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Palaeogeography of the uppermost Carboniferous and lowermost Permian deposits in the NE part of the Intra-Sudetic Depression

Based on analysis of sediments of the uppermost Carboniferous and the lowermost Permian, the fundamental palaeogeography of the Intra-Sudetic Depression has been reconstructed at the boundary of the Westphalian and Stephanian (the Asturian phase). Main source areas in the upper Westphalian occurred south of Wałbrzych and west of Nowa Ruda. The Wałbrzych region and the present area of the Góry Sowie Block were the source areas of the coarse-grained material, sedimentation being development mainly near the present Polish-Czech border and on the Czech side of the Intra-Sudetic Depression. River deposition, dominant in the uppermost Carboniferous, gradually changed to lacustrine deposition.

INTRODUCTION

The present paper represents a continuation of the considerations on Upper Carboniferous and Permian palaeogeographic development in the NE part of the Intra-Sudetic Depression (published by the authors in the preceding volume of *Geological Quarterly* — A. Bossowski, A. Ihnatowicz, 1994).

It presents the probable palaeogeography of the uppermost Upper Carboniferous (Westphalian C — Stephanian, the Glinik Formation) and the Lower Permian (Autunian, the Świerki and the Słupiec Formations). Aiming at continuity, similar palaeogeographic intervals (Figs. 2–6) have been used, presenting the distribution of regions with a predominance of the channel, overbank and lacustrine facies, respectively. Data suitable for the construction of the intervals were obtained from accessible borehole and mining evidences.

It should be stressed here that the regions discussed display differing degrees of geological understanding, the best being in areas of hard coal prospecting and exploitation.

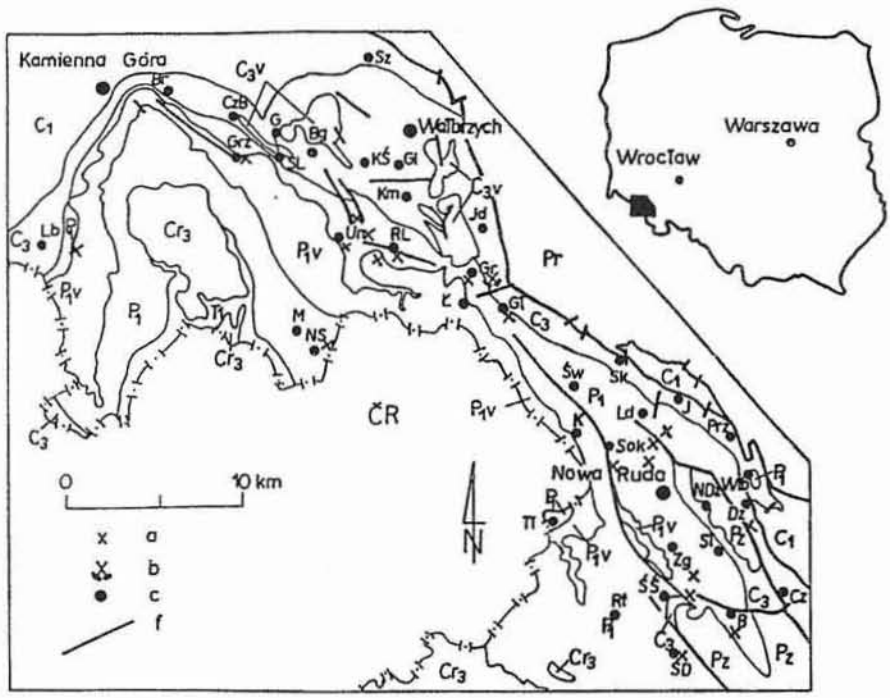

Fig. 1. Geological sketch-map of the Polish part of the Intra-Sudetic Depression

Pr — Precambrian — gneisses; Pz — Lower Palaeozoic — phyllites, amphibolites, gabbros; C_1 — Lower Carboniferous — conglomerates, sandstones; C_3 — Upper Carboniferous — conglomerates, sandstones, mudstones, siltstones, hard-coal seams, C_3v — rhyolites, trachybasalts; P_1 — Lower Permian — sandstones, conglomerates, mudstones, P_1v — rhyolites, trachybasalts; T_1 — Lower Triassic — sandstones; Cr_3 — Upper Cretaceous — sandstones; a — main boreholes; b — closed down uranium mine; c — localities (Bg — Boguszów, Br — Borówno, B — Bożków, CzB — Czarny Bór, Cz — Czerwieńczyce, Dz — Dzikowiec, Gl — Glinik, Gł — Głuszyca, G — Gorce, Gr — Grzmiąca, Grz — Grzędy, Jd — Jedlina Zdrój, J — Jugów, Km — Kamionka, K — Krajanów, KŚ — Kuźnice Świdnickie, Lb — Lubawka, Ld — Ludwikowice, Ł — Łomnica, M — Mieroszów, NS — Nowe Siodło, NDz — Nowy Dzikowiec, Prz — Przygórze, RL — Rybnica Leśna, Rt — Ratno, Sł — Słupiec, Sk — Sokolec, Sok — Sokolica, SL — Stary Lesieniec, Sz — Szczawno, ŚD — Ścinawka Dolna, ŚŚ — Ścinawka Średnia, Św — Świerki, Tł — Tłumaczów, Un — Unisław Śląski, Wlb — Wolibórz, Zg — Zagórzyn); f — faults

Szkic geologiczny polskiej części depresji śródsudeckiej

Pr — prekambr — gnejsy; Pz — starszy paleozoik — fyllity, amfibolity, gabra; C_1 — karbon dolny — zlepieńce, piaskowce; C_3 — karbon górny — zlepieńce, piaskowce, mułowce, iłowce, węgiel kamienny, C_3v — ryolity, trachybazalty; P_1 — perm dolny — piaskowce, zlepieńce, mułowce, P_1v — ryolity, trachybazalty; T_1 — trias dolny — piaskowce; Cr_3 — kreda górna — piaskowce; a — ważniejsze otwory wiertnicze; b — nieczynna kopalnia uranu; c — miejscowości; f — uskoki

The geologic scheme (Fig. 1) presents only the main boreholes where the deposits under description were drilled. In fact the real number of the boreholes analyzed was several times higher. The present analysis contains materials from the former R-1 company from Kowary, not accessible earlier.

Lithostratigraphy of the uppermost Carboniferous and Lower Autunian deposits in the north-eastern part of the Intra-Sudetic Depression (partly after W. Nemec *et al.*, 1982; A. Grocholski, 1981; J. Miecznik, 1989)

AGE				Lithostratigraphic units		Lithology			
				Formation	Member	Wałbrzych region		Głuszyca – Nowa Ruda region	
PERMIAN	LOWER	AUTUNIAN	LOWER	Góry Kamienne Mts.		trachybasalts, rhyolites, ignimbrites, tuffs			
				SŁUPIEC	RATNO	megacycle III	claystones and mudstones with calcite cement, limestone lenses and concretions	megacycle III	Walchia shales horizon, claystones, mudstones with calcite cement
					ZAGÓRZYN		claystone and mudstone with calcite cement, limestone lenses and concretions		horizon of building sandstones
				ŚWIERKI	KRAJANÓW	megacycle II	limestone lenses — Bećkov horizon sandstones, mudstones and claystones with calcite cement at top	megacycle II	horizon of upper Anthracosia shales horizon of red mudstones and claystones horizon of quartzitic conglomerates with lydites at bottom
					LUDWIKOWICE	megacycle I	horizon of lower Anthracosia shales sandstones, conglomerates (the Unisław conglomerates), subordinately — mudstones and claystones	megacycle I	horizon of lower Anthracosia shales mudstones and claystones with limestone conglomerates horizon of platy sandstones horizon of main conglomerates
CARBONIFEROUS	UPPER	STEFANIAN	C						
			B	GLINIK	ŁOMNICA	polimictic conglomerates, sandstones, mudstones			polimictic conglomerates, sandstones, mudstones and claystones, locally coal seams at top
			A		hiatus — Asturian phase				
		WESTPHALIAN	D		GRZMIĄCA	sandstones, mudstones, claystones, subordinately conglomerates			
			C		PETROVICE	conglomerates, sandstones, locally coal seams		conglomerates, sandstones	
			B	ŽACLEŘ	UPPER PART	sandstones, conglomerates, mudstones, claystones, coal seams no. 301–323		sandstones, conglomerates, mudstones, claystones, coal seams no. 301–304	

GEOLOGICAL STRUCTURE

STRATIGRAPHY

According to generally existing opinions, deposits of the uppermost Carboniferous and the lowermost Autunian were formed in river and lacustrine environments in progressively drying climate conditions. This is evidenced by an increasing percentage of red and reddish-brown colour of the deposits towards the top of the profile. Coal seams are still present in the deposits of the Glinik Formation, especially on the Czech side of the Intra-Sudetic Depression, while they are completely sporadic in the lowermost Autunian deposits (within the lower Anthracosia shale).

To increase the clearness of the text, detailed stratigraphic description of the deposits under discussion, together with Table 1, is in the chapter on the evolution of the sedimentary basins.

TECTONICS

Thanks to long-term geologic and borehole investigations, as well as the exploitation of hard coal, tectonic understanding of the Intra-Sudetic Depression is quite satisfactory. Main fault directions are parallel to the NW–SE axis. Apart from big dislocations displaying downthrows as much as 1000 m, known in the literature for a long time, there is a net of small faults often unnoticed during standard cartographic work. They are seen in detailed geologic investigations (drilling grid of 100 x 100 m) in the area of the uranium mine in Grzmiąca (closed since the sixties). Faults of tens to hundreds metres are observed there, the pattern of which seems to be typical for the whole Intra-Sudetic Depression and should be taken into account in attempts at stratigraphic correlation.

Dips of the layers are of about 20° for the majority of the area under discussion, but in the Głuszyca – Ludwikowice region they reach 50°.

METHODS

Uppermost Carboniferous and the lowermost Permian deposits are of fluvial, partly lacustrine origin. Palaeogeographic reconstruction corresponds, therefore, to zones with a predominance channel deposits, areas of alluvial plains, denudation areas, alluvial fans and lakes for the determined time-span. Main transport directions of the coarse-grained material were also determined.

Aiming at reconstruction of the palaeogeography, numerous maps of equal scale were compared for the different parts of the section, which resulted in significant palaeogeographic conclusions. Four parameters were analyzed: thickness, sandstone-shale ratio, percentage of conglomerates (typical channel deposits) and percentage of mudstones and claystones (typical overbank or lacustrine deposits). Some theoretical dependences between these parameters were taken into account when drawing palaeogeographic conclusions, namely:

— zones characterized by a high content of coarse-grained material, high sandstone-shale ratio and significant thickness correspond to river channels or alluvial fans (in the second case — all the parameters listed display a rapid decrease in the same direction);

— zones characterized by insignificant thickness, high percentage of mudstones and claystones and low sandstone-shale ratio correspond to alluvial plains or lakes; in the second case some aspects characteristic for lacustrine deposits were also taken into account, such as presence of limestone interlayers, limestone concretions, lack of distinct lamination etc.

It is obvious that determinations such as "significant" or "insignificant thickness", "low percentage of conglomerates", etc., have a completely relative character and are related only with the variation of the parameters occurring in the analyzed part of the section.

Results of the analysis, conducted at is was described above, were further supplied with provenance information on petrographic composition of the pebbles, on presumable position of alimentation (source) areas, on transport directions, zones of maximum subsidence etc.

EVOLUTION OF SEDIMENTARY BASINS

GLINIK FORMATION

Formation of the deposits from the Glinik Formation started in the Westphalian C. The top of coal seam no. 301 from the Žacleř Formation has been accepted as the bottom of the Glinik Formation. Deposits from the area of Wałbrzych which occur above that seam could have corresponded (according to R. Tásler, 1979) to the conglomerate and sandstone member from Petrovice on the Czech side of the Intra-Sudetic Depression. Such an opinion was accepted by A. Grocholski (1981) who distinguished the same member on the Polish side, as a part of the Glinik Formation rather than the Žacleř Formation, however. That is why such a position of the member discussed has been accepted by the authors of the present paper.

Two other members — of the Grzmiąca sandstones and mudstones and the Łomnica conglomerates — lie above the deposits of the Petrovice conglomerates and sandstones. That division was first presented by J. Miecznik (1989), who correlated Polish stratigraphy with earlier work on the Czech side of the depression. He also tried to divide sediments from the different members in the profiles of deep boreholes between Wałbrzych and Nowa Ruda. Supplementary to the work done by J. Miecznik the authors of the present paper conducted numerous correlation lines based on information from the deep boreholes mentioned above and on archive materials (A. Bossowski, A. Ihnatowicz, 1990).

In many localities it was difficult to separate deposits from the two older members (the Petrovice and the Grzmiąca Members), so they were treated together in the palaeogeographic discussion. In places where the deposits of both the members may be separated, a distinct similarity is observed in the location of the main palaeogeographic units, i.e., areas of water flows, areas of overbank deposition, source areas, etc.

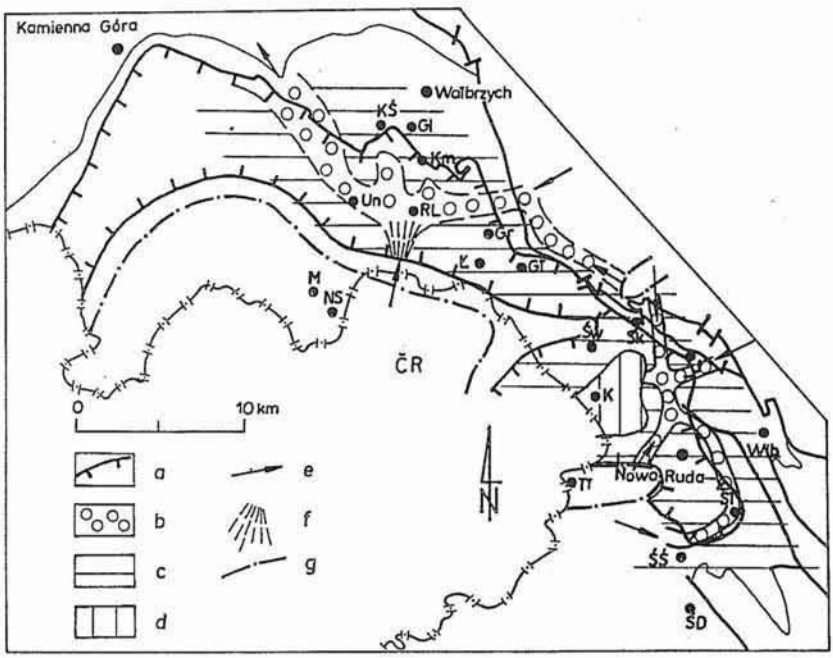

Fig. 2. Palaeogeographic sketch-map — Westphalian C and D — Glinik Formation — Petrovice (sandstones and conglomerates) and Grzmiąca Members (sandstones and mudstones)

a — present extent of deposits, b — zones of prevailing channel deposition, c — zones of prevailing extra-channel deposition, d — zones of prevailing lacustrine deposition, e — main transport directions of coarse material, f — alluvial fans, g — primary extent of deposits; other explanations as in Fig. 1

Szkic paleogeograficzny — westfal C i D — formacja z Glinika — ogniwo z Petrovic (piaskowce i zlepieńce) i z Grzmiącej (piaskowce i mułowce)

a — dzisiejszy zasięg osadów, b — strefy o przewadze sedymentacji korytowej, c — strefy o przewadze sedymentacji pozakorytowej, d — strefy o przewadze sedymentacji jeziornej, e — kierunki transportu materiału gruboklastycznego, f — stożki napływowe, g — pierwotny zasięg osadów; pozostałe objaśnienia jak na fig. 1

THE PETROVICE AND THE GRZMIĄCA MEMBERS

The Petrovice and the Grzmiąca Members (compare with A. Grocholski, 1981) are mainly represented by light-grey conglomerates and sandstones often with a greyish-green shade. Sporadically there occur mudstones and claystones with coal seams. Extremely arkosic character of the sandstones is a very common feature. Apart from the main petrographic components, such as quartz, quartzite and lydite, characteristic of the deposits of the underlying Žacleř Formation, there appear also feldspars and some clasts of granitoid rocks, gneisses, metamorphic schists, as well as — in the Wałbrzych region — volcanites. The thickness of the Petrovice Member varies from 20 to 150 m, the later value, however, should be treated carefully due to the difficulties in differentiation of the deposits discussed from those of the channel facies of the Glinik Member. These difficulties have probably caused numerous errors in preparation of the detailed geological map (e.g., between Głuszyca in NW and Sokolec in SE).

The Grzmiąca Member is represented mainly by fine-grained sandstones, mudstones and claystones. Coarse-grained sandstones and conglomerates occur rarely. In general they indicate channel facies. The deposits display mostly greyish-green or reddish-brown colour, occasionally with light grey, dark grey, greyish-violet or black parts. Deposition of these rocks occurred along the river valleys present in the Westphalian C and display characters similar to the Petrovice Member, but in conditions of significantly lower transport energy.

The thickness of the deposits from the Grzmiąca Member varies from about 20 m in the Nowa Ruda region to over 500 m south of Wałbrzych. In the Nowa Ruda region the deposits were probably significant eroded, so the present low thickness is generally not primary (A. Bossowski, A. Ihnatowicz, 1990).

It is clear from the palaeogeography during the formation of the Petrovice and Grzmiąca Members, that in comparison to earlier periods some changes in directions of transport of the coarse-grained material occurred (compare to A. Bossowski, A. Ihnatowicz, 1994) north-to. These changes were already noted, with a special stress on the presence of material absent in the directly underlying deposits (J. Kornaś, 1974).

In the Nowa Ruda region the changes in the palaeogeography were more distinct than those in the Wałbrzych region. In the Lower Westphalian, transport direction changed from south-to-north (compare with A. Bossowski, A. Ihnatowicz, 1994), to northeast-to-north-west. Remnants of Lower Westphalian scarps, which played the role of watersheds between Nowa Ruda – Słupiec and Głuszyca Górna – Świerki (compare *op. cit.*) are still preserved.

The most significant changes in palaeogeography occurred in the western part of the Nowa Ruda region close to the Polish-Czech frontier. Deep foredeeps were presumably formed (Fig. 2) instead of the uplifted areas present in the Lower Westphalian — the source areas for the productive deposits of the Žacleř Formation. The thickness of the deposits in the western part of the Nowa Ruda region is not only more significant than that between Głuszyca and Nowa Ruda, but also the lithologic character of the rock points to distant source areas, which in this case were transferred NE towards the present Góry Sowie region. In the boreholes situated near the present frontier there occur abundant claystones with limestone concretions in the upper part of the Grzmiąca Member which could suggest a periodical change to lacustrine deposition.

South of Wałbrzych the deposition of the Petrovice and Grzmiąca Members occurred in the same palaeogeographic conditions as in the Lower Westphalian (compare to *op.cit.*), i.e., the main zone of the channel deposits trended from the south-east to the north-west with a transport direction towards the NW. The main source area was placed south of Unisław – Rybnica Leśna and probably represented fragments of a presumed "southern massif" (D. Pawlik, 1939; A. K. Teisseyre, 1968; T. Gunia, 1968). Areas of widespread alluvial plains with some peat-bogs were placed north of the reconstructed channel zone. That fact is evidenced by narrow coal seams and interbeds younger than seam no. 301 (the uppermost seam of the Žacleř Formation) present in the Kamionka vicinity so-called the Kamienica coal seam) and in the boreholes from Kuźnica Świdnicka area.

The primary extent of the deposits of the Petrovice and Grzmiąca Members is shown in Figure 2. Changes in palaeogeography in relation to the earlier periods were obviously caused by tectonic movements in the Lower Westphalian C precedings the main movements of the Asturian phase (compare with Fig. 7). Apart from the foredeep zones west of Nowa

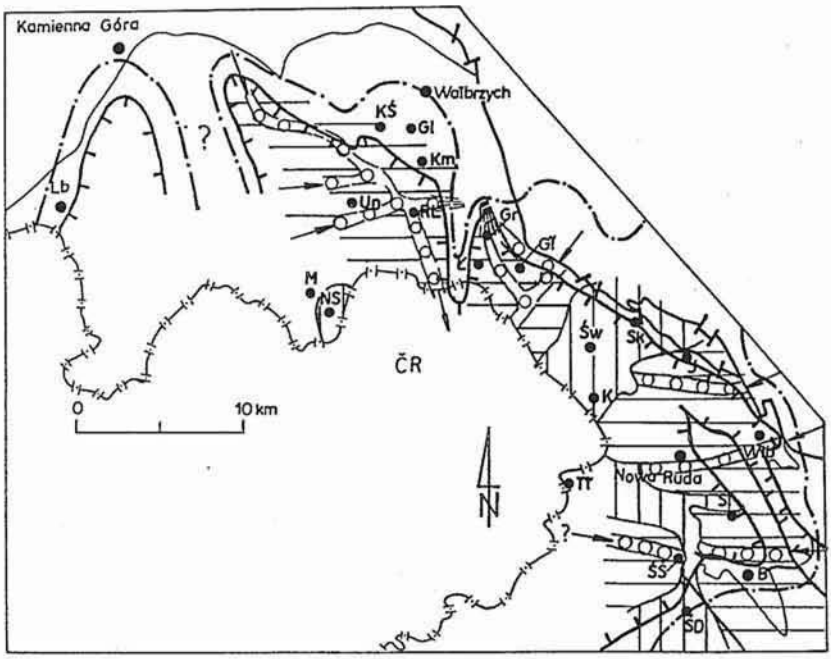

Fig. 3. Palaeogeographic sketch-map — Stephanian A and B — Glinik Formation — Łomnica Member
Explanations as in Figs. 1 and 2
Szkic paleogeograficzny — stefan A i B — formacja z Glinika — ogniwo z Łomnicy
Objaśnienia jak na fig. 1 i 2

Ruda, the temporary re-juvenation of the almost totally denuded scarp north of Sokolec in the Westphalian B is worth notice (compare with A. Bossowski, A. Ihnatowicz, 1994).

THE ŁOMNICA MEMBER

The polymictic character of sandstones and conglomerates is the important feature of the conglomeratic Łomnica Member. Apart from quartz, quartzite and lydite, the following types of clasts are present: granitoids, gneisses, mica schists, sandstones, mudstones, pink feldspars, Mikołajki-type and Zdanów-type schists, as well volcanites, mainly rhyolites. The last rocks, generally displaying a cream colour, occur mostly between Krajanów and Jugów. They are responsible for the characteristic yellowish shade of sandstones and conglomerates. According to J. Miecznik (1989) the presence of rhyolite clasts in the Nowa Ruda region is a diagnostic feature differentiating the deposits of the Łomnica Member from those of the lower members of the Glinik Formation. Sandy-conglomeratic deposits occur mainly in the lower parts of the profile, the content of the sandstones and mudstones increases towards the top of the profile. Mudstones are mostly reddish-brown or greyish-green.

The thickness of the deposits of the Łomnica Member oscillates between 50 and 250 m, exceptionally exceeding 600 m in the Głuszyca Górna vicinity. That exceptional case is

possibly a result of the activity of a synsedimentary graben where deposition lasted longer than elsewhere in the Polish part of the Intra-Sudetic Depression. Close to the top of the deposits under description there occurs a coal seam, which, according to J. Miecznik (*op. cit.*), corresponds to the so-called Radwanice seams on the Czech side.

Due to the tectonic movements of the Asturian phase there occurred an intensive reorganization of the palaeogeography prior to the deposition of the Łomnica Member. This new palaeogeography lasted, with some insignificant alterations, until the lowermost Autunian (Figs. 3–6).

In the Nowa Ruda region the deposition occurred with a distinct material supply from the east. Based on the different maps (of thickness, content of clasts, percentage of conglomerates and mudstones) three latitudinal channel zones (Fig. 3) have been reconstructed. These zones terminated in two lakes: the first one placed between Ścinawka Dolna, Ścinawka Średnia and Tłumaczów, and the second between Krajanów in the SW and Sokolec in the NE (Fig. 3). Both lakes probably formed part of one bigger body of water on the present Czech side, which, however, penetrated the present Polish side south of Mieroszów. That conclusion has been drawn by the authors based on re-interpretation of the old, German borehole in Nowe Siodło.

The analysis of the material from the last boreholes south of Wałbrzych generally indicates that material supplied from the north, north-west and north-east was transported towards the south. Water flows probably terminated south of Mieroszów in the lake already mentioned. This situation could have been a result of contemporary or earlier uplift of the volcanites in the Wałbrzych region. At the same time a distinct scarp was developed in the area between Rybnica Leśna and Grzmiąca, being further denuded in the initial period of deposition of the Łomnica Member. The second hypothetical scarp displaying a NNW–SSE direction could occur between Kamienna Góra and the region west of Mieroszów. It could be indicated by the coarse-grained deposits of the Łomnica Member in the borehole near Lubawka, as well as by the lack of those deposits near Kamienna Góra.

The theoretical primary extent of the deposition of the Łomnica Member deposits has been presented in Figure 3. Apart from the above mentioned scarps, the northern regions of Wałbrzych and those adjacent to the present Bardo structure and the Kłodzko metamorphic unit were denuded areas. As seen from the analysis of the material from the Nowa Ruda mine and numerous boreholes, strong erosion of previously deposited rocks of the Petrovice and Grzmiąca Members, as well as of the coal-bearing series of the Žacleř Formation, e.g., in the Bożków region (compare with A. Bossowski, A. Ihnatowicz, 1990), took place in the immediate neighbourhood of those units.

THE ŚWIERKI FORMATION

The paper of K. Dziedzic (1961) was the last published synthesis of the Rotliegendes deposits in the Intra-Sudetic Depression. Many deep boreholes have been drilled since that time providing a lot of new data. Information concerns mainly the deposits from megacycle I, i.e., those terminated by the so-called lower Anthracosia shale. A compilation of detailed palaeogeographic schemes based on the new data and described further in this paper was possible for those deposits (Figs. 4, 5).

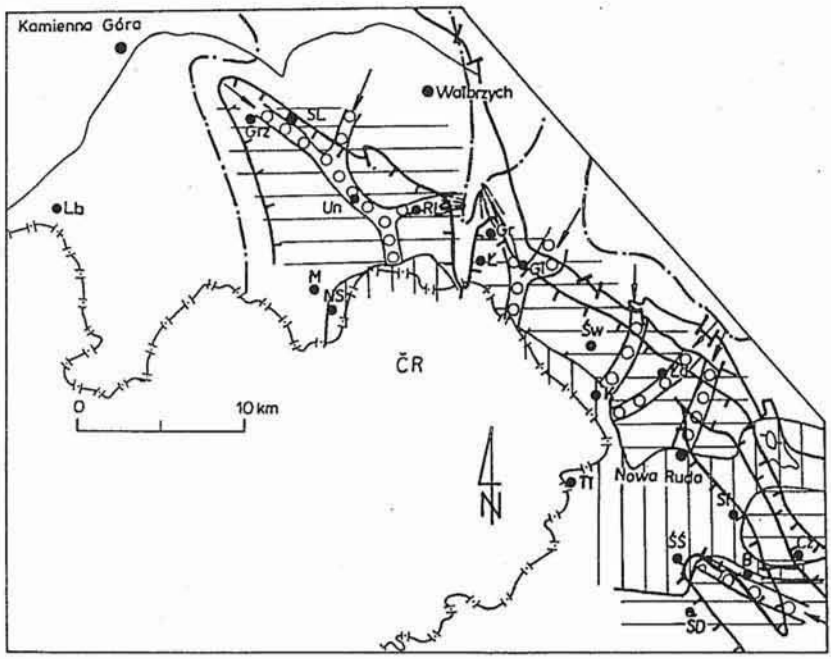

Fig. 4. Palaeogeographic sketch-map — Stephanian C/lowest Autunian — Świerki Formation — Ludwikowice Member

Explanations as in Figs. 1 and 2

Szkic paleogeograficzny — stefan C /najniższy autun — formacja ze Świerków — ogniwo z Ludwikowic

Objaśnienia jak na fig. 1 i 2

Less information was provided for the deposits above the Anthracosia shale horizon (megacycle II). It resulted, however, in a revision of some of the hitherto existing opinions concerning the development of the palaeogeography of lowermost Autunian.

The "Świerki Formation" (megacycles I and II) was proposed by J. Miecznik (1981, 1989). It comprises the former Ludwikowice and Krajanów Formations (W. Nemec *et al.*, 1982).

MEGACYCLE I — THE LUDWIKOWICE MEMBER

The deposits of megacycle I are divided into two parts: the lower part mainly represented by sandy-conglomeratic deposits of fluvial origin, and the upper one represented by lacustrine mudstone-claystone deposits forming the lower Anthracosia shale. In the area between Głuszyca in the NW and Bożków – Czerwieńczyce in the SE the following horizons were distinguished in the deposits of the lower part listed above, namely: the so-called main conglomerate at the bottom, and platy sandstones at the top (J. Oberc, 1975; J. Don, 1961; K. Dziedzic, 1961). The lower Anthracosia shale corresponds to the series of fine-grained sandstones, mudstones and claystones displaying grey, greyish-green or black colour, occasionally with coal seams.

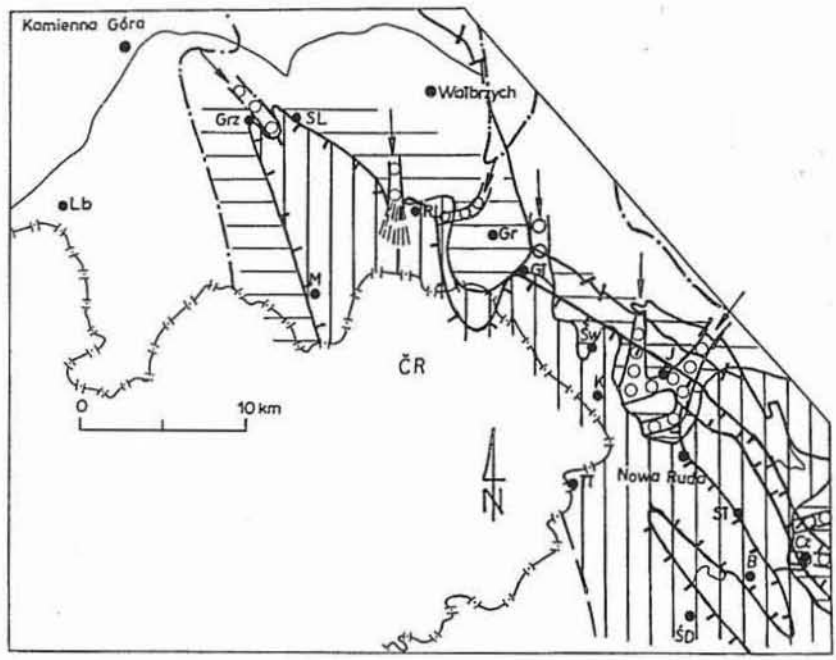

Fig 5. Palaeogeographic sketch-map — Lower Autunian — Świerki Formation — Ludwikowice Member — lower Anthracosia shales

Explanations as in Figs. 1 and 2

Szkic paleogeograficzny — dolny autun — formacja ze Świerków — ogniwo z Ludwikowic — poziom łupków antrakozjowych dolnych

Objaśnienia jak na fig. 1 i 2

The opinions presented above are not confirmed by the results from the boreholes. Continuity of the horizons of the main conglomerates and platy sandstones is not found. In many localities the deposits assigned to the sandstones are developed as mudstones and claystones with carbonate concretions, i.e., they display features of lacustrine deposits. These facts lead to the conclusion that the lakes were formed earlier than was presumed and that the grey coloured deposits — previously interpreted as those of the lower Anthracosia shale — may represent only a phase of maximum depth of the basins and may be the result of a wetter climate.

South and west of Wałbrzych in the lower part of megacycle I there dominate sandy-conglomeratic deposits (conglomerates from Unisław).

The thickness of the sediment in megacycle I (taking the modified division into the fluvial and lacustrine deposits into account) varies from about 100 m near Grzędy – Stary Lesieniec to over 400 or even 500 m south of Rybnica Leśna and between Słupiec and Ścinawka Średnia.

Deposition occurred in palaeogeographic conditions similar to those in the uppermost Carboniferous (compare with Figs. 3 and 4), the extent of the deposits, however, increased towards the south and the north. Shift of the source areas towards the SW (Fig. 4) occurred

in the south-east, i.e., from the Góry Sowie Block, as can be concluded from the character of the deposits between Głuszyca and Bożków. According to the earlier suggestion of K. Dziedzic (1961), a predominantly denudational area (without the deposits of megacycle I) was probably situated in the western part of the Intra-Sudetic Depression, i.e., between Kamienna Góra and Lubawka (Figs. 4 and 5).

Analysis of the borehole material from the NE part of the depression (especially from the frontier vicinity) indicates that the transport energy decreased gradually from the E and NE towards the W and SW and that deposition changed from fluvial to lacustrine. A similar conclusion can be drawn for the area south of Wałbrzych, where an increase of the deposit thickness can be observed parallel to the increase in content of the coarse-grained material. Several concentric water flows were reconstructed based on the analysis of the maps. Those flows finished in the lake already formed in the uppermost Carboniferous (compare with Fig. 3), placed on the Czech side in lowermost Autunian (Fig. 4).

In the final stage of the deposition of megacycle I the lake under discussion increased its extent, due to the progressive erosion of the northern and north-eastern parts of the Intra-Sudetic Depression, and covered the area south of Wałbrzych and between Głuszyca and Nowa Ruda. Dark grey clay-mudstone deposits assigned to the lower Anthracosia shale (Fig. 5) were formed there. According to H. Scupin (1922) the origin of those deposits may be connected with a temporary moistening of the climate, an opinion supported later by K. Dziedzic (1961). This hypothesis was often neglected, especially by the Czech geologists. In their opinion the dark grey colour of the deposits discussed is a result of local facies changes within the body of water (transition from the oxidation to the reduction zone).

Due to the analysis of never borehole data in the regions of Rybnica Leśna, Głuszyca Górna, Ludwikowice – Krajanów, Nowa Ruda and Słupiec the authors of the present paper believe H. Scupin's opinion to be reliable. The following facts support that opinion:

1. Dark grey colour of the deposits displays a large horizontal extent, while only a small interval in the vertical profile of the lacustrine deposits. It is usually restricted only to one interval.

2. Dark grey or grey colour occurs not only in the lacustrine deposits — typical Anthracosia shales — but also partly in the overlying deposits of fluvial origin (best seen in the Słupiec vicinity).

3. Thin coal lenses occur sporadically in the grey coloured deposits.

The extent of the lake presented in Figure 5 does not support the suggestion of K. Dziedzic (1961) on existance of an uplifted structural element in the lowermost Permian — the so-called Kłodzko – Kamienna Góra Ridge — between Mieroszów in the north-west and Tłumaczów in the south-east. With a high probability, such an element, formed in the Carboniferous (compare with Fig. 3), could have occurred more to the west between Kamienna Góra in the NNW and the region west of Mieroszów in the SSW.

MEGACYCLE II —THE KRAJANÓW MEMBER

The following rocks, distinguished on numerous sheets of the Polish geological maps at a scale of 1:25 000, were assigned to megacycle II from the bottom: quartzitic conglomerates with lydites at the bottom and the so-called upper Anthracosia shale. Such a division refers mainly to the south-eastern part of the Intra-Sudetic Depression — the vicinity of Nowa Ruda. In the north-western part, i.e., between Stary Lesieniec to the NW and Głuszyca

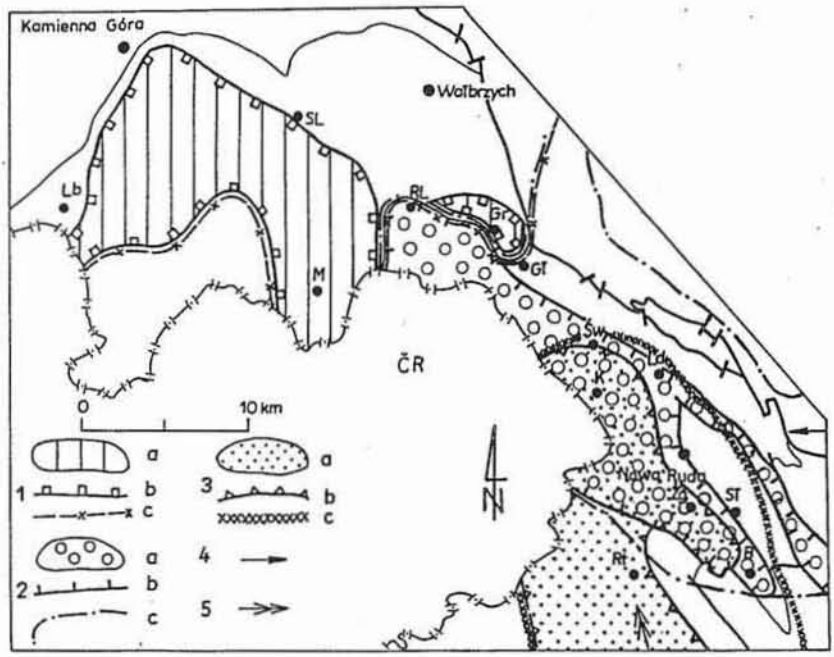

Fig. 6. Palaeogeographic sketch-map — Lower Autunian — Świerki Formation — Krajanów Member and Słupiec Formation

1: a — areas of long-term lacustrine sedimentation, b — present extent of deposits, c — primary extent of deposits; 2: a — quartzitic conglomerates with lydite in bottom (II megacycle), b — present extent of deposits, c — primary extent of deposits; 3: a — building sandstones (III megacycle), b — present extent of deposits, c — primary extent of deposits; 4 — main transport direction of material during quartzitic conglomerates deposition; 5 — main transport directions of material during building sandstones deposition

Szkic paleogeograficzny — dolny autun — formacja ze Świerków — ogniwo z Krajanowa i formacja ze Słupca

1: a — obszary o ciągłej sedymentacji jeziornej, b — granice obecnego zasięgu, c — granice pierwotnego zasięgu; 2: a — zlepieńce kwarcytowe z lidytami w spągu (II megacykl), b — granice obecnego zasięgu, c — granice pierwotnego zasięgu; 3: a — piaskowce budowlane (III megacykl), b — granice obecnego zasięgu, c — granice pierwotnego zasięgu; 4 — kierunki transportu materiału w okresie tworzenia się zlepieńców kwarcytowych z lidytami w spągu; 5 — kierunki transportu materiału w okresie tworzenia się piaskowców budowlanych

to the SE, it was impossible to divide the deposits; this fact is supported by the detailed cartographic work of German geologists and confirmed further by the results of drilling in the neighbourhood of Rybnica Leśna and Grzmiąca as well as Głuszyca Górna. Red-brownish mudstones and claystones are predominant there, at the top of which often occur interbeds of grey and greyish-green claystones and small lenses of limestones or accumulations of carbonate concretions. The accumulations of the carbonate concretions can be referred to the upper Anthracosia shale from the Nowa Ruda region or to the so-called Bećkov horizon from the Czech side of the Intra-Sudetic Depression.

The total thickness of the deposits of megacycle II can be estimated with variation from 80 m near Rybnica to over 300 m near Głuszyca Górna and Słupiec.

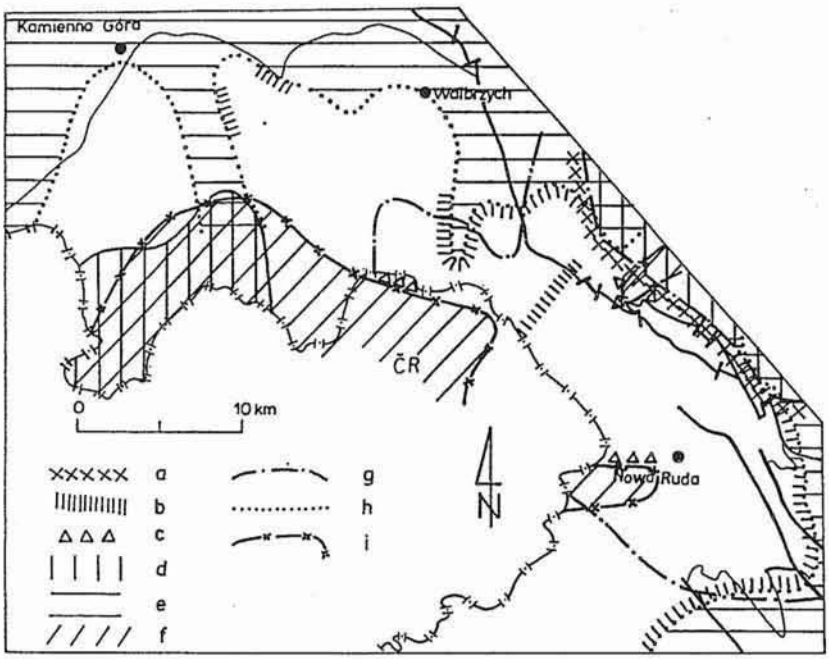

Fig. 7. Sketch-map of tectonic development of the NE part of the Intra-Sudetic Depression during uppermost Carboniferous and the Lower Autunian

a — significant movement zones during Lower Autunian (after lower Anthracosia shales deposition), b — significant movement zones during Asturian phase, c — significant movement zones during Westphalian C, d — uplifted areas during Lower Autunian (after lower Anthracosia shales deposition), e — uplifted areas resulted from Asturian phase, f — uplifted areas during Westphalian C, g — primary extent of fluvial deposits after lower Anthracosia shales deposition (see Fig. 6), h — primary extent of deposits after Asturian phase (see Fig. 3), i — primary extent of deposits during Westphalian C (see Fig. 2)

Szkic rozwoju tektonicznego NE części depresji śródsudeckiej w najwyższym karbonie i dolnym autunie

a — strefy mobilne w dolnym autunie (po zakończeniu tworzenia się łupków antrakozjowych dolnych), b — strefy mobilne fazy asturyjskiej, c — strefy mobilne westfalu C, d — obszary wypiętrzone w dolnym autunie (po zakończeniu tworzenia się łupków antrakozjowych dolnych), e — obszary wypiętrzone w wyniku ruchów fazy asturyjskiej, f — obszary wypiętrzone w westfalu C, g — pierwotny zasięg osadów fluwialnych bezpośrednio po utworzeniu się łupków antrakozjowych dolnych (por. fig. 6), h — pierwotny zasięg osadów bezpośrednio po ruchach fazy asturyjskiej (por. fig. 3), i — pierwotny zasięg osadów w westfalu C (por. fig. 2)

The detailed reconstruction of the palaeogeographic image is impossible for the lowermost Rotliegendes period because of lack of abundant and satisfactory information from the boreholes. A suggestion, however, on continuation of the lacustrine deposition in the western part of the Intra-Sudetic Depression can be proposed, based on the surface data and the material from new boreholes in the neighbourhood of the present frontier. The deposition presumably also covered the already denuded area between Kamienna Góra and Lubawka (compare to K. Dziedzic, 1961). In the eastern part of the regions discussed lacustrine deposition temporarily changed into fluvial deposition. Due to the intensive supply of

coarse-grained material from the Góry Sowie Block several interfingering alluvial fans formed leading to a horizon of quartzitic conglomerates with lydites at the bottom (Fig. 6). As is concluded from the boreholes both at the frontier and the Unisław Śląski regions the last horizon pinches out westwards. The area of the present boundary between the Intra-Sudetic Depression and the Góry Sowie Block (Fig. 7) could, therefore, have been tectonically active (zones of mobilization).

THE SŁUPIEC FORMATION

MEGACYCLE III — THE ZAGÓRZYN AND RATNO MEMBERS

Analogous as in the case of megacycle II the Słupiec Formation was recognized thanks to the boreholes, but only to some extent.

The Słupiec Formation comprises the upper clayish-sandy series which occurs above the upper Anthracosia shale. In the Nowa Ruda region the so-called building sandstones lie at the bottom of the series, being covered mainly by red mudstones and claystones with interbeds of grey claystones, which form the so-called horizon of the Walchia shale.

In the north-western part of the Intra-Sudetic Depression (between Stary Lesieniec and Głuszyca Górna) mudstones and claystones are distinctly predominant in the whole profile of the deposits of the Słupiec Formation, with some fine carbonate lenses and concretions — similarly to the top part of megacycle II. It is practically impossible to differentiate the deposits of the Słupiec and Świerki Formations.

In the final stage of deposition, due to the volcanic activity of the region, several horizons of trachybasalts, rhyolites and their tuffs were formed (the volcanic formation of the Góry Kamienne Mts.).

The thickness of megacycle III, most easily estimated in the Nowa Ruda region, reaches 450 m. In the area of Rybnica Leśna, Grzmiąca and Głuszyca its maximum roughly equals 350 m.

The palaeogeography did not change distinctly during the deposition of megacycle III. Lacustrine deposition was predominant. Between Głuszyca and Bożków — after deposition of the quartzitic conglomerates with lydites at the bottom — there occurred a short return of lacustrine deposition (horizons of red mudstones and claystones and the upper Anthracosia shale) being followed again by intensive supply of coarse-grained material from the south. The so-called building sandstones were deposited that time, the extent of which is presented in Figure 6.

Contrary to the lower Anthracosia shale the formation of grey marine deposits, i.e., the upper Anthracosia shale or the Bećkov limestones (megacycle II) as well as of the Walchia shale (megacycle III) might rather be referred to the facies differentiation within the basin than to climate changes. These facts would be evidenced by the narrower horizontal extent of those deposits in comparison to the lower Anthracosia shale, by dispersion of grey parts within the long distances of the profile and by their lenticular character. These features can be clearly seen in the numerous pits excavated for copper exploitation in the Głuszyca Górna vicinity (J. Tomaszewski, 1955).

CONCLUSIONS

The following conclusions can be drawn from the hitherto presented discussion on formation of uppermost Carboniferous and lowermost Permian deposits:

1. Deposition of the lower part of the Glinik Formation in the Wałbrzych region occurred in palaeogeographic conditions similar to those of the Žacleř Formation (compare to A. Bossowski, A. Ihnatowicz,. 1994). In the Nowa Ruda region the re-juvenation of the morphological scarp (separating the area from the Wałbrzych region) took place, as well as sinking of the earlier uplifted (i.e., in the Namurian but mostly in the Lower Westphalian) areas which had supplied the material to the coal-bearing series under formation.

2. Due to the tectonic movements of the Asturian phase, the palaeogeographic structure of the region discussed was totally reorganized. Main source areas moved from S and N to SE and NE, respectively directions of transport of the coarse-grained material turned and the large-scale lacustrine deposition between Mieroszów in the NE and Ścinawka Średnia in the SE started.

3. No distinct changes in palaeogeographic structure are observed at the boundary between the Carboniferous and the Permian.

4. A further increase in extent of the lacustrine deposition, especially towards the west, occurred in the Lower Permian (Autunian). The source areas lay mainly in the east and the south. Their temporary uplift resulted in supply of coarse-grained material at two times the which in its turn, led to a temporary break in lacustrine deposition.

5. According to many earlier suggestions the formation of the lower Anthracosia shale is connected with moistening of the climate. Grey colour of some overlying lacustrine deposits (the upper Anthracosia shale or the Walchia shale) is probably a result of local facies changes in the body of water.

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PALEOGEOGRAFIA UTWORÓW NAJWYŻSZEGO KARBONU I NAJNIŻSZEGO PERMU W NE CZĘŚCI DEPRESJI ŚRÓDSUDECKIEJ

Streszczenie

Przedstawiono rozwój budowy geologicznej północno-wschodniej części depresji śródsudeckiej od westfalu C (karbon górny) do autunu dolnego (perm). Podstawą jej odtworzenia była próba rekonstrukcji paleogeografii. Artykuł stanowi kontynuację rozważań nad środowiskiem osadów depresji śródsudeckiej przedstawioną przez A. Bossowskiego i A. Ihnatowicza (1994), a dotyczącym utworów od przełomu wizenu i namuru po dolny westfal C.

Przeprowadzono analizę miąższości, zawartości materiału gruboklastycznego i węglonośności. Zestawiono 6 szkiców, które etapowo przedstawiają paleogeografię regionu. Dane do opracowania uzyskano z materiałów kopalnianych i wierceń poszukiwawczo-dokumentacyjnych. Sedymentacja utworów najniższej części formacji z Glinika (ogniwo piaskowców i zlepieńców z Grzmiącej) zachodziła w zbliżonych warunkach paleogeograficznych jak formacji z Žaclerza. W fazie asturyjskiej nastąpiła przebudowa paleogeografii omawianego rejonu. Główne

obszary alimentacyjne przesunęły się z S i SE na N i NE, a kierunki transportu uległy odwróceniu (z NE ku SW, zamiast z SW na NE jak w westfalu A–C). Analiza danych wiertniczych wskazuje na przechodzenie od sedymentacji rzecznej do jeziornej między Głuszycą a Bożkowem. Podobnie było na południe od Wałbrzycha, gdzie w kierunku południowym nastąpił wzrost miąższości osadów, przy jednorazowym spadku zawartości materiału gruboklastycznego.

W końcowej fazie sedymentacji utworów najniższego autunu (ogniwo zlepieńców i piaskowców z Ludwikowic) na znacznej części depresji śródsudeckiej doszło do utworzenia rozległego jeziora, czego efektem było powstanie ilasto-mułowcowego poziomu dolnych łupków antrakozjowych.

W wyższej części dolnego autunu (ogniwo zlepieńców i piaskowców z Krajanowa i formacja ze Słupca), można przyjąć, że paleogeografia obszaru nie uległa zasadniczej zmianie, a transport materiału odbywał się również z NE i N. Jedynie nastąpiło dalsze rozszerzenie strefy sedymentacji jeziornej, przy czym sedymentacja ta objęła prawdopodobnie również rejon Kamiennej Góry – Lubawki (W część obszaru).