A C T A G E O L O G I C A P O L O N I C A

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The present state of the stratigraphy and paleogeography of the Carboniferous in the Holy Cross Mts.

ABSTRACT: Biostratigraphic and lithological bases of the stratigraphic division of the Lower Carboniferous in the Holy Cross Mts. have been given in this work which also discusses the division of the Tournaisian and Visean into biostratigraphic zones and subzones, as well as the problem of the boundary between the Devonian and Carboniferous of this area. The previous division of the Carboniferous of the Holy Cross Mts. elaborated by J. Czarnocki has been revised and extended. The facial-paleogeographical development of the Carboniferous of the Holy Cross Mts. has been presented with reference to adjacent areas (the Nida trough, the west and north-west margins of the Holy Cross Mts.).

INTRODUCTION

The Holy Cross Mts. are one of the three areas in Poland in which the Carboniferous outcrops on the surface and is accessible to geological investigations. Only the Lower Carboniferous (Tournaisian and Visean) is here recorded as a final sediment of the Variscan cycle in this area.

At present, the Carboniferous deposits are preserved only in small, isolated patches found in the central and south-western parts of the Holy Cross Paleozoic massif (figs. 1 and 2). They occur in the cores of synclines overturned to the south and folded mostly in the Variscan orogeny. These deposits are strongly crushed and squeezed (particularly argillaceous ones) and are mostly marked by considerable dips. The contacts of Carboniferous strata varying lithologically (e.g. argillaceous and calcareous ones) are tectonic in character. Due to the intensity of the tectonics of the Paleozoic core of the Holy Cross Mts., the contact between the Carboniferous and superimposed (Permian) series, as well as older (Devonian) deposits is frequently of the tectonic nature and occurs along longitudinal faults. Here and there (e.g. the eastern part of the region), tectonic gaps in the Carboniferous strata are of the order of several hundreds (?) of meters. Along these faults, the Devonian is overthrust

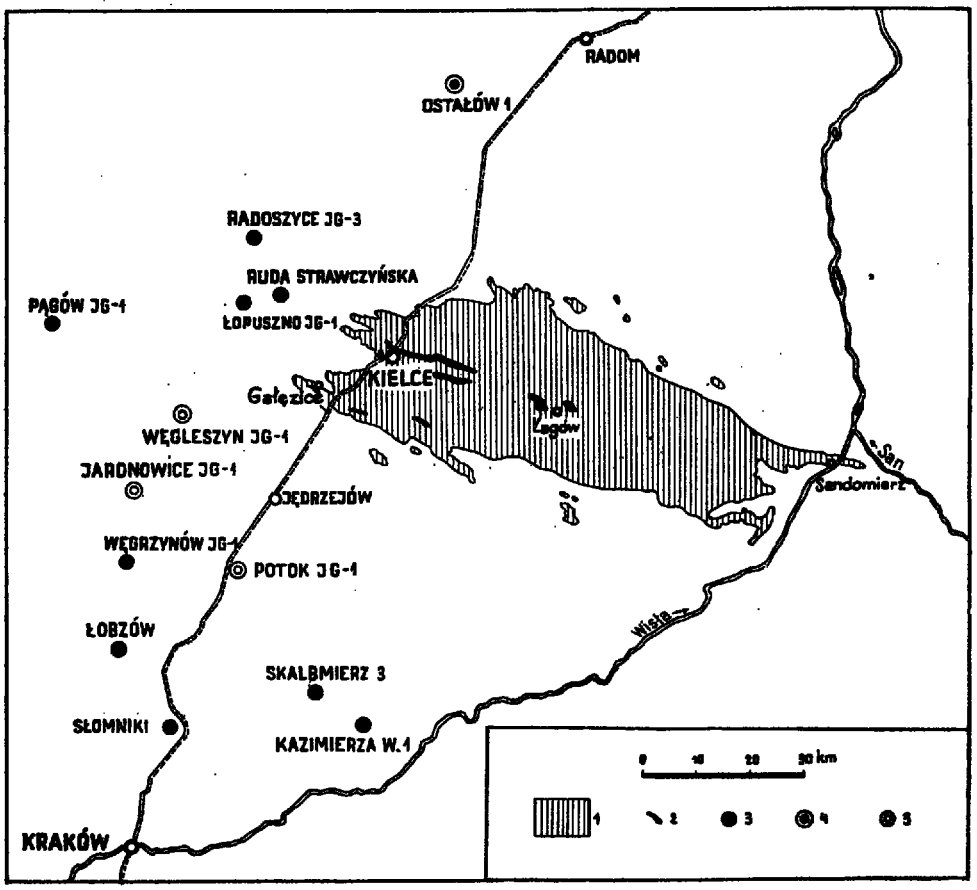


Fig. 1

Sketch map of the areas investigated and adjacent territory in Central Poland

1 Paleozoic massif of the Holy Cross Mts., *2* outcrops of the Lower Carboniferous, *3* boreholes with the Carboniferous underlaying younger formations, *4* a borehole with only the Famennian underlaying the Permian and Mesozoic formations, *5* boreholes in which the Carboniferous and Upper Devonian do not occur under the Permian and Mesozoic formations

on the Carboniferous or the last-named on older deposits. During the younger tectonic movements, the Carboniferous deposits were cut by transversal faults, which divided the outcrop belts of Carboniferous deposits into small horsts and grabens (e.g. in Gałęzice syncline, cf. fig. 3).

The most complete Carboniferous profiles occur in the central part of the Holy Cross Mts. (figs. 1 and 2; Table 1), that is, in Kielce–Łagów synclinorium. Here and there, shortened profiles have been preserved in this unit and in the south-western part of the region, which was caused by tectonic disturbances, or lacunae probably stratigraphic in character, or else by the post-Variscan erosion of sediments.

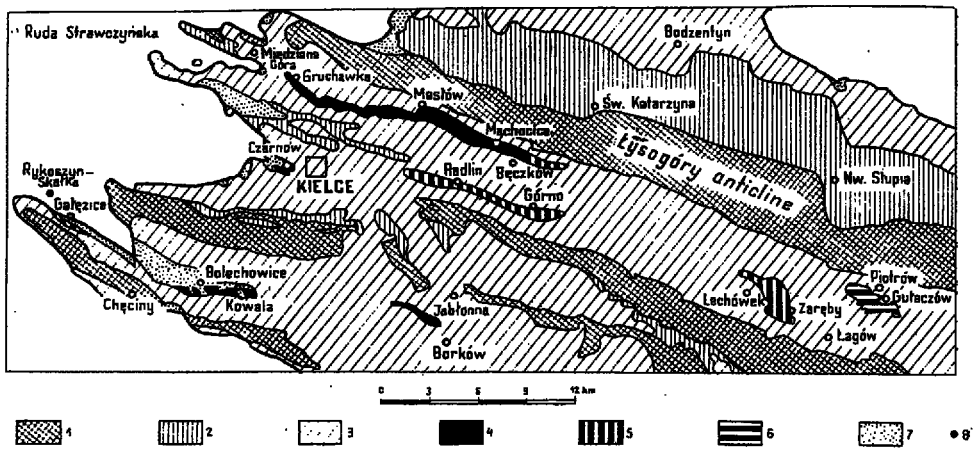


Fig. 2

Sketch map of the Lower Carboniferous in the Paleozoic massif of the Holy Cross Mts.

1 Cambrian, *2* Ordovician and Silurian, *3* Devonian, *4—6* Carboniferous (*4* Tournaisian, *5* Tournaisian and Visean, *6* Visean), *7* Permian, *8* boreholes with the Carboniferous underlying the Permian and Mesozoic formations

The Carboniferous formation in the Holy Cross Mts. was discovered by J. Czarnocki (1916) in Gałęzice syncline (fig. 3). He established a lithological triplicty of the Carboniferous sediments which occur in this syncline north of the Ostrówka Hill (cf. Table 1). This geologist also recognized the Carboniferous in other parts of the region and described the transition of the Devonian into the Carboniferous at Kowala (fig. 2). These observations were published in the form of brief notes (Czarnocki 1924, 1928, 1932, 1933, 1939, 1948; Czarnocki & Sujkowski 1932). Certain information may be also found in J. Czarnocki's archival elaborations concerning shallow boreholes made in Miedziana Góra syncline in 1950 (cf. Żakowa & Pawłowska 1966).

The stratigraphy of the Carboniferous is based in J. Czarnocki's works on lithological characters of deposits, comparisons with the Carboniferous profile of Germany, superposition of rock complexes and, sometimes, the presence of flora (Upper Visean). The transition of the Devonian into Carboniferous at Kowala referred to above was justified by J. Czarnocki only lithologically. The Visean fauna (brachiopods, crinoids, corals, gastropods, trilobites, cephalopods), named in the form of a list, was mentioned by J. Czarnocki (1916) from the limestones of Gałęzice where, according to his assumption, two zones occurred: that "with *Productus sublaevis*" and that "with *Productus giganteus*" (Czarnocki 1922, 1928, 1965). Furthermore, he cited the following species:

Posidonia becheri Bronn (Radlin, environs of Łagów and Rykoszyn-Skałka borehole near Gałęzice — fig. 2), *Glyphioceras striatum* Sow. (Rykoszyn-Skałka borehole), *Glyphioceras* cf. *macrocephalum* Frech (environs of Łagów) and some of the trilobites. In addition, the stratigraphy of the Carboniferous of the environs of Gałęzice and Łagów was presented by J. Czarnocki (1928) in the tabular form.

J. Czarnocki (1916, 1948) divided the Carboniferous on maps into "limestones" and "Culm" or into „C_1" (Culm and part of Upper Famennian), "C_2" (Visean limestones) and "C_3" (shales and graywackes).

Information on the occurrence of the Carboniferous in the easternmost area (Piotrów syncline) was given only in geological maps and in a work by J. Samsonowicz (1926) who mentioned that "clastic deposits with plant detritus" occurred in that region.

It was only in posthumous editions of J. Czarnocki's works that the description of the Carboniferous from the Rykoszyn-Skałka borehole (Czarnocki 1965) was published, as well as his remarks on the possibility of finding the Carboniferous or at least Devonian-Carboniferous transitional layers in the Łysogóry region (Czarnocki 1957). Pebbles of argillaceous-siliceous rocks (with microflora, gastropods and pelecypods) found in the Röth pebbly sandstones north of the Łysogóry range (Samsonowicz 1925, 1926) would be indicative of such a possibility.

The views on the stratigraphy of the Holy Cross Carboniferous, presented above, have been cited in an unchanged form, both in the works on general geology and in those devoted to the Holy Cross Mts. only, up to the 1960s (Kwiatkowski 1959, Pawłowska 1961a, b, Osmólska 1962). Remarks on the petrography of the Carboniferous rocks were given by Z. Sujkowski (1933) who also found microflora and conodonts in the Tournaisian and Visean sediments and radiolarians abundantly occurring in the Culm phosphatic concretions. Information on Lower Carboniferous tuffites in the environs of Łagów was given by S. Małkowski (1954). The Carboniferous drilled in the Radoszyce 3 borehole (fig. 1) was described by S. Kwiatkowski (1957). The fauna, found in the latter borehole, was preliminarily revised by the present writer (Żakowa 1961).

In 1958, as part of the Geological Institute's regular studies, the present writer started a detailed description of individual outcrops of the Carboniferous in the Holy Cross Mts. (Żakowa 1960, 1962a—e, 1967a—c, 1968b; Żakowa & Pawłowska 1961, 1965, 1966; Jurkiewicz & Żakowa 1961, 1965; Freyer & Żakowa 1967; Żakowa & Jurkiewicz 1966; Gromczakiewicz & Żakowa 1968). Until now, the Carboniferous has not yet been revised in Kielce syncline (Czarnów) and in Borków-Jabłonna area (fig. 2 and Table 1). Information on its occurrence in these localities has been taken from J. Czarnocki's (1928, 1948) and H. Osmólska's (1962) works.

Due to the scarcity of outcrops and a considerable overburdening of the Carboniferous by the Quaternary deposits, many excavations

(hundreds of test pits, several scores of trenches) and mining works (a dozen or so shafts, 14 boreholes) were made. Despite all this work, no detailed information could be obtained on the Carboniferous in the northern limbs of the synclines where a larger overburden of the Quaternary deposits (more than 3—4 m) is recorded in particular along the fault zones.

The materials collected so far gave the following results:

1) a recognition of the Carboniferous in the localities so far little investigated such as Piotrów and Miedziana Góra synclines;

2) a cartographical revision of the range of the Carboniferous in all areas investigated except for Bolechowice-Kowala region;

3) a determination of lithostratigraphic profiles and the thickness of sediments which enabled a correction of J. Czarnocki's (1928) stratigraphic table and introduction of a regional lithostratigraphic division;

4) a description of tectonic deformations of the Carboniferous deposits;

5) an investigation of transitional layers between the Devonian and Carboniferous which occur not only in the Kowala profile known to J. Czarnocki (1933), but also in new profiles (Bęczków, Bolechowice) in which biostratigraphic data are the evidence of the continuity of profiles;

6) a faunal documentation of the occurrence of the Tournaisian in various facies and a discovery of fauna in the Lower Visean;

7) an accumulation of interesting collections of the Upper Visean fauna from so far unknown localities (such as, e.g., the uppermost member of the Carboniferous at Gałęzice, Piotrów syncline, Górno graben);

8) a documentation of Pericyclus impressus, Goniatites crenistria and Goniatites granosus zones (the latter of an index importance on all-Poland's scale);

9) a correction of the stratigraphic position of the Carboniferous limestones from Gałęzice;

10) a description of the symptoms of volcanism (pyroclastic rocks) and establishment of their stratigraphic position (Kardymowicz 1961; Żakowa 1962a—d, 1968b; Ryka & Żakowa 1964; Żakowa & Pawłowska 1965, 1966);

11) an elaboration of the petrography of the Carboniferous rocks on the basis of samples localized in the stratigraphic profile (Żakowa 1962a, b, 1967a; Żakowa & Pawłowska 1961, 1965, 1966; Pawłowska 1970);

12) an introduction of microfloristic studies on the Tournaisian and Upper Visean; part of the rich materials collected has already been described by A. Jachowicz (1961, 1962, 1967; Jachowicz & Żakowa 1969), the rest is now, with the present writer's cooperation, being prepared for print; these microfloristic materials were helpful in identifying particular zones of the Tournaisian in the region under study and —

since in the Holy Cross Mts. the microfloristic standards are, on the whole, well correlated with micro- and macrofauna — supplied such standards of the Lower Carboniferous for the correlation of other profiles in Poland;

13) a collection of materials for detailed studies on anthozoans, brachiopods, microfauna and conodonts from the Upper Visean limestones of Gałęzice.

The stratigraphy and paleogeographical development of the Carboniferous in the Holy Cross region, presented below, are based on the present writer's investigations and on the latest works by other authors (also unpublished ones). In addition, the present paper contains an extensive discussion of earlier views on the stratigraphy of the Carboniferous in the Holy Cross Mts.

TRANSITION OF THE DEVONIAN INTO THE CARBONIFEROUS

Investigations have shown that the Famennian deposits in the Holy Cross Mts. pass into the Carboniferous ones. Despite investigating a few continuous profiles, this problem has not, however, been completely explained because of a still insufficient elaboration of the Famennian profiles and tectonic disturbances which, in many places, make an unequivocal interpretation of profiles impossible. Nevertheless, the results obtained so far show that in Poland the best prospects of biostratigraphic studies on the problem of the Strunian occur, in addition to the environs of Cracow, in the Holy Cross Mts.

The Strunian deposits were distinguished on the basis of various factors, such as, the presence of a mixed Devonian-Carboniferous macrofauna (brachiopods, trilobites, pelecypods), the correlation of this fauna with microflora, ostracods and conodonts, as well as of the sedimentary continuity of the deposits.

The Strunian from Gałęzice (cf. figs. 2 and 3; Table 1) is cited in literature on the basis of a work by S. Kwiatkowski (1959) who gave a list of mixed fauna of brachiopods (such as, *Cyrtospirifer tenticulatum* (Murch., Vern. & Keys.), *Spirifer* cf. *strunianus* Goss., *Pugnax pugnus* Mart., *Echinoconchus elegans* (McCoy) and *Dielasma sacculus* Mart.) from Stokóweczka Hill. For lack of a description of fauna which, according to S. Kwiatkowski, was found in a limestone block wedged in the Tournaisian deposits, this problem has not been definitely elucidated. The occurrence of the Strunian in that locality was not, however, confirmed by the present writer's studies which showed that only Permian deposits might be found in the place described by S. Kwiatkowski (1959). The environs of the Besówka Hill, the northern slope of the Ostrówka Hill and maybe also the eastern slope of the Dąbrówka Hill (fig. 3) are, in

the present writer's opinion, the areas in which this problem may be solved within limits of Gałęzice syncline. In the localities mentioned above, the Famennian occurs in the form of narrow lenses wedged in between the Givetian and Tournaisian or Givetian and Upper Visean

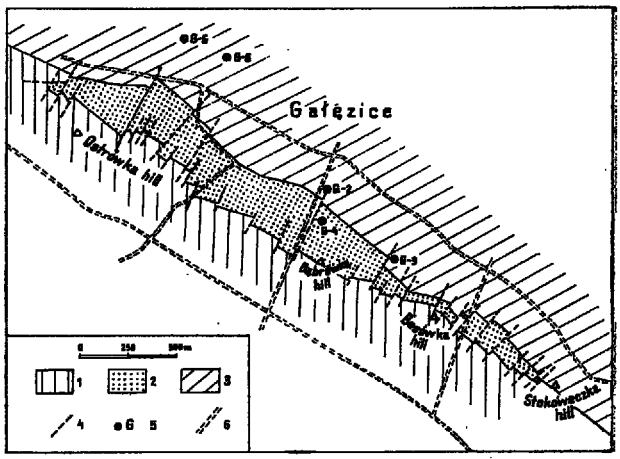


Fig. 3

Sketch map of the Lower Carboniferous in the southern limb of Gałęzice syncline

1 Devonian, 2 Lower Carboniferous, 3 Permian, 4 faults, 5 boreholes with the Lower Carboniferous (not drilled through), 6 roads

deposits. The presence of the Wocklumeria stage has already been stated by J. Czarnocki (1928, 1948) who based this statement on the presence of rich assemblages of clymenias which, however, were never described so far. This view is also confirmed by preliminary studies on ostracods and, recently, conodonts (Wolska 1967), which mark out on the Besówka and Ostrówka hills a zone of Spathognathodus costatus including *S. costatus costatus* (E. R. Branson), *S. aculeatus* (Branson & Mehl), *Polygnathus communis* (Branson & Mehl) and *Palmatolepis gonioclymeniae* Müller. The layers belonging to this zone are contacted tectonically by Tournaisian layers which represent only a higher part of this stage as indicated by microflora, trilobites (Osmólska 1962) and a brachiopod *Orbiculoidea tornacensis* Dem. (cf. Żakowa 1970a).

The area of Bolechowice (fig. 2 and Table 1) is a profile of transitional Devonian–Carboniferous layers best elaborated biostratigraphically, although even in this region not all of the problems have been satisfactorily solved. In this region, materials were obtained from a borehole which, under the Permian, reached and pierced the Tournaisian, the entire Famennian and part of the Frasnian (Żakowa 1967a). Transitional layers are developed as marls with limestone nodules and intercalations of green argillites and bituminous shales (to 20 cm in thickness). Conodonts, whose descriptions from the entire Famennian and part of the Tournaisian profiles are based on samples from rather widely spaced sampling places (Freyer & Żakowa 1967), mark out the Spathognathodus costatus zone, particularly its middle and, as it seems, also upper part (at a depth of 147.5 m) where the presence of *S. costatus ultimus* Bischoff and *Pseu-*

dopolygnathus trigonica Ziegler was discovered (Table 1). The next conodonts were obtained from overlaying layers at a depth of 145.5 m where already Carboniferous species *Siphonodella duplicata* (Branson & Mehl) and *S.* cf. *obsoleta* Hass were found. Pelecypods *Posidonia (Karadjalia) venustiformis* Sad., *P. (Karadjalia)* cf. *venustiformis* Sad. var. *globosa* Sad. and *P. (Karadjalia)* cf. *venusta* Mstr. (characteristic of similar deposits in Kazakhstan), Carboniferous ostracods — *Sansabella* sp., *Aurigerites* sp., as well as microflora of the Devonian type but without *Hymenozonotriletes lepidophytus* Kedo and *H. pusillites* Kedo have been found in an interval assigned to the Strunian (at a depth of 146.0 to 147.5 m). The last named two species mark out a microfloristic biozone of the Strunian determined not long ago in Dinant synclinorium and in the Rhenish Slate Mts. (Owens & Streel 1967, Streel 1967). The Gattendorfia stage is clearly marked out by macrofauna and conodonts above this interval. A complete profile of the Famennian below the separated Strunian was proved primarily by the presence of conodonts. Both the Famennian and the Lower Tournaisian are developed in this borehole in a uniform calcareous-marly facies.

The transition of the Devonian into Carboniferous at Kowala (fig. 2) mentioned by J. Czarnocki (1933, 1939) and based only on lithology, at present may be more accurately explained (Osmólska 1962, Żakowa 1967a, Wolska 1967). J. Czarnocki's suggestion is now confirmed by the lithological correlation of the Kowala profile with the Bolechowice borehole, by the studies on trilobites indicative of the Wocklumeria and Gattendorfia stages and, partly, by the presence of conodonts which mark out the central part of the Spathognathodus costatus zone. The transition at Kowala takes place, much the same as at Bolechowice, in the calcareous-marly facies, except for the position of bituminous shales which so far is not sufficiently explained. According to J. Czarnocki's (1939) last remarks, these shales are supposed to occur in the uppermost Famennian, which may be an equivalent of the entire Strunian as suggested by the presence of conodonts and clymenias (Wolska 1967, Różkowska 1969).

The transition of the Devonian into the Carboniferous, only lithological in character, has been observed in the south-eastern part of Miedziana Góra syncline at Bęczków (Żakowa & Pawłowska 1966), whereas at other points of this unit (Gruchawka, Masłów) the contact of the Devonian with the Carboniferous is of the tectonic nature. The transitional layers at Bęczków (20 m thick) were separated in top part of argillaceous Famennian deposits containing intercalations of marls and limestones with *Posidonia (Karadjalia) venusta* Mstr. The transitional layers are represented by argillaceous deposits with intercalations of shales of the Famennian (clayey and marly shales) or Carboniferous (siliceous shales) character. In addition, they contain lenses of siderites, tuffogenic and argillaceous-tuffogenic shales, tuffites and bentonite clays, all of

them also occurring in the overlaying series which is assigned to the Carboniferous on the basis of microflora.

Famennian-Tournaisian tectonic contacts were recorded at Jabłonna in the region of Borków and in Łagów syncline (Żakowa 1962b, 1970b; Jurkiewicz & Żakowa 1965), which resulted from a different plasticity of the deposits (Famennian — calcareous or marly-calcareous and Tournaisian — siliceous-argillaceous series). Despite these facts, the observations given below are indicative of a continuity of the basin during the period from the Devonian to the Carboniferous.

Trilobites described from the area of Jabłonna (Osmólska 1962) are evidence of the Wocklumeria and Gattendorfia stages. Trilobites of the Wocklumeria stage are also accompanied by cephalopods, brachiopods, corals and, less frequently, pelecypods and gastropods. Except corals (Różkowska 1969) this fauna have not, however, been described so far. Conodonts, including such species as, *Spathognathodus costatus spinulicostatus* (E. R. Branson) and *Palmatolepis gonioclymeniae* Müller mark out the zone of Spathognathodus costatus (Wolska 1967).

In Łagów syncline, the palecypods *Posidonia (Karadjalia)* ex gr. *venustiformis* Sad., characteristic of the Wocklumeria and Gattendorfia stages, occur in contact zones. In the Uppermost Famennian, microflora is of the mixed nature but contains typically Devonian elements (Jachowicz 1967) which do not occur any longer in the products of the maceration of rocks from bottom part of Tournaisian deposits. Despite extensive microfloristic studies, no biozone of lepidophytus have been found in this locality, the same as at Bolechowice, which might be caused by a still insufficient sampling of the Uppermost Famennian. This problem requires continued studies, the more so as the Holy Cross region is a chance of proving the existence of the microfloristic biozone of the Strunian.

To conclude these considerations, it should be mentioned that the presence of the Devonian-Carboniferous transitional layers may be expected, on the basis of geological premises, in Radlin syncline, in the environs of Górno, in Miedziana Góra syncline (near Mąchocice) and in Kielce syncline (near Czarnów) (cf. Table 1 and fig. 2). The elucidation of this problem in the localities mentioned above requires, however, drilling new boreholes or at least deep shafts.

TOURNAISIAN

Except for the easternmost outcrop (fig. 2 and Table 1), the Tournaisian deposits occur in all areas of the Holy Cross Carboniferous.

The Tournaisian of the Holy Cross Mts. is more varied lithologically and faunally than believed by J. Czarnocki (1924, 1928, 1933, 1948, 1965) and Z. Sujkowski (1933). These authors mentioned only variegated and

mostly black clayey shales, lydites, flints, phosphorite concretions containing radiolarians, tuffogenous material, microflora, conodonts and marls with limestone nodules, trilobites and goniatites. Prior to the publication of H. Osmólska's, A. Jachowicz's and the present writer's works, not a single form of the groups of organisms referred to above, hase ever been described or illustrated (except for certain radiolarians and traces of microflora). At first the deposits from Gałęzice syncline mentioned above were considered by J. Czarnocki (1916) as the Uppermost Famennian (the uppermost Clymenia Beds), but in his later papers he assigned these deposits, along with those from other regions but analogous lithologically to the Tournaisian and — in his stratigraphic table of the Holy Cross Mts. — separated them as "Horizon I" (Czarnocki 1928). On the other hand, on the basis of reviewing petrographical studies, Z. Sujkowski (1933) called these deposits a "radiolarite" or "radiolarian series".

Recently, the Tournaisian has been distinguished on the basis of biostratigraphic data (brachiopods, trilobites, pelecypods, microflora and conodonts). The division of the Tournaisian into the lower (Gattendorfia stage) and upper parts has been made only in the profiles in which index fossils were found enabling such a division. The Gattendorfia stage has been separated on the basis of microflora, conodonts, pelecypods and trilobites, whereas the Upper Tournaisian was determined by brachiopods, microflora, trilobites and, in part, pelecypods. Besides, the division of the Tournaisian has also been based on lithological criteria and, in some profiles, on the occurrence of a transition between Lower Carboniferous sediments and the Famennian. Regional lithostratigraphic names have been introduced for the Tournaisian deposits. Zaręby Beds and Radlin Beds (Table 1) determine various facies of sediments and, consequently, various biotopes. The term Masłów Beds has been introduced for a profile in which the facies of Zaręby and Radlin Beds overlap each other.

Zaręby Beds, first described from Łagów syncline (Żakowa 1962b) where they are developed in the entire profile and are the thickest (Żakowa & Jurkiewicz 1966, Żakowa 1970b), are a predominant type of layers in the Tournaisian of the Holy Cross Mts. Organic remains enable the division of the Tournaisian into the lower and upper part. The lower part, approximately corresponding to the Gattendorfia stage, contains rich assemblages of microflora distinguished as member T_1 (Jachowicz 1967). In this section, such pseudoplanctonic pelecypods as, *Posidonia (Karadjalia) mariannae* Tchern., *P. (Karadjalia) venustiformis* Sad. and *P. (Karadjalia)* cf. *venustiformis* Sad., so far known only from Kazakhstan, have also been found. Their presence would confirm the occurrence of the Lower Tournaisian about 90 m in thickness. They are accompanied by macroflora, remains of trilobites, ostracods with a fairly extensive stratigraphic range, ordinary brachiopods and indeterminate remains of conodonts and goniatites.

In Łagów syncline, the lower part of the Tournaisian is represented by strongly jointed dark-gray and black clayey shales and claystones with many transitions to siliceous shales. This series contains many intercalations of tuffogeneous material. It also contains intercalations of pyroclastic rocks of the type of porphyry or quartz keratophyry (tuffs, tuffites) not subject to a longer transportation but mostly strongly washed (Kardymowicz 1961, Pawłowska 1970). In addition, there are also intercalations of bentonites, thin layers of bituminous shales, phosphorite concretions and abundant radiolarians of the groups *Spumellaria* and *Nassellaria*.

In its lower section, the Upper Tournaisian of Łagów syncline is developed analogously as the Lower Tournaisian. It contains microflora, which, according to A. Jachowicz (1967) determines members T_2 and T_3, as well as some forms of *Posidonia (Karadjalia) mariannae* Tchern. (cf. var. *hemicyclia* Sad.), ordinary brachiopods and ostracods, remains of conodonts, macroflora and *?Typhloproetus angustigenalis* Osm. In the upper section of the Upper Tournaisian, there are hard, greenish clayey and siliceous shales abounding in trilobites (Table 1) of the genera *Liobole, Cyrtosymbole, Typhloproetus* and others (Osmólska 1962). *Tornquistia schmiereri* Paeckelm., fragments of other brachiopods and, now and then, the detritus of crinoids may also be found in this section.

A similar thickness is displayed by Zaręby Beds in Miedziana Góra syncline which are marked by more abundant intercalations of shales and benthonic clays but they contain only sporadically occurring organic remains (macro- and microflora) which on the whole are indicative of the Lower Carboniferous. Stratigraphy has been determined as a result of lithological correlations, much the same as in the case of the Carboniferous discovered below the Triassic and Permian in the Ruda Strawczyńska borehole (figs. 1 and 2). The Tournaisian, found in this borehole at a depth of about 822 to 853.7 m, contains siliceous-argillaceous sediments, that is, those of the type of Zaręby Beds devoid of organic remains.

In the south-western part of this region, the Tournaisian, developed like Zaręby Beds, occurs in the region of Gałęzice, Bolechowice and Kowala, where, as mentioned above, these layers represent the Upper Tournaisian.

As mentioned in the previous chapter, at Gałęzice, the distinction of the Upper Tournaisian only is based on microflora, brachiopods and trilobites. Although the latter are endemic forms *Liobole zarembiensis* Osm., *Cyrtosymbole (Macrobole) brevispina Osm.*, they characterize the upper part of the Tournaisian in Łagów syncline where it was distinguished on the basis of other factors. The problem of the occurrence of the Gattendorfia stage in this locality remains open to study since the Tournaisian has not been drilled through in the boreholes at Gałęzice and, due to a considerable Quaternary overburden and the presence of barren, weathered sediments (Żakowa 1970a), it could be only insufficiently stu-

died in the outcrops. Intercalations of siderites and fairly thick packets of tuffogenic siltstones are characteristic of the Tournaisian of Gałęzice. The thickness of the Tournaisian given in Table 1 is the maximum one observed in boreholes and outcrops. In the present writer's opinion, the correlation of the Tournaisian of Gałęzice with the Carboniferous of the Rykoszyn-Skałka borehole indicates that the Tournaisian occurs in this borehole at a depth of 487.0 to 509.4 m. These are strongly slickensided, steeply dipping clayey and siliceous shales which contain plant remains only (Czarnocki 1965).

At Bolechowice, this series has been drilled through (about 35 m thick) and revealed a multitude of various siliceous rocks such as, jaspers, hornstones, lydites, radiolarites, etc. which overlapped each other (Żakowa 1967a). The macroscopic distinction of particular varieties was impossible. The presence of the Upper Tournaisian in this locality is indicated by *Cyrtosymbole (Macrobole) brevispina* Osm., *Orbiculoidea* cf. *davreuxiana* (de Kon.) and, partly, *Posidonia (Karadjalia) mariannae* Tchern. var. *hemicyclia* Sad. The microflora, also found there, does not supply any definite stratigraphic premise. Fauna is more numerous in the lower section of the Upper Tournaisian. It is represented by pelecypods (*Posidonia (Karadjalia) mariannae* Tchern., *P. (Karadjalia)* aff. *mariannae* Tchern., *P. (Karadjalia) mariannae* Tchern. var. *hemicyclia* Sad.), indeterminate gastropods and trilobites, as well as conodonts. The latter mark out, with a certain reservation, the cooperi-isosticha zone (= upper part of the Siphonodella crenulata zone) which corresponds to the lowermost part of the Pericyclus stage, that is, the bottom section of the Upper Tournaisian (Freyer & Żakowa 1967). In the nearby Kowala, Zaręby Beds have been distinguished only on the basis of J. Czarnocki's (1933) lithological description and the present writer's field observations but their thickness could not be determined accurately.

Siliceous-argillaceous deposits which, as mentioned in the previous chapter, contain trilobites and directly overlay the Uppermost Famennian (Wocklumeria stage) occur in Kielce syncline (environs of Czarnów) and in the region of Borków (at Jabłonna). At Jabłonna, the presence of trilobites is indicative of the Gattendorfia stage. In the vicinities of Czarnów (Osmólska 1962), these are endemic forms, Carboniferous in character, such as *Cyrtosymbole (? Macrobole) differtigena* Osm. and *C. (Mirabole) kielanae* Osm. The deposits of this type also seem to belong to Zaręby Beds. For lack of more accurate descriptions, their thickness has not been determined so far.

A different development of the Tournaisian is represented by Radlin Beds which have been found in the central part of the region, in Radlin syncline, in the environs of Górno (first described, on the basis of borehole materials, by H. Żakowa and J. Pawłowska in 1961) and at Bolechowice and Kowala in the south-western part of the region. In regard to

lithology, this is a calcareous-marly series (marly shales with intercalations of marls and limestones or marls with calcareous nodules and intercalations of marly claystones). The Tournaisian age of this series is determined by macrofauna and conodonts, but it is not at all points that such a determination is unequivocal.

Argentiproductus decheni (Paeckelm.), *Eomartiniopsis* cf. *elongata* Sok. and *Semenewia* sp. have been found in the central part of the region in Radlin Beds of Górno; the latter species being very similar to the Strunian and Tournaisian forms which occur in the Rhenish Slate Mts. This fauna is accompanied by indeterminable remains of other brachiopods and trilobites, as well as by pelecypods of the genera *Posidonia* and *Parallelodon*. The Tournaisian has not been drilled through in this locality, the same as in Radlin syncline where only *Semenewia* sp., indeterminate brachiopods and pelecypods of the genera *Parallelodon*, *Posidonia* (?) and *Posidoniella* were found in these deposits. Lithological analogies of the series from Radlin to the documented Tournaisian from Górno enable the comparisons of these deposits. A section 12—20 m thick directly underlaying the Lower Visean has been investigated by borings. Probably, only the upper part of the Tournaisian is represented in this section which, however, does not result from the fauna cited. As seen from geological data, a total thickness of the Tournaisian amounts to about 100 m and the remaining part of the Tournaisian may not differ lithologically from that examined by means of borings.

At Bolechowice, only the Gattendorfia stage, determined in this locality by the assemblage of pseudoplanctonic pelecypods, *Posidonia (Karadjalia) mariannae* Tchern., *P. (Karadjalia)* aff. *mariannae* Tchern., *P. (Karadjalia)* cf. *mariannae* Tchern. and *P. (Karadjalia)* cf. *venustiformis* Sad., is developed as the same type as that of Radlin Beds. These pelecypods are accompanied by the remains of indeterminate trilobites and conodonts which are most likely to mark out the Siphonodella triangula inaequalis zone as contain, among other species, *Siphonodella duplicata* (Branson & Mehl) and *S.* cf. *obsoleta* Hass. The thickness of these deposits is very small (about 4.5 m). It is also at Kowala that the Gattendorfia stage is developed in the calcareous-marly facies as is indicated by lithological correlations with the profile at Bolechowice and the occurrence of trilobites (Osmólska 1962). *Cyrtosymbole (Waribole) abruptirhachis* (R. & E. Rich.) is here an index of this stage.

The layers of the same type as Masłów Beds have so far been found only in Miedziana Góra syncline in the Masłów borehole where they were not drilled through (Żakowa & Pawłowska 1966). As follows geological data, the thickness of these deposits may be similar to the maximum thickness of Zaręby Beds. Masłów Beds are of the mixed lithological type and they are marked by the occurrence of deposits known from the profiles of Zaręby and Radlin Beds. They occur in the form of alternately

disposed, strongly slickensided and folded argillaceous rocks, marls, limestones, siliceous and marly shales, tuffites, tuffs and transitions which are difficult to observe both macro- and microscopically. In addition, there occur phosphorite concretions with radiolarians, lenses of siderites, remains of indeterminate brachiopods and straight nautiloids, as well as detritus of macro- and microflora. The floristic material is on the whole indicative of the Tournaisian.

VISEAN

Deposits of the Lower Visean occur only in the central part of the Holy Cross Mts. (fig. 2 and Table 1), that is, in Radlin and Łagów synclines, as well as in the environs of Górno (Żakowa & Pawłowska 1961; Żakowa 1960, 1962b). The presence of these deposits has already been pointed out by J. Czarnocki (1916, 1922, 1928, 1948) who mentioned variegated shales with lenses of limestones and tuffites, as well as with trilobites and pelecypods which he determined on the whole up to the taxonomic rank of genus. However, he assigned these deposits to „Horizon I", that is, to the Tournaisian. It should be recalled that the Lower Visean („the zone with *Productus sublaevis*"), developed in calcareous facies was mentioned by J. Czarnocki (1922, 1928) from Gałęzice.

Analyzing the outcrops at Gałęzice, the present writer has found (Żakowa 1962e) that the Carboniferous profile established by S. Kwiatkowski (1959) on Besówka Hill was incorrect. From that locality S. Kwiatkowski (1959) cited *Plicatifera humerosa* (Sow.) as an index of the Lower Visean (horizon C_2) which he found in the bottom part of what is known as „Carboniferous alternate limestones", overlaying the organodetrital and organogenic limestones whose fauna was indicative of the Upper Visean. As results from the present writer's studies, the „Carboniferous alternate limestones" represent the Lower Zechstein and the overlaying deposits determined by S. Kwiatkowski as a „greywacke series", or the uppermost unit of the Carboniferous of Gałęzice, belong even to the Middle Zechstein. The writer's conclusions, negating the presence of the Lower Visean at Gałęzice, were later confirmed (Czarniecki et al. 1965) by the revision of the form *Plicatifera humerosa* (Sow.) which turned out to be a typical Lower Zechstein species *Horridonia horrida* (Sow.).

Deposits of the Lower Visean in the central part of the Holy Cross region were distinguished on the basis of the sedimentary continuity with the Tournaisian and Upper Visean documented biostratigraphically by lithological correlations and the presence of goniatites. These deposits, described as beds from Górno (Żakowa & Pawłowska 1961, Żakowa 1962b), are developed in the form of black, dark-gray, greenish and gray argillites and clayey shales with a local cherry-colour tint at the bottom. In Łagów syncline, they were examined by test pits which revealed an addi-

tional occurrence, in the lower section of the profiles, of siderites, tuffs and mudstones with sphaerosiderites, macro- and microfauna. The latter is unimportant stratigraphically (Jachowicz 1967), but the macrofauna, consisting on the whole of ordinary brachiopods, gastropods and pelecypods, also contains the form *Pericyclus* cf. *impressus* (de Kon.) which may be indicative of the Lower Visean (Table 1). Certain premises may also be based on the presence of trilobites (Osmólska 1962). Despite the lack of fauna in the deposits assigned to the Lower Visean of Radlin and Górno (discovered by means of borings and test pits), such a stratigraphical position of these deposits seems to be indicated by the lithological correlations with the Lower Visean of Łagów syncline and by their situation between the proved Tournaisian and Upper Visean with the sedimentary continuity which was found in this region.

It should be mentioned that in Piotrów syncline, the unquestionable Upper Visean is underlaid by barren argillaceous shales with indeterminate thickness overthrust, in the southern limb of the syncline, on Famennian deposits (Żakowa & Pawłowska 1965). For lack of evidence, they were only conditionally assigned to the Lower Visean (Table 1).

Next to the Tournaisian, the Upper Visean is among the best proved units of the Carboniferous deposits in the Holy Cross Mts. Except for Kielce syncline and the environs of Bolechowice, Kowala and Borków, they occur in all the remaining Carboniferous outcrops but the most complete profile proved by the evidence of fauna is known only from Gałęzice syncline (fig. 3 and Table 1). The Upper Visean is developed in various facies and hence the stratigraphic correlations are based on various faunal and lithological criteria.

In the central part of the region, J. Czarnocki (1924, 1928, 1948) found black shales with sphaerosiderites, trilobites, pelecypods and goniatites, which he assigned to „zone II — *Pericyclus*" despite the fact that he also cited, from these shales, the presence of *Posidonia becheri* Bronn and *Glyphioceras* cf. *macrocephalum* Frech. He also stated that dark-gray shales with intercalations of greywackes and tuffites and with plant detritus were situated upwards. He assigned them to „zone III — *Glyphioceras*" but added an annotation that the age of these deposits could not be determined.

Recent studies have confirmed the fact that, in Kielce–Łagów synclinorium, the Upper Visean is developed in the form of clastic deposits which are, however, more strongly differentiated lithologically in particular localities of their occurrence. This fact has been emphasized by the introduction of two different regional lithostratigraphic names, that is, Lechówek Beds (Żakowa 1962a) and Gułaczów Beds (Żakowa & Pawłowska 1965). The same index fauna found in bottom sections of Lechówek and Gułaczów beds gives evidence for the synchronism of these facies.

The name of Lechówek Beds was given to a series of strongly folded, gray, dark-gray and black argillites and clayey shales which locally are slightly marly and contain lenses and nodules of clayey siderites and thin intercalations of mudstones (rarely arenaceous ones), siliceous shales and tuffites. The thickness of the latter reaches locally 50 cm. On the other hand, the name of Gułaczów Beds was given to a series of strongly slickensided and locally folded, greenish and dark-gray clayey shales with intercalations of greywacke shales, greywackes and siliceous shales, as well as — in fracture zones — with lydite breccia (Żakowa & Pawłowska 1961) and siliceous-clayey shales. They also contain phosphorite concretions abounding in radiolarians and lenses of siderites. Greywacke layers are more abundant and thicker (to 80 cm) in the upper part of these beds in which already no fauna is recorded. Hieroglyphs (flow marks) and convolute bedding have also been observed in these layers (Piotrów syncline). As indicated by the petrographical composition of greywackes, those of Piotrów syncline were deposited nearer the alimentation area than those from Radlin and Górno. Greywackes are marked by a good state of preservation of feldspar which indicates that they come from not very distant plutonic rocks. Clearly, then, the lack or the presence of greywacke deposits make up the basis for the distinction of Lechówek and Gułaczów beds. The thickness of the Upper Visean deposits in various profiles of the central part of the Holy Cross Mts. has been determined on the basis of general geological data.

The index fauna referred to above, which was found in lower sections of Lechówek and Gułaczów beds, comprises (Table 1): *Goniatites crenistria* Phill., *Nomismoceras vittiger* (Phill.) and *Prolecanites* cf. *serpentinus* (Phill.). This fauna gives evidence for the Goniatites crenistria (Goα) zone whose thickness is difficult to determine. The index fauna is accompanied by pelecypods: *Posidonia becheri* Bronn, *Nuculavus lucinaeformis* (Phill.), *Limipecten dissimilis* (Flem.), *Dunbarella radiata* (Phill.), etc.; brachiopods: *Plicochonetes tricornis* (v. Sem.), etc.; straight nautiloids: *Dolorthoceras kionoideum* Schmidt, *D. striolatum* (v. Meyer) etc.; indeterminate remains of goniatites, trilobites, crinoids and echinoids, as well as plants (Lycopodinae and Equisetinae). The presence of rich assemblages of microflora indicative of the Upper Visean (Jachowicz 1961, 1962) has also been proved in Łagów syncline. In Radlin syncline, no fauna has been found by the present writer, although *Posidonia becheri* Bronn which is an index species of the Upper Visean was cited by J. Czarnocki (1948) from greywacke deposits of Radlin. The assignment of shales and greywackes from Radlin to the Upper Visean is confirmed by the lithological correlations with the Upper Visean profile of the nearby Górno where an index fauna has been found and correlations with Gułaczów Beds of Piotrów syncline.

The upper section of Gułaczów Beds is devoid of fauna and only

locally contains flora, whereas the upper part of Lechówek Beds revealed the *Posidonia becheri* Bronn overlaid by barren clayey shales with intercalations of siliceous shales, arenaceous mudstones and, locally, lenses of clayey siderites. The thickness of the upper part of Gułaczów Beds and Lechówek Beds seems to be approximately the same as that of zone Goα. It may well be that the deposits under study, despite the lack of stratigraphic data, may already represent a higher goniatite zone (Goβ). Clearly, then, the top limit of the Upper Visean of the central part of the Holy Cross Mts. has not so far been sufficiently determined (Table 1).

Also noteworthy is the problem of the occurrence of the Upper Visean in Miedziana Góra syncline where in 1967, during his cartographical field studies P. Filonowicz found at Bęczków fragments of clayey shales with unquestionable specimens of *Posidonia becheri* Bronn and *Nomismoceras vittiger* (Phill.), determined by the present writer. The sequence and thickness of the Upper Visean profile of Bęczków, as well as its relationship to the Tournaisian deposits described in detail from that syncline (Żakowa & Pawłowska 1966) have not been determined until now.

In the south-western part of the Holy Cross Mts., although the Upper Visean occurs only in Gałęzice syncline (figs. 2 and 3; Table 1), it is more interesting lithologically and stratigraphically.

In the environs of Gałęzice, J. Czarnocki (1916) separated limestones with fauna and, although in his papers, such species as, *Productus giganteus* Mart., *Productus latissimus* Sow. and *Glyphioceras sphaericum* (Sow.) were cited from these limestones, he placed them in „zone II — *Pericyclus*" of his stratigraphic table (Czarnocki 1928). An upper complex of the Carboniferous bored below the Lower Triassic and Permian in the Rykoszyn-Skałka borehole (cf. figs. 1 and 2) was considered by J. Czarnocki (1928) to be an equivalent of these limestones. It is clear from the description of this boring (Czarnocki 1965) that the upper complex of the Carboniferous is developed in the form of shales with intercalations of limestones containing flora and fauna (brachiopods, pelecypods, goniatites, nautiloids and crinoids). This fauna, the same as that from Gałęzice limestones, has neither been described nor illustrated. From the Rykoszyn-Skałka borehole J. Czarnocki (1965) cited only *Chonetes hardrensis* Phill., *Posidonia becheri* Bronn and *Glyphioceras striatum* Sow. The latter two forms are indicative of the Upper Visean. Greywacke sandstones and clayey shales with flora, later called by S. Kwiatkowski (1959) by the name of „greywacke series" were distinguished by J. Czarnocki (1916, 1928, 1948) above limestones at Gałęzice. He assigned (Czarnocki 1928) these layers to „zone III — *Glyphioceras*" and compared them with the Culm of Gołonóg (Czarnocki 1916, 1928), but he made it clear that for lack of fauna the age of these deposits was indeterminate and that they might be terrestrial in character.

A list of fauna from Gałęzice limestones was given by S. Kwiat-

kowski (1955, 1959) who, however, described and illustrated only one *Conularia*. This author adopted J. Czarnocki's stratigraphical division of the Carboniferous of Gałęzice syncline. From the discussed limestones H. Osmólska (1967, 1968a, b) described also a few trilobites.

As is clear from recent studies, based on many excavations and boreholes, that the Upper Visean of Gałęzice syncline overlies the Tournaisian and the contact of both series is tectonic in character. A detailed division of the Upper Visean is enabled by index species of brachiopods, corals, goniatites, pelecypods and microfloristic assemblages (Żakowa 1962c—e, 1967b, c, 1968b, 1970a; Jachowicz & Żakowa 1969).

The lower part of the Upper Visean is composed of limestones, laterally intercalated by 2—40 cm thick argillites (data based on borings). These limestones are organodetrital or, less frequently, crystalline, bituminous or marly. Locally, they contain exotic components as, fragments of phosphorite concretions and shales with plant remains (the Tournaisian). Clearly visible banks are formed in limestones by colonial and solitary corals, crinoids and brachiopods. This fauna is accompanied by trilobites, ostracods, foraminifers, conodonts, bryozoans, algae, gastropods, pelecypods, conularia, fish remains, worms and cephalopods. There also occur many index forms of which brachiopods (Table 1) mark out horizons D_2 and D_{2-3}, for instance: *Gigantoproductus giganteus* (Mart.), *G. latissimus* (Sow.), *G.* ex gr. *gigantoides* (Paeckelm.), *Antiquatonia costata* (Sow.), *A. insculpta* (Muir-Wood), *Pugilis pugilis* (Phill.), *Eomarginifera tissingtonensis* (Sibly) and *Striatifera spinifera* (Paeckelm.). Many forms of colonial and solitary corals of the genera *Dibunophyllum, Lithostrotion, Clisiophyllum, Arachnolasma, Palaeosmilia, Koninckophyllum* etc. are according to J. Fedorowski indicative of the Upper Visean. There are also new genera and species. The thickness of limestones in outcrops may reach 50 m (Czarnocki 1916, 1948, estimated it at about 30 m). In boreholes, the greatest thickness of the equivalents of this series amounts to about 11 m. Goniatites, *Nomismoceras* cf. *vittiger* (Phill.) and ex gr. *crenistria*, which are characteristic of the lower part of the Upper Visean, were also found there.

The fact that the overlaying clastic series contains index fossils of the uppermost zone of the Upper Visean, that is, the zone of *Goniatites granosus* (Goγ) gives evidence for the hypothesis that the limestones of Gałęzice are most likely to be an equivalent of the goniatite zones Goα and Goβ. This may be confirmed on the basis of the material from boreholes as the deposits accessible under Quaternary test pits or trenches are strongly weathered and on the whole contain poorly preserved plant remains. It was only in one place that limonitized fragments of fauna have been found by the present writer in a shale directly overlaying limestones (north of Ostrówka Hill). The occurrence of flora in this series was already mentioned by J. Czarnocki (1916), but fauna has only recently

been discovered by the present writer (Żakowa 1962c, d, 1967b, c, 1968b, 1970a). This enabled an ultimate solution of the so far debatable problem of age of the complex described.

Since the clastic series corresponds facially to Lechówek Beds, the same name was adopted for it. In the bottom part, it consists of dark-gray and black argillites with intercalations of siliceous rocks and locally with phosphorite concretions, lenses and intercalations of siderites, tuffites and, rarely, mudstones and sandstones. The pyroclastic material is scattered all over the deposit. Thin intercalations of crinoidal limestones are still observed here and there in the lowermost part. Intercalations of mudstones are more and more numerous topwards. Fairly thick sets of compact sandstones also occur in this place. In the upper part of this series, clayey deposits are locally replaced by arenaceous rocks. A maximum thickness of the clastic series reaches 154 m in boreholes and slightly exceeds 160 m in outcrops.

A lower section of the profile, a 65 m thick, abounds in macrofauna such as, many goniatites, pelecypods, nautiloids, coniconchs and, less frequent, gastropods, brachiopods and trilobites. Near the contact line with limestones, clayey deposits also contain crinoids, bryozoans and, probably, algae. The fauna is accompanied by macro- and microflora which are indicative of the Upper Visean. Above, in a section of the profile up to 43.5 m in thickness, fauna is rarer but flora occurs in abundance (distinct thin layers of a coalified detritus) which is also characteristic of overlaying deposits about 17 m thick and marked by the lack of fauna. The uppermost section of the clastic series (about 8 m thick) which contacts the Permian (with tectonic breccia occurring in the contact place) is devoid of organic remains and mostly cherry-coloured.

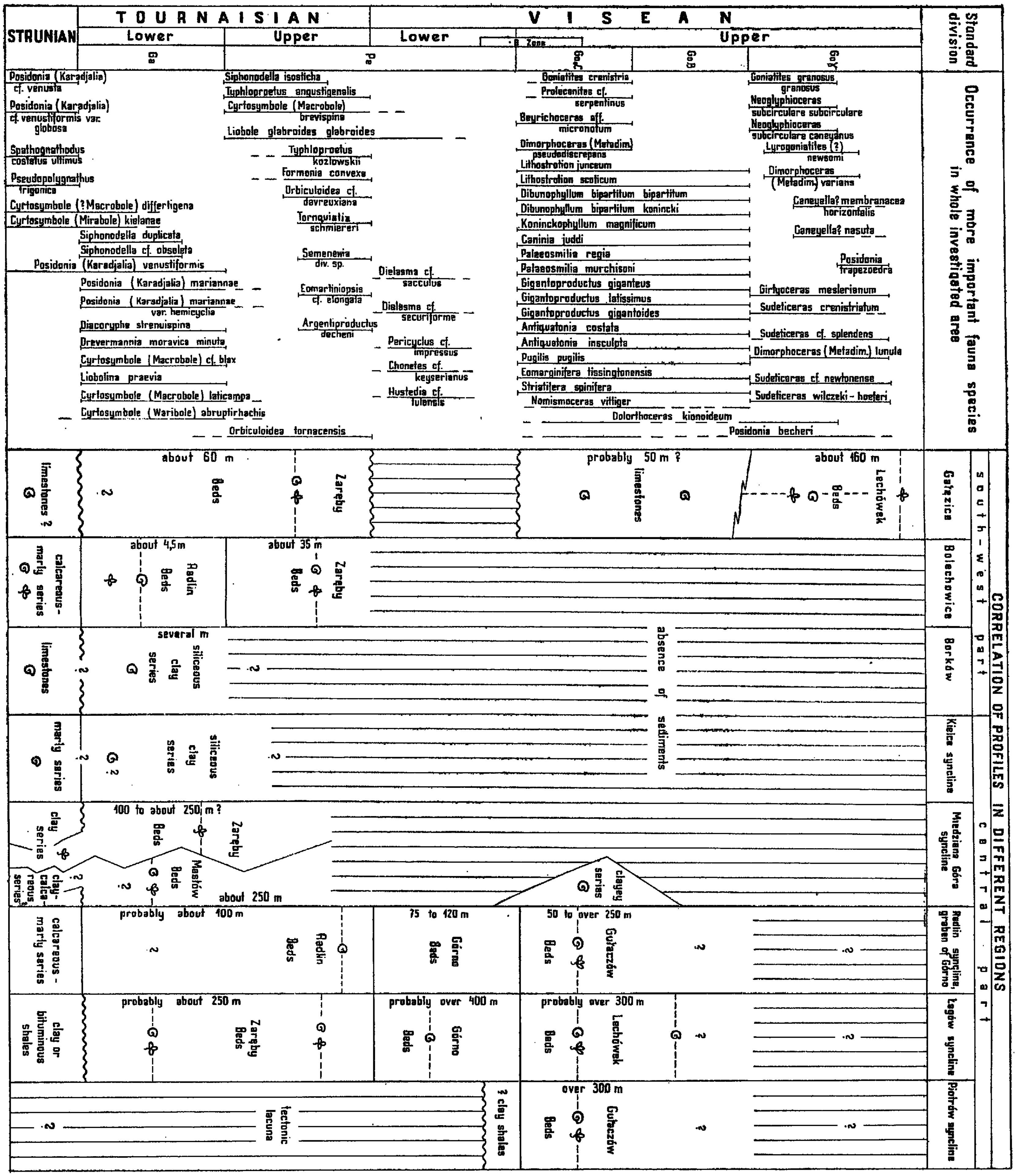
The fossiliferous part of the profile contains index fossils of the Goniatites granosus zone of the genera *Goniatites, Sudeticeras, Neoglyphioceras* and *Lyrogoniatites* (Table 1). They are accompanied by, among other species, *Girtyoceras meslerianum* (Girty), *Dimorphoceras (Metadimorphoceras) lunula* Knopp, *D. (Metadimorphoceras) varians* Moore, *Dolorthoceras kionoideum* Schmidt, *Dol. striolatum* (v. Meyer), *Posidonia becheri* Bronn, *P. trapezoedra* (Rupr.), *Caneyella? membranacea horizontalis* Yates, *C. ?nasuta* Girty, *Pararineceras* cf. *luidi* (Flem.), *Cluthoceras* sp. ?, *Orbiculoidea newberryi marshallensis* (Girty), *O. newberryi ovata* (Girty), *Coleolus* cf. *carbonarius* Dem., *Hyolithes sturi* (v. Kleb.). The lower part of the profile with fauna is marked by the occurrence of *Goniatites granosus* Portl. and *Neoglyphioceras subcirculare caneyanus* (Girty) which are index species of the subzone $Go\gamma_1$ which, consequently, may be separated at Gałęzice. A maximum thickness of this subzone amounts to 25.3 m. Since there are no distinct indices of the subzone $Go\gamma_2$, the rest of the profile with fauna is on the whole assigned to the zone Goγ. It should be mentioned that specimens identified as *Sudeticeras* cf.

splendens (Bisat) and *S.* cf. *newtonense* (Moore) occur in the entire section of the layers with fauna including the subzone $Go\gamma_1$. At Gałęzice, *Sudeticeras crenistiatum* (Bisat) has a similar range resulting in a more extensive stratigraphic range of this fossil which has so far been considered an index of the subzone $Go\gamma_1$. Previously, the latter form was erroneously determined by the present writer as *Goniatites* ex gr. *crenistria* (Phill.) which caused that considerable part of the clastics at Gałęzice was assigned to the Goniatites crenistria zone (Żakowa 1962c, d).

The deposits with flora and the uppermost barren deposits are also assigned to the zone $Go\gamma$ and considered as final sediments of the Lower Carboniferous cycle which were deposited in a gradually shallowing basin. This hypothesis is supported by the lack of pronounced index fossils of the uppermost subzone ($Go\gamma_2$), small thickness of deposits with flora and barren sediments, predominant occurrence of the arenaceous material, unquestionable proofs of the occurrence, at Gałęzice, of the subzone $Go\gamma_1$ only, premises resulting from microfloristic works and correlations with recently described profiles of the zone $Go\gamma$ in Central and Western Europe.

It should be mentioned that preliminary petrographic studies of the clastic series of the Goniatites granosus zone have not confirmed the occurrence of greywacke deposits in this series and, therefore it can be hardly called a „greywacke series". The fact should be also emphasized that both Gałęzice limestone and the overlaying clastic deposits belong to the Upper Visean, the last-named deposits representing only the upper part of this substage, that is, the zone $Go\gamma$.

In the light of the results of the studies on the Carboniferous profile at Gałęzice, it is difficult to determine accurately the age of the upper complex of the Carboniferous in the Rykoszyn-Skałka borehole (according to the present writer's interpretation, at a depth of 453 to 487 m). It may be only roughly estimated as being the Upper Visean. Such a situation results from the lack of a description of fauna and from the loss of collections which precludes any possibility of a revision. The Upper Visean here overlies the Tournaisian with a conspicuous discordance. It may be an equivalent of Gałęzice limestones (a peripheral facies of these limestones, much the same as the deposits found in boreholes at Gałęzice) and, if such is the case, the presence of *Glyphioceras striatum* Sow. in this locality is quite likely. There is also another alternative, according to which the bottom layer of limestone from the Rykoszyn-Skałka borehole might be compared with Gałęzice limestones and the remaining part containing shales with intercalations of limestones — with the lowermost part of the Goniatites granosus zone from the area of Gałęzice which also contains calcareous intercalations locally occurring among clayey deposits and which is related lithologically and even faunally. In such an aspect, the occurrence of *Glyphioceras striatum* Sow. at Rykoszyn seems


STRUNIAN
TOURNAISIAN
VISEAN
Lower
Upper
Lower
Upper
B Zone
Ga
Pe
GoB
Standard division
Occurrence of more important fauna species in whole investigated area
Posidonia (Karadjalia) cf. venusta
Posidonia (Karadjalia) cf. venustiformis var. globosa
Spathognathodus costatus ultimus
Pseudopolygnathus trigonica
Cyrtosymbole (?Macrobole) differtigena
Cyrtosymbole (Mirabole) kielanae
Siphonodella duplicata
Siphonodella cf. obsoleta
Posidonia (Karadjalia) venustiformis
Posidonia (Karadjalia) mariannae
Posidonia (Karadjalia) mariannae var. hemicyclia
Diacoryphe strenuispina
Drevermannia moravica minuta
Cyrtosymbole (Macrobole) cf. blax
Liobolina praevia
Cyrtosymbole (Macrobole) laticampa
Cyrtosymbole (Waribole) abruptirhachis
Orbiculoidea tornacensis
Siphonodella isosticha
Typhloproetus angustigenalis
Cyrtosymbole (Macrobole) brevispina
Liobole glabroides glabroides
Typhloproetus kozlowskii
Formonia convexa
Orbiculoidea cf. davreuxiana
Tornquistia schmiereri
Semenewia div. sp.
Eomartiniopsis cf. elongata
Argentiproductus decheni
Dielasma cf. sacculus
Dielasma cf. securiforme
Pericyclus cf. impressus
Chonetes cf. keyserianus
Hustedia cf. tulensis
Goniatites crenistria
Prolecanites cf. serpentinus
Beyrichoceras aff. micronotum
Dimorphoceras (Metadim.) pseudodiscrepans
Lithostrotion junceum
Lithostrotion scoticum
Dibunophyllum bipartitum bipartitum
Dibunophyllum bipartitum konincki
Koninckophyllum magnificum
Caninia juddi
Palaeosmilia regia
Palaeosmilia murchisoni
Gigantoproductus giganteus
Gigantoproductus latissimus
Gigantoproductus gigantoides
Antiquatonia costata
Antiquatonia insculpta
Pugilis pugilis
Eomarginifera tissingtonensis
Striatifera spinifera
Nomismoceras vittiger
Dolorthoceras kionoideum
Goniatites granosus granosus
Neoglyphioceras subcirculare subcirculare
Neoglyphioceras subcirculare caneyanus
Lyrogoniatites (?) newsomi
Dimorphoceras (Metadim.) varians
Caneyella? membranacea horizontalis
Caneyella? nasuta
Posidonia trapezoedra
Girtyoceras meslerianum
Sudeticeras crenistriatum
Sudeticeras cf. splendens
Dimorphoceras (Metadim.) lunula
Sudeticeras cf. newtonense
Sudeticeras wilczeki - hoeferi
Posidonia becheri
CORRELATION OF PROFILES IN DIFFERENT REGIONS
south-west part
central part
Gałęzice
Bolechowice
Borków
Kielce syncline
Miedziana Góra syncline
Radlin syncline, graben of Górno
Łagów syncline
Piotrów syncline
limestones ?
about 60 m
Beds
Zaręby
probably 50 m ?
limestones
about 160 m
Lechówek Beds
calcareous-marly series
about 4,5 m
Radlin Beds
about 35 m
Zaręby Beds
limestones
several m
siliceous clay series
absence of sediments
marly series
siliceous clay series
clay series
400 to about 250 m ?
Zaręby Beds
clay-calcareous series
Masłów Beds
about 250 m
clayey series
calcareous-marly series
probably about 100 m
Radlin Beds
75 to 120 m
Górno Beds
50 to over 250 m
Gułaczów Beds
clay or bituminous shales
probably about 250 m
Zaręby Beds
probably over 100 m
Górno Beds
probably over 300 m
Lechówek Beds
tectonic lacuna
? clay shales
over 300 m
Gułaczów Beds

improbable. Since there is a considerable similarity in the sculpture of some *Glyphioceras* and *Sudeticeras* and since the sudeticerases have not yet been described in 1925—1926 when J. Czarnocki elaborated the profile of the Rykoszyn borehole, it is likely that that was a specimen of the group *Sudeticeras crenistriatum* (Bisat). J. Czarnocki's (1928, 1965) view on the stratigraphic position of the upper complex of the Carboniferous from the Rykoszyn-Skałka borehole should be rectified regardless of these reservations. This complex does not belong to the „zone II — *Pericyclus*" but to the Upper Visean. Even accepting the second alternative, its profile was considerably shortened which probably resulted from the post-Carboniferous erosion, as well as from the tectonic squeezing out of sediments.

The results of studies on the Radoszyce 3 borehole and of recent borings at Łopuszno 1 and Pągów 1 (cf. fig. 1) significantly supplement the data on the development of the Visean in the Holy Cross region.

Carboniferous sediments about 625 m thick and overlaid by the Zechstein have been drilled in the Radoszyce 3 borehole. These are strongly cracked, locally folded sandstones and greywackes intercalated by mudstones and argillites which abound in plant detritus. Goniatites and gastropods have been found only in the middle part of this series (Kwiatkowski 1957) and the revision of goniatites confirmed the hypothesis that this section of deposits belonged to the Goniatites crenistria zone (Żakowa 1961). This fact is proved by the occurrence of the specimens of *Beyrichoceras* aff. *micronotum* (Phill.) and *Dimorphoceras (Metadimorphoceras) pseudodiscrepans* Moore (Table 1). It may well be that clastic deposits overlaying the zone Goα should already be considered as equivalents of the zone Goβ or even Goβ + Goγ. It may be also assumed that the deposits of the last-named subzones are absent in the area of Radoszyce. Most premises induce one to assign the entire Carboniferous of Radoszyce to the Upper Visean. The Carboniferous of Radoszyce has been several times investigated from the viewpoint of the presence of microflora but the results were negative.

In the Łopuszno 1 borehole, clastic deposits of the Upper Visean about 175 m thick have been drilled below the Zechstein. On the basis of a fairly abundant index fauna, which in the lower part of the profile marks out the subzone $Go\gamma_1$ (Żakowa 1969), all these layers were assigned to the Goniatites granosus zone. This macrofauna is accompanied by macro- and microflora. The profile of this Carboniferous is analogous facially to the deposits of the zone Goγ occurring in Gałęzice syncline, that is, to Lechówek Beds distinguished in that locality (Table 1). The analogy is also emphasized by the Goniatites granosus zone which occurs in both areas. The facts discussed above and the lack of the Upper Carboniferous in these areas are evidence of a similar development of

the Carboniferous cycle and of identical environmental conditions that occurred in the uppermost part of the Upper Visean.

Analogous clastic deposits of the Goniatites granosus zone have been drilled below the Mesozoic in the Pągów 1 borehole. However, they contain poorly preserved index goniatites, accompanied by flora.

PALEOGEOGRAPHICAL CONSEQUENCES

On the basis of the results obtained, the development of the Carboniferous cycle in the Holy Cross Mts. may be fairly well and accurately characterized. The sedimentation of the Carboniferous is continuously accompanied by a diastrophic activity of the Variscan cycle manifested by vertical movements, which do not cause intervals in sedimentation except, maybe, in the south-western part of the Holy Cross Region.

In the final stage of the Famennian, the marine environment is marked by facies resembling in character the Lower Famennian. A shallow-water, clayey-calcareous facies covers the most extensive area. A calcareous or calcareous-marly facies, confined to subaqueous elevations, probably running along a west-east line (Bolechowice, Łagów), develops only locally. The effects of a clayey facies, developed further to the north-west of the Holy Cross Mts., are also marked in the region under study in the form of narrow zones entering the area of Kielce–Łagów synclinorium and reaching as far as the environs of Łagów, Kowala and, north of the Holy Cross Mts., the region of Szydłowiec (data from the Ostałów borehole). Locally and periodically, there comes to the formation of almost completely closed, shallow basins with an atrophic environment of sedimentation (bituminous deposits).

As compared with the Strunian, in the Tournaisian, a considerable increase is observed in the range of clastic facies which, in the Upper Tournaisian, covers the entire south-western part of the Holy Cross Mts. Despite the fact that most deposits of this stage are siliceous-clayey ones (Zaręby Beds), the Tournaisian was developed in an epicontinental basin, founded on a stabilized Caledonian substratum. The most shallow-water in character are the deposits of the Gattendorfia stage at Bolechowice, Kowala and Czarnów (?), as well as Radlin Beds in the central part of the region. Their formation is related to subaqueous elevations of the Paleozoic substratum of the Holy Cross Mts. In these directions, an alternation is also observed of calcareous and siliceous-clayey facies which thus form deposits of a mixed type (Masłów Beds). The formation of Zaręby Beds might be also related to the deepening of some parts of the sea (e.g., undulated elevations, transversal depressions). Certain areas of the

basin might be partly isolated from the open sea (dark bituminous deposits). Unfavorable living conditions have been repeatedly observed in both the bottom and surface zones (even pseudoplanctonic pelecypods are lacking).

The character of the Tournaisian biotopes, the arrangement of the facies and their variability in a general west-east and north-south directions are related not only to a variable relief of the sea bottom but also to not very extensive vertical movements of the substratum (Żakowa 1967a) which are of the continuous nature and cannot be strictly dated. The Bretonian phase of movements in the Holy Cross Region was not marked by gaps in the Tournaisian sedimentation or on the Devonian-Carboniferous boundary, as was believed by J. Czarnocki (1928). Changes took then place only in sedimentative environments. They occurred on the Upper-Lower Tournaisian boundary in the southern and at the end of the Tournaisian (e.g., an immigration of the benthonic fauna in the area of Łagów which is evidence of a closer contact with open sea) and at the turn of the Tournaisian to the Visean — in the central part of the region.

In the center of the region, the sea persisted from the Lower to the Upper Visean inclusively. This problem is not completely clear in the south-western part of the region where the Upper Visean directly overlies the Tournaisian (at Gałęzice) and where no Lower Visean is recorded. Since the contact between these series is of the tectonic nature, this may be a secondary phenomenon. Analyzed in the aspect of paleogeographical phenomena that took place in areas adjoining that of Gałęzice in the south-west, the problem of the lack of the Lower Visean seems to be also explainable by the stratigraphic gap.

Since the Carboniferous limestone of the lowermost Upper Visean of Gałęzice was formed in a shallow basin marked by the features characteristic of a reef shelf, the shallowing of the basin in the south-western part of the region, started with the Tournaisian, is related to the final effect of the Bretonic phase of movements. The occurrence of traces of the Tournaisian material in limestones is an evidence of the erosion of these rocks in nearly situated alimentation areas (islands ?). The shallowing of the basin might be accompanied by the elevation of the area of Gałęzice in the Lower Visean which caused a sedimentative gap.

Owing to new borings, considerable paleogeographical changes in the Carboniferous have been recently discovered in the Nida trough. They suggest a supposition that, during the Carboniferous, a fairly extensive land area was situated in the Jędrzejów — Potok — Węgleszyn — Jaronowice region (fig.1) which was an alimentative area (Żakowa 1970a). It was probably one of the sources of coarse-clastic material of conglomerates from the region of Węgrzynów (Żakowa 1968a), recorded in that region in the Lower and in the bottom part of the Upper Visean (Jurkie-

wicz & Żakowa 1969). In that region, the Visean overlies the Famennian. As a result of the intervals in a lively diastrophic activity within the alimentative area referred to above, shallow-water limestones, similar biocenotically to the calcareous facies of Gałęzice and existing at the same time with it (lower part of the Upper Visean), were periodically deposited in the area of Węgrzynów. In the Węgrzynów borehole, a clastic series of the Goniatites granosus zone overlies limestones.

The facts described above are undoubtedly determined by vertical movements also observed in the development of the Carboniferous further to the south in the Nida trough (fig. 1), in the Łobzów-Słomniki area and in the environs of Skalbmierz and Kazimierza (Kicuła & Żakowa 1966). These movements might be of a far-reaching nature and they could exert a direct influence on the extent of the Carboniferous inundation in the south-western part of the Holy Cross Mts. (Gałęzice). In the light of these considerations, the explanation of the absence of the Lower Visean from the area of Gałęzice by the existence of a sedimentary gap is very likely to be correct, the more so as the Carboniferous deposits are also absent from the Jędrzejów-Jaronowice area.

In the Holy Cross Mts., the Upper Visean was developed in various facies. In the lowermost section, that is the Goniatites crenistria zone, deposits determined as Lechówek Beds and abounding in nekton and pseudoplancton (pelecypods) were formed in the axial part of a relatively narrow bay deeply indenting in the "San land". Nearer the shore, only clayey deposits were developed with characteristic greywackes (Gułaczów Beds) and a shallow-water facies of limestones with a rather limited range and conditions favorable for the development of benthonic fauna was deposited only in the south-western part of the region (Gałęzice). During that period, probably only clastic deposits were formed further to the west (Łopuszno and Pągów boreholes) and sediments related to the open sea flysh (according to J. Znosko, 1965, a residual sedimentary furrow) — to the north-west (Radoszyce borehole). The "San land" which bounds these areas in the north and probably also emerged parts of this area of the sea basin (the region of Przedbórz ?) were probably the source of an arenaceous material fairly abundantly deposited in this region.

In the overlaying horizon, that is, the Goniatites striatus zone, the distribution of the facies and the range of sea were not subject to major changes. It was only in the Holy Cross bay east of Gałęzice that an intensified diastrophic activity and a pronounced tendency to shallowing the basin, along with the disappearance of organic remains, were recorded. Assuming that clayey deposits overlaying Goα zone in which *Posidonia becheri* Bronn was still found, represented an equivalent of this zone, a contact with the open sea was possible along the axis of the bay in the

environs of Lechówek. The calcareous facies in the area of Węgrzynów (the Nida basin) was likely to form during that period.

Significant changes in the distribution of the facies, both in the Holy Cross basin and in the area of Węgrzynów, took place at the turn of Goβ to Goγ zones (pre-Sudetic phase ?). Intensifying Variscan movements might cause considerable contraction of the Holy Cross bay in its eastern section and even a regression of the sea (no indices were recorded of Goγ zone, as well as no reliable evidence was here found of the formation of deposits in zone Goβ). In the south-western part of the region and in the area of Węgrzynów, the facies of the Carboniferous limestone disappeared at the turn of Goβ to Goγ zones and was replaced by the clastic sedimentation. In the Goniatites granosus zone of both these areas, there took place a deepening of the basin. At Gałęzice, this change was not sudden as indicated by intercalations of limestones occurring in argillites of the bottom part of this horizon and by palaeoecological data based on gastropods (Gromczakiewicz & Żakowa 1968). In the Holy Cross region, the sea basin in Goγ zone was, however, marked by living conditions on the whole unfavorable, at least in its bottom zone (a not abundant benthos) and by a certain tendency to atrophy manifested by a large quantity of pyrite and dark coloration of sediments. As shown by an abundant and constant inflow of nektonic fauna and a mass occurrence of pseudoplanctonic pelecypods, this basin was, however, in contact with the open sea. At the end of the existence of this horizon, the intensifying orogenic movements caused a gradual shallowing of the basin, supply of a large quantity of the arenaceous material, extinction of fauna, formation of deposits with an allochthonous flora and, subsequently, of barren deposits with which the Lower Carboniferous cycle was ended in the Holy Cross Mts. On the basis of data obtained so far, it seems that further to the west and north-west of Gałęzice, at least in the areas of Łagów, Łopuszno and Radoszyce, the sedimentative cycle is confined within the boundaries of the Lower Carboniferous. Since no fauna of the Goniatites granosus zone has ever been found at Radoszyce, this cycle might even not reach Goγ zone in this area.

In the region of Węgrzynów, in addition to flora, fauna of the Goniatites granosus zone without any distinct changes in the character of deposits, which in the entire section of this horizon are represented by claystones and sandstones with intercalations of mudstones, occurs up to the top of the Carboniferous deposits. For lack of evidence it cannot be stated that the Carboniferous cycle terminates after the Upper Visean, the less so as the Lower Triassic overlies these sediments.

To conclude these considerations, the fact should be emphasized that the lack of upper parts of the Carboniferous, of stratigraphic evidence of the Lower Permian and an unquestionable erosion of the deposits uplifted during the Variscan orogeny do not allow one for dating parti-

cular phases of these orogeny which folded the Holy Cross anticlinorium For this reason, the opinion on a decisive role of the Sudetic phase in Holy Cross region should be considered as incompletely motivated.

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OBECNY STAN STRATYGRAFII I PALEOGEOGRAFII KARBONU W GÓRACH ŚWIĘTOKRZYSKICH

(Streszczenie)

Praca zawiera podsumowanie najnowszych wyników badań stratygraficznych karbonu Gór Świętokrzyskich i obszarów przyległych, a przeprowadzonych przez autorkę samodzielnie, bądź przy współpracy innych badaczy (Żakowa 1960, 1962a—e, 1967a—c, 1970a, b; Żakowa & Pawłowska 1961, 1965, 1966; Żakowa & Jurkiewicz 1966; Gromczakiewicz & Żakowa 1968; Jachowicz & Żakowa 1969). Omawiając poszczególne ogniwa stratygraficzne ustosunkowano się do dotychczasowych opracowań na temat stratygrafii karbonu świętokrzyskiego.

Uzyskanie przez autorkę nowych danych, gromadzonych od 1958 roku, możliwe było dzięki przeprowadzeniu licznych robót ziemnych i wierceń. Zebrany tą drogą materiał pozwolił m.in. na: rozpoznanie karbonu w miejscach dotąd słabo zbadadanych (np. synklina piotrowska i miedzianogórska); kartograficzne skorygowanie zasięgu karbonu we wszystkich zbadanych obszarach (fig. 1—3) z wyjątkiem rejonu Bolechowic — Kowali; ustalenie profilów litologiczno-stratygraficznych, co umożliwiło wprowadzenie regionalnych wydzieleń stratygraficznych (tabl. 1); zbadanie warstw przejściowych między dewonem a karbonem, nie tylko w znanym profilu w Kowali (Czarnocki 1933), lecz także w profilach nowych (Bęczków, Bolechowice); udokumentowanie faunistyczne turneju w różnych facjach i odkrycie fauny w niższym wizenie; zebranie fauny górnego wizenu, z nie znanych dotąd stanowisk (np. najwyższe ogniwo karbonu w Gałęzicach, synklina piotrowska, rów tektoniczny Górna); udokumentowanie poziomów Pericyclus impressus, Goniatites crenistria i Goniatites granosus (ostatni o reperowym znaczeniu w skali ogólnopolskiej); korektę pozycji stratygraficznej wapieni węglowych z Gałęzic. Rozpoczęcie badań mikroflorystycznych turneju i górnego wizenu (Jachowicz 1961, 1962, 1967; Jachowicz & Żakowa 1969) pozwoliło uzyskać podstawowe wzorce mikroflorystyczne dolnego karbonu, istotne dla innych profilów Polski.

W dalszej części pracy przedstawiono konsekwencje paleogeograficzne wynikające z przeprowadzonych szczegółowych badań stratygraficznych, które uwzględniły także dane z wierceń (Żakowa 1961, 1968a, 1969; Kicuła & Żakowa 1966; Jurkiewicz & Żakowa 1969) położonych w sąsiedztwie cokołu paleozoicznego Gór Świętokrzyskich.

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