profiles and a discussion of the stratigraphic division of the Muschelkalk in Lower Silesia make up the subject of a monograph now being prepared by Zawidzka (*in preparation*).


LADINIAN
Fassanian
KEUPER
Lettenkohle
Upper
Middle
Lower
ANISIAN
Illyrian
Pelsonian
MUSCHELKALK
BUNTER
Röt
2400
2450
2500
2550
2600
2650
2700
H.(M.)suevica
P. muelleri
G. haslachensis
G. mombergensis media
G. mombergensis mombergensis
G. mombergensis media
G. prava
P. muelleri
Glomospira densa
G. navicula
G. navicula
N. kockeli
A
B
1
2
3
4
5
6
7
8
9
a
b

question was found at the boundary between the Górażdże and Gogolin beds (Fig. 2) in the locality Górażdże (*29* in Fig. 3). The lowermost occurrence of *Glomospira densa* has been recorded 6 m below the lower boundary of the Górażdże Beds (sample *0170* in Fig. 2). Generally speaking, *G. densa* occurs within an interval of about 45 m in the middle part of the Lower Muschelkalk, appearing about 35 m above the bottom and disappearing about 35 m below the top of the Lower Muschelkalk.

An assemblage of alternating beds of marly shales and pelitic and detrital limestones occurs in the upper part of the Gogolin Beds, in which *Glomospira densa* is recorded. Oolitic limestones appear in the top. Detrital limestones are on the whole biocalcarenites containing fragmentary shells of brachiopods, gastropods and pelecypods, trochites of crinoids, as well as ostracods, bryozoans, foraminifers and numerous scolecodonts (*cf.* Zawidzka 1971). Sometimes, these rocks also contain a considerable admixture of terrigenic material (quartz, mica, *etc.*). The following foraminiferal assemblage occurs in sample *0170* (*cf.* Fig. 2):

Agathammina sp.
Ammodiscus sp.
Glomospira densa (Pantić) — vide Pl. 3, Fig. 3
Glomospirella sp.
Hemigordius sp.

The Górażdże Beds are developed as alternating detrital sparitic and micritic limestones (*cf.* Fig. 2), which contain detrital quartz. The detrital limestones consist of micro-onkoids and bioclasts, frequently covered with onkolitic coatings. Bioclasts sometimes contain fragmentary shells of brachiopods, pelecypods and gastropods, plates of echinoderms, tests of ostracods and foraminifers. In addition, lumps and pellets are frequent. The Górażdże Beds abound in conodonts (*cf.* Zawidzka 1970), which only in beds of onkolitic limestones are very rare.

In this locality, *Glomospira densa* has been recorded in the following assemblages occurring in several samples (*cf.* Fig. 2):

Sample no. 70/98:
Glomospira densa (Pantić) — vide Pl. 3, Figs 4—5
Glomospira sp.

Fig. 1

Muschelkalk column in Radziątków 5 borehole

1 limestones, *2* marls and marly limestones, *3* dolostones (*a* with oolites), *4* dolomitic marls, *5* anhydrite (*a* rock-forming, *b* admixture in other rocks), *6* sandstones, *7* siltstones, *8* claystones, *9* correlation error interval
A data obtained from core, *B* data obtained from electric logs and borings
All conodonts are in the same scale; photos taken by L. Łuszczewska, M. Sc.

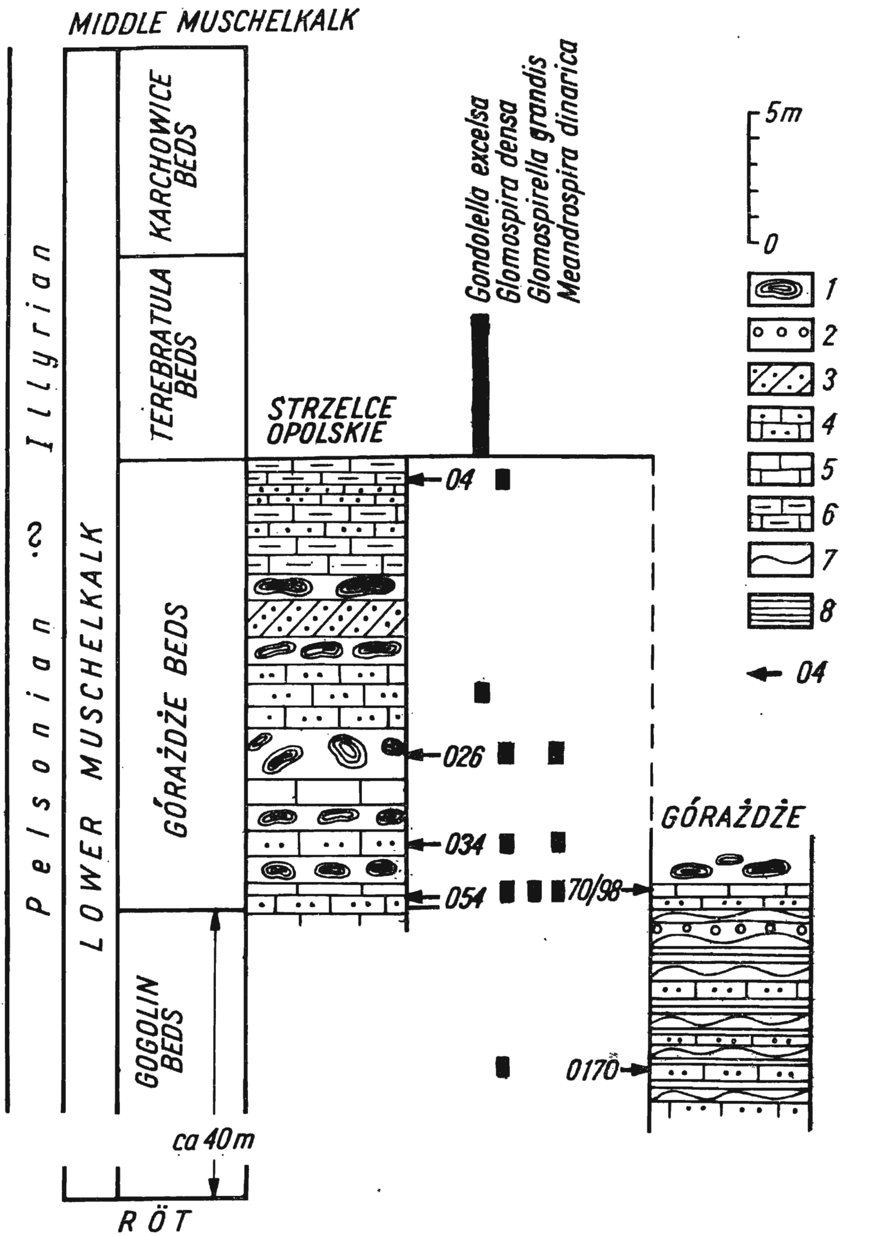


Fig. 2

Muschelkalk columns of the discussed outcrops in Lower Silesia

1 onkolitic limestones, *2* oolitic limestones, *3* cross-bedded crinoid limestones, *4* calcarenites, *5* micritic limestones, *6* marly limestones, *7* crumpled limestones, *8* slates, *9* samples with *Glomospira densa* (Pantić)

Glomospirella grandis (Salaj)
Glomospirella sp.
Hemigordius sp.
Meandrospira dinarica Kochansky-Devidé & Pantić
Lagenidae gen. et sp. div.

Sample no. 054:
Glomospira densa (Pantić)
Glomospira cf. *densa* (Pantić) — vide Pl. 4, Fig. 4
Glomospira sp.
Glomospirella sp.
Lagenidae gen. et sp. div.

Sample no. 034 (Pl. 4, Figs 5—6):
Glomospira densa (Pantić) — vide Pl. 3, Figs 1—2
Glomospira sp.
Meandrospira dinarica Kochansky-Devidé & Pantić — vide Pl. 4, Figs 1—2
Lagenidae gen. et sp. div.

Sample no. 026:
Glomospira densa (Pantić)
Meandrospira dinarica Kochansky-Devidé & Pantić
Agathammina sp.

Sample no. 04:
Glomospira densa (Pantić) — vide Pl. 3, Fig. 6
Glomospira sp.
Glomospirella cf. *grandis* (Salaj) — vide Pl. 4, Fig. 3
Lagenidae gen. et sp. div.

Stratigraphic position

The occurrence of *Glomospira densa* (Pantić) has been stated (Fig. 2) in the entire profile of the Górażdże Beds and in the top part of the Gogolin Beds (Hauptwellenkalk).

According to earlier workers (*cf.* Assmann & Rauff 1937, Assmann 1944, Senkowiczowa 1962), the boundary between the Pelsonian and the Illyrian runs within the Górażdże Beds, while Kozur (1971) shifts this boundary up to the top of the Karchowice Beds, believing, therefore, that the Lower Muschelkalk of Silesia corresponds to the Hydaspian and Pelsonian only. Due to the fact that *Paraceratites trinodus* (Mojsisovics), an index form of the Illyrian, was found by Assmann & Rauff (1937; *cf.* also Assmann 1944, Senkowiczowa 1972) in the upper part of the Górażdże Beds, this view is groundless, the more so that the conodont *Gondolella excelsa* (Mosher), which appears in the uppermost Pelsonian and persists until the Ladinian (Mosher 1968, Kozur & Mostler 1971, Mock 1971) occurs as early as in the middle part of the Górażdże Beds (*cf.* Zawidzka 1970).

As follows from the facts discussed above, *Glomospira densa* (Pantić) occurs in Lower Silesia in the Pelsonian and the lower part of the Illyrian (*cf.* Fig. 2).

SYSTEMATIC DESCRIPTION

Family **Ammodiscidae** Reuss, 1862
Genus *GLOMOSPIRA* Rzehak, 1885
Glomospira densa (Pantić, 1965)
(Pl. 1, Figs 1, 3*a*, 5, 6*a*, 7*a*; Pl. 3, Figs 1—6)

1965. *Pilammina densa* n. sp.; S. Pantić, pp. 191—192, Pl. 1, Figs 1—2; Pl. 2, Figs 1—9.
1967. *Pilammina densa* Pantić; J. Salaj & *al.*, Pl. 1, Fig. 7.
1967. *Pilammina densa* Pantić; S. Pantić, Pl. 1, Fig. 1.
1968. *Pilammina densa* Pantić; M. Dimitrijević & *al.*, Pl. 2, Fig. E1; Pl. 8, Fig. 5.
1969. *Glomospira* cf. *densa* (Pantić); L. Koehn-Zaninetti, pp. 27—29, Pl. 4, Figs A—C.
1969. *Pilammina* ex gr. *densa* Pantić; M. Gaetani, Pl. 32, Figs 3—4.
1969a. *Pilammina densa* Pantić; J. Salaj, Pl. 2, Fig. 1.
1970. *Glomospira densa* (Pantić); K. Borza, pp. 180—181, Text-figs 2, 3, 5—8.
1970. *Glomospira densa* (Pantić); S. Pantić, Pl. 4, Fig. 8.
1971. *Glomospira densa* (Pantić); A. Baud & *al.*, pp. 80—81, Pl. 1, Figs 1—4.
1971. *Pilammina densa* Pantić; I. Premoli Silva, pp. 325—326, Pl. 21, Figs 1—3; Pl. 22, Figs 3—4.
1971. *Glomospira densa* (Pantić); D. Urošević, Pl. 2, Figs 1, 12.

Remarks. — The species under study belongs to the genus *Glomospira* Rzehak, as shown by Koehn-Zaninetti (1969) and not to *Pilammina* Pantić, as believed by some authors (*cf.* synonymy).

In the Radziątków 5 borehole and in the Lower Silesian forms from the Muschelkalk do not differ in structure from those described and illustrated by other authors (*cf.* synonymy).

Association. — In Poland, the form under study is accompanied by a typical assemblage (*cf.* subchapters "Description of the microfacies'; *also* Pantić 1965, Borza 1970 and Zaninetti & *al.* 1972).

Occurrence. — As given in chapter "Stratipraghic importance of *Glomospira densa*".

STRATIGRAPHIC IMPORTANCE OF *GLOMOSPIRA DENSA* (PANTIĆ)

The species *Glomospira densa* (Pantić) is known from the Anisian only. Some authors, maintaining that this form occurs in the Anisian, do not state precisely its range (Pantić 1965, 1967; Dimitrijević & *al.* 1968). In the profiles described by Dimitrijević & *al.* (1968), this species is, however, cited from the beds assigned to the higher part of the Anisian.

According to some other authors, *G. densa* occurs only in the Upper Anisian (Koehn-Zaninetti 1969, Gaetani 1969, Salaj 1969a, b, Baud & *al.* 1971, Premoli Silva 1971, Zaninetti & *al.* 1972). Salaj (1969a) defined the zone of *Glomospira densa* as including in its vertical range the entire Illyrian of the Western Carpathians. This zone with the same vertical range was found by Premoli Silva (1971) in the region of the Giudicarense Alps. Zaninetti & *al.* (1972) defined the zone of *Glomospira densa* which vertical range was very narrow and restricted to the lower part of the Illyrian only.

Borza (1970) cited this form from the Hydaspian and Illyrian of Western Carpathians. In his opinion, the microfacies with *G. densa,* found within the Hydaspian, comes from the Gutensteinerkalk complex. However, the Gutensteinerkalk facies persists in Slovakia sometimes as long as to the Illyrian (Salaj & *al.* 1967) and usually includes, in addition to the Hydaspian, considerable part of the Pelsonian (*cf.* Bystrický & Biely 1966). It is only in the Slovakian Karst that the Gutensteinerkalk limestones have been assigned only to the Hydaspian on the basis of their occurrence in a profile below the limestones and dolomites containing *Oligoporella pilosa* Pia, which surely represents the Pelsonian (*cf.* Andrusov 1959, Bystrický 1964, Bystrický & Biely 1966). It should also be mentioned that the calcareous algae, on the basis of which the age of overlaying beds was determined by Bystrický (1964), are within the Anisian of a smaller stratigraphic importance that it was believed (Ott 1972). Under such circumstances, Borza's (1970) determination of the age of samples containing *G. densa* as Hydaspian cannot be considered reliable, the more so as they came from a small, isolated outcrop, in which apart from foraminifers none other index fauna has been found. Furthermore, this outcrop is located in the zone of a tectonic loosening between the Scythian shales and the Middle Triassic carbonate rocks, where there occur the only tectonic slabs of the Gutensteinerkalk (*cf.* Bystrický & Biely 1966).

Urošević (1971) separates the Hydaspian in the profile of the Middle Triassic of the Stara Planina Mts on the basis of the appearance of *G. densa,* which is unjustified, the more so as, according to Urošević, the same part of profile also contains the conodonts *Neospathodus kockeli* (Tatge) and *Hindeodella (Metaprioniodus) spengleri* (Huckriede). The former of these conodonts is an index form of the Pelsonian (Kozur 1971, Kozur & Mostler 1972), while the latter appears as late as the Illyrian (Huckriede 1958) and, therefore, they should not appear together. The cause of such a concurrence (the condensation and mixing of fauna, erroneous determination?) cannot be elucidated in the present paper. At any rate, the chances are that the deposits with *G. densa* from the Stara Planina Mts do not belong to the Hydaspian.

The form under study is cited by Pantić (1970) from the Pelsonian of Eastern Serbia. On the basis of the conclusions, which follow from the papers discussed above, we may assume that *Glomospira densa* (Pantić) occurs not only in the Illyrian, but also it appears as early as the Pelsonian.

The fact that in Lower Silesia it also has been found in the Pelsonian allows one to conclude that the zone of Glomospira densa *sensu* Salaj (1969a) and, in particular, *sensu* Zaninetti & *al.* (1972) was based on a partial range of the form *G. densa.* The zone under discussion was, therefore, treated too narrowly and, consequently, it was the merozone

(*Teilzone*). The determination of a full range of of this taxon requires further studies. Only after conducting them it will be possible to settle the zone of *Glomospira densa* as the holozone.

At present, we are only able to prove that the range of *G. densa* includes the Pelsonian and Illyrian in both the epicontinental basin of Poland and the geosynclinal basin. It is likely that this range is, however, somewhat less wide and does not include the lowermost Pelsonian and the uppermost Illyrian.

PALEOGEOGRAPHICAL PROBLEMS

Paleogeographical distribution of Glomospira densa (Pantić)

Glomospira densa (Pantić) has so far been a form known from many areas of the European part of Tethys (Fig. 3). Considering the then distribution of continents (*cf.* Dewey & Bird 1970; Smith 1971; Smith, Briden & Drewry 1973), we may add that the localities in the Dinarides (Pantić 1965, 1967; Dimitrijević & *al.* 1968) in the Pre-Alps (Baud & *al.* 1971), in the Austrian Alps (Koehn-Zaninetti 1969) and in the Slovakian Carpathians (Salaj & *al.* 1967, Salaj 1969, Borza 1970) were situated within the western margin of the Tethys. Despite certain vagueness concerning the stratigraphic range of *G. densa*, it may be shown on the basis of the available data that this stratigraphic range diminishes westwards and appears later and later. This may be indicative of its migration from the east to the west. It is worth stressing that the conodontophorid animals spread then in a similar way (*cf.* Trammer 1972b).

The paleogeographical situation of the localities with *G. densa* in the area of the Stara Planina Mts (Urošević 1971) and which are described in the present paper from the epicontinental basin of Poland is a separate problem. The paleogeographical position of the area of Stara Planina during the Triassic has for a long time been a controversial problem. The facial development, particularly of the Scitian and the Anisian, displays here considerable analogies to the German Triassic, while the presence of the Alpine fauna induces many authors' to include this area in the geosynclinal region. To underscore the transitional character of the Triassic of the area under study, Urošević (1971) suggested to term it a "Carpatho-Balkan type".

The localities described from Poland are situated within the range of the Polish-Danish Trough. The Radziątków borehole (*27* in Fig. 3) is located near the subsidence axis of this trough and penetrates deeper facies. The microfacies containing *G. densa* is developed in this locality in a typical manner. On the other hand, the localities in Lower Silesia occur near the southern margin of the trough in the zone of shallow-water facies. This is indicated by the occurrence of many onkolites, oolites and fossils, primarily algae and corals. Noteworthy is also the abundance of terrigenic material and smaller thickness of the Lower Muschelkalk than in other regions. The onkolitic microfacies in Lower Silesia contains less numerous *G. densa,* which occur as a secondary component of microfacies (*cf.* Pl. 4, Figs 5—6). The environmental conditions were here probably less favorable to the development of *G. densa* than in the Radziątków region. The earlier appearance of *G. densa* in Silesia than in the Alpine area should be underscored as a paleogeographically important character. It indicates that the migration of this species from the Asian part of the Tethys to the Polish-Danish Trough took place earlier than to the area of the Alps, much the same as in the Balkan region.

Glomospira densa found in the area of the epicontinental basin supplies a new index fossil for the purposes of the stratigraphy of the Muschelkalk and its correlation with the Tethyan Triassic. The geographical distribution of *Glomospira densa* is subject to extension and, therefore, the zone it determines may be traced both in the upper part of the Anisian of the Tethys and in the Anisian of at least the eastern part of the epicontinental basin (*cf.* Fig. 3).

Paleogeography of the Lower Muschelkalk

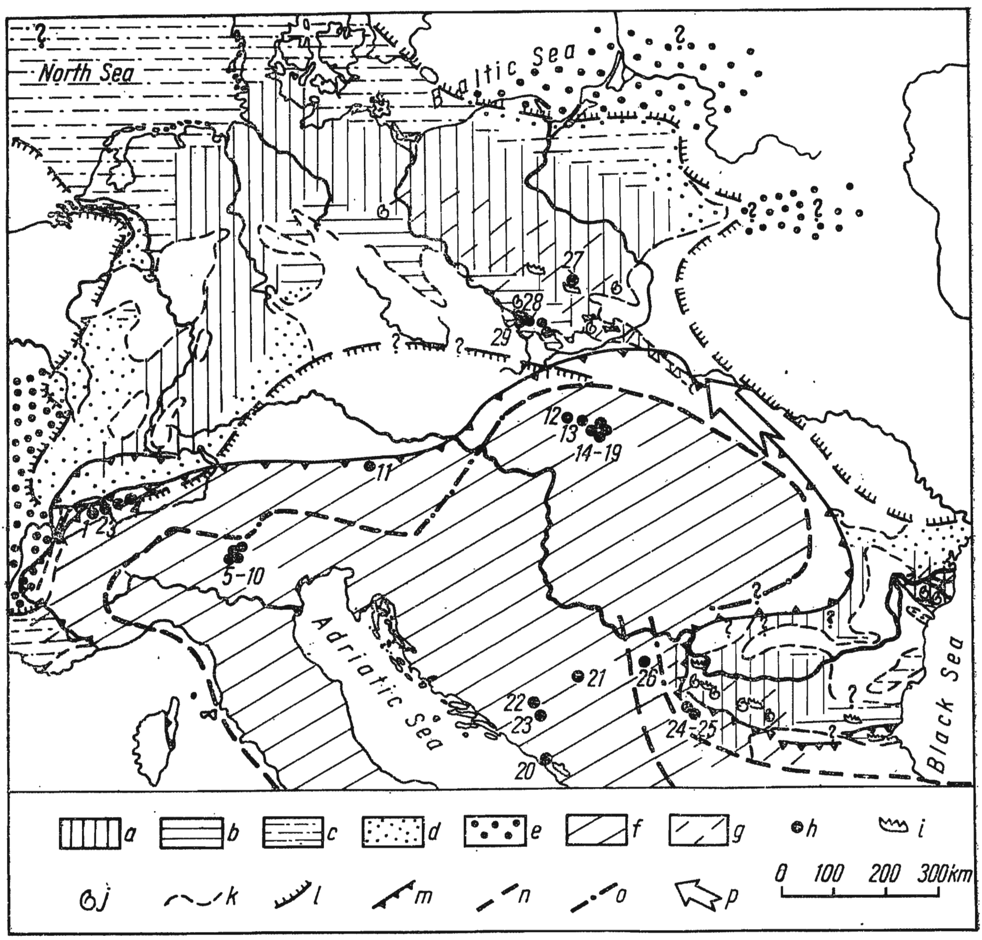
The paleogeography of the Lower Muschelkalk basin has been presented (Fig. 3) on the basis of many works (Brinkmann 1954; Gignoux 1960; Ricour 1962, 1963a, b; Sorgenfrei & Buch 1964; Alexiev & Gnoevaja 1965; Atanasiu & Chiriac 1965; Pătrut & *al.* 1965; Ganev & *al.* 1967; Kent 1967; Rusitzka 1967; Geiger & Hopping 1968; Hinz 1968; Răileanu & *al.* 1968, Rusitzka & Jubitz 1968; Würster 1968; Audley-Charles 1970a, b; Warrington 1970; Wills 1970; Schwarz 1970). As concerns the territory of Poland, in addition to the writers' own observations, the most suitable turned out to be the papers of Senkowiczowa & Szyperko-Śliwczyńska (1961, 1968) and Senkowiczowa & *al.* (1970).

Europe's German basin is developed along two almost perpendicular subsidence axes. In the western part, this is "The Rhine direction" (SSW-NNE) and in the eastern part — the direction of the Polish-Danish Trough (NW-SE). The two lines intersect in the zone of the "Pompecki swell". The marly-calcareous facies, a typical Wellenkalk, predominates along these axes. In the western part, the marly-calcareous deposits pass into sandy formations of the Muschelsandstein, both westwards, in France (*cf.* Ricour 1962, 1963a; Schwarz 1970) and south-eastwards, where a similar facies was formed in Bavaria on the margin of the Vindelician swell (*cf.* Gignoux 1960, Würster 1968, Schwarz 1970). The basin in question was closing in the region of the Jura Mts and their deposits further passed south-westwards and westwards into an inland continental deposits (Brinkmann 1954; Ricour 1962, 1963a; Schwarz 1970). Thus, in the SE

France, there was no connection between the German and the Mediterranean basins and the Provencal basin was independently connected with the Tethys (Ricour 1963b).

To the north, the German basin gradually became shallower in the Anisian and the facies on the territories of the North Sea, Denmark and in the Baltic area turned into clayey-marly ones (Sorgenfrei & Buch 1964, Kent 1967, Rusitzka 1967, Hinz 1968, Würster 1968, Warrington 1970, Wills 1970). There are divergent opinions on whether this basin was connected with the Greenland basin or not. While some authors indicate such a connection (Wills 1970), some others express the opinion that the shore might occur in the region of Dogger Bank (Hinz 1968). At any rate, the German basin had a considerable range in the zone of the North Sea. This fact contradicts some view expressed earlier (Brinkmann 1954, Gignoux 1960, Würster 1968).

In the eastern part of the German basin, Muschelkalk calcareous sediments marked by a considerable thickness were deposited along the



Polish-Danish Trough. In this area, the Muschelkalk displays a very strong Alpine influence which reaches as far as Ruedersdorf near Berlin. Characteristically, in the Polish-Danish Trough deeper facies pass south--westwards into shallow carbonate facies, while there is no belt of clastic deposits analogous to the Muschelsandstein. These deposits were probably situated further to the south on the territory of the present Bohemian Massif, but they probably became eroded in this region mostly as a result of old-Kimmerian movements. The shallowing, the existence of islands in the Silesian area and the complete lack of traces of epicontinental deposits as far as the Pieniny zone of subduction — all these make up evidence that a continental zone of the Vindelician swell stretched at a certain distance to the south of the erosional boundaries of the Silesian Muschelkalk. This view is confirmed by the occurrence of a considerable admixture of clastic material in the Muschelkalk deposits in Silesia.

It is unlikely, therefore, that a separate connection might exist between the German and the Tethyan basin in the region of the Moravian Gate as believed before. The analysis of the thickness of deposits in Central Poland (Kutek & Głazek 1972) and the occurrence of many Alpine faunal elements in this area give ample evidence that such a connection did exist along the Polish-Danish Trough during the older Anisian and

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Fig. 3

Paleogeographic map of the younger Anisian in Central Europe
German basin: *a* intra-basinal limestone-marly facies (Wellenkalk), *b* shallow carbonate facies, *c* shallow silt-marly facies, *d* shallow sandy facies (Muschelsandstein), *e* continental sandy-clayey deposits

f Tethyan region (intrageosynclinal ridges and microcontinents are omitted), *g* strong invasion of Tethyan organisms into the German basin
h referenced localities with *Glomospira densa* (Pantić)

1 Eperon de Nant, France (Baud & al. 1971), *2* Saint-Triphon, Switzerland (Baud & al. 1971), *3* Rocher Plat, Switzerland (Baud & al. 1971), *4* Wirienhorn, Switzerland (Baud & al. 1971), *5* Dosso Alto, Italy (Premoli Silva 1971), *6* Bersone, Italy (Premoli Silva 1971), *7* Pescheira, Italy (Premoli Silva 1971), *8* Val Noera, Italy (Premoli Silva 1971), *9* Stabol Fresco, Italy (Premoli Silva 1971), *10* Lozzolo, Italy (Premoli Silva 1971), *11* Almtal region, Austria (Koehn--Zaninetti 1969), *12* Zámostie, Slovakia (Borza 1970), *13* Muráň Plateau, Slovakia (Salaj & al. 1967), *14* Szarosz-szoba, Slovakia (Salaj 1969), *15* Štit, Slovakia (Salaj 1969), *16* Silická Brezová — Silica, Slovakia (Salaj & al. 1967), *17* Horkai hegy, Slovakia (Salaj & al. 1967), *18* Gemerská Horka, Slovakia (Salaj & al. 1967), *19* Silická Brezová, Slovakia (Borza 1970), *20* Glibovi, Montenegro (Pantić 1965), *21* Tara Mts, Serbia (Pantić 1967), *22* N from Tjentišta, *23* S from Tjentišta, both Bosna and Hercegovina (Dimitrijević & al. 1968), *24* Grdeščica, Serbia (Urošević 1971), *25* Senkos, Serbia (Urošević 1971), *26* Zdrelo anticline, Serbia (Pantić 1970)
27 borehole Radziątków 5, *28* Strzelce Opolskie, *29* Góraždže

i Tethyan conodonts in German basin, *j* Tethyan cephalopods in German basin, *k* erosional limits of Lower Muschelkalk deposits, *l* supposed limits of German basin during the Lower Muschelkalk, *m* margin of Alpine orogenic overthrusts, *n* subduction zones within the Alpine orogen, *o* transform fault, *p* principal route of migration of the Tethyan organisms into the German basin during the Lower Muschelkalk up to the Lower Illyrian. This connection is indicated not only by the presence of the Muschelkalk deposits under the Carpathians in SW Poland, but also by the occurrence in the eastern part of the Carpathians of the Muschelkalk exotics (Uhlig 1908).

The paleogeographical picture outlined above concerns the older Anisian. In the younger Illyrian, hypersaline facies appeared in the German basin. This was evoked by the structural remodelling, which caused the closing of the connection discussed above and opening of another connection in the west through the Burgundian Gate (*cf.* Brinkmann 1954). In the territory of Poland, the Muschelkalk Group pass into the Keuper Group earlier than in the western part of the German basin and included only the lower part of the Ladinian (*cf.* Brinkmann 1954; Trammer 1971, 1972b).

Connections between the German and Tethyan basin

Several fossils widely occurring in the Tethyan deposits, but unknown from Germany have been found in the Lower Muschelkalk of Poland. These were cephalopods (*cf.* Rassmuss 1913; Łuniewski 1923; Assmann 1926, 1944; Assmann & Rauff 1937; Trammer 1972a), conodonts (*cf.* Zawidzka 1970; Trammer 1971, 1972b), in particular *Gondolella navicula* Huckriede and *G. excelsa* (Mosher), as well as diplopores (*e.g.* Assmann 1926) and spores *Globochaete alpina* Lombard (*cf.* Popiel 1967, Zawidzka 1972). It has been recently shown that in the Pelsonian the area of the Holy Cross Mts belonged to the conodont Austro-Alpine province and in the Hydaspian it was nearer the Asian province than the Austro-Alpine and Western-Mediterranean territories (Trammer 1972b).

Recently found foraminifers, in particular *Glomospira densa* (Pantić), *Glomospirella grandis* (Salaj) and *Meandrospira dinarica* Kochansky-Davidé & Pantić are new Tethyan fossils of the Triassic identified in the Lower Muschelkalk of Poland and not known from deposits of the same age in Germany.

All these facts show that the Polish province was in the Lower Muschelkalk closely connected with the Tethys province; the view being in the conformity with those expressed earlier (Samsonowicz 1929, Senkowiczowa 1962).

During the same period, there were no influences of the Tethys province in the west, both in the region of the Burgundian Gate and in Provence (*cf.* Ricour 1962, 1963a, b).

Opposite conditions predominated in the Upper Muschelkalk when a connection existed in the west through the Burgundian Gate, Provence and Western Mediterranean (Brinkmann 1954, Gignoux 1960). The effects of this connection was strongly marked even in the upper part of the Middle Muschelkalk by the presence of diplopores in Lorraine (Laugier 1963).

Geotectonic remarks

It is a fact known for a long time that the Tethyan and German provinces in Europe little differed from each other in the sedimentary conditions in the Scythian and the Anisian. The existence of different organic assemblages within their range is a fundamental element which differs them. The expansion of the Tethyan fauna and flora in Europe took place gradually to the west along the spreading geosynclinal basin. At the same time, such an expansion occurred along the trough stretching from Dobrudja through Poland to Denmark. Previously, Trammer (1972b) described such an expansion of the conodontophorid fauna over the area of Poland. The Tethyan conodonts also occur (*cf.* Fig. 3) in the area of the Moesian Platform and in Dobrudja (*cf.* Budurov 1962, Mirauta 1964, Budurov & Stefanov 1965, Budurov & Kulaksazov 1968). At present, it is obvious that the foraminifers were spread in an identical manner with that of the conodontophorid fauna.

On the basis of these premises and of the previously known occurrence of macrofauna, it is possible to prove that the opening of the basin of the Western Tethys and the trench running from Dobrudja through Poland to Denmark took place simultaneously after the Variscan orogenesis during the older Triassic (Scythian, Anisian). It was during that period that the migration of the Tethyan fauna was marked in Dobrudja and then in Central Poland. We may conclude that the aulacogen developed simultaneously with the opening of the western termination of the Tethys on the SW side of the Tornquist-Teisseyre line. This interpretation seems to be also confirmed by a anomalous ("rift") character of the Earth's crust along this aulacogen: Moho discontinuity at a depth of about 50 km, with the thick high-velocity layer of seismic waves in the interval of 7.2 to 7.8 km/sec in the lower part of the crust (*cf.* Guterch 1968, 1970; Constantinescu & Cornea, *in* Müller 1972).

The triple-point, from which the western part of the Tethys and Danish-Polish-Dobrudjan aulacogen was opening, was situated in the neighborhood of the present Black Sea. The strong Triassic volcanism in Dobrudja (Dzotsenidze 1968) indicates the existence in this region of a "mantle plum" (*cf.* Wilson 1972) which occurred when the aulacogen under study was opened. Another mantle plum existed at that time in the Oslo Graben. During the entire Alpine diastrophic cycle, the Danish-Polish--Dobrudjan aulacogen separated a relatively stable part of the European Platform from the pericratonic basin (*cf.* Bogdanov 1968). Both the area west of the Tornquist-Teisseyre line, determined by Bogdanov (1968) and the Moesian Platform may be treated together as one pericratonic basin. They were separated only as a result of the consumption of a belt of the Earth's crust about 200 to 300 km wide in the Pieniny zone of subduction during the Alpine folding. In the earlier period of the Alpine diastrophic cycle, this belt was a SW margin of the Danish-Polish-Dobrudjan aulacogen. Such an interpretation seems to be confirmed by the occurrence of both the non-metamorphized Silurian deposits in the Moesian Platform (Baltes & Beju 1963) and the non-metamorphized Cambrian deposits in the substrate of the Silesian Coal Basin (Kotas 1973).

The Danish-Polish-Dobrudjan aulacogen under study started to be marked as a narrow zone of a strong subsidence as early as in the Upper Permian and in the Anisian it was already completely flooded by the sea. As an axis of subsidence it was marked over the entire Mesozoic (*cf.* Kutek & Głazek 1972).

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ALPEJSKA MIKROFACJA Z *GLOMOSPIRA DENSA* (PANTIĆ) W WAPIENIU MUSZLOWYM POLSKI I WYNIKAJĄCE KONSEKWENCJE PALEOGEOGRAFICZNE ORAZ GEOTEKTONICZNE

(Streszczenie)

Na obszarze epikontynentalnego (germańskiego) zbiornika triasowego, w wyższej części dolnego wapienia muszlowego (pelson-illyr) na Śląsku Opolskim i w Polsce Środkowej (fig. 1—2) stwierdzono alpejską mikrofację otwornicową z *Glomospira densa* (Pantić). Gatunkowi temu towarzyszą inne tetydzkie otwornice, m. in. *Glomospirella grandis* (Salaj) i *Meandrospira dinarica* Kochansky-Devidé & Pantić. Ponieważ *G. densa* (Pantić) znaleziona została nie tylko w illyrze, lecz także w pelsonie, więc poziom Glomospira densa (zarówno *sensu* Salaj 1969, jak i *sensu* Zaninetti & *al.* 1972 mający obejmować wyłącznie osady illyru) musi ulec rozeszerzeniu. Rozprzestrzenienie geograficzne wskaźnikowego gatunku poziomu, *Glomospira densa* (Pantić), ulega także rozszerzeniu, gdyż występuje on nie tylko w prowincji tetydzkiej, ale również w równowiekowych osadach wschodniej części zbiornika epikontynentalnego. Zestawiając znane dotychczas (fig. 3) stanowiska *G. densa* (Pantić) wskazano na wcześniejsze pojawienie się tej formy na Bałkanach i w Polsce Środkowej niż w Alpach. Zwrócono także uwagę, że jednocześnie z jej rozprzestrzenianiem migrowały z obszaru Tetydy zwierzęta konodontonośne, które do Polski dotarły wcześniej niż na teren Alp (*por.* Trammer 1972b).

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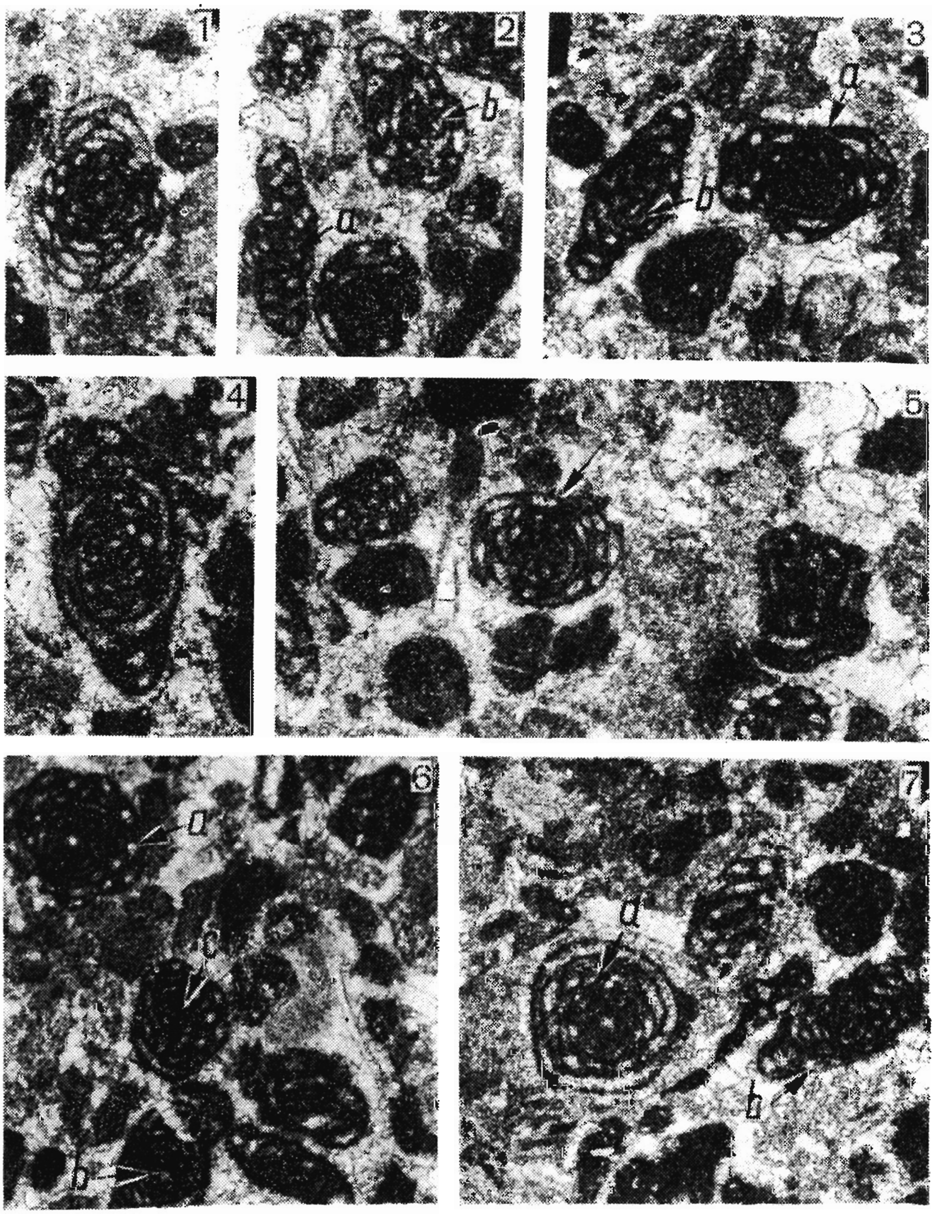


Uppermost Pelsonian — lowermost Illyrian, borehole Radziątków 5 (depth c. 2556.2 m)

1 — *Glomospira densa* (Pantić).

2a — *Glomospirella grandis* (Salaj), 2b — *Glomospira* cf. *densa* (Pantić).

3a — *Glomospira densa* (Pantić), 3b — *Glomospirella grandis* (Salaj).

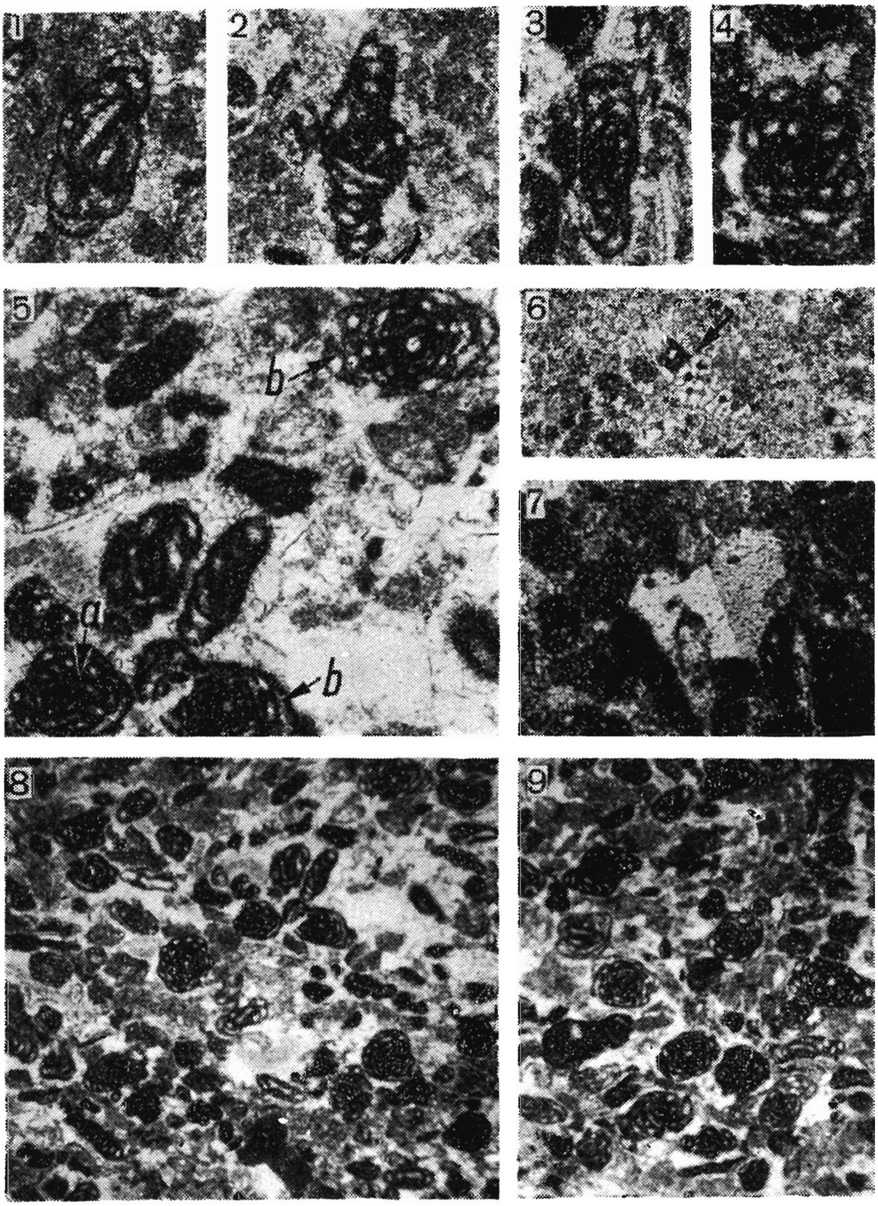
4 — *Glomospirella* cf. *grandis* (Salaj).

5 — *Glomospira densa* (Pantić) — arrowed.

6a — *Glomospira densa* (Pantić), 6b — *G.* cf. *densa* (Pantić), 6c — *G. articulosa* Plummer.

7a — *Glomospira densa* (Pantić), 7b — *Glomospirella grandis* (Salaj).

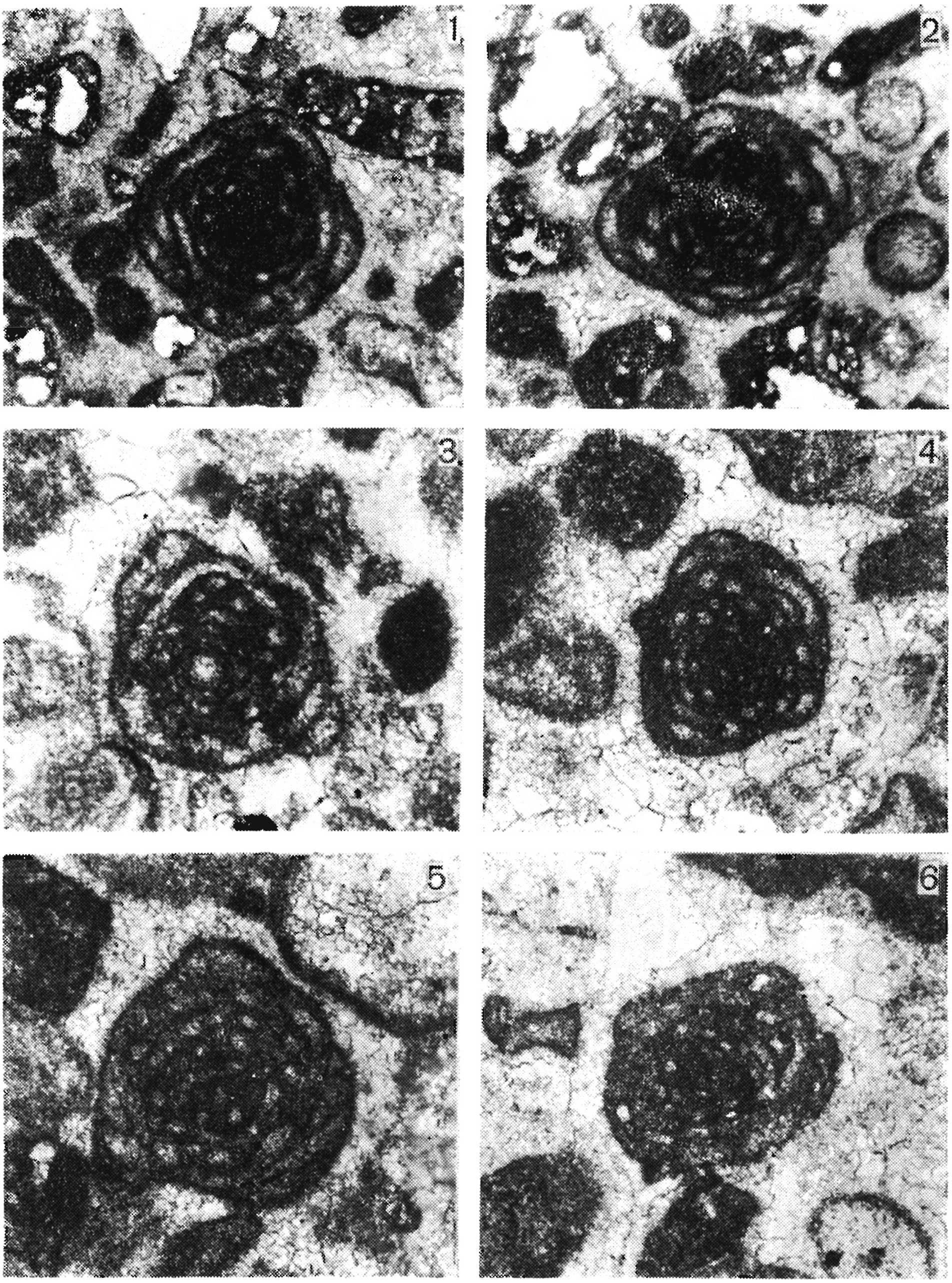
All photos × 50; taken by Dr. J. Głazek



Uppermost Pelsonian — lowermost Illyrian, borehole Radziątków 5 (depth *c.* 2556.2 m)

1 — *Glomospira senensis* Ho.
2 — *Glomospirella grandis* (Salaj).
3 — *Glomospirella* sp.
4 — *Glomospira regularis* Lipina.
5a — *Glomospira articulosa* Plummer, 5b — *G.* cf. *densa* (Pantić).
6 — Assemblage of spores *Globochaete alpina* Lombard; nicols oblique.
7 — Brittle star vertebra; nicols oblique.
8 and 9 — General view of the *Glomospira densa* microfacies.

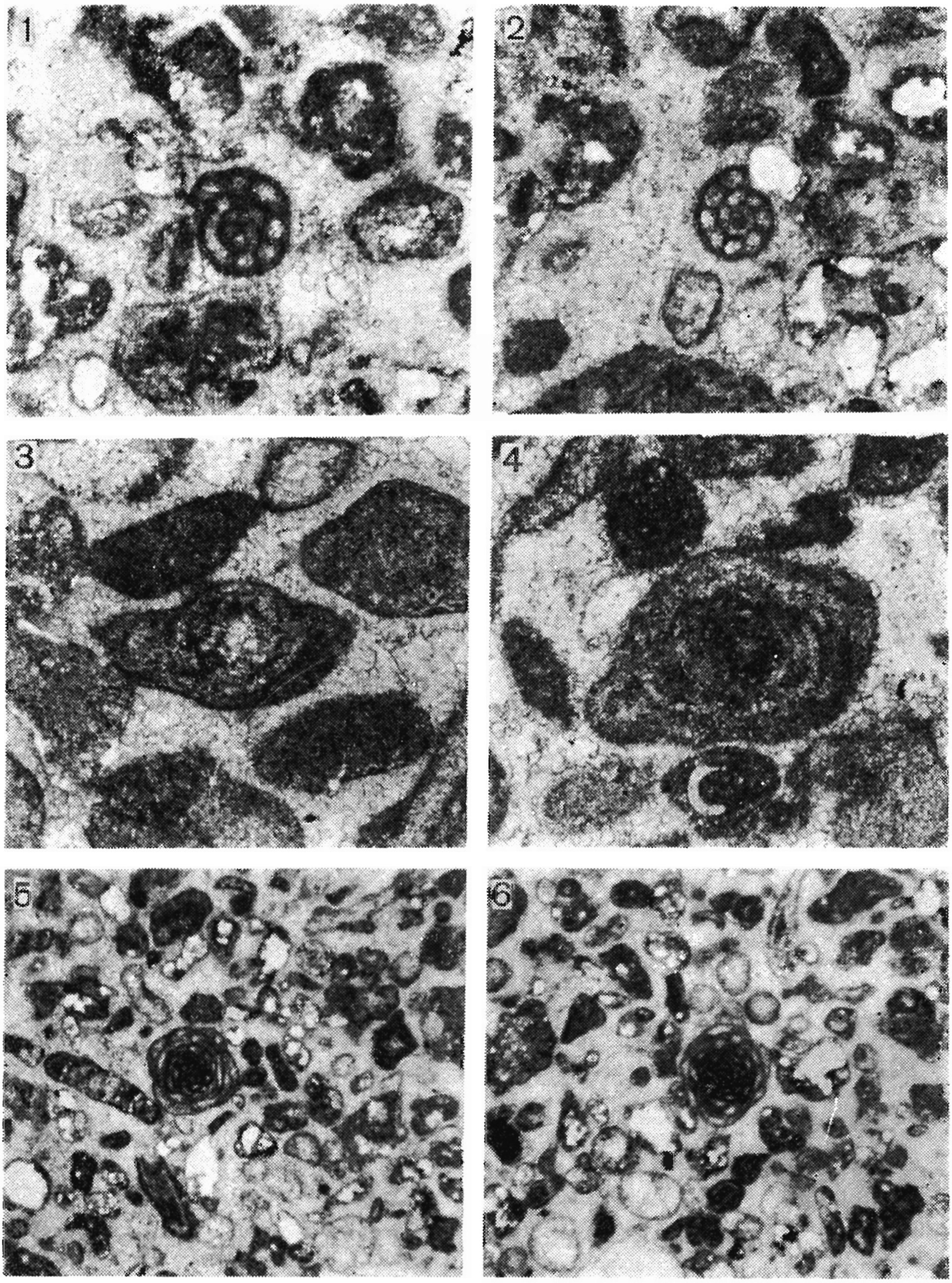
Figs 1—7 × 50, Figs 8—9 × 20
All photos taken by Dr. J. Głazek



Glomospira densa (Pantić) from the Lower Muschelkalk of Lower Silesia

1-2 — Górażdże Beds, Pelsonian, Strzelce Opolskie (sample *034*).
3 — Gogolin Beds, Pelsonian, Górażdże (*0170*).
4-5 — Górażdże Beds, Pelsonian, Górażdże (*70/98*).
6 — Górażdże Beds, Illyrian, Strzelce Opolskie (*04*).

All figures × 50, taken by Dr. J. Głazek; for detail localization see Fig. 2



Microfacies with *Glomospira densa* (Pantić) from the Górażdże Beds (Lower Muschelkalk); Strzelce Opolskie in Lower Silesia

1-2 — *Meandrospira dinarica* Kochansky-Devidé & Pantić; Pelsonian (sample *034*).

3 — *Glomospirella* cf. *grandis* (Salaj); Illyrian (*04*).

4 — *Glomospira* cf. *densa* (Pantić); Pelsonian (*054*).

5-6 — General view of microfacies with *Glomospira densa* (Pantić); Pelsonian (*034*).

Figs 1—4 × 50, Figs 5—6 × 20, taken by Dr. J. Glazek; for detail localization see Fig. 2