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The Middle Cambrian of the Klimontów anticlinorium, Holy Cross Mts

ABSTRACT: The geological structure of the Klimontów anticlinorium is composed of Lower Cambrian rocks and also of sandstones of hitherto uncertain age. On the basis of newly found fossils and of lithological and structural criteria these sandstones are assigned to the Middle Cambrian. The analysis of stratigraphy, lithology and tectonics of the Cambrian deposits in the Holy Cross Mts shows, contrary to previous opinions, that no orogenic phase was marked here at the Middle/Upper Cambrian boundary.

INTRODUCTION

The Klimontów anticlinorium, the SE part of the Palaeozoic massif of the Holy Cross Mts, consists almost exclusively of Cambrian rocks and is bordered in the north by younger Palaeozoic deposits of the Kielce-Opatów synclinorium, and in the south and east by marine deposits of the Miocene (Tortonian).

The stratigraphy of the anticlinorium deposits was recognized by Samsonowicz (1918, 1920), who described at first some fossils from greenish siltstones and fine-grained sandstones outcropping in the vicinity of Gierasowice, indicating the Holmia Zone of the Lower Cambrian. Samsonowicz (1959a, b, c, 1960, 1962) continued mapping and collecting fauna for several years. An extensive collection, consisting mainly of trilobites, made possible the subdivision of the Lower Cambrian into the Holmia and Protolenus zones; whereas the Sub-Holmia Zone was distinguished mainly on the basis of lithologic and tectonic criteria. Samsonowicz has also made the uncovered geologic maps of the anticlinorium (1959a, 1960, 1962), marking the extension of particular zones and main structural units. These maps are all the more valuable in that the whole area of the Kli-

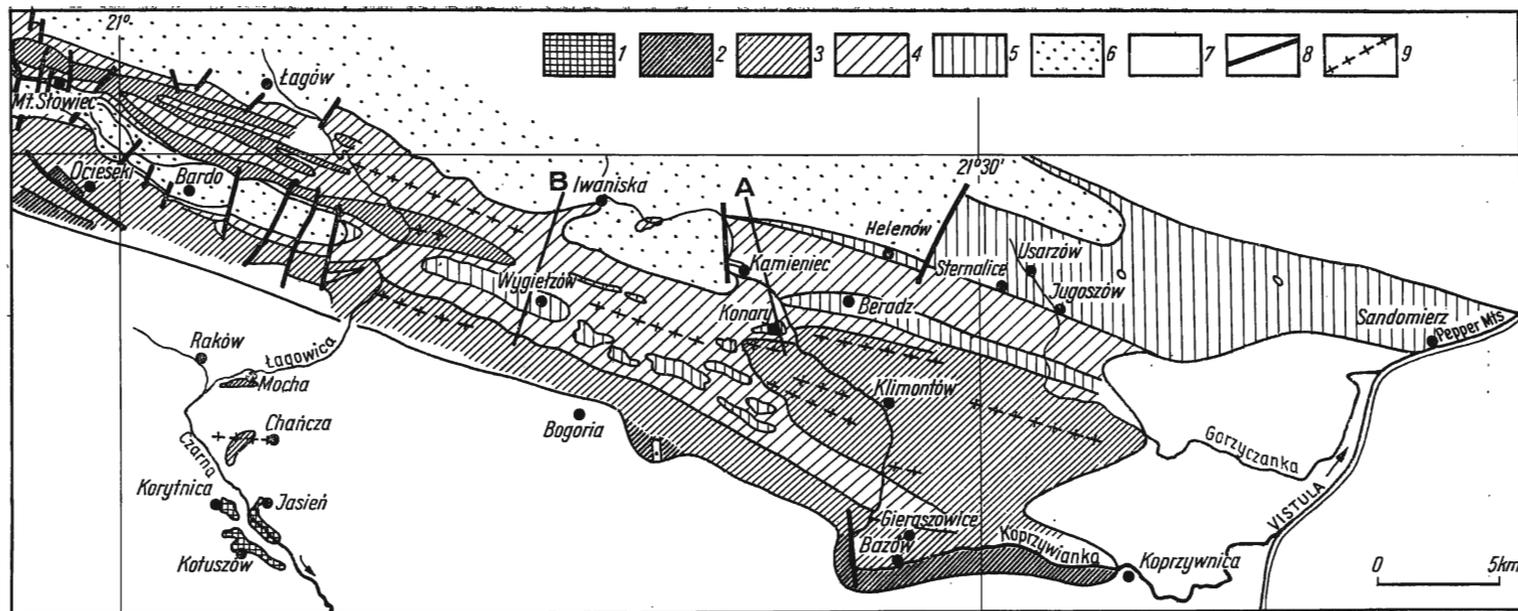


Fig. 1

Geological map of the Klimontów anticlinorium (according to Samsonowicz 1962; completed by the author) and lines of the cross sections presented in Fig. 2

1 Precambrian, 2 Lower Cambrian, Sub-Holmia Zone, 3 Lower Cambrian, Holmia Zone, 4 Lower Cambrian, Protolenus Zone, 5 Middle Cambrian, 6 post-Cambrian Palaeozoic deposits, 7 marine Miocene (Tortonian), 8 faults, 9 anticlinal axes

montów anticlinorium is covered by thick Quaternary deposits, mainly by loess. Outcrops of the Palaeozoic substrate are relatively scarce, lithologic series weakly differentiated and the intense tectonics strongly obscures the geological structure.

The stratigraphy of the Cambrian in the western part of the anticlinorium was studied by Czarnocki (1919, 1927).

The occurrence of the Sub-Holmia Zone was recently confirmed by the discovery of a guide fossil, *Platysolenites antiquissimus* Eichw., in the vicinity of Jasiń (Michniak & Rozanow 1969) and abundant floral and faunal remains in the Bazów borehole (cf. Fig. 1). The most significant forms such as *Sabellidites*, *Pelagiella*, *Hyolithellus*, *Linevitus* and numerous Acritarcha, provides also a rich paleontologic evidence for this zone (Żakowa & Jagielska 1970).

MIDDLE CAMBRIAN DEPOSITS AND THEIR FAUNA

The Cambrian deposits of the Klimontów anticlinorium are folded into several anticlines and synclines (Figs 1 and 2), extending parallel to the longer axis of the anticlinorium (*i.e.* ESE-WNW). The olive or olive-rusty shales and siltstones, assigned to the Lower Cambrian (Sam-

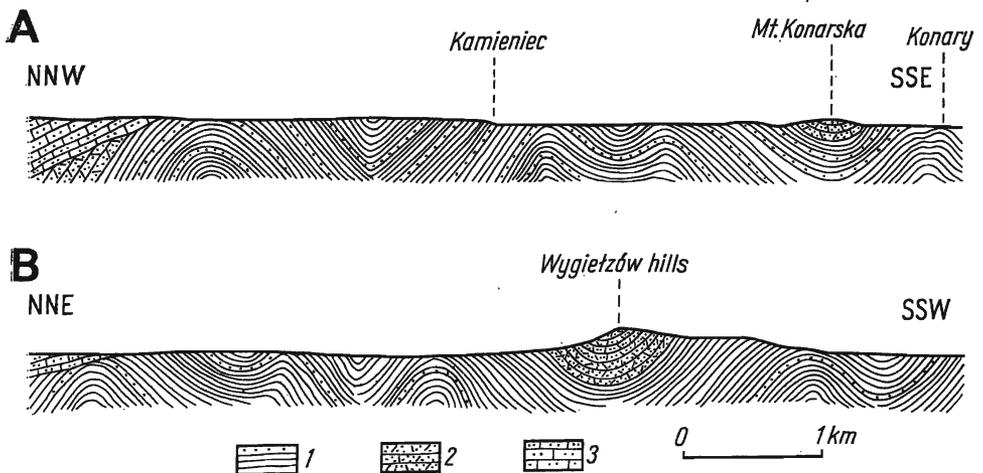


Fig. 2

Geological cross sections through the Klimontów anticlinorium (cf. Fig. 1):

A through Mt. Konarska at Konary

B through the Wygieźów hills at Wygieźów

1 shales and siltstones of the Lower Cambrian, 2 sandstones of the Middle Cambrian, 3 sandstones of the Lower Devonian

sonowicz 1960) are overlaid by lithologically different rocks in synclinal cores. These rocks are represented by various types of sandstones, generally far more resistant to weathering and therefore marked as chains of hills or isolated hills. The Wygiełzów hills, built of the sandstones called *the Wygiełzów sandstones* by Samsonowicz (1960), are the most prominent in morphology (cf. Fig. 2B).

Samsonowicz (1959a, 1960, 1962) was uncertain as to the age of the Wygiełzów sandstones. In one of the papers (Samsonowicz 1960), he assigned them to the Middle Cambrian by analogy to the sandstones exposed at Mt. Słowiec, and on the basis of fauna collected, from which, however, he determined only one genus, *Strenuella*. On the other hand, Samsonowicz (1959a, 1960, 1962) marked the same sandstones as the „supposed Middle Cambrian” on maps, as opposed to the Middle Cambrian with paleontologic evidence.

In the 60's, the Middle Cambrian with abundant fauna was recognized in the area directly adjoining the Klimontów anticlinorium from the north (cf. Fig. 1). Its deposits are perfectly exposed in the Jugoszów-Usarzów section and in the vicinity of Sternalice and Helenów (Orłowski 1964a), i.e. 6—12 km from the Wygiełzów sandstones at Konary, and 13—20 km from the Wygiełzów hills.

The Middle Cambrian age of sandstones outcropping at Mt. Słowiec was confirmed by the revision of rich, mainly trilobite fauna (Orłowski 1964b, 1965).

It follows from the above that the problem of the „supposed” Middle Cambrian in the Klimontów anticlinorium and of the age of the Wygiełzów sandstones should be necessarily resolved. These unsorted sandstones consist exclusively of quartz or contain small clay admixture, the latter sometimes in a form of irregular intercalations. The sandstone layers are commonly 10—20 cm thick, but may attain up to 1 m in thickness; their colour is light-gray, bluish or gray-rusty. The sandstones are of variable hardness, usually very hard, but always harder than underlying shales and siltstones. Strikes of beds are generally latitudinal; dips equal 30—45°. The individual beds are usually strongly fractured and often slickensided, although their folding is less intensive than in the underlying shales and siltstones. The analysis of particular outcrops indicates that the different competence has led here to the formation of some tectonic loosening in the contact zone of these various lithologic complexes.

The faunal remnants, found occasionally in the sandstones, are primarily represented by trilobite fragments, usually too small for identification. The only exception is the outcrop at Konary, situated almost in the central part of the anticlinorium, where the Cambrian sandstones are exposed in the rural quarries situated close to the tops of two hills, north off the village (cf. Fig. 1 and Fig. 2A). Here, under thick loess cover

there are exposed coarse-grained and compact, very hard sandstones, light-gray in colour, with a bluish shade and numerous rusty spots. The sandstones are often intercalated with coarse-grained layers, consisting of quartz grains, 1—2 mm and occasionally up to 5 mm in diameter. In sandstones, pieces and pebbles of greenish or yellowish shales (1—2 cm, occasionally up to 5 cm in diameter) are numerous, but voids after such pebbles of shales are still more frequent. The sandstones are medium- to thick-bedded (20 cm to 1 m in thickness), strongly fractured and slickensided.

The faunal remains are quite frequent in coarse-grained varieties of sandstones at Mt. Konarska; the predominance of trilobite fragments is distinct. Strongly fragmented pleurae, librigenae and cranidia of usually large individuals, most often not attributable to definite species are to be found. Only some 20 specimens were sufficiently preserved for generic or specific identification. They represent cranidia or their large fragments, although poorly preserved; besides, the hyolithids are also present. The list of fossils is as follows (cf. Pl. 1):

Strenuella (Comluella) hupei Orłowski, 1964 — 5 cranidia

Strenuella sp. — 6 cranidia

Kingaspis (Kingaspis) henningsmoeni Orłowski, 1964 — 2 cranidia

?*Ellipsocephalus longus* Orłowski, 1959 — 3 cranidia

?*Paradoxides* sp. — 1 pygidium

Hyolithes sp. — 1 specimen

The above listed faunal assemblage corresponds to that one from the Jugoszów-Usarzów section, assigned to the lower part of the Middle Cambrian, the Oelandicus stage (Orłowski 1964a). The Middle Cambrian of that section is represented by gray, fine- and medium-grained sandstones, intercalated by siltstones and shales. The lowest part of these beds, so called the Jugoszów sandstone, is outcropping to the west of Sternalice and Helenów (cf. Fig. 1).

The Wygiełzów sandstones on the other hand are lithologically very close to the Middle Cambrian sandstones of Mt. Słowiec, where representatives of the genera *Strenuella* and *Ellipsocephalus* are also numerous (Orłowski 1964b, 1965).

The Middle Cambrian of Mt. Słowiec, western part of the Klimontów anticlinorium, is situated at the margin of the Bardo syncline, built of the Ordovician, Silurian and Devonian deposits (cf. Fig. 1). The Bardo syncline wedges out toward the east, which results from the great zone of transversal faults, continuing along the Łagowica river and uplifting the eastern part of the anticlinorium. Therefore, the synclinal structure of the Wygiełzów hills, continuing along the axis of the Bardo syncline, is built up only of the Middle Cambrian deposits.

It therefore appears that besides the lithostratigraphic and tectonic data indicating the occurrence of Middle Cambrian deposits in the Klimontów anticlinorium, there also exist paleontologic data univocally solving the problem of the age of the Wygiełzów sandstones. Probably a further collecting of trilobites will lead to a more precise stratigraphic position of these sandstones.

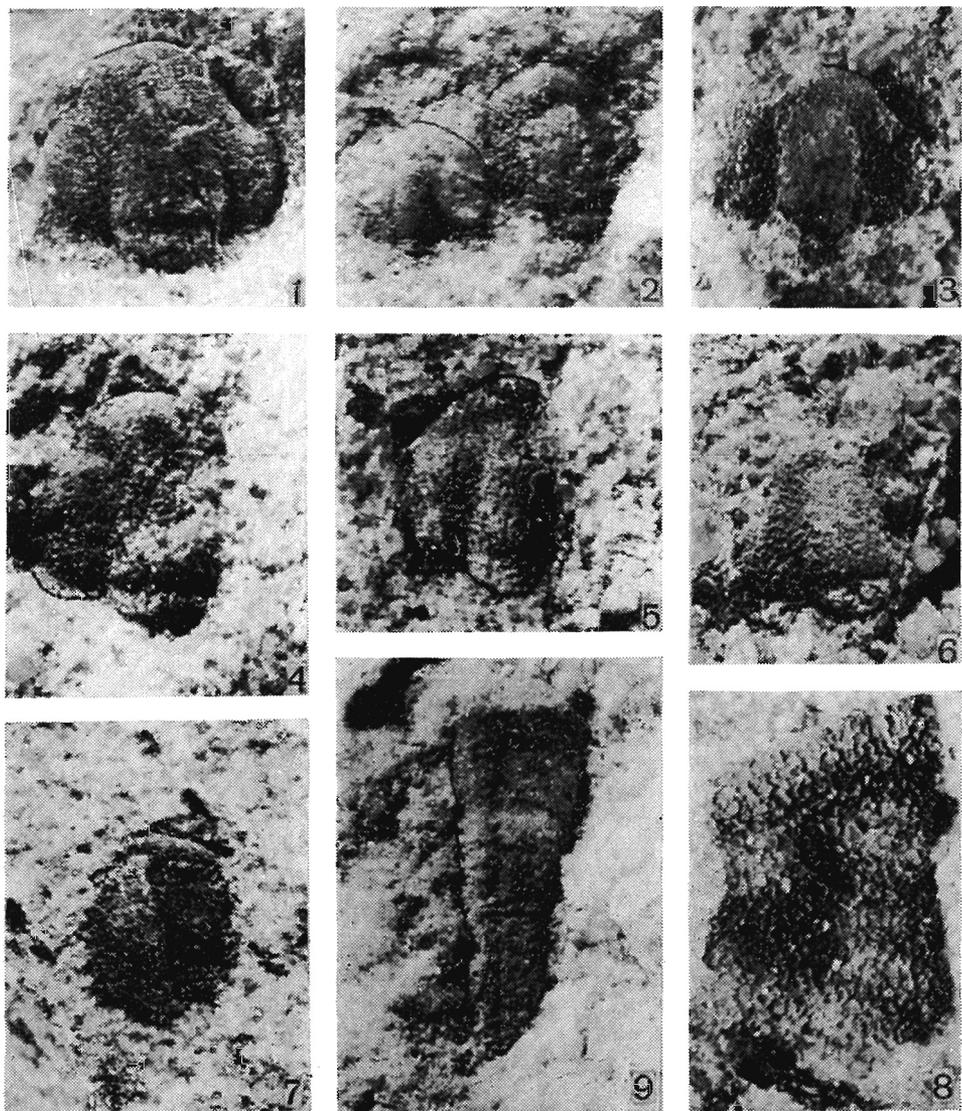
PROBLEM OF THE CAMBRIAN TECTONICS

The tectonics of the Cambrian deposits in the Holy Cross Mts has hitherto been disputable. According to Samsonowicz (1934), the Cambrian sea spread to SE from the Holy Cross Mts, and shallowed toward the land presently buried under the Carpathians; the sedimentation in the basin was interrupted by a notable regression in the uppermost Cambrian (the VIth zone after the Scandinavian subdivision of the Upper Cambrian) and in the lowermost Tremadoc. The stratigraphical gap, corresponding to that regression has been related by Samsonowicz to an orogeny, thought to have folded the Cambrian deposits and uplifted the mountain range, the so-called Sandomierz range. This view was supported by the fact that the Upper Tremadoc conglomerates and sandstones are directly overlying the folded and planated different links of the Cambrian.

Czarnocki (1919, 1950) treated the Cambrian paleogeography of the Holy Cross Mts in a different manner than Samsonowicz did, and accepted the existence of the Łysogóry and Kielce regions characterized by different sedimentary-diastrorphic conditions. The Łysogóry region was thought to be geosynclinal, whereas the Kielce region was considered as a geanticline. The latter, comprising the Klimontów anticlinorium, was characterized by sedimentary discontinuities, development of shallower facies and by high condensation of sedimentary sequences as well. Czarnocki believed that the sea retreated during the Lower and Middle Cambrian junction and returned in the lowermost Ordovician, after the movements of the pre-Ordovician *i.e.* the Kielce orogenic phase (Czarnocki 1950).

The problems of the age and intensity of orogenic movements in the Holy Cross Cambrian was also undertaken by Tomczyk (1964) who claimed the existence of a great unconformity at the Middle/Upper Cambrian boundary in the Łysogóry region (Tomczyk 1964, Fig. 3), resulting from movements of the Holy Cross phase. Tomczyk assigned the age of the Sandomierz phase to the Lower Tremadoc.

According to Pożaryski & Tomczyk (1969), the significance of the Cambrian orogenic movements is far greater; in their scheme of tectonic



1-3 — *Strenuella (Comluella) hupei* Orłowski — four different cranidia.
 4-6 — *?Ellipsocephalus longus* Orłowski — three different cranidia.
 7 — *?Paradoxides* sp. — pygidium.
 8 — *Kingaspis (Kingaspis) henningsmoeni* Orłowski — a half of the cranidium,
 × 2; the specimen from J. Samsonowicz's collection.
 9 — *Hyolithes* sp.

All figures (except Fig. 8) × 3; taken by B. Drozd, M. Sc.

subdivision of Poland, several orogenic and synorogenic phases are distinguished. The Holy Cross phase, according to them was to be manifested in the Holy Cross Mts and in the adjoining areas, in a final stage of the Assynthian geosyncline. This structural substage in the Holy Cross Mts includes the Upper Ryphean, and Lower and Middle Cambrian rocks. The Holy Cross phase was to have acted intensively after the Middle Cambrian. On the other hand, the Upper Cambrian of the Łysogóry anticline, was included into the Taconian cover stage, characterized by tectonic gaps, one of which had corresponded to the Sandomierz phase.

The conclusions of Tomczyk (1964) and Pożaryski & Tomczyk (1969) concerning the tectonics of the Cambrian in the Holy Cross Mts do not seem to take into account the newest stratigraphic, sedimentary and tectonic data. These were Samsonowicz (1959a, b, c, 1960), Bednarczyk, Jurkiewicz & Orłowski (1965) who precised the stratigraphy of the Lower Cambrian, while Orłowski (1964a, b, 1965) documented the complete development of the Middle Cambrian. Moreover, the lithology stratigraphy and tectonics of the Upper Cambrian have been recognized (Orłowski 1968a, b; Orłowski, Radwański & Roniewicz 1970).

As it follows from above, the Lower Cambrian in the Klimontów anticlinorium is overlaid in continuity by the Middle Cambrian sandstones; moreover, both these links have undergone a simultaneous folding. The present geological situation is the effect of a long-spanning erosion and peneplanation removing a large volume of deposits differing in age. The youngest deposits stated in the eastern part of the anticlinorium are dated as the Middle Cambrian, whereas to the west, the Ordovician, Silurian and even Devonian rocks are preserved in the Bardo syncline. In the vicinity of Konary, only the lowermost stage of the Middle Cambrian is represented, whereas the middle one as well has been noted at Mt. Słowiec.

From the north, a wide belt of Middle Cambrian outcrops adjoins the anticlinorium (Fig. 1). The Middle Cambrian deposits from the Jugoszów-Usarzów section, vicinity of Sternalice and Helenów and from the Pepper Mts are the best known (Orłowski 1964a, b). To the north, the younger links appear in succession. The Middle Cambrian from this belt is included into the Kielce-Opatów synclinorium, but owing to tectonic uplift of the eastern part of the synclinorium, the younger deposits have been almost completely removed by subsequent erosion and the Cambrian rocks are covered only by the Quaternary.

Differences in dips and slightly different strikes were recorded in the contact zone of the Lower and Middle Cambrian deposits (Jugoszów, Helenów), where sedimentary and stratigraphic continuity was noted (Orłowski 1964a). These differences may be explained by a different competence of Lower Cambrian shales and siltstones and Middle Cambrian sandstones and siltstones for the activity of tectonic agents.

The contribution of soft, clay dark shales, commonly called the alum shales, increases rapidly in the top parts of the Middle Cambrian. These shales are overlaid in continuity by the Upper Cambrian (Orłowski 1964b, 1968a, b, c; Orłowski, Radwański & Roniewicz 1970). The Upper Cambrian begins with a series of thick-bedded, very hard, quartz sandstones with subordinate intercalations of siltstones and shales, and attains up to 350 m in thickness. These very resistant sandstones form the main elevations of the Łysogóry Range. The sandstones dip monoclinally to the north and are concordantly overlaid by thick series of alternating shales, siltstones and sandstones of the younger Upper Cambrian. The Upper Cambrian of the Łysogóry anticline is transversally faulted into separate structural units.

The clay shales of the Middle Cambrian, underlying the thick series of competent Upper Cambrian sandstones, are strongly disturbed tectonically, but no sedimentary gaps were stated. On the contrary, the shale series bear the sandstone intercalations and there are shaly intercalations in sandstone series, to a variable extent. Particular lithological complexes are distinguished on the basis of the predominant rock type, but the related types of clastic rocks always occur through the Middle/Upper Cambrian boundary. Differences in development of tectonic structures in the Middle Cambrian deposits (soft shales with sandstone intercalations) and in the Upper Cambrian ones (thick-bedded, very hard sandstones) may be easily explained by a different reaction of lithologic complexes on the activity of tectonic movements, with the additional fact, that the shales were a lubricant for competent sandstone masses being translocated to the south during the orogenic movements (Orłowski 1968a).

Neither sedimentary gap, nor sediments confirming the beginning of a new transgression were noted at the Middle/Upper Cambrian boundary along the whole Łysogóry anticline. Some bathymetric changes are noted in the Cambrian sequence, but it is a typical phenomenon in the basin of the miogeosyncline type. Thus, it must be stressed that there is no proof for the orogenic movements at the Middle/Upper Cambrian boundary in the Holy Cross Mts.

It is evident that the Cambrian deposits in the Holy Cross Mts have been folded, and it occurred in a pre-Upper Tremadoc time. It is also evident, that only the Lower and Middle Cambrian deposits occur in the Kielce region, whereas only the Middle and Upper Cambrian ones are present in the Łysogóry region.

The lack of the upper links of the Middle Cambrian and the whole Upper Cambrian in the Klimontów anticlinorium may be easily explained by the erosion activity, which has removed deposits of various age from particular regions. Such changes are marked not only from S to N, but

also from E toward W. For example, the Middle Cambrian occurs in the eastern part of the Kielce-Opatów synclinorium (the Pepper Mts, Jugoszów-Usarzów section), whereas, in the central part of the synclinorium, the borehole near Łagów penetrated into the deposits of the Protolenus Zone of the Lower Cambrian, directly underlying the Devonian rocks (Bednarczyk, Jurkiewicz & Orłowski 1965).

The Palaeozoic massif of the Holy Cross Mts underwent a few orogenic and denudation cycles. The post-Variscan, Permo-Mesozoic cover which was deposited on the whole area of the Holy Cross Mts, has also been completely removed, and it took place early in the Tertiary (Głazek & Kutek 1970).

It finally may be stated that the single pre-Upper Tremadoç orogenic phase accepted, together with other geological agents such as movements of basin bottom and facial changes during the Cambrian period, and erosion of uplifted rock masses after the orogeny, are sufficient for explaining the lithology, stratigraphy and paleogeography of particular members of the Holy Cross Cambrian as well as their tectonics and present distribution.

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S. ORŁOWSKI

KAMBR ŚRODKOWY ANTYKLINORIUM KLIMONTOWSKIEGO

(Streszczenie)

Utwory kambru antyklinorium klimontowskiego (fig. 1) badane były przez J. Samsonowicza (1918, 1920, 1959a, b, c, 1960, 1962), który stwierdził tutaj obecność kambru dolnego, reprezentowanego przez kolejne trzy poziomy: subholmiowy, holmiowy i protolenusowy. W strefach synklijalnych na kambrze dolnym spoczywają (por. fig. 1—2) piaskowce średnio- i gruboziarniste, silnie spękane i bardzo twarde (tzw. piaskowce wygiełzowskie), które w oparciu o kryteria litologiczne J. Samsonowicz (1960) zaliczał warunkowo do kambru środkowego. Na podstawie znalezionej fauny, głównie trylobitów (pl. 1), autor udowadnia środkowokambryjski wiek tych piaskowców i rozpatruje dokładniej ich stosunek do niżej leżących łupków kambru dolnego (fig. 2).

W rozdziale dotyczącym tektoniki kambru Gór Świętokrzyskich zwrócono uwagę, że tektonika ta budziła zawsze żywe zainteresowanie (Czarnocki 1919, 1950; Samsonowicz 1934), przy czym w nowszych pracach (Tomczyk 1964, Pożaryski & Tomczyk 1969) bardzo wyeksponowano rolę fazy orogenicznej zwanej świętokrzyską, a mającej jakoby mieć miejsce na pograniczu kambru środkowego i górnego. Wszystkie jednak opracowania faunistyczno-stratygraficzne (Samsonowicz 1959a, b, c, 1960; Orłowski 1964a, b, 1965, 1968a, b) wskazują wyraźnie, że pomiędzy kambrem środkowym i górnym istnieje tutaj ciągłość sedymentacyjna, a okres fałdowań przypada dopiero na dolny tremadok. Pogląd o obecności ruchów fałdowych na pograniczu kambru środkowego i górnego w Górach Świętokrzyskich musi być zatem stanowczo odrzucony.

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