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Direction of the Aalenian transgression in the area of the Mid-Polish Trough

The hitherto existing arguments for three different directions of the Aalenian transgression have been analysed in the paper. An explanation that the transgression followed due to downwarp movements along faults bordering the trough was further a basis for creation of theoretical suggestions on the direction of transgression. Palaeogeographic conditions in the neighbourhood of two presumed straits: the south-eastern and western ones — have been discussed. The following features are disscused: a possible marine connection, intensity of subsidence, lability of the adjacent denudation areas, presence of open-sea nectonic fauna, presence of Ca/Mg carbonates in cement of deposits and the geotectonic similarity to the situation in the Toarcian. Based on these data, it has been concluded that the Aalenian sea entered the area of the Mid-Polish Trough through a depression formed in the foreland of the Bohemian Massif.

INTRODUCTION

Evolution of the theories on the direction of the Early Aalenian[1] marine transgression of Poland has had three stages. Each stage being limited by different solutions to the problem of direction. The last 35 years have brought a lot of new data due to the intensification of studies in different parts of the Middle Jurassic basin. Changes of previous conclusions seem to be quite natural in face of new facts. If each successive paper had questioned the arguments of the previous paper, there would not exist any need for a historical analysis of the interpretations of that important palaeogeographic event. The successive papers, how-

[1] The Early Aalenian age of the sandy sediments with the marine foraminifers, which mark the transgression has been proved by individual ammonites (e.g. *Tmetoceras* sp. from the Góra Łysiec — S. Z. Różycki, 1953); in general it is accepted due to its position in the geological section, below the faunally well documented Upper Aalenian, and over the continental complex of sediments assigned to the Upper Toarcian (K. Dayczak-Calikowska, J. Kopik, 1973).

ever, neglect the previous arguments, so all three hypotheses (to some extent) exist in parallel, while being chronologically successive. The present paper's author has doubts concerning the final version of the south-eastern direction of the transgression. These doubts stem from studies on the Middle Jurassic history of sedimentation and on palaeotectonics in the Holy Cross part of the Mid-Polish Trough. This problem was a fragment of collective research on the palaeogeography and palaeotectonics of the Permian-Mesozoic in the area discussed. This work was done at the Institute of Geological Sciences, Polish Academy of Sciences.

REVIEW OF THE HITHERTO EXISTING HYPOTHESES AND ARGUMENTS

The direction of the Aalenian transgression was first determined by R. Dadlez (1958). Based on the studies of the Lower and Middle Jurassic sediments between Szczecin and Koszalin this author stated that the Aalenian basin of Middle Poland was connected to the German one through the Middle Odra region. J. Znosko (1959), in his paper on the Aalenian and Bajocian transgression in the Polish Lowlands, developed the first hypothesis with some modifications based on borehole localities penetrating the Aalenian sediments, and a map showing the thickness of these sediments and the outline of the denudation area. These data were compared to drilling results from Germany. The transgression was thought to enter from the west, from the Brandenburgian and Meklemburgian area, through the Lower Odra "...occupying a long and narrow trough earlier filled with continental Liassic sediments ... As it was presented by R. Dadlez (1958) the same way was used by the marine ingressions into Pomerania."

A connection with the epicontinental basins of Western Europe had already been suggested by J. Kopik in 1956 who wrote that the assemblage of foraminifers in the Borucice borehole in the Kujawy area was very similar to that in north-western Germany.

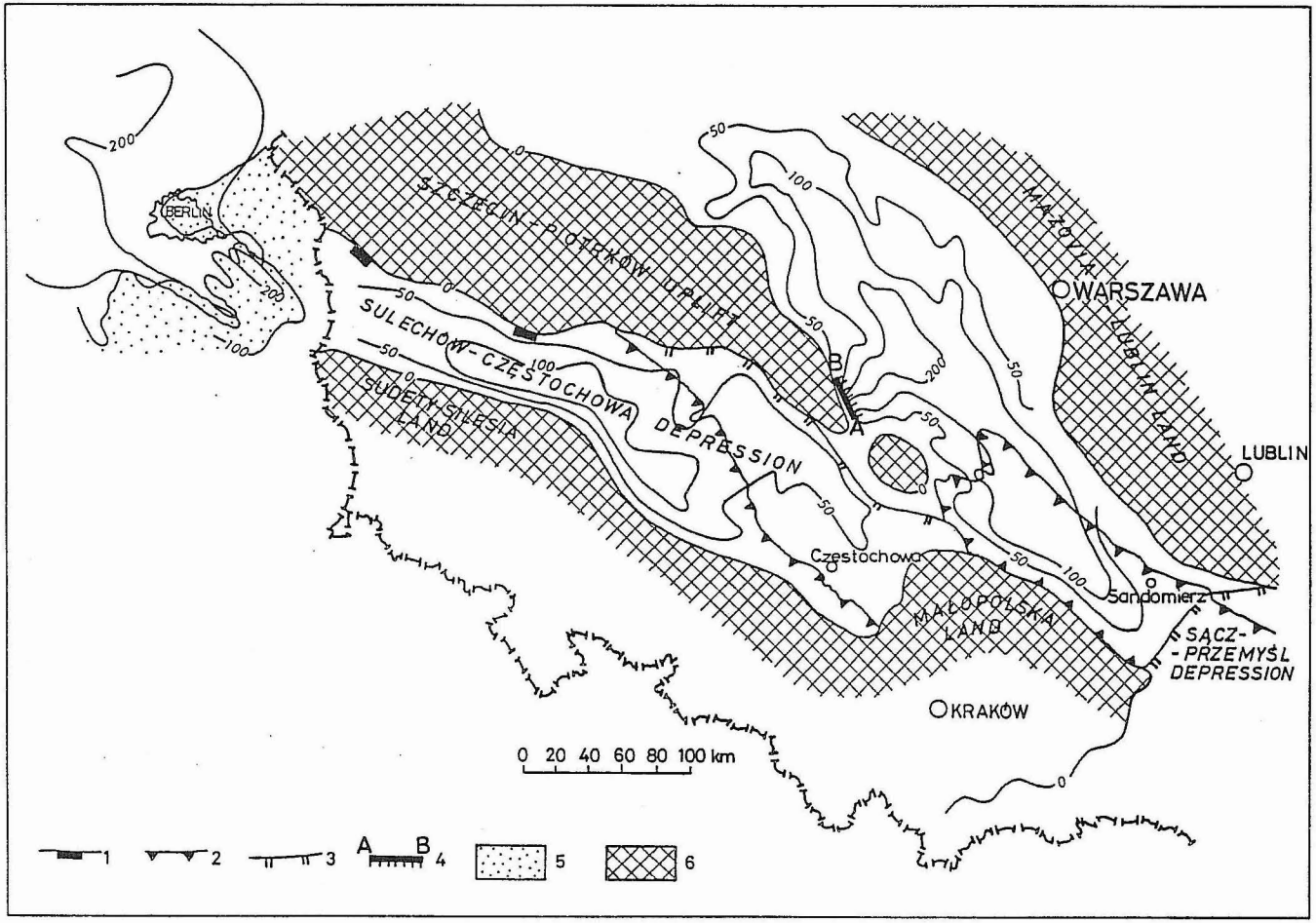
The fifties and early sixties brought exploration for iron ores at the northern and north-eastern margins of the Holy Cross Mts. Based on this work J. Daniec (1970) presented the stratigraphy and lithology of the Middle Jurassic sediments and the hypothesis on the north-western direction of the Aalenian transgression. The following facts supported the theory: (1) distinct reduction in the thickness of the Aalenian sediments south-eastwards from Brudzewice (located in the Gielniów Anticline, where the thickness exceeds 200 m) to Wyszmontów (near Ożarów, 11 m), (2) narrowing of the basin in the south-east to a form of a narrow bay, (3) development of the lowermost units of the Middle Jurassic in the Zalesie Antoniowskie profile (behind the Vistula line) pointing to a transgressive position of the Bajocian sediments in respect to the Aalenian ones further towards the south-east.

The third direction of the transgression under discussion was proposed by R. Dadlez and J. Kopik (1972). "The complete development and great thicknesses of the clay sediments in the Kujawy Trough and in neighbourhood of the Holy Cross Mts. seem to point to the fact that the ingression came from the south-east. The thickness reduction occurs towards the north-west and in the Western Pomerania a thin, sandy-clayey series of brackish-marine origin is developed ...". If this reduction concerns the Aalenian of the Holy Cross Mts. margin, the facts presented by J. Daniec on the thickness and lithological character of the sediments there do not support such a solution of the problem. Without

doubt, however, a north-western direction of the transgression, understood as the opening of the marine connection through the Western Pomerania region, must be excluded. R. Dadlez and J. Kopik (*op. cit.*) mention also some facts, which taken together suggest not south-eastern, but a western direction of the transgression, just through the Middle Odra, namely: (1) the extent of the Toarcian marine deposits is V-shaped opened towards WNW, (2) in the lowermost Toarcian the ingression comes from the west, (3) continuous transition of the sediments from the uppermost Liassic to the Aalenian points to the ingressive character of the change of conditions from continental to marine, (4) in the Western Pomerania area "... ingressions of the marine basin could have come from the west even earlier — the ingression in Eastern Germany corresponds to the uppermost Toarcian and Lower Aalenian, while the maximum of transgression in Central Poland — to the Upper Aalenian". It can be supposed that the facts presented above, being not so exactly expressed in the earlier paper (R. Dadlez, 1958) were, however, the basis of the former hypothesis of one of the authors.

The concept of a transgression from the south-east was supported by K. Dayczak-Calikowska (1976*a*, 1977) in her conclusions from the analysis of the Middle Jurassic sediments from the Pomerania Swell, Kujawy Swell and the Łódź Trough. She stated, namely, that towards the south-east the lacustrine Aalenian series is replaced by marine sediments, stratigraphic gaps are less frequent and the thickness increases. The last feature was also observed by the quoted author in the southern part of the Kujawy Trough (K. Dayczak-Calikowska, 1976*b*), but then conclusions are not credible when applied to the area of the Holy Cross Mts. Apart from the repeated argument on the great thickness and clayish character of the Aalenian, two others appear, namely: (1) "... an existance of sedimentation continuity between the uppermost Toarcian and the Lower Aalenian ...", (2) "... mainly in that area the ammonites are grouped being found rather sporadically in the northern parts of the Lowlands ..." (K. Dayczak-Calikowska, *op. cit.*). The argument for the specific clayish character and great thickness of the lowest parts of the Middle Jurassic has not been confirmed in borehole sections (J. Daniec, 1963, 1965). The significance of conformity between the uppermost Toarcian and the Lower Aalenian as proof for the south-eastern direction of the transgression is also unclear, since K. Dayczak-Calikowska (1977) suggested that tendency for conformity for the whole Mid-Polish Trough. As for the ammonites, the Aalenian forms have not been found at the north-eastern margin of the Holy Cross Mts.

The hypothesis on the south-eastern direction of the transgression has been recently supported (R. Dadlez, 1987, 1989; K. Dayczak-Calikowska, W. Moryc, 1988), undoubtedly due to better borehole data from the Middle Jurassic sediments in the Carpathian Foredeep, as well to the presumable presence of the Lower Bajocian in Czarna Sędziszowska and Będziemyśl south of Mielec (W. Moryc, 1987). In paper on the development of the Middle Jurassic sedimentary basin in Poland K. Dayczak-Calikowska and W. Moryc (1988) discuss only the south-eastern direction of the transgression, although the same paper gives arguments for a western direction: "... with the transgression in the slightly younger Aalenian there formed a south-western arm of the Aalenian sea in the foreland of the Sudety-Silesian Land which had z connection with the German basin. That arm was separated from the north-western part of the trough by the land uplifted at Late Keuper/Early Norian-Rhaetian time ..." (comp. to Fig. 1). It is especially difficult in this region to


BERLIN
SZCZECIN - KUJAWY UPLIFT
SULECHÓW - CZĘSTOCHOWA DEPRESSION
SUDETY - SILESIA LAND
MAZOVIA - LUBLIN LAND
WARSZAWA
LUBLIN
Częstochowa
Sandomierz
MAŁOPOLSKA LAND
SANOK - PRZEMYŚL DEPRESSION
KRAKÓW
A
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0 20 40 60 80 100 km
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distinguish the slightly younger Aalenian since it is undivided there. The arm of the sea could, therefore, have existed since the beginning of the Aalenian.

It can be stated, after considering the arguments for three different theories apparently excluding each other, that a western direction of the transgression would be the only solution not in opposition to any of the presented facts. Reverse transgression directions (NW and SE) could only be created in closed or narrowed terminations of the trough.

THE CAUSE OF THE TRANSGRESSION AND PALAEOGEOGRAPHIC DATA ON ITS DIRECTION

Which facts, pointing to the direction of the transgression, could be expected when marine waters enter a narrow inland basin? The cause of the transgression should be determined to answer that question. On the curves of the eustatic level constructed by A. Hallam (1984) and B. U. Haq *et al.* (*fide* Ch. K. Wilgus *et al.*, 1988) the Aalenian represents an age of sea-level lowstand. Whether we accept the global significance of these curves or not, the Aalenian has a regressive character in the West European basins close to the Mid-Polish Trough (P. A. Ziegler, 1990). Moreover, in the Carpathian domain there occurs either evidence for a shallowing of the sedimentation conditions at the boundary of the Toarcian and Aalenian (J. Lefeld, 1973), or the existance of constant sedimentation conditions (in the Pieniny Klippen Belt — K. Birkenmajer, 1977). It should be concluded, therefore, that a rise of sea level in the adjacent basins could not be considered as the cause of the transgression. In fact — despite the probable fall of the sea level (or stagnation) — marine waters entered the trough. It is probable that downwarp movements along the faults boundering this trough caused subsidence, resulting in the influx of marine waters.

The position of an area of relatively thick deposits in the marginal parts of basin should be a clear indication of the direction of the transgression. Greater thickness points to an intensive subsidence which could be followed by the opening of a connection with the adjacent marine basin. Such a zone should also display facies different from those present in the rest of the basin. In comparison to the rest of the basin such facies should display a more open-sea character, an increased degree of salinity, especially when the transgression first entered the fresh water inland basin. The narrower the connection with the open sea,

Fig. 1. Distribution of denudation areas and thickness: of the Aalenian in the Mid-Polish Trough, of Aalenian–Late Bajocian until *tetragona* Zone in the Sulechów – Częstochowa Depression (after K. Dayczak-Calikowska, W. Moryc, 1988) and of the whole Middle Jurassic in the area of east Germany (after H. Kölbel, 1968)
Extent of epigenetic erosion: 1 — pre-Cretaceous, 2 — post-Cretaceous; 3 — limit of undivided sediments of the Aalenian, Lower Bajocian and lower part of Upper Bajocian; 4 — synsedimentary fault; 5 — areas without Middle Jurassic sediments due to epigenetic erosion in the area of Germany; 6 — areas without primary sedimentation
Rozmieszczenie obszarów denudowanych w aalenie oraz miąższość aalenu w bruździe śródpolskiej, aalenu-późnego bajosu do poziomu *tetragona* w obniżeniu sulechowsko-częstochowskim (według K. Dayczak-Calikowskiej, W. Moryca, 1988) i całej jury środkowej na terenie wschodnich Niemiec (według H. Kölbela, 1968)
Zasięg erozji epigenetycznej: 1 — przedkredowej, 2 — pokredowej; 3 — granica nierozdzielonych osadów aalenu, bajosu dolnego i niższej części bajosu górnego; 4 — uskok synsedymentacyjny; 5 — obszary pozbawione osadów jury środkowej wskutek erozji epigenetycznej na terenie Niemiec; 6 — obszary pierwotnie nie objęte sedymentacją

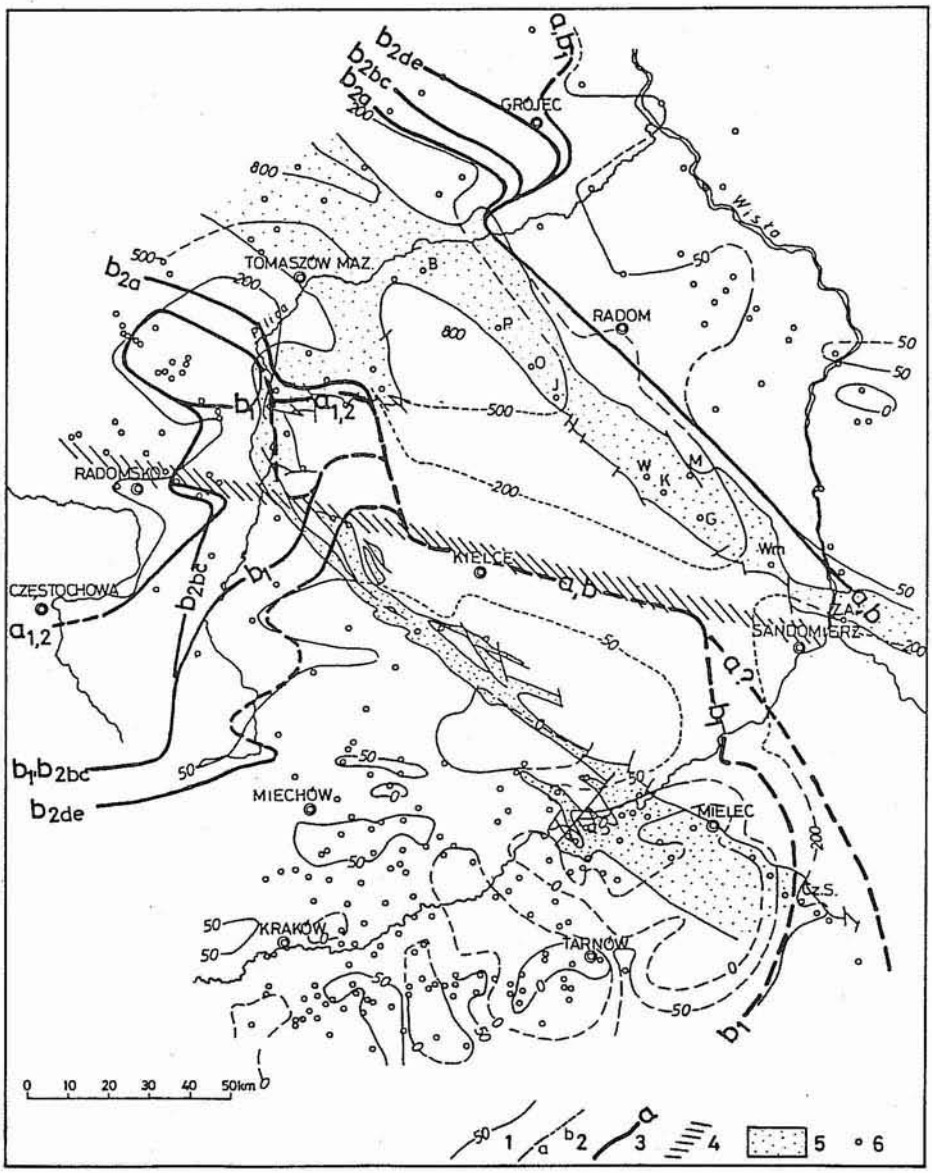


Fig. 2. Map of thickness of the Middle Jurassic sediments in the Holy Cross part of the Mid-Polish Trough and in adjacent areas (with reference to the unpublished reports of M. Giżejewska, 1977–1984)
Isopachs: 1 — sure, 2 — hypothetical: a — due to lack of data, b — due to epigenetic erosion; 3 — extents of: a_1 — Lower Aalenian, a_2 — Upper Aalenian, b_1 — Lower Bajocian, b_2 — Upper Bajocian; Zones: b_{2a} — *subfurcatum*, $b_{2b,c}$ — *garantiana* and *tetragona*, $b_{2d,e}$ — *subarietis, parkinsoni* and *schloenbachi*; 4 — Holy Cross Dislocation; 5 — outcrops of Middle and Upper Jurassic; 6 — boreholes: B — Brudzewice, P — Podłęki, O — Omięcin, J — Jastrząb, W — Władysław, K — Karczma Kunowska, M — Mołdawa, G — Gutwin, Wm — Wyszmontów, Z. A. — Zalesie Antoniowskie, Cz. S. — Czarna Sędziszowska

the more hydrodynamic conditions should characterize those sediments because that is the area of water mixing, of creation of currents due to the equilibration of salinity and of the water levels. Presence of open-sea fauna can also point to those places, nectonic fauna would be more significant here due to the tendency of the heavier, saline waters to sink towards the close-to-bottom parts of the basin. Ammonites should be a better indicator than the more frequent benthonic foraminifers.

In relation to the above mentioned features the palaeogeographic situation in the areas close to the presumed western and south-eastern straits will be described.

PALAEOGEOGRAPHIC SITUATION NEAR THE PRESUMED STRAITS

It is difficult to reconstruct the outline of the denuded lands due to the later epigenetic pre- and post-Cretaceous erosion, and due to the Middle Jurassic erosion documented for the *subfurcatum* Chron. Just the Mazovia-Lublin Land is not the cause of controversial discussions — in contrary to the outline of the other denudation areas.

THE SOUTH-EASTERN STRAIT

On the map of the Aalenian (K. Dayczak-Calikowska, K. Moryc, 1988) the whole area of the Holy Cross Mts. was included in the subsiding trough (Fig. 1). The careful analysis of the extent of the lower stages and substages of the Middle Jurassic, i.e. the Aalenian, Lower and Upper Bajocian, exhibits an orientation nearly perpendicular to the belt of the outcrops in the south-western Mesozoic margin of the Holy Cross Mts. (Fig. 2). This proves that zone was not a palaeogeographic element at the beginning of Middle Jurassic (comp. M. Giżejewska, 1984). At the northern and north-eastern margins of the Holy Cross Mts. the sediments discussed are completely developed, and their isopachs correspond to the margin of the Mazovia-Lublin Land and of the East-European Platform. To reconstruct the successive extents across the area where sediments have been removed by erosion, the palaeogeographic importance of the Holy Cross Dislocation should be accepted. This dislocation defined the northern margin of the Małopolska Land. Further proof of the importance of this dislocation is found in the area of Radomsko. Here, the zone representing the western continuation of the dislocation shows distinct synsedimentary activity — the northern side underwendt a greater subsidence than the area to the south. It seems that the width of the eventual strait in the south-east should be distinctly narrower than on the map of K. Dayczak-Calikowska and W. Moryc (1988) and could have a maximum width of about 30 km near Sandomierz (Fig. 2).

Mapa miąższości osadów jury środkowej na świętokrzyskim odcinku bruzdy śródpolskiej i na obszarach przyległych (z uwzględnieniem prac archiwalnych M. Giżejewskiej 1977–1984)
Izopachyty: 1 — pewne, 2 — przypuszczalne: a — ze względu na brak danych, b — ze względu na epigenetyczną erozję; 3 — zasięgi: a_1 — aalen dolny, a_2 — aalen górny, b_1 — bajos dolny, b_2 — bajos górny; poziomy: b_{2a} — *subfurcatum*, $b_{2b,c}$ — *garantiana* i *tetragona*, $b_{2d,e}$ — *subarietis, parkinsoni* i *schloenbachi*; 4 — dyslokacja świętokrzyska; 5 — wychodnie jury środkowej i górnej; 6 — otwory wiertnicze (patrz podpis angielski)

Based on the archive materials and the papers of J. Daniec (1963, 1965, 1970) there was constructed a cross-section along the line of Brudzewice – Zalesie Antoniowskie (Fig. 3), aimed at better illustration of changes occurring along the axis of the Holy Cross part of the Mid-Polish Trough. During the Early Aalenian the subsidence decreased from Brudzewice to the last point of the cross-section line. During the Late Aalenian the subsidence was small but constant in the long southern interval. Only just in the Early Bajocian it started to increase from Brudzewice to Jastrząb and again increased slowly behind Wyszmontów towards the south.

In the major part of the cross-section discussed the Lower Aalenian is composed of poorly sorted sandstones with quartz debris. A laterally extensive horizon of siderite pebbles occurs, being the proof of synsedimentary erosion. All those facts suggest relatively high-energy environments. In the two south-eastern most boreholes, however, the grain fraction is distinctly finer and the sediments do not exhibit traces of erosion.

In the Upper Aalenian the fraction of the sediments is in general fine-grained. There occur marly-sideritic concretions which prove a low sedimentation rate or even omissions. The last two sites of occurrence also reveal a fine, clayey-muddy fraction, without siderite concretions, however. This indicates that more mobile waters could be expected in comparison to the north-western part, while the sediment itself points to a low-energy environment.

Not till the Early Bajocian can an increased depth of the basin be observed in the interval of Władysław – Gutwin, expressed by a simultaneous increase in thickness and the appearence of finer, clayey-muddy facies different in their character from the general sandy trend of that substage. The facies at the south-eastern end of this cross-section (Fig. 3) are varied. They are more sandy than in Władysław and Gutwin, but also more clayey and more calcareous than in Brudzewice and near Omięcin. In the Lower Bajocian there appear, in the south-eastern part of the trough, ammonites pointing to the *humphriesianum* Zone (K. Dayczak-Calikowska, J. Kopik, 1973). In the Lower and Upper Aalenian, benthonic foraminifers are the only marine organisms.

The character of the Aalenian sediments in the south-east also points to the high stability of the lands existing so near-by (Fig. 2). Sediments from the boreholes (Karczma Kunowska – Mołdawa), situated on the line perpendicular to the margin of the East- European Platform, do not exhibit an increase in grain size towards the platform.

THE WESTERN STRAIT

Analysis of the situation in the western area will be based on the discussion of facts from papers done by other authors, especially by K. Dayczak-Calikowska and W. Moryc (1988). As for the outline of the denudation areas, the most doubtful one is that fragment of the Szczecin – Piotrków Uplift, where a synsedimentary fault has been presented (Fig. 1). This fault is the only one of that type in the whole area of Poland. As it is shown, the isopachs are perpendicular to the fault. If, however, we connect a disturbance in distribution of thickness with the activity of a synsedimentary fault, it follows that the vertical component of the fault causes a long-lasting differentiation in the subsidence rate on both sides of the fault (Fig. 4a). That is why the position of the isopachs must be concordant with their cause, when reflecting the process, i.e. with the fault. So that position must be parallel.

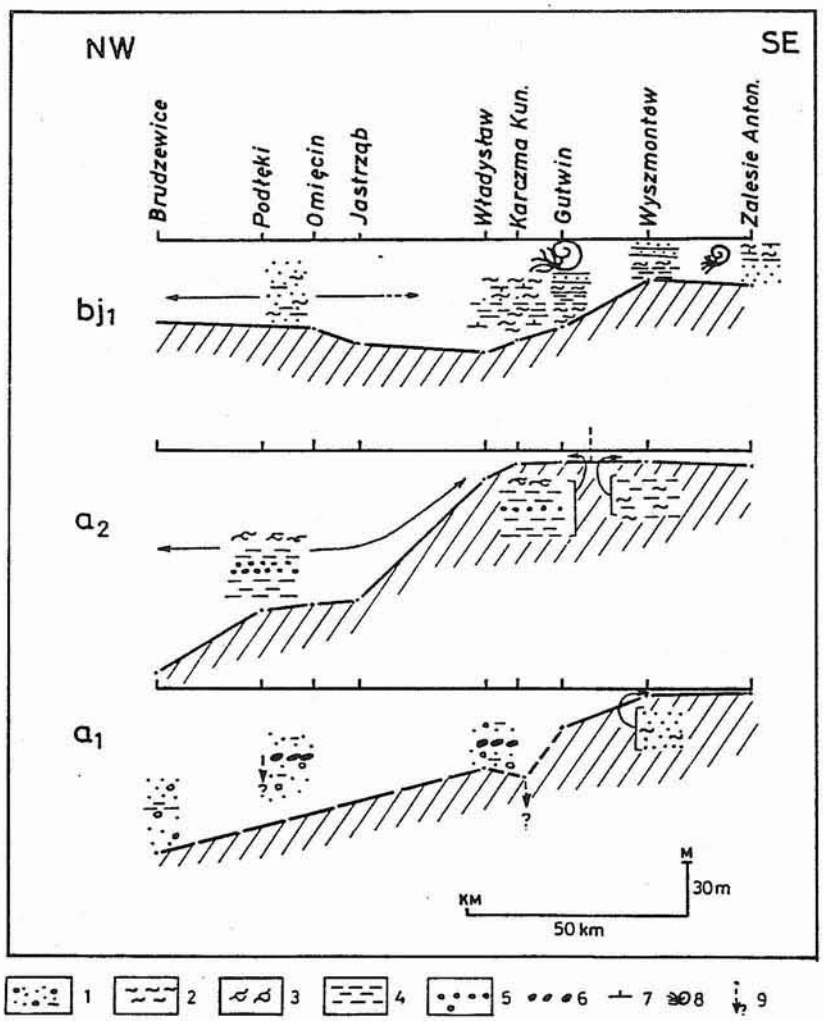


Fig. 3. Variation in subsidence in Aalenian and Early Bajocian in the Holy Cross part of the Mid-Polish Trough (longitudinal section)

a_1 — Early Aalenian, a_2 — Late Aalenian, bj_1 — Early Bajocian; 1 — sandstones with gravels, poorly sorted, 2 — mudstones, 3 — ruffled mudstones, 4 — claystones, 5 — marly-sideritic concretions, 6 — pebbles of siderites, 7 — presence of Ca/Mg carbonates in cement, 8 — fauna occurrence, 9 — non-drilled sediments; location of section in Fig. 2

Zmienność subsydencji w aalenie i wczesnym bajosie na świętokrzyskim odcinku bruzdy śródpolskiej (przekrój podłużny)

a_1 — wczesny aalen , a_2 — późny aalen , bj_1 — wczesny bajos; 1 — piaskowce ze żwirem, źle wysortowane, 2 — mułowce, 3 — mułowce mierzwiste, 4 — iłowce, 5 — konkrecje marglisto-syderytyczne, 6 — otoczaki syderytów, 7 — wapnistość spoiwa, 8 — stanowiska fauny, 9 — osady nie przewiercone; lokalizacja przekroju na fig. 2

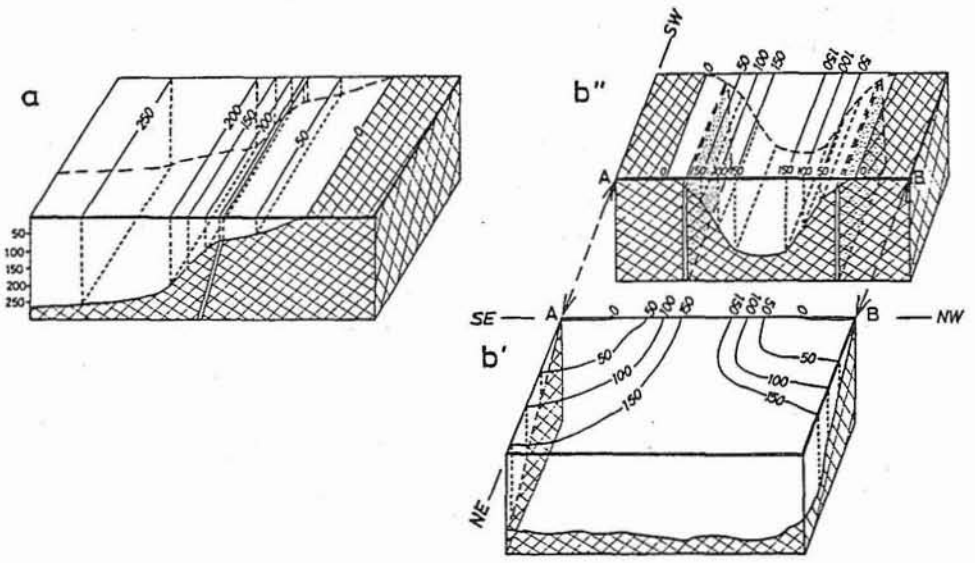


Fig. 4. Relation of isopachs to synsedimentary faults
a — changes of subsidence due to faulting with one side displaying permanent subsidence; attempt at palaeotectonic re-interpretation of subsidence process at south-eastern margin of Szczecin Uplift in Pabianice region: b′ — southern part of Kujawy Trough, b″ — inlet between Szczecin and Piotrków Uplifts after re-interpretation; lines on horizontal planes — isopachs, hatched parts — basement, AB interval — synsedimentary fault on map of K. Dayczak-Calikowska, W. Moryc (1988, Fig. 1), dotted surfaces — synsedimentary faults responsible for path of palaeoisopachs after re-interpretation
Stosunek izopachyt do interpretowanych na ich podstawie uskoków synsedymentacyjnych
a — zmiany subsydencji wywołane uskokiem, którego jedno ze skrzydeł ulega permanentnemu obniżaniu; próba paleotektonicznej reinterpretacji procesu subsydencji na południowo-wschodnim krańcu wyniesienia szczecińskiego w okolicach Pabianic: b′ — południowa część bruzdy kujawskiej, b″ — przesmyk między wyniesieniem szczecińskim a piotrkowskim po reinterpretacji; linie na płaszczyznach poziomych — izopachyty, części zakratkowane — podłoże, odcinek AB — uskok synsedymentacyjny na mapie K. Dayczak-Calikowskiej, W. Moryca (1988, fig. 1), powierzchnie zakropkowane — uskoki synsedymentacyjne odpowiedzialne za przebieg paleoizopachyt po reinterpretacji

A high gradient of thickness over the fault zone results in densely spaced isopachs co-shaped with that zone (Fig. 4a). The interpretation in Fig. 1 is completely opposite: due to perpendicularity of the isopachs to the area without sediment, the authors quoted have drown the fault under discussion. It should be concluded that such isopachs suggest that in the Aalenian there existed no elevated area in this region. If we apply the general rule presented in the blockdiagram (Fig. 4a) to the interpretation of the upper surface of the blockdiagram (Fig. 4b′), we obtain a depression limited by faults (dotted surfaces in Fig. 4b″), i.e. a depression displaying the character of a transverse tectonic graben. Towards the south-west that depression could be connected with the depression in the foreland of the Sudety Land stated by K. Dayczak-Calikowska and W. Moryc (*op. cit.*).

If we project the thickness of Middle Jurassic sediments from Eastern Germany (based on the map of H. Kölbel, 1968 — Fig. 1), we would get the subsidence axis of south-eastern Brandenburg reaching the Sudety-Silesian Land. It seems, therefore, that the northern

boundary of that land should be shifted towards the south (Fig. 5). Such a change makes comparisons with the countours of the Bohemian Massif in Germany easier, shown in P. A. Ziegler's atlas (1990). The similar narrowing of the same land in relation to the Carnian and the Upper Bajocian was done by R. Dadlez (1989).

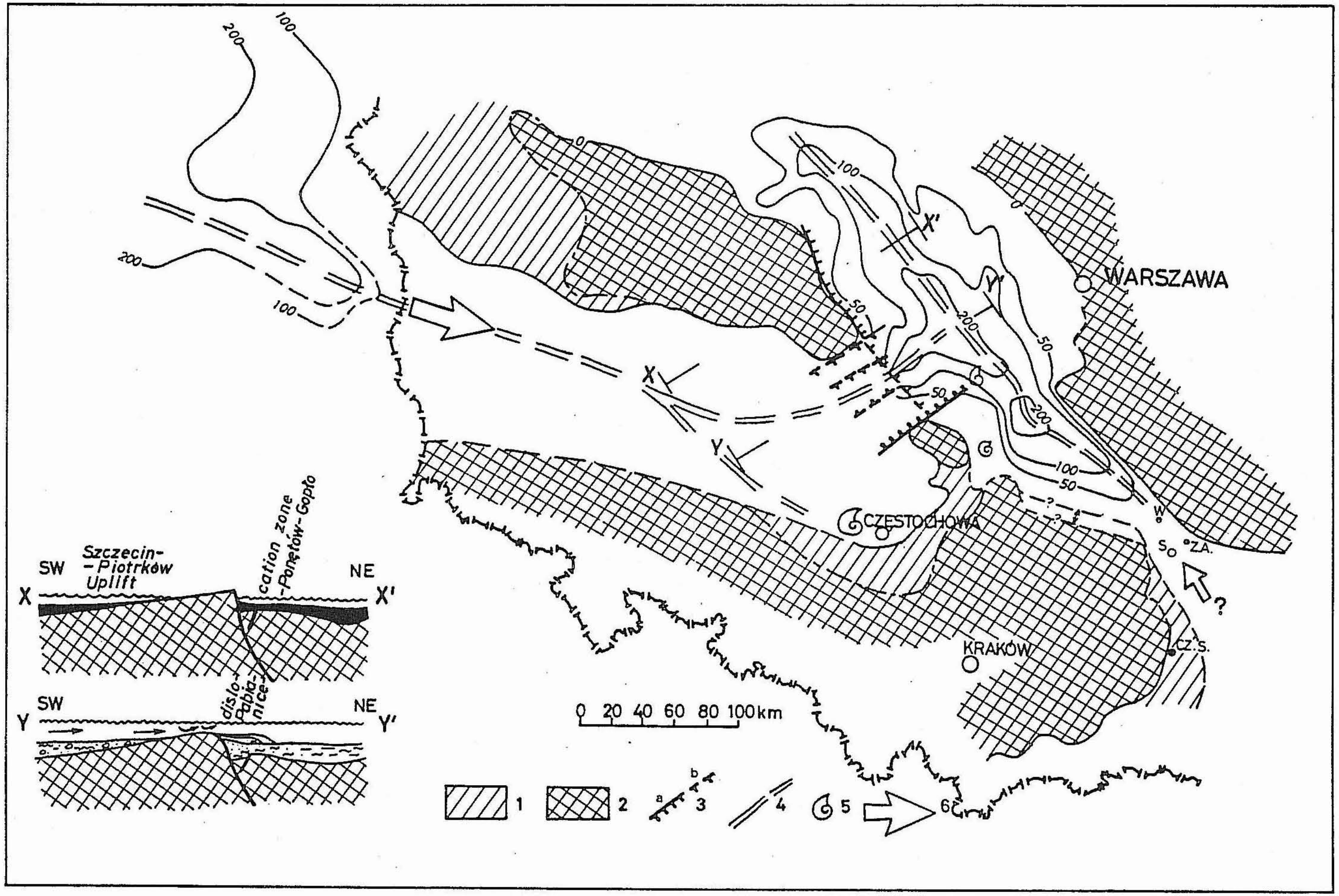
The western strait was probably formed over the tectonic graben which could have even been built by two fault steps (Fig. 5). One of the faults was located on the line of Bełchatów – Buków and recognized as synsedimentary for nearly all the stages and substages of the Middle Jurassic. The degree of subsidence and a distribution of the facies suggested continuous subsidence of the northern side. The fault on the opposite side of the graben, symmetrical to the first one, can possibly be identified with the Sierpów fault stated by R. Dadlez and S. Marek (1977).

What has happened with the Aalenian sediments which should have filled the graben? The first possibility corresponds to their erosion before the Early Bathonian (sediments of the *zigzag* Zone occur first), precisely — in the *subfurcatum* Chron, when the extent of the basin diminished distinctly to the axial zone of the trough (Fig. 2). Erosion could have occurred also in the *schloenbachi* Chron, because the general tendencies of regression are marked there. Thus a temporary uplift of the area can not be excluded.

The Middle Jurassic epigenetic erosion is not the only explanation possible for the sedimentary gap from the Upper Toarcian to the Upper Bajocian at the south-eastern margin of the Szczecin Uplift. Another interpretation follows the fact that the north-eastern margin of that uplift is a fragment of the big fault zone of Gopło – Ponętów – Pabianice which, in its turn, represents the synsedimentary limit of the south-western part of the Mid-Polish Trough (R. Dadlez, M. Franczyk, 1976; R. Dadlez, S. Marek, 1977). The cross-section (X–X' in Fig.5) through the uplift, known also as the Wielkopolska Ridge, illustrates the palaeogeographic significance of the fault zone discussed. Salt pillows grew up on the uplift, related to the tectonic activity of the fault zone. At the south-eastern part, the salt pillows of Śladkowice and Poddębice (R. Dadlez, S. Marek, *op. cit.*) are placed strictly in the zone of the presumed transversal tectonic graben. Their growth in the Aalenian could have caused the formation of an syn-Aalenian under-water scarp in the strait (cross-section Y–Y' in Fig. 5). The contemporary erosion of the scarp could have made sedimentation impossible, despite the downwarp tendencies caused by the activity of the transverse faults. It is, therefore, impossible to draw palaeoisopachs within the inlet which in its character is similar to the antecedent gate: the uplift developing in the bottom is eroded by sea currents.

The palaeogeographic situation described above could been repeated with some breaks until the *schloenbachi* Chron. It could also be an explanation for the lack of the uppermost Toarcian (R. Dadlez, M. Franczyk, 1976) without the necessity for subaerial Aalenian erosion. Such erosion would be an extraordinary event, incompatible with the sedimentary continuity at the boundary of the Toarcian and the Aalenian proved over a wide-spread area (J. Daniec, 1970; K. Dayczak-Calikowska, 1976*b*, 1977).

What is the facies character of the sediments adjacent to the enlarged (60 km) western strait? In the south-west there are sandstones, similar to the Kościelisko ones, displaying varied grain size and poor sorting, often containing quartz gravels. In the Bełchatów region there often occur scoured surfaces in the sandstones (K. Mrozek, 1975). All the facts point to a high-energy environment — in contrary to the situation in the south-eastern margin of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the trough. The adjacent denudation areas are characterized by high lability, due to the activity of the limiting faults and development of the salt pillows.

North-east of the inlet the sediments are better sorted and finer grained. Although great subsidence occurred there, the facies boundaries are not follow the path of the isopachs. This is proof that sedimentation was intensive enough to fill the depression being formed in the basement without any bathymetric changes. Such a situation can be compared with the increased sedimentation in the lagoon at the mouth of the tidal inlet, although the scale of the process is distinctly larger.

The Aalenian nectonic organisms (ammonites) come from the Częstochowa region (S. Z. Różycki, 1953), the western margin of the Holy Cross Mts. (Sylwerynów near Paradyż — J. Daniec, 1970) and the southern part of the Łódź Trough (the Justynów Anticline — K. Dayczak-Calikowska, 1976*b*). Their preservation and discovery there may be quite accidental (Fig. 5), but still it is a suggestion for a more open-sea character of the waters near the western strait.

Finally, it is necessary to recall the well-known tendency concerning the lithological character of the platform Mesozoic: the more distinct and wider are the connections with the warmer Tethys basin, the more calcareous are the sediments in the epicontinental basin. The Aalenian sediments are non-calcareous.

CONCLUSIONS

Table 1 contains a recapitulation of the arguments for the hypothesis of western direction of transgression caused by the tectonic depression of the foreland of the Bohemian Massif and the Mid-Polish Trough.

Figure 6 presents the suggested palaeogeographic modifications in the Aalenian in respect to the denudation areas in Germany. Although Aalenian opening of a sea connection in the south-east is not excluded, such an interpretation has been poorly supported even by indirect premisses. Even if we accept that in the Early Aalenian two inlets towards the adjacent seas were opened — one in the south-east and the second in the west — the western direction seems to be more intensive in the transgression process, namely: active in sedimentation, currents and water mixing.

Fig. 5. Comparison of palaeogeographic situation in Aalenian near zones of eventual connections with adjacent marine basins

Lands denuded in: 1 — Aalenian, 2 — Aalenian and Early Bajocian; 3 — synsedimentary faults: (a) sure, (b) hypothetical; 4 — axes of subsidence of Aalanian sedimentary basin; 5 — sites of Aalenian ammonites; 6 — direction of transgression; X–X' and Y–Y' — cross-section lines; localities: W — Wyszmontów, Z. A. — Zalesie Antoniowskie, Cz. S. — Czarna Sędziszowska, S — Sandomierz

Porównanie sytuacji paleogeograficznej w aalenie w pobliżu stref ewentualnych połączeń z sąsiadującymi zbiornikami morskimi

Obszary lądowe denudowane w: 1 — aalenie, 2 — aalenie i wczesnym bajosie; 3 — uskoki synsedymentacyjne pewne (a) i przypuszczalne (b); 4 — osie subsydencji aaleńskiego zbiornika sedymentacyjnego; 5 — stanowiska amonitów aaleńskich; 6 — kierunek transgresji; X–X' i Y–Y' — linie przekrojów; miejscowości jak w podpisie angielskim

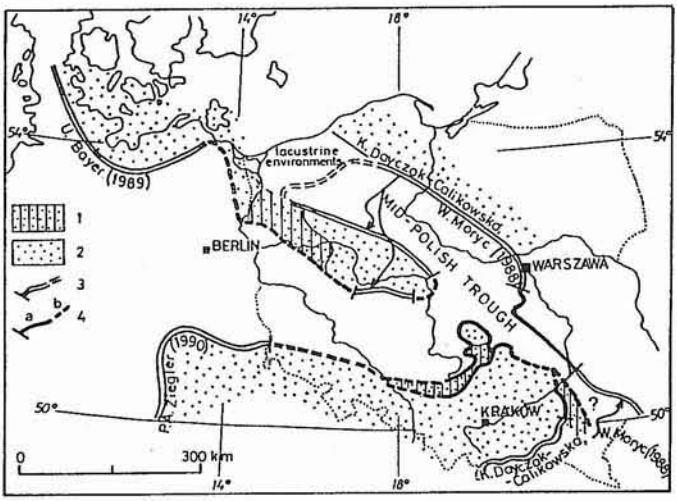

Fig. 6. Extent of Aalenian sedimentary basin in Poland in relation to German basin
Lands denuded in: 1 — Aalenian, 2 — Aalenian and Early Bajocian; 3 — boundaries based on papers of other authors; 4 — re-interpreted boundaries of higher (a) and lower (b) degree of certainty
Zasięg aaleńskiego basenu sedymentacyjnego na obszarze Polski w nawiązaniu do basenu niemieckiego
Obszary lądowe denudowane w: 1 — aalenie, 2 — aalenie i wczesnym bajosie; 3 — przebieg granic na podstawie prac innych autorów; 4 — zreinterpretowany przebieg granic o większym (a) i mniejszym (b) stopniu pewności

Table 1

The arguments for the direction of transgression

Transgression features	Strait	
	western	south-eastern
width of strait	larger: 60 km	smaller: 30 km
subsidence near strait	increased: about 200 m	distinctly reduced: about 10 m
hydrodynamic conditions	high-energy environments: coarse-grained sediments, poorly sorted, frequent scoured surfaces	low-energy environments: fine-grained sediments
stability of adjacent denudation areas	labile: synsedimentary faults, growth of salt pillows	stable: fine-grained sediments in spite of proximity of two big lands, fraction does not increase towards East-European Platform
open-sea fauna	nectonic organisms:ammonites from region of Częstochowa, Paradyż, Justynów	benthonic foraminifers
geotectonic similarity to Toarcian	+	–
lack of Ca/Mg carbonates in cement	+	–

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KIERUNEK TRANSGRESJI AALEŃSKIEJ NA OBSZARZE BRUZDY ŚRÓDPOLSKIEJ

Streszczenie

Przegląd dotychczas proponowanych w literaturze kierunków transgresji w aalenie na obszarze Polski prowadzi do wniosku, ze jedynie kierunek zachodni nie stoi w sprzeczności z obserwacjami pochodzącymi z różnych rejonów basenu.

Poszukiwanie bezpośrednich przesłanek kierunku transgresji wymaga na wstępie określenia, co było jej bardziej prawdopodobną przyczyną: czy podniesienie się poziomu morza, czy też tektoniczne obniżenie podłoża basenu sedymentacyjnego. Podniesienie się poziomu morza we wczesnym aalenie należy raczej wykluczyć, gdyż w sąsiednich basenach, zarówno zachodnioeuropejskich, jak i w basenie tatrzańskim, na przełomie wczesnej i środkowej jury mamy do czynienia z przejawami warunków regresywnych. Również na krzywych eustatycznych ten przedział czasowy jest charakteryzowany obniżającym się poziomem oceanu światowego. Przyczynę transgresji aaleńskiej w bruździe śródpolskiej należy więc wiązać z postępującymi ruchami obniżającymi, które zachodziły dzięki aktywności uskoków ją obrzeżających. Prawdopodobnie były to te same uskoki, które wyznaczały basen intensywnej, silikoklastycznej sedymentacji fluwialno-limniczno-brakicznej w liasie, gdyż istnieje daleko idące podobieństwo wykształcenia litologicznego najwyższych osadów jury dolnej i leżących na nich zgodnie najniższych osadów jury środkowej.

Rozkład obszarów pozbawionych dziś morskich osadów aalenu daje dwie możliwości połączeń z otwartymi zbiornikami morskimi: od zachodu, poprzez północne przedpole masywu czeskiego, i ostatnio przyjmowane połączenie południowo-wschodnie, poprzez bramę przemyską. Analiza prawdopodobnych zarysów obszarów denudowanych w aalenie w pobliżu miejsc domniemanych połączeń z otwartym morzem prowadzi do dwóch istotnych modyfikacji dotychczasowego (fig. 1, K. Dayczak-Calikowska, W. Moryc, 1988) obrazu paleogeograficznego. Zostaje znacznie zawężona (do 30 km) cieśnina południowo-wschodnia, co wynika z przebiegu izopachyt i zasięgów niższych pięter i podpięter jury środkowej w rejonie świętokrzyskim i niecki miechowskiej (fig. 2). Do obszarów denudowanych lądu małopolskiego zostaje włączony region kielecki aż po dyslokację świętokrzyską. Druga zmiana polega na otworzeniu szerszego połączenia (ok. 60 km) na zachodzie, w południowej części niecki łódzkiej. Wynika to z odmiennej od dotychczasowej interpretacji rozkładu subsydencji i uskoków synsedymentacyjnych w tym rejonie (fig. 4, 5).

W pobliżu tych dwóch możliwych cieśnin zostały przedyskutowane warunki sedymentacyjne: dynamika sedymentacji, labilność podłoża i stabilność sąsiednich obszarów denudowanych (fig. 3, 5). Duża dynamika sedymentacji (na którą wskazuje różnoziarnistość osadów, ich zła selekcja, obecność frakcji żwirowej, liczne powierzchnie erozyjne), znaczna subsydencja (duża miąższość świadcząca o tendencji do zapadania się w tym miejscu podłoża basenu), labilność obszarów denudowanych (wynikająca z ograniczenia czynnymi synsedymentacyjnie uskokami i z prawdopodobnych ruchów mas solnych) oraz obecność pełnomorskiej, nektonicznej fauny aaleńskiej to przesłanki przemawiające za zachodnim kierunkiem transgresji. Kierunek zachodni należy uznać za bardziej aktywny w procesie transgresji — aktywny w procesie sedymentacji, prądów i mieszania się wód. Argumentem dodatkowym za zachodnim kierunkiem jest bezwapnistość osadów aaleńskich.