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New data on geology of the Kamieniec Shale Formation (Lower Cambrian, Holy Cross Mts)

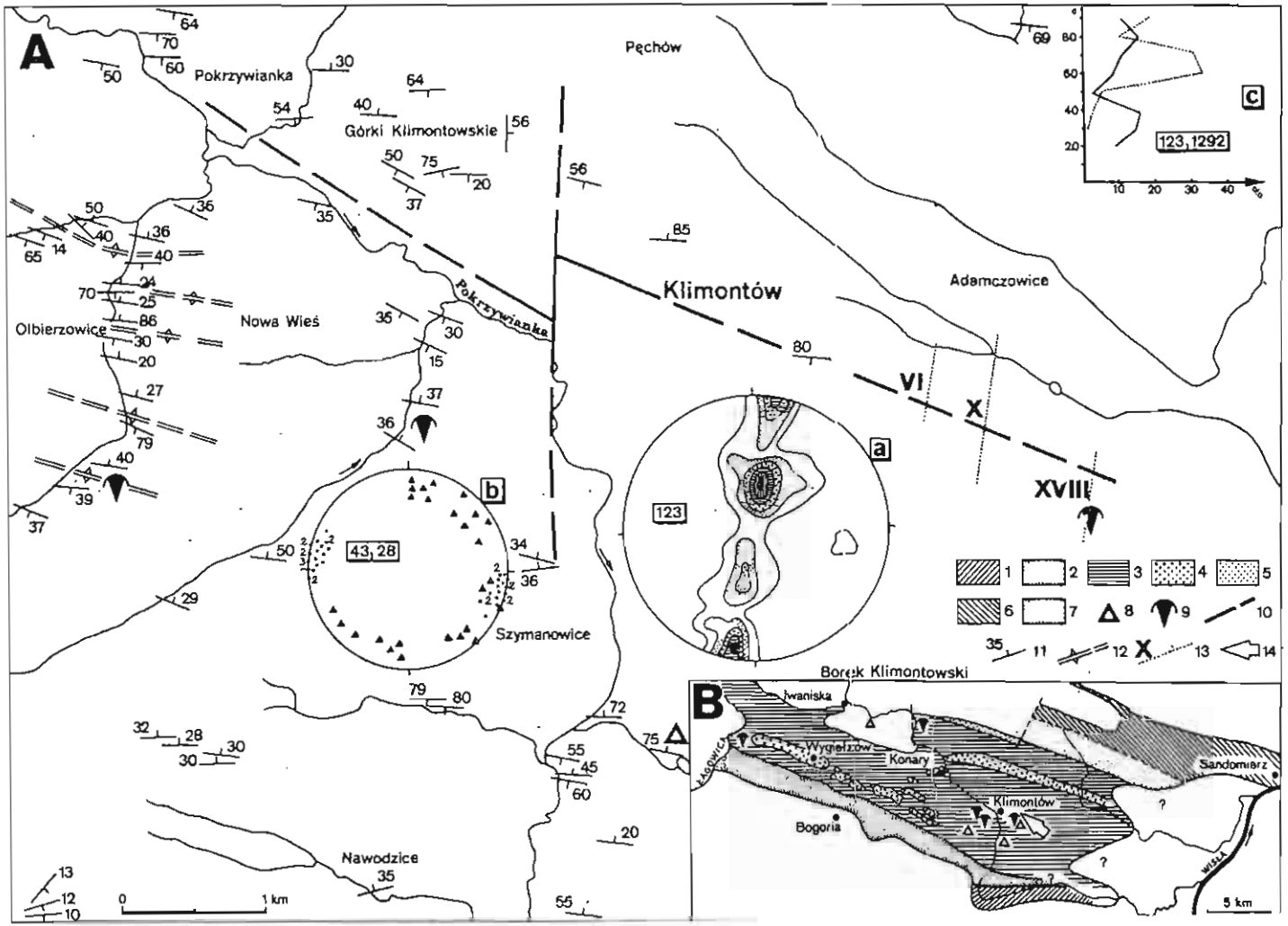
The minimal thickness of the Kamieniec Shale Formation is estimated for 600 m. The analysis of trylobite fossils confirms the upper part of the Lower Cambrian age of the formation. The shales are considered to be first deposited in a zone of external shelf or in deep basin, under oxide shortage conditions close to the bottom and then have been a subject of continuous and discontinuous deformation during the Sandomirian and Variscan phases.

INTRODUCTION

Outcrops of the Kamieniec Shale Formation, building a part of Klimontów Anticlinorium, are exposed over large area E of Klimontów village and in the lower course of the Pokrzywianka River. They are underlying the Middle Cambrian deposits of the Wygiezłów Ridge. To the south and east they are progressively covered by marine Miocene, losses and covers of weathered deposits. It can be assumed that Kamieniec Shale Formation deposits are probably reaching up to the Vistula River Valley, south of Sandomierz town, but they are not exposed at the surface.

To the south the deposits are limited by the outcrops of the Ociesęki Sandstone Formation, to the north by the outcrops of Usarzów Sandstone Formation or by Lower Devonian sandstones (Fig. 1B).

Soft clayey shales and mudstones of the Kamieniec Shale Formation are poorly exposed at the uplands and are usually covered by younger deposits or very often have been the subject of strong weathering processes leading to the soil deposits. They are exposed along the river and stream — valleys as well as in artificial exposures. It must be noted that the amount of natural exposures is recently systematically decreasing.


A
Pokrzywianka
Górki Klimontowskie
Pęchów
Klimontów
Adamczowice
Olbierzowice
Nowa Wieś
Szymanowice
Borek Klimontowski
Nawodzice
Pokrzywianka
123,1292
c
a
123
b
43,28
VI
X
XVIII
B
Iwaniska
Wygiełzów
Konary
Sandomierz
Klimontów
Bogoria
WISŁA
0
1 km
5 km

The Kamieniec Shale Formation have been distinguished as a separate lithostratigraphical unit by S. Orłowski (1975). Due to scarcity of fossils and trace fossils the age of the formation could not have been precisely determined until now. Additionally intensive tectonic processes locally observed within the formation make the estimation of real thickness of the deposits very difficult.

The research carried out in few last years have provided numerous new data on geology of the Kamieniec Shale Formation. The previous data have been completed due to the results obtained from the boreholes drilled by the Geological Enterprise, South — Kraków. Over 50 boreholes drilled to a depth of 60 m each in a 3 line pattern (Fig. 1A) have provided new data especially on the tectonics of the region. Master degree theses carried out in the Department of Geology, Warsaw University as well as research carried under the project *Analysis of the Paleozoic Tectonic Structures of the Holy Cross Mts (CPBR 03.04)* have provided additional data on Kamieniec Shale Formation. The results of the latter project have been included in this paper.

Previously known geological data as well as the most recent studies have led to more precise palaeontological, sedimentological, stratigraphical and tectonical syntheses of the Kamieniec Shale Formation.

PALEONTOLOGY AND STRATIGRAPHY

The Kamieniec Shale Formation has been recognized for the first time by S.Orłowski (1975) upon partial stratotypes situated E of the Łagowica River. In the

Fig.1. Tectonic map of the Klimontów area (A) and geological sketch of the Klimontów Antyclinorium (B) — after J.Samsonowicz (1962), with many changes

a – diagram of the attitude of strata (in rectangle – numbers of measurements) – contours of 1, 2, 4, 6, 8, 10%; b – diagram of fold axes (circles) and of faults (triangles); projections of the upper hemisphere (in rectangle – numbers of measurements of fold axes and faults); c – diagram of the dip of strata without dip-direction; line – measurements from the core, dotted line – measurements from the outcrops; in rectangle – numbers of measurements from outcrops and from the core; 1 – 3 – Lower Cambrian: 1 – Czarna Shale Formation, 2 – Ociesęki Sandstone Formation, 3 – Kamieniec Shale Formation; 4 – 6 – Middle Cambrian: 4 – Słowiec Sandstone Formation, 5 – Usarzów Sandstone Formation, 6 – Góry Pieprzowe Shale Formation; 7 – younger deposits, different in age; 8 – diabases and lamprophyres; 9 – trilobite localities; 10 – main faults; 11 – strikes and dips; 12 – axes of anticlines; 13 – borehole lines; 14 – borehole area

Mapa tektoniczna okolic Klimontowa (A) na tle szkicu geologicznego antyklinorium klimontowskiego (B) — według J.Samsonowicza (1962), zmodyfikowane i uzupełnione

a – diagram położenia warstw (w prostokącie – liczba pomiarów) – izarytmy procentowe: 1, 2, 4, 6, 8, 10; b – diagram osi faldów (kółka) i powierzchni uskokowych (trójkąty); projekcja na górną półkulę osi fałdów i normalnych do powierzchni uskokowych; w prostokącie – odpowiednio liczba pomiarów osi fałdów i powierzchni uskokowych; c – diagram kąta upadów warstw; linia ciągła – pomiary z rdzeni wiertniczych, linia przerywana – pomiary z odsłonięć; w prostokącie liczba pomiarów odpowiednio z odsłonięć i rdzeni wiertniczych; 1 – 3 – dolny kambr: 1 – formacja łupków Czarnej, 2 – formacja piaskowców z Ociesęk, 3 – formacja łupków z Kamieńca; 4 – 6 – środkowy kambr: 4 – formacja piaskowów ze Słowca, 5 – formacja piaskowców z Usarzowa, 6 – formacja łupków z Gór Pieprzowych; 7 – utwory młodsze od kambru; 8 – diabazy i lamprofiry; 9 – stanowiska trylobitów; 10 – ważniejsze uskoki; 11 – biegi i upady warstw; 12 – osie antyklin; 13 – linie wierceń; 14 – obszar wierceń

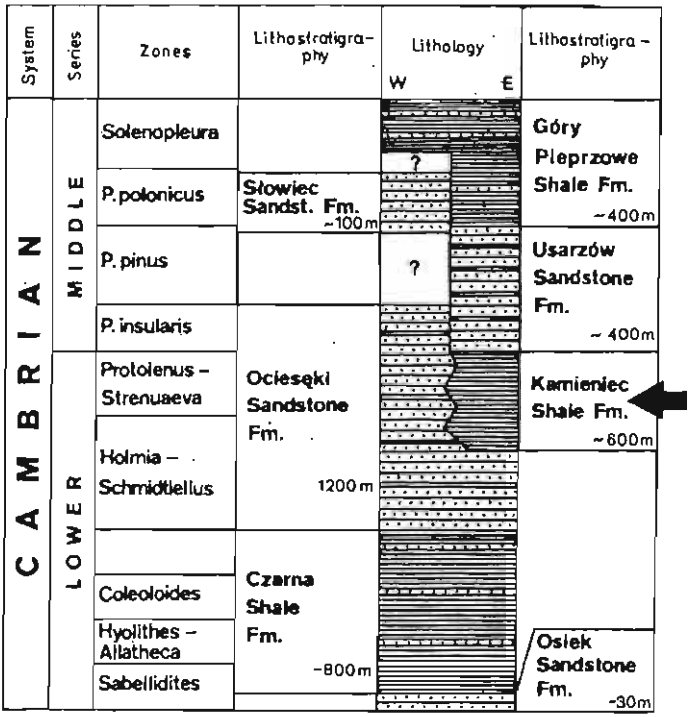


Fig. 2. Cambrian startigraphic subdivision in the Holy Cross Mts (after S.Orłowski, 1988). The discussed formation is arrowed

Podziały stratygraficzne kambru Gór Świętokrzyskich (S.Orłowski,1988). Formacja rozpatrywana oznaczona strzałką

next years due to trylobite description the age determination and the stratigraphical correlation of the formation was made (S. Orłowski, 1985, 1988).

The fossil remain assemblage of the Kamieniec Shale Formation is presented by rarely found trylobites, brachiopods and hyolithoites, but only the trylobites have been a subject of palaeontological studies (S.Orłowski, 1985). Up to now the trylobites have been collected in 4 outcrops only but now the trylobites are also described from the drill cores (Fig. 1).

On the basis of two trylobite assemblages two biostratigraphic zones have been recognized:

The older Holmia – Schmidtiellus Zone (S.Orłowski, 1985) is characterized by: *Holmia marginata* Orłowski, *Micmacca (Acanthomicmacca) klimontowi* Orłowski, *Ellipsocephalus simplex* Orłowski (S.Orłowski, 1985).The trilobites were found in shales sandstone intercalations in Dąb and Kucebrza outcrops located SW from Klimontów.

The younger Protolenus – Strenuaeva Zone is characterized by *Protolenus (Protolenus) expectans* Orłowski, *P. (Latoucheia) glabellosus* Orłowski, *Strenuaeva*

trifida Orłowski, *Serrodiscus primarius* Orłowski (S.Orłowski, 1985) found in sites of Kamieniec and Wola Jastrzębowska.

In some borehole profiles obtained from boreholes drilled E from Klimontów following trylobites and trylobite fragments have been recognized: *Protolenus (P.) expectans* Orłowski, 1985 — free cheek: Klimontów XVIII-18a, depth 55.5 m; ?*Protolenus (L.) glabellosus* Orłowski, 1985 — half of cranidium: Klimontów XVIII 26, depth 33.6 m; *Serrodiscus primarius* Orłowski, 1985 — two pygidia: Klimontów XVIII 22b, depth 61.6 m and Klimontów XVIII 18a, depth 51.2 m.

The above mentioned trylobites indicate the Protolenus – Strenuaeva Zone (Fig. 2). Trace fossils are sporadically reported from the Kamieniec Shale Formation. Some traces of *Cruziana* sp. and *Bergaueria perata* Prantl have been found in clayey--siltstones and fine-grained sandstones exposed along the Łagowica River. In siltstone shales intercalations *Planolites* is more common but unfortunately this ichnogenus is of small stratigraphic and paleobathimetric significance. Other organic traces are very rare. Among them only *Phycodes pedum* Seilacher from the Kamieniec outcrop found together with trylobites is of stratigraphic significance.

In drill-core profiles from borehole located E of Klimontów most common are *Planolites* rollers, rarely accompanied by *Teichichnus* and single specimens of *Phycodes palmatum* (Hall) — Klimontów XVIII 27a, depth 24 m and *Arcuatichnus wimani* Kowalski (Klimontów XVIII 22 b, depth 58.3 m).

The above mentioned trace fossils due to sporadical occurrence can not be considered as a typical assemblage indicating certain bathymetric zone of the basin. Some conclusions may be made only on a basis of comparative analysis between the Ociesęki Sandstone Formation and Kamieniec Shale Formation. It can be stated that Kamieniec Shale Formation is indicating the deeper part of the basin than the Ociesęki Sandstone Formation. The Kamieniec Shale Formation was sedimented below the *Cruziana* facies.

LITHOLOGY

The Kamieniec Shale Formation is represented by monotonous bundles of silty--claystones, siltstones, claystones and sporadically of thin intercalations of fine--grained sandstones. Olive-green (in sites and in near-surface zone) or greyey (in deeper parts) shales are the dominant rock component. Olive-green, greyey up to black sandstones occur in form of few mm in thickness and few cm long lenses or as thin intercalations. Only in Klimontów XVIII 16 and Klimontów X 13 boreholes traces of 2.5 m in thickness sandstone were noted.

The Kamieniec Shale Formation have been sporadically, in few places intruded by the diabaze and lamprophyre intrusions (Fig. 1). Also some boreholes of the Klimontów VI profile have indicated the presence of diabaze veins comparable to the diabaze from Widełki and Samotnia in the vicinity of Klimontów.

SEDIMENTARY STRUCTURES

The boreholes have provided complete cores useful for sedimentological studies. All recognized sedimentary structures were found within silty-clay shales. The thicker siltstone, claystone bundles and some sandstone intercalations are homogenous. The most common sedimentary structure is parallel lamination with average laminae thickness of 1–3 mm. It's planar type occurs rarely, commonly laminae are wavy due to unstable density stratification. Locally lenticular lamination with fine lenses of silty or rarely fine sandy material within clay matrix is visible. Occasionally clusters of load-casted ripples are observed.

Trace fossils are abundant in some intervals. The most common are Pascichnia of ichnogenus *Planolites* ranging from several mm up to over 1 cm in diameter (Fig. 3, 4), forming concentrations of tens specimens per 1 dm^2 on some bed surfaces. Fodinichnia of ichnogenus *Teichichnus* occur rarely and their average diameter exceeds 1 cm (Fig. 4). Their maximal concentration attains several specimens per 1 dm^2 on bed surface.

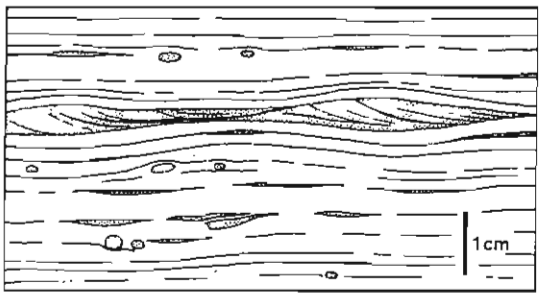


Fig. 3. Load-casted current ripples in horizontally laminated silty- clayey shale. Small burrows — *Planolites* sp. sp. Coarser material – shaded. Borehole Klimontów X 13, depth 57.0

Pogrzęźnięte zmarszczki prądowe w horyzontalnie laminowanym łupku mułowcowo-ilastym. Drobne "oczka" — *Planolites* sp. sp. Skały o grubszej frakcji zakropkowane. Otwór Klimontów X 13, głęb. 57,0 m

SEDIMENTARY ENVIRONMENT

The silty and clayey deposits dominate within the studied sequence. Structures suggesting mechanical sediment reworking are not observed. The main component of the sequence, fine laminated sediment shows neither gradation nor graded beddings. These features suggest quiet, slow deposition from suspension. The horizontal lamination probably reflects changes in sediment supply to sedimentary basin. Rarely found very fine, isolated ripples (Fig.3) indicate just season activity of weak bottom currents.

Most of the recent sedimentary environments of fine-clastic deposition are characterized by high activity of deposit-feeders which in many cases completely rework sediment, destroying its primary structure. Preservation of the primary structures is possible only in conditions excluding the existence of infauna. The main factor, eliminating infauna (particularly the highly tolerant for physical-chemical

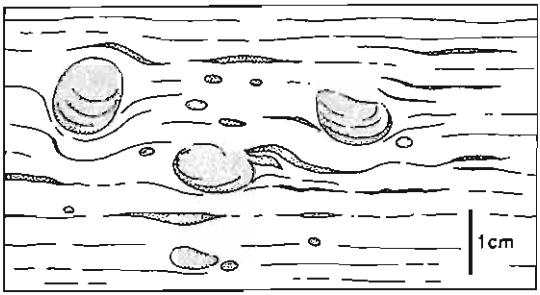


Fig. 4. Lamination in silty-clayey shale wavy disturbed around compactionally deformed burrows *Teichichnus* sp. sp.Smaller burrows — *Planolites* sp. sp. Coarser material — shaded. Borehole Klimontów X 13, depth 53.5 m

Laminacja w łupku mułowcowo-ilastym, faliście zaburzona wokół zdeformowanych kompakcyjnie dużych nor *Teichichnus* sp. sp. Drobne "oczka" — *Planolites* sp. sp. Skały o grubszej frakcji zakropkowane. Otwór Klimontów X 13, głęb. 53,5 m

conditions soft-bodied organisms),is oxygen deficiency within bottom waters (C.W.Byers, 1979).

In studied sequence the laminated deposit with traces of moderate non-skeletal infauna activity prevails. Among them the producers of *Planolites* burrows are more sensitive to oxygen deficiency than relatively tolerant organisms producing the *Teichichnus* traces (C.E.Savrda, D.J.Bottjer, 1986). Almost complete lack of skeletal benthos as well as occurrence of only very fine *Planolites* in many horizons suggests that the bottom waters were deficient in oxygen. Fine lamination undisturbed by bioturbations, observed in short intervals indicates even temporary anoxia (C.W.Byers, 1979).

Low energy character of the environment dominated by deposition from suspension, indicates the depth of the basin bottom below storm wave base. Weak water circulation created poor oxygenation of bottom waters, which in turn resulted in faunal scarcity. Such conditions are the most typical for outer shelf or deep basin out of reach of the turbidity currents (P.E.Potter et al.,1980).

TECTONICS

The strike of the Kamieniec Shale Formation of the investigated part of Klimontów Anticlinorium is generally between 90-120° (Fig. 1A). Different strikes are observed sporadically and are related to the fault zones disturbing neighbouring beds.

The direction of Lower Cambrian beds is similar to the direction observed in the whole Łysogóry Region of the Holy Cross Mts but is different from bed strikes of the same age from central part of the Kielce Region (Ciesęki Sandstone Formation — W.Mizerski et al., 1986). The process could be the result of dislocation of individual blocks of the Klimontów Anticlinorium along faults or indicate diversity of influence

of particular tectonic phases (and related fold movements) on Lower Cambrian deposits from various parts of the Kielce Region.

Dips of the Kamieniec Shale Formation are variable and form several maxima in diagrams (Fig. 1A — diagram a). The maximal number of measurements is located in two domains: 100/25N and 110/80-90S, but also third domain of 100/35S with lower number of data is manifested.

All three diagram maxima are located along one line and together with field data suggest that the studied fold structures have similar axis azimuths. The character of domain 100/90-80S suggests often bed inversion in form of vertical bed position and is confirmed by well data.

The analysis of the diagram of bed dips (Fig. 1 — diagram c) led to the same conclusion. The dips of Lower Cambrian beds have two main maxima: 20-40° and 60-90°. The first maximum is always connected with fold structures occurrences, the second one is related to the positions of bed of large fold structures as well as of fine folds, formed due to transformations of bed positions from normal to vertical and inverted ones.

Variable bed position is a characteristic feature for dominant part of investigated area though some fragments of stable bed dips and bed strike are found (Fig. 1A). Stability of bed dip and strike is observed eastwards of Klimontów, what has been documented mainly with boreholes, placed along profiles of nearly N–S direction (Fig. 1). Over 1000 bed dip measurements were taken in well core, unfortunately without indicating strike of dip as the cores were not oriented. The bed dip diagrams of the above mentioned region (Fig. 1A — diagram c) indicates only maximum of 60-90°. The fold hinges were not noted in well cores what together with the diagram (Fig. 1A — diagram c) analysis suggests that the beds occurring nearby wells have monoclinal position and that bed inversions were caused by bed transformation from normal to vertical and inverted position.

Analysis of field and archival data, particularly of the *Detailed Geological Map of Poland*, Sheet Klimontów (A.Romanek, G.Słowiok, 1975) and of its explanations (A.Romanek, 1977) indicates in the studied area the presence of zones with monoclinal bed orientation as well as of zones with intensively folded Lower Cambrian deposits. Stratigraphic relations of the Cambrian rocks suggests, that these deposits became younger northward and are characterized by mainly monoclinal dip to north.

Several fold structures of various size occur within the Kamieniec Shale Formation. Most of them are invisible on site and may be only interpreted from bed positions of adjoining outcrops.

Most of the fold axes indicate the azimuth of 90–100°. They are horizontal or slightly inclined east- and northward (Fig. 1A — diagram b) what confirms that strikes of Lower Cambrian beds are very similar all over the studied area.

The main unit of second order within Klimontów Anticlinorium is — according to A.Romanek (1977) the Wygiezłów–Nawodzice Syncline characterized by an axis strike of about 120° and distance of 10 km. Recent studies do not confirm the existence of such structure. The fold structures, visible in particular outcrops, can not be considered to be a part of one larger fold structure with axis azimuth of 120° as their fold axes indicate azimuths 90–100°. The existence of Wygiezłów–Nawodzice

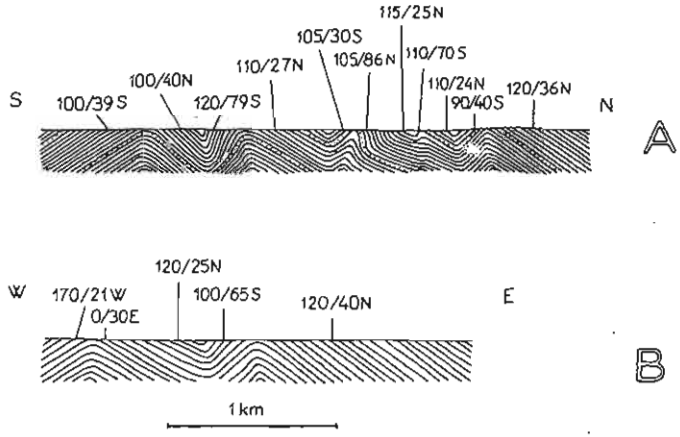


Fig. 5. Geological sections along the small rivers
A – near the Olbierzowice village; B – E from the Nowa Wieś village
Przekroje geologiczne wzdłuż strumieni
A – przez Olbierzowice; B – na wschód od Nowej Wsi

Syncline with axis azimuth of about 120° is contradictory to general strike of Lower Cambrian beds, estimated for 100°. In that case the existence of hypothetic syncline should be questioned. Only the presence of the Wygiezłów Syncline, marked by occurrence of Middle Cambrian sandstones in axis zone is evident.

West and south of Klimontów several third order folds could be distinguished (Fig. 1A).

Frequent fold structures were exposed creeks, flowing by Olbierzowice (Fig. 1A). Folds, visible within Lower Cambrian rocks, are varying in size and geometry (Fig. 5). They are mainly described as asymmetric folds with south vergence, some of them could be regarded as large drag folds, indicating southward tectonic transport. Occasionally the presence of folds with north vergence and high inclination of axial surfaces is noted.

A.Romanek (1977) suggests that third order folds within Lower Cambrian deposits have large continuity of about 2–3 km. Such large fold forms were noted only in several locations (Fig. 1A). They are presented mostly by fold structures with limited continuity or they are dislocated with transverse faults.

During fold generation the axis of main stress was horizontal and its direction was nearly meridional (about 10°). It is the same direction as observed in axis of main stresses during Variscan activity in Łysogóry Region. Such conformity is not accidental and is probably connected with Variscan activity within this part of the Kielce Region and the Holy Cross Mts.

The above studied fragment of the Kielce Region varies strongly in stage of tectonic involvement of Cambrian rocks from the investigated Ociesęki Region (W.Mizerski et al., 1986), where deposits of the same age but other lithology occur. The fold deformations are characteristic for the Kamieniec Shale Formation of

Klimontów area while within the Ociesęki Sandstone disjunctive tectonics prevails. It is the next proof for disharmonious folding of Cambrian rocks of the Kielce Region.

The age of fold structures in the Kamieniec Shale Formation could be defined according to the angle discordance between Cambrian and Ordovician deposits, occurring east of studied area. Such deformation should be connected, partly anyway, with Sandomirian tectonic movements. The undissolved problem is the stage of structural rebuilding of the area during the later periods of tectonic activity. It seems that some folds, particularly those with significant southern vergence pointing southward tectonic transport, could be connected with Variscan activity of the whole area of the Holy Cross Mts.

Few faults were noted in exposures of Cambrian rocks in the Klimontów area. They are mainly fine forms with variable strikes and steep dip (Fig. 1A — diagram b). The dislocation zones were also described from well cores.

For disjunctive tectonic of the Klimontów area the most significant is the dislocation zone of WNW–ESE direction and meridional dislocation (Fig. 1A).

The mentioned WNW–ESE dislocation zone was found in brickfield in the Klimontów area and its continuation — in well cores eastwards from the region. This zone, with character of dip-slip fault with southern downthrown side, is highly inclined — its dip is 70–90°. Locally some fold structures are visible in its northern side (Fig. 6). This dislocation runs probably westwards and the Pokrzywianka Valley passes along it (Fig. 1A).

The meridional dislocation is of dip-slip type throwing western limb of anticlino-

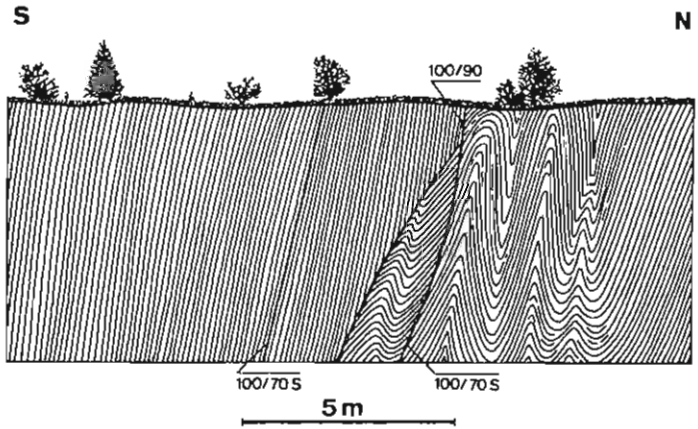


Fig. 6. Folded shales in the outcrop situated E of Klimontów
Tektonika łupków w cegielni na E od Klimontowa

rium. It seems that this structure belongs to the system of meridional faults in Klimontów Anticlinorium, with western downthrown sides. The largest among them are: Łagowica, Łukawka and Samotnia faults. These faults involve a gradual uplift of the Palaeozoic towards the east and exposuring of older rocks.

In other region of the Klimontów Anticlinorium the faults of NW–SE and NE–SW directions were regarded to be formed during Sandomierz as they are not cutting

Ordovician rocks (W.Mizerski et al., 1986). It suggests that the earlier described faults can be connected with Sandomirian movements. Similar conclusions are also made by P.Kabulski (1987), describing Cambrian deposits from Gieraszowice area neighbouring the region studied here.

The faults with WNW–ESE directions as well as rare faults with NNW–SSE orientation could be the result of the younger phase of tectonic activity after Devonian (probably Variscan Phase) and they could be related to tectonic rebuilding of studied area.

Common polished tectonic surfaces, visible in well cores of Cambrian rocks from the Klimontów Region, are interesting phenomena of disjunctive tectonics. They occur in core parts where bed dip is very high up to 90°. Slip striae on bed surfaces point that the main tectonic transport occurred along dip planes. It indicates that during folding or also in the later periods of tectonic activity, the stresses were discharged as interbed slips. That explains small fault amount, noted in outcrops.

Other elements of fine tectonics were also registered during field studies. In several outcrops — located in limbs of sloping fold structures — pencil-shape cleavage with azimuth about 10° were found. They could be the result from transpression during folding or from influence in the Palaeozoic of the Łysogóry Region and are interesting as the oldest stresses of Variscan Phase of tectonic activity in the whole region (W.Mizerski, 1988).

The thickness estimation of the Kamieniec Shale Formation was difficult due to: partial stratotypes of formation, rock folding and existence of perpendicular and longitudinal faults. Thickness was initially calculated for at least 200 m (S.Orłowski, 1975, 1988). Thickness measurements in river sections, flowing by Olbierzowice and eastwards from Nowa Wieś (Fig. 1A, 5) define it for at least 600 m.

CONCLUSIONS

1. Sedimentary environment of the Kamieniec Shale Formation was dominated by slow deposition from suspension in the outer shelf or deep basin zone under condition of low sea-floor oxygen concentrations what explains the scarcity or lack of benthos.

2. The thickness of the Kamieniec Shale Formation is estimated at at least 600 m.

3. Five places with trylobites were stated in the Kamieniec Shale Formation. The trilobites situated this formation in the upper part of the Lower Cambrian.

4. The Kamieniec Shale Formation are characterized by the diversity of tectonical processes — monoclinal bed position as well as fold structures are reported.

5. The Lower Cambrian deposits were deformated in at least two phases of tectonic activity connected with Sandomirian and Variscan movements.

6. The comparison of tectonic processes between Kamieniec Shale and Ociesęki Sandstone formations the same in the age indicates a significant role of disharmonious folding processes in genesis of the internal structure of Klimontów Anticlinorium.

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NOWE DANE DO GEOLOGII FORMACJI ŁUPKÓW Z KAMIEŃCA (KAMBR DOLNY, GÓRY ŚWIĘTOKRZYSKIE)

Streszczenie

Łupki z Kamieńca (fm) występują we wschodniej części antyklinorium klimontowskiego, gdzie budują znaczną jego część (fig. 1B). Wykonane w ostatnich latach w okolicach Klimontowa płytkie wiercenia (fig. 1A) dostarczyły nowych danych na temat litologii, stratygrafii, środowiska sedymentacji oraz tektoniki tej formacji.

Badane utwory stanowią zespół przeławicających się łupków ilastych i mułowców z cienkimi wkładkami drobnoziarnistych piaskowców. Miąższość formacji łupków z Kamieńca oszacowano na co najmniej 600 m.

Zespół skamieniałości charakteryzuje się znacznym ubóstwem. Sporadycznie znajdowano szczątki trylobitów, ramienionogów i hiolitów.Te pierwsze pozwoliły na wydzielenie w obrębie formacji 2 poziomów zespołowych: *Holmia–Schmidtiellus* i *Protolenus–Strenuaeva* wyższej części kambru dolnego (fig. 2). Ze skamieniałości śladowych najczęściej spotykane są *Planolites* sp., nieliczne zaś: *Teichichnus* sp.,*Phycodes palmatum* (Hall) i *Arcuatichnus wimani* Kowalski.

Środowisko sedymentacji badanych utworów zdominowane było przez spokojną depozycję z zawiesiny w strefie zewnętrznego szelfu bądź głębokiego basenu, w warunkach pewnego niedoboru tlenu przy dnie a okresowo nawet anoksycznych.

Łupki z Kamieńca (fm) cechują się zmiennym zaangażowaniem tektonicznym, co powoduje, iż niektóre fragmenty obszaru badań wykazują monoklinalne ułożenie warstw, inne zaś są silnie sfałdowane. Utwory dolnokambryjskie były poddane deformacjom ciągłym i nieciągłym co najmniej w 2 fazach aktywizacji tektonicznej regionu: pierwszej związanej z ruchami sandomierskimi, drugiej — z ruchami waryscyjskimi.Porównanie tektoniki formacji łupków z Kamieńca (fm) z tektoniką równowiekowej formacji piaskowców z Ociesęk prowadzi do wniosku, że dużą rolę w formowaniu wewnętrznej struktury antyklinorium klimontowskiego odegrały procesy fałdowania dysharmonijnego.