Kwartalnik Geologiczny, t. 35, nr 2, 1991 r., str. 221–234

Andrzej PIOTROWSKI

The influence of sub-Quaternary basement on the development of Lower Odra Valley in Pleistocene and Holocene

The relations between the development of Lower Odra Valley in Quaternary and the basement are described. The influence of the salt tectonics on the development of relief and the facial development of the area was especially stressed. In the relation of Odra River bed with salt pillows, the pattern of the XVIII-th century river bed system of so called Old Odra was considered. The problem of the influence of the salt tectonics on the development of Odra Lobe is considered to be the broader background of the phenomena in the Odra Valley.

INTRODUCTION

The results of the geological, geomorphological, palaeogeographic investigations and the results of the analysis of cartographic materials and aerial photographs were used in this paper.

The author, considering the distribution of the structures in the basement, used the papers of R. Wienholz (1967) for Germany and the collective papers edited by M. Jaskowiak-Schoeneich (*Budowa geologiczna* ...., 1979), by R. Dadlez et al. (1980) for Poland.

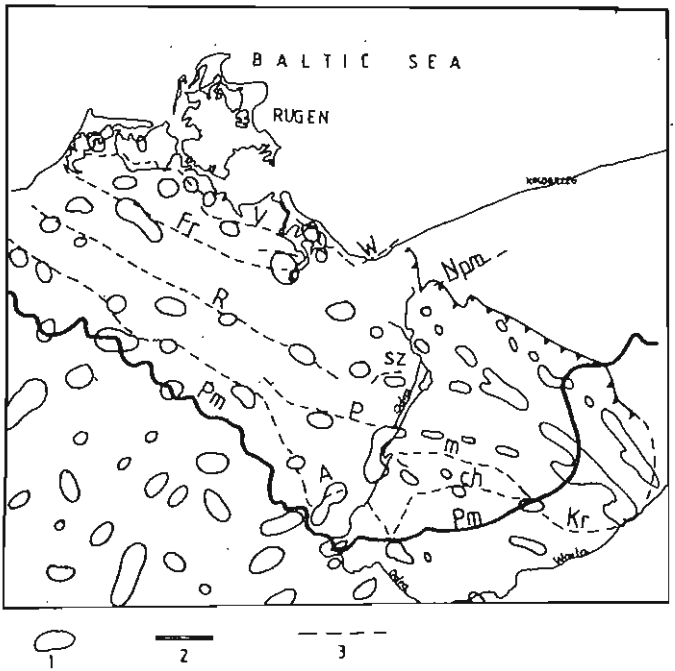

Fig. 1. Lines of extension of the frontal moraines of Pommeranian Phase and subphases against the background of the distribution of the salt pillows

1 — salt pillows; 2 — extension of the moraine of Pommeranian Phase (Pm); 3 — extention of moraines of subphases: Kr — Krajno, ch — Chojna (A — Angermünde), m — Mielęcin (P — Penkun), sz —Szczecin (R — Rozental), Npm — North-Pommeranian (Fr — Franzburg), W — Wolin (V — Velgast)

Linie zasięgów moren czołowych fazy pomorskiej i subfaz na tle rozmieszczenia poduszek solnych

1 — poduszki solne; 2 — zasięg moren fazy pomorskiej (Pm); 3 — zasięg moren subfaz: Kr — krajeńskiej, ch — chojeńskiej (A — Angermünde), m — mielęcińskiej (P — Penkun), sz — szczecińskiej (R — Rozental), Npm — północnopomorskiej (Fr — Franzburg), W — wolińskiej (V — Velgast)

THE INFLUENCE OF THE GENERAL STRUCTURAL SYSTEM OF THE BASEMENT ON THE DEVELOPMENT OF ODRA LOBE

The shaping front of the continental glacier forms at the stage of deglaciation the outline of Odra Lobe, of similar scale as Wisła Lobe. The outline of the edge of this lobe shows the connection with the structural lines of the basement (Fig. 1). The SW flank of the lobe, determined by the range of frontal moraines, is well aligned, and reaches along the extension of the salt pillows from Mecklemburg Bay to Cedynia Anticline. The southern edge of the lobe is not oval, but runs along the parallel of latitude, what is concordant with the system of the salt anticlines and the fault lines in the area of Gorzów Block. The SE edge of the lobe shows the arc-shaped bend of about 90° in the northern direction.

The strong bend of the lobe lies at the convergence of streches of anticlines from the west (Gryfino—Chabowo—Wierzbno—Choszczno —Radęcin) and north-west (Goleniów—Wierzchosław—Maszewo—Suliszewo). The eastern wing of the lobe runs from Choszczno in the direction of Ińsko Anticline. Especial role in giving direction to the wing played the strech of partly perforated salt plugs and salt combs of the central zone of Szczecin Trough (Grzęzno—Oświno—Ińsko—Drawno), beeing tectonically most active. The length of the eastern wing of the Odra Lobe is in the evident disproportion with the length of the south-eastern wing. The lobe axis, that is the line from the center of the lobe to its most advanced edge, runs along the dislocation zone Goleniów—Krzyż—Szamotuły and is concordant with the lobe axis of the Krajno Subphase, preceding the Pommeranian Phase.

THE TECTONIC AND STRUCTURAL FEATURES OF LOWER ODRA VALLEY

Lower Odra Valley is the only valley with water cutting through the morainic upland of the Odra Lobe. All important rivers flowing through the lobe (Warnow, Recknitz, the valley of Malchiner and Kummerower lakes, Tollense, Wkra, Rendowa, Rurzyca and Płonia) are situated in the direction of the valleys in the sub-Quaternary basement.

In the case of Odra Valley this dependence is less distinct, because it is connected with the broad dislocational zone of Lower Odra Valley. The valleys of the above mentioned rivers have structural features in the sub-Cainozoic basement. For all these rivers there are characteristic valleys that are distinctly marked in the relief of the terrain up till the line of moraines of the maximal extension of the Pommeranian Phase of North-Polish Glaciation. The line of the morains is rather low over the sea level. The fact that caused the Odra Valley to become the main valley draining subglacial water of Odra Lobe, was the strong erosion by the subglacial water. The strength of the erosion was produced by the shortest distance between the lobe center and its edge, and by relatively strong development of salt structures in the dislocational zone of Lower Odra Valley. The convergence of the Odra Valley in its meridional course is more in accordance with the dislocational zone in the deep basement than with the valley in the sub-Quaternary basement. The valley in the sub-Quaternary basement at the sector Szczecin—Osinów Dolny probably never existed. The valleys along the parallel of latitude (south of Bukowe Mountains and in the area of Gorzów Block) are more distinctly marked. They are crossing the dislocational zone of Lower Odra changing their directions to NW and, after connecting with the valley in the basement of Rendowa, are running in the southern direction. The valley from the period of Cromerian Interglacial, running along the line Myślibórz—Chojna —Krajnik Dolny, has the same direction. If mę admit that the valley in the sub-Quaternary basement with the direction of the Odra Valley existed, then the magnitude of the neotectonic dislocations during Pleistocene would amount to 70.0 m.

The age of the glacial tills existing in the area allows to accept, that the forming of the valley happend during the stage of the Great Interglacial. Deeper valleys along

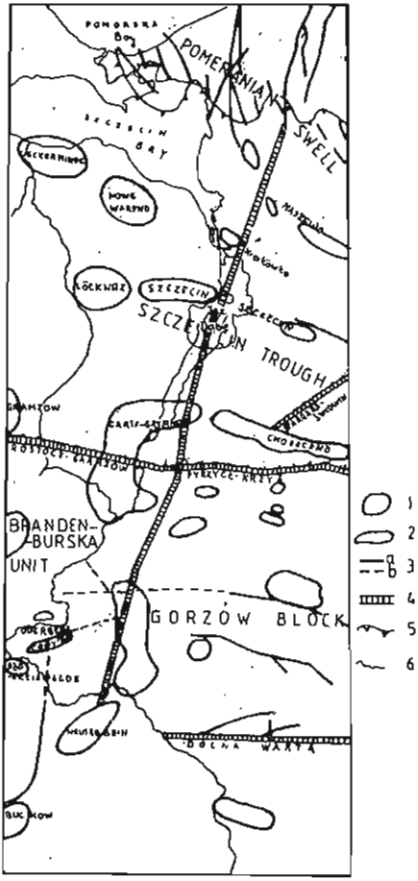

Fig. 2. Course of the beds of Old Odra and Rendowa against the background of the tectonical map of the Zechstein-Mesozoic complex (according to R. Dadlez et al., 1980; *Budowa geologiczna...*, 1979; R. Wienholz, 1967 and the *Detailed Geological Map of Poland*, 1:50 000)

1 — salt pillows; 2 — salt anticlines; 3 — faults (a — certain, b — probable); 4 — dislocational zones; 5 — extension of denudation of Cretaceous formations under cover of Cainozoic; 6 — bed of Old Odra

Przebieg koryta Starej Odry i Rendowy na tle mapy tektonicznej kompleksu cechsztyńsko-mezozoicznego (wg R. Dadleza i in., 1980; *Budowy geologicznej...*, 1979; R. Wienholza, 1967 oraz *Szczegółowej mapy geologicznej Polski* 1:50 000)

1 — poduszki solne; 2 — wały solne; 3 — uskoki (a — pewne, b — przypuszczalne); 4 — strefy dyslokacyjne; 5 — zasięg denudacyjny utworów kredy pod przykryciem kenozoiku; 6 — koryto Starej Odry

the parallel of the latitude are filled with clays even of the oldest glaciation (for instance, under Warszewo Hills at the depth of 140.0 m exists the bottom of the bed of this age). In the Great Interglacial the Odra Valley, developping along the dislocational zone, forms the valley to the SW of Ognica and in the southern direction of Moryń. The Eemian valley with the sane direction forms the condition for the development of Rurzyca Lobe. The valley of Odra formed at the stage of the maximal extension of the Pommeranian Phase definitely in the direction Ognica—Bielinek —Osinów—Oderberg.

The results of the analysis of thickness of the Tertiary and Quaternary formations in the longitudinal and axial sections of Lower Odra and Rendowa valleys are shown in the simplified way at Fig. 4.

The distribution of the thickness of sediments of different ages shows the connection with the structural scheme of the Zechstein – Mesozoic complex. In the zones of the salt pillows and salt anticlines the top of the Mesozoic formations is lying high, and the thickness of Cainozoic is small. The top of the Mesozoic in the zones of salt

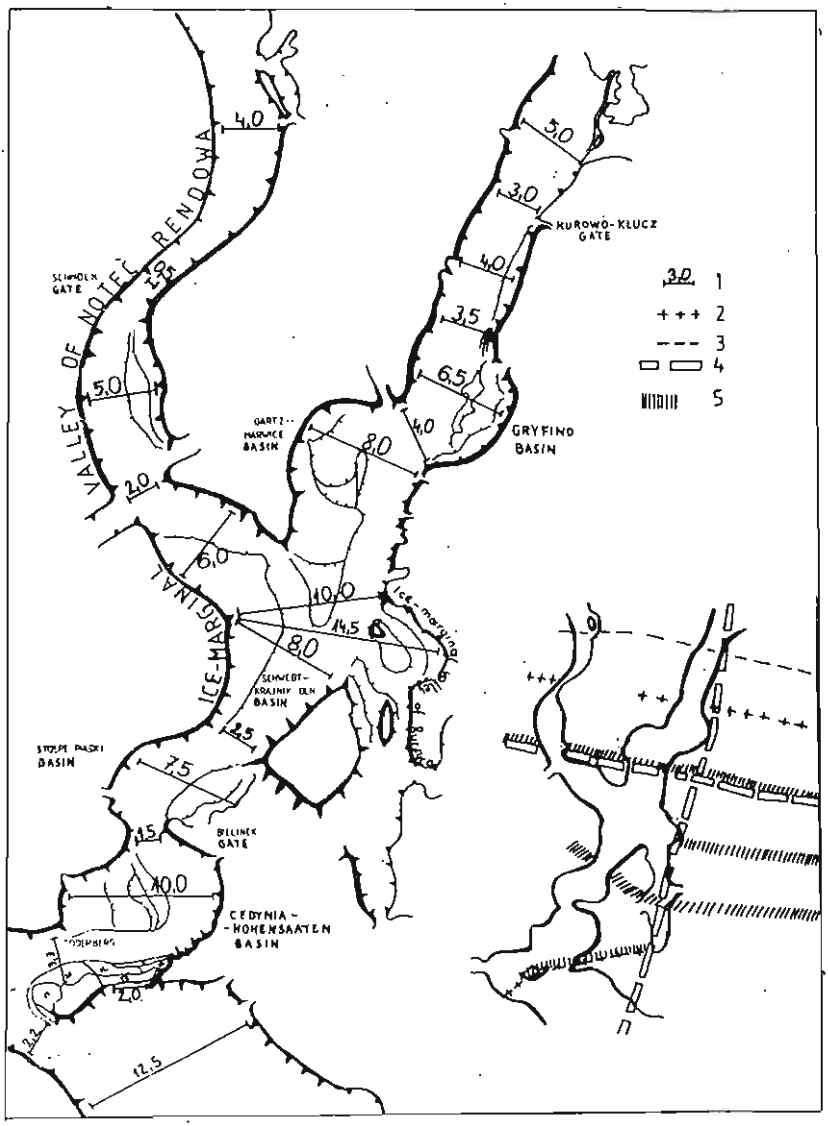

Fig. 3. Main elements of the relief and morphometry of Lower Odra Valley and Rendowa Valley against the background of the structures in the basement

1 — distance in km; 2 — axis of salt anticline; 3 — axis of syncline; 4 — dislocational zone; 5 — bank of Tertiary sediments in basement of Quaternary

Główne elementy rzeźby i morfometria Doliny Dolnej Odry i doliny Rendowy na tle struktur podłoża

1 — odległość w km; 2 — oś antykliny wału solnego; 3 — oś synkliny; 4 — strefa dyslokacyjna; 5 — wał osadów trzeciorzędowych w podłożu czwartorzędu

squeezing is lowered and the thickness of Cainozoic is very great. The differentiation of these thicknesses sets the measure of the movement of salt upwards and the index of continuity of this process in time (in Tertiary, Pleistocene and Holocene).

THE INFLUENCE OF THE SUB-QUATERNARY BASEMENT ON THE GENERAL FEATURES OF THE RELIEF OF LOWER ODRA AND RENDOWA VALLEYS

The relief of the Lower Odra and Rendowa valleys was formed in stages at the end of North-Polish Glaciation and in Holocene. These valleys played in turn the roles of subglacial channels, ice-marginal valleys and river valleys.

The changing of the relief forms of the sub-Quaternary basement (humps and valleys) and the deeper structures of Zechstein – Mesozoic complex (faults, salt pillows and salt anticlines), most of them running in the direction transversal to Odra and Rendowa valleys, shows the conformity with general features of the sculpture (Fig. 3).

For the relief of Odra Valley there is characteristic the occurrence of following basins: Cedynia Basin, Piaski—Stolpe Basin, Krajnik Dolny—Schwedt Basin, Gartz and Gryfino basins, separated from each other by the narrows, which can be defined as gates, because at some stage they were the gates of the vauclusian springs. The valleys of the basins are in the sub-Quaternary basement, and in their gates exist Miocene humps, anticlines and dislocational zones. The ice-marginal valleys of Rurzyca and Rendowa lie along the dislocational zone Rostock —Gramzow—Piła—Krzyż. The sector of Odra Valley from Gryfino to Klucze has elongated shape, parallel to the dislocational zone of the Lower Odra Valley. River Odra in the plain of Odra—Szczecin Flood, flowing generally in the direction N–S (Szczecin—Trzebież) and SE–NW (Trzebież—Świnoujście) lays at the fault lines between the anticlines of Szczecin, Nowe Warpno, Krakówek and Lubiń. The ice-marginal valley of Rendowa in its course passes by the salt pillows of Gartz, Gramzow, Löcknitz and Ueckermünde, changing suitably its direction. The strong narrowing (Schmölin Gate) and the change in the direction of the valley is concordant with the dislocational zone Rostock— Gramzow—Piła—Krzyż. The bifurcation area Welse—Rendowa appears also in this place. River Rendowa is connected with River Uecker deviating its course to NW (the influence of the salt pillow Ueckermünde). The mouth of Rendowa and its branches in the vicinity of Nowe Warpno and Brzózki, marked at the XVI-th century maps (map of Lubinus and others), are probably introduced as a mistake.

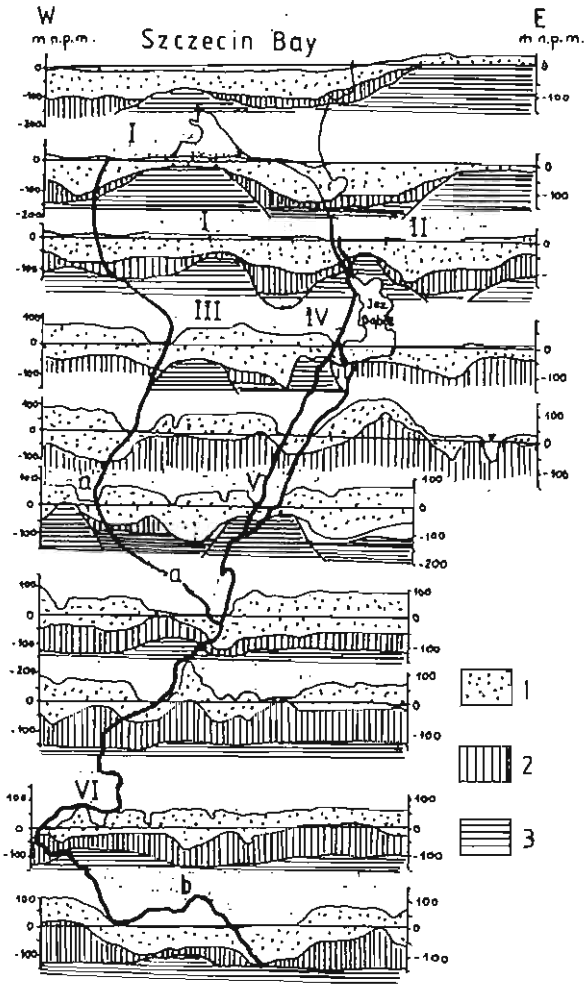

Fig. 4. The thickness of Tertiary and Quaternary sediments in the valleys of Odra and Rendowa

1 — Quaternary; 2 — Tertiary; 3 — Cretaceous; I — VI — anticlines: I — Nowe Warpno, II — Krakówek, III — Löcknitz, IV — Szczecin, V — Gryfino, VI — Cedynia; a,b — ice-marginal-valleys: a — of Rendowa, b — of Toruń-Eberswalde

Miąższość osadów trzeciorzędowych i czwartorzędowych w dolinach Odry i Rendowy

1 — czwartorzęd; 2 — trzeciorzęd; 3 — kreda; I — VI — antykliny: I — Nowe Warpno, II — Krakówek, III — Löcknitz, IV — Szczecin, V — Gryfino, VI — Cedynia: a,b — pradoliny: a — Rendowy, b — Toruńsko-Eberswaldzka

THE COURSE OF THE RIVER BEDS IN THE RELATION TO SUB-QUATERNARY RELIEF FORMS AND THE STRUCTURES IN ZECHSTEIN – MESOZOIC COMPLEX

The analysis of old XVII-th and XVIII-th century maps allowed for the determination of the flow of so called Old Odra. Although Odra was for several centuries the regulated river in dome degree, the cut-through establishing its course in fully different way was made not earlier than at the end of the XVIII-th century.

The bed of Old Odra can be accepted as shaped by the natural agents, and therefore its flow can be examined in the relation to sub-Quaternary relief forms and the structures in Zechstein – Mesozoic complex (Fig. 4). The series of maps from the XVII-th century determine the flow of Odra beginning from Kostrzyn along the eastern edge of the valley up till Łysogórki, where the river takes the turn in the directrion of the western edge of the valley. In this way Odra flows around part of the terrain which seems to be uplifted by the salt pillow Neutrebbin.

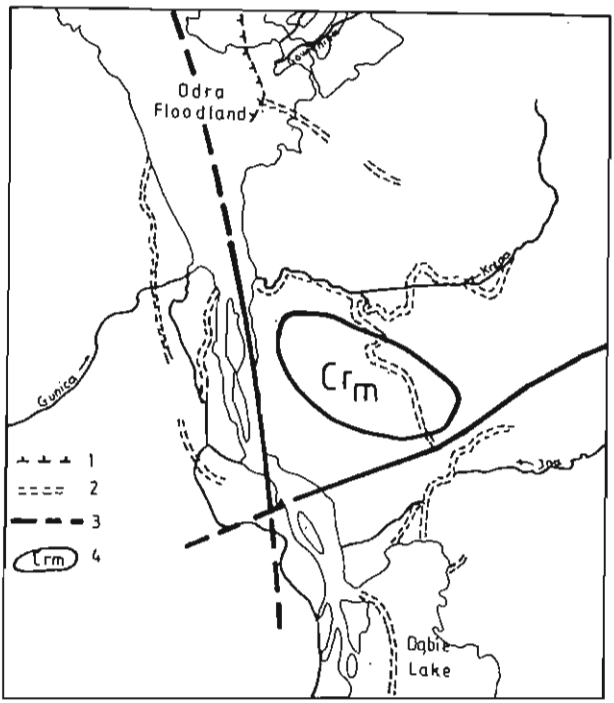

Fig. 5. Pattern of the fossil river branches of Odra, Ina and Kępa in the relation to the Krakówek Anticline defined according to old maps and acrial photographs

1 — fossil coastline; 2 — fossil river branch; 3 — fault; 4 — culmination of Krakówek Anticline

Układ kopalnych ramion Odry, Iny i Kępy w relacji do antykliny Krakówka określony na podstawie starych map i zdjęć lotniczych

1 — kopalna linia brzegowa; 2 — kopalne ramię rzeki; 3 — uskok; 4 — kulminacja antykliny Krakówka

The area through which the river valley runs, shows the local uplift and earlier settlements. Farther in the northern direction Odra River flows around the salt pillow Bad Freienwalde and the Cedynia Anticline. Even at the stage of runoff of water through the ice-marginal valley of Noteć—Rendowa, the upland around which the river meanders forms as the Neuenhagen Upland with Cedynia Anticline in its basement. Characteristically the breach of Odra in Osinów Dolny never happened, taking into account the fact that the flow at the level of the terrace II already existed. The cut-through in Osinów Nowy was made in the end of the XVIII-th century; if it happened in the place of the old river bed, it could be treated as the evidence for the rise of the terrain during the last thousand years. Farther to the north, Odra River flows in broad arches, forming overflows in the individual basins. In the region of Gartz and Gryfino, Odra River flows in two branches on both sides of the valley in the direction of SSW–NNE, concordant with the direction of the salt anticline Gartz—Gryfino (SSW–NNE).

Odra, after crossing the Szczecin Anticline, undercutting the eastern slopes of Warszewo Hills, is changing its direction to the meridional, so that to avoid the strongly upheaved Krakówek Anticline. The outline of the coast line of Dąbie Lake shows some dependence on the courses of the synclines and anticlines (K. Schoeneich, 1962). Little Dąbie Lake, lying along the line of the Szczecin Anticline, is separated by the fault running W–E from Great Dąbie Lake, the eastern coast of which moved to the east during the last 300 years, as it results from the analysis of old

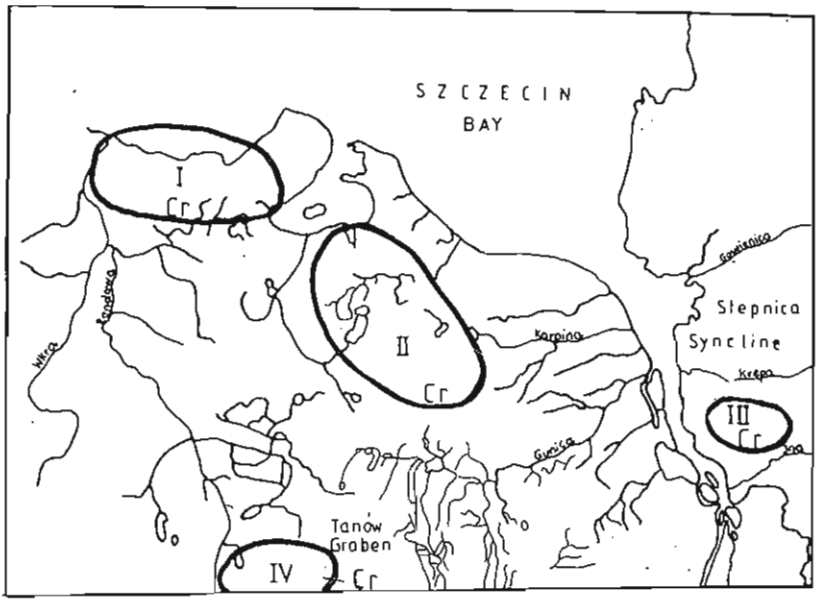

Fig. 6. Pattern and density of the surficial waters against the backround of culmination (Cr) of anticlines
I— Ueckermünde, II — Nowe Warpno, III — Krakówek, IV — Löcknitz
Układ i gęstość sieci wód powierzchniowych na tle kulminacji (Cr) antyklin
I — Ueckermünde, II — Nowego Warpna, III — Krakówka, IV — Löcknitz

maps. The widest part of the lake is lying along the axis of Szczecin Syncline. According to the analysis of old maps and aerial photographs, the Krakówek Anticline has some influence on the course of the beds of tributaries of Odra. Ina River flows around the Krakówek Anticline from SE and the straight to Dąbie Lake. One of the tributaries of Ina, called Martwa Kępa, flowing earlier transversally through the area having the Krakówek Anticline in the basement, ceased to exist.

River Gowienica, flowing in the broad arch, leaves its branches and in shortest way runs to the axis of Stepnica Syncline. The tendency of lowering of the terrain along the axis of the anticline has as a symptom the transgression of Stepnica Bay and moving of the coastline about 300 m to the east in the last 200 years.

Nowe Warpno Anticline exerted the influence on forming of Nowe Warpno Peninsula during the Littorina transgression.

As it results from the comparison of present time maps of Wkrzańska Forest with old ones (for instance Gille Map from the end of the XVIII-th century), the superficial river system is abundant in the area of Tanów Graben but poor and decaying in Nowe Warpno Anticline. This observation shows that in the area of synclines the descensive took place, and there were ascensive movements in the area of anticlines (Fig. 6).

THE LONGITUDINAL PROFILE OF THE RIVER AN EXPRESSION OF RECENT MOVEMENTS OF THE EARTH'S CRUST

The longitudinal profiles of the river water levels are the precise indicator of the influence of the basement on the level of the terrain (Fig. 7). In the Gorzów Block the longitudinal profile shows relatively great hydraulic gradient, and it is possible to distinguish the sections of gradually diminishing gradient (0.19–0.25‰).

In the zones of subsurface structures (anticlines, upthrusts) and the uplands of frontal moraines the diminishing of the gradient is observed. The gradient is increasing after this zone. The gradients amount to (correspondingly) 0.033 and 0.187‰ for the Cedynia Anticline — highlands of frontal moraines; 0.05 and 0.144‰ (for the structural uplift of Miocene sediments near Bielinek — the frontal moraines of Chojna Subphase). The crossing of the zone of frontal moraines of Mielęcin Subphase and the crossing of the boundary of Gorzów Block and Szczecin Trough is connected with declining gradient (0.029–0.020‰). The section of Odra Valley in the area of Szczecin Trough has uniform and very low gradient (0.003‰). The influence of the subsurface structure on the hydraulical gradient at this section is not marked in spite of the existence of the strongly uplifted salt structures. This fact shows the correspondingly greater subsidence of the trough in comparison with the block.

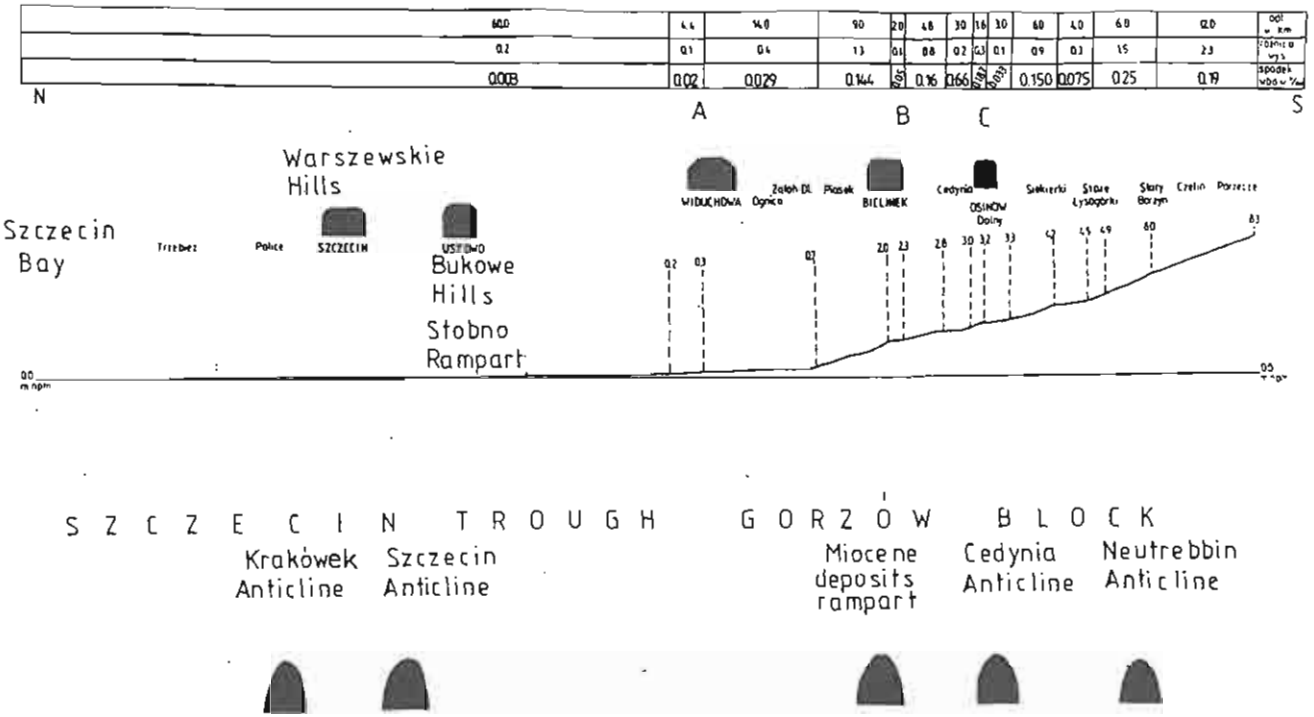

Fig. 7. Longitudinal profile of Odra River water level with the elements of subsurface structures and the relief of the terrain as the condition of the increase and decrease of the hydraulical gradient

A-C — frontal moraines: A — of Mielęcin Subphase, B — of Pommeranian Subphase, C — of Pommeranian Phase

Profil podłużny powierzchni wód Odry z elementami struktur wgłębnych i rzeźby terenu warunkującymi zwiększenie i zmniejszenie spadku

A-C — moreny czołowe: A — subfazy mielęcińskiej, B — subfazy pomorskiej, C — fazy pomorskiej

CONCLUSIONS

The great thickness of Cainozoic sediments in the area of Odra Lobe diminishes the legibility of the connections between Quaternary relief and the older basement. In the Lower Odra Valley and Rendowa Valley there exists some conformity of the localization and directions of the elements of sub-Quaternary relief, and the structures of sub-Cainozoic basement, to the general direction of these valleys, their fundamental relief, the course of the river beds and their longitudinal profiles. Similar dependencies exist in the whole area of Odra Lobe. The dislocational zone of Lower Odra Valley established the tectonical predisposition for the forming of the valley in the Great Interglacial, and then for the erosion of glacial and river water.

The difference between the processes of erosion and accumulation in Pleistocene, characterized by the periodical staying of the thick ice covers, resulted in the action of the overburden on the masses of salt than in the older geological epochs, with preserving the astonishing similarity of the geological processes in the zones of depression and uplift. The relations between the masses of salt and ice (which to some extent are similar in physical properties) took part through the circulating saline waters, which expressed itself in the geological processes, sediments and relief forms.

Samodzielna Pracownia Geologii Wybrzeża Morskiego
Państwowego Instytutu Geologicznego
Szczecin, ul. Storrady 1
Received: 14.05.1991

REFERENCES

DADLEZ R., DECZKOWSKI Z., GAJEWSKA I., KŁOSSOWSKI J., MAREK S., STOLARCZYK J., STOLARCZYK F. (1980) — Mapa tektoniczna cechsztyńsko-mezozoicznego kompleksu strukturalnego na Niżu Polskim, 1:500 000. Wyd. Geol. Warszawa.

BUDOWA GEOLOGICZNA NIECKI SZCZECIŃSKIEJ I BLOKU GORZOWA (1979) — Red. M. Jaskowiak-Schoeneichowa. Pr. Inst. Geol., 96. Warszawa.

SCHOENEICH K. (1962) — Żywe procesy tektoniczne w Polsce północno-zachodniej. Szczecińskie Tow. Nauk. Wydz. Nauk Techn., 3, z. 1.

WIENHOLZ R. (1967) — Über den geologischen Bau des Untergrundes in Nordostdeutschen Flachland. Jb. Geol., 1.

Andrzej PIOTROWSKI

WPŁYW PODŁOŻA PODCZWARTORZĘDOWEGO NA ROZWÓJ DOLINY DOLNEJ ODRY W PLEJSTOCENIE I W HOLOCENIE

Streszczenie

Wskazano zależności, jakie zachodziły w rozwoju Doliny Dolnej Odry w czwartorzędzie w relacji z podłożem. Duża miąższość osadów czwartorzędowych i trzeciorzędowych zmniejsza czytelność związków procesów geologicznych z podłożem. W Dolinie Dolnej Odry oraz w dolinie Rendowy istnieje zbieżność lokalizacji i kierunków elementów rzeźby podczwartorzędowej oraz struktur podłoża podkenozoicznego z ogólnym ukierunkowaniem tych dolin, zasadniczymi rysami ich rzeźby, przebiegiem koryt rzecznych oraz ich profilem podłużnym. Sposób ukształtowania lobu Odry wskazuje na związki z strukturami tektoniki solnej.