POLYGENESIS OF THE BRODY — DREWITZ RAMPART (SOUTH-WESTERN GREAT POLAND)

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The Brody-Drewitz Rampart is immense form located in south-west part of Lubsko Highland, where the Nysa Łużycka river flows into the Odra river. It has not unequivocal distinguished geological structure and genesis.

This form has not got explicitly identified geological structure, origin nor age.

The hypotheses formulated until now suggest that it is a form of one origin (Bartkowski 1967) or a complex one (Krygowski 1961).

Nowadays research shows that the Brody-Drewitz Rampart is not the form of composite geological structure. There are sands, gravels and mud glacitectonically disturbed in the east, middle and south-west part of the form. On the west and north-west part of the form there are sands, gravels, glacial till and boulders (Blockpackung) – deposits that are typical for sedimentary scarp. Earlier such forms were described by Kasprzak and Kozarski (1984), Kozarski (1965). Beside that the Brody-Drewitz Rampart is one, morphologically consistent form, and geological and sedimentary data indicate at least two paleogeographical episodes.

Key words: end moraine, pushed moraine, glaciotectonic structures, fluvioglacial depositis

LOCATION AND MORPHOLOGY

The Brody-Drewitz Rampart is a big form situated in the south-western part of the Lubsza Plateau to the south of the Nysa Luzycka river and the Odra River confluence (**Fig. 1, 2**).

It has distinct, well-defined escarpments, only in its south-eastern part (in the vicinities of Marianka village) it evolves gently into the widening of the Głogów-Baruth Pradolina – the Zasieki Basin / the Barszć Basin. To the north and the east the rampart slopes descend steeply to the Lubsza River valley and westward to the Nysa Luzycka River valley. According to the current researches (CEPEK, et al., 1973; CEPEK and NOVEL, 1991; LIPPSTREU et al. 1995), the second part of the rampart stretches to the west of the Nysa Luzycka River Valley.

As far as morphology is concerned the rampart is rather inconsiderably varied (**Fig. 2**). The height differences all over the rampart are small. Only in its eastern part the slight differences in height in the order of 30 m occur.

RESEARCHES TO DATE

This form has not got explicitly identified geological structure, origin nor age.

The hypotheses formulated until now suggest that it is a form of one origin (BARTKOWSKI 1967) (**Fig. 3**) or a complex one (KRYGOWSKI 1961). BARTKOWSKI (1967) announced that the rampart consists of fluvioglacial sands and gravels. Therefore he considered this form as a kind of an outwash rampart built on the ice-mass edge lying in place of today's Lubsza Plain (Równina Lubszy). He regards Brody-Drewitz Rampart as a marginal form probably of the Leszno stage (BARTKOWSKI 1961, 1963, 1967). The attempt at determining the end moraines course of the last Scandinavian ice-sheet maximum limit on that area was earlier made by TIETZE (1911). The course was marked from Liebrose to Gubin and to Zielona Góra. From such perspective Brody-Drewitz Rampart, situated to the south of the above mentioned limit, is a plateau on the foreland of the end moraine hills.

KRYGOWSKI (1961) or CZŁOPA, et al. (1976) treat Brody-Drewitz Rampart as an end moraine. KRYGOWSKI ed. (1953) in his later publication, on the geomorphological map marks this form as a undulating morainic plateau in the southern part and in the north-central and eastern ones as a zone of the undulating end moraine hills. On that map he sets also the course of the maximum limit of the last Scandinavian ice-sheet (the Leszno stage) along the longer axis of the studied form.

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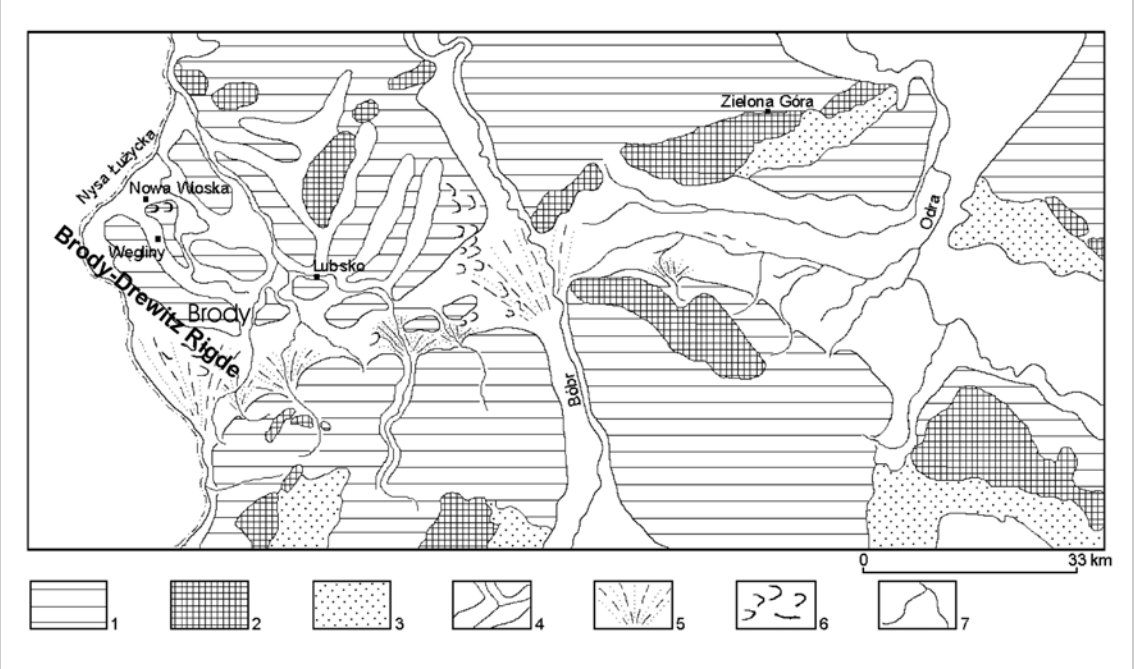

Fig. 1 Geomorphological map of the Lubsza Plateau
(after Nowaczyk, 1996, amended; 1— morainic plateau; 2 — end push moraine ridges; 3 — outwash plan; 4 — valley's bottoms; 5 — alluvial fans; 6 — dunes; 7 — rivers patterns

On the geological map in the scale of 1:200 000 (MOJSKI, J.E. ed. 1976) (the basic sheet 1:50 000, MILEWICZ, 1976) the Brody-Drewitz Rampart is marked as a form built of the fluvioglacial sands and gravels of the Baltic glaciation Leszno stage and makes the outwash form.

The Brody-Drewitz Rampart is treated as an end moraine of the Leszno stage (Brandenburger Stadium Maximum des Weichsel-Glazials) by German researchers (CEPEK, et al., 1973; CEPEK and NOWEL, 1991; LIPPSTREU et al. 1995). They mark the end pushed moraine along the northern escarpment of the Rampart and its middle and southern parts treat as an outwash the same way as KRYGOWSKI ed. (1953).

Since the origin of this form has not been unambigously defined so far, the range limit of the last Scandinavian ice-sheet glaciation maxi-

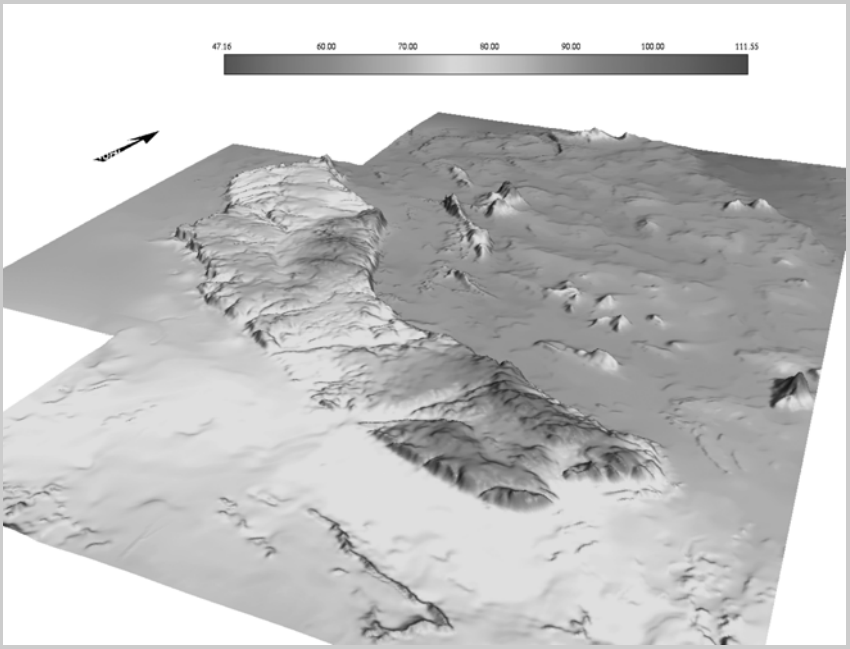

Fig. 2 Morphology of the Brody-Drewitz Rampart, 3D model

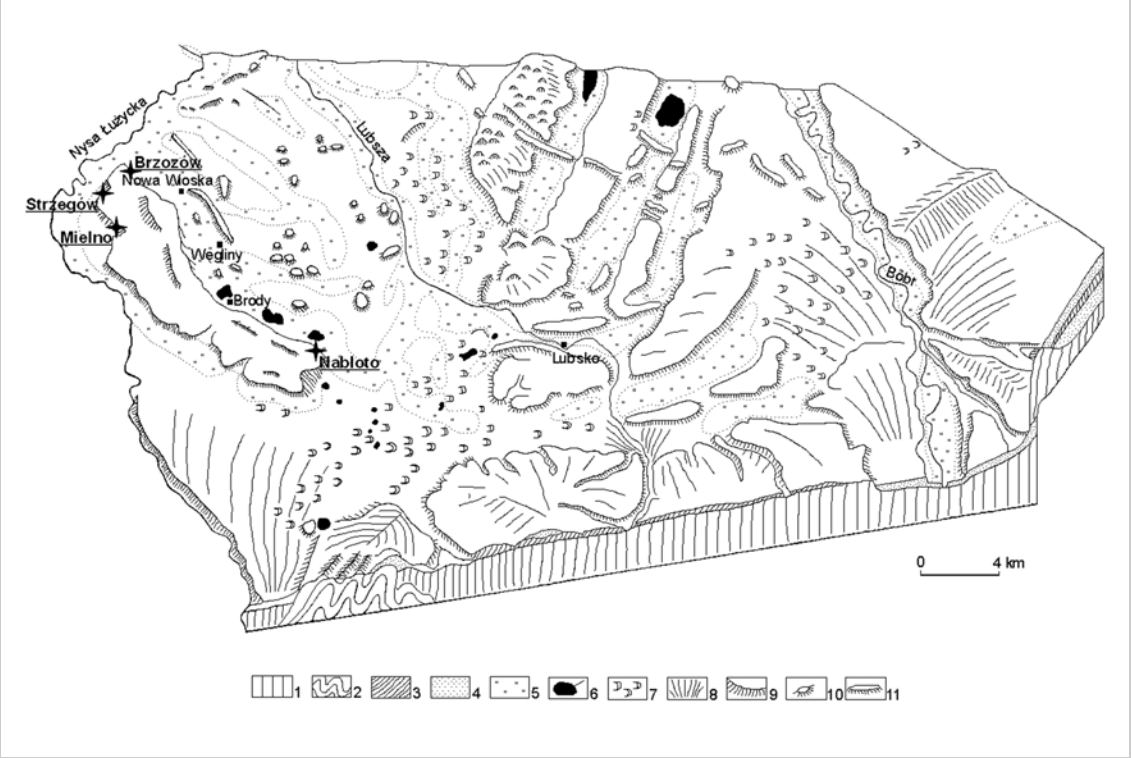

Fig. 3 Marginal zone of the Leszno phase in vicinity of Lubsko (BARTKOWSKI 1963, amended); location of research sites; 1.— Pliocene (Poznan clay); 2 — glacitectonically disturbed deposits (Miocene and older Pliocene); 3 — older Pliocene (glacial till); 4 — Pleistocene not separated (sands and gravels); 5 — flat bottoms (meadows, peatbogs); 6 — lakes and the most important rivers; 7 — dunes; 8 — alluvial fans; 9 — edges; 10 — kames; 11 — eskers

mum has not been explicitly outlined on a given research area as well.

The current knowledge about the geological structure and the origin of the form justifies the undertaken researches and their purpose. The author conducted her researches into five sites located in the Rampart escarpment. Altogether 15 exposures have been analysed. 150 handborings to a depth of 4 m on average have been also done in four profile lines. Apart from this, owing to the lack of the natural or anthropogenic outcrops on the Rampart, the attempts have been made at applying the digital analysis of surface features.

SEDIMENTS OF THE BRODY-DREWITZ RAMPART AND THEIR PALAEOGEOGRAPHICAL SIGNIFICANCE

DEPOSITIONAL STRUCTURES

Depositional structures have been analysed in the Rampart western escarpment in the sites of Strzegów and Późna as well as in the northwestern escarpment – in Brzozów site (**Fig. 3**). In Strzegów site there is a prevalence of gravels, gravels with the additive of variously grained sands, gravels with argillaceous cement, sands with a huge amount of iron. There is a predominancy of the massive structure, only the sandy-clayey gravels are slightly imbricated, low-angle cross-stratified. The directional elements indicate the north-western and north-eastern strike. In Późna site there is the sandy-clayey brown glacial till in the outcrop bottom. There are massive, medium — and fine — grained sands with sandy loams intercalations above.

In Brzozów site the material is supercoarse-grained, stony, developed in the form of so called Blockpackung with the additive of gravel and hardly sorted coarse sand. Sediments of that kind were described by KOZARSKI (1965) in the vicinities of Cedynia in Western Poland and by KŁYSZ (1990) on the Drawskie Lakeland (Pojezierze Drawskie) near the Siecino lake northward from Złocieniec.

Interpretation deposits and their structural features indicate the sedimentation in the fluvioglacial environment and one may suppose that this part of the Rampart is the kame terrace.

Accumulation of the coarse-grained material in the form of Blockpackung in the end-morainic landforms used to give grounds for the morainic ramparts being interpreted as the depositional ones.

DEFORMATIONAL STRUCTURES

Deformational structures have been observed in various sites of the Rampart escarpment: in Brzozów site discussed above, in Mielno site – both are located in the northwestern part of the Rampart – and Nabłoto site in the eastern part (**Fig. 3**).

Identified deformational structures are the glaciotectonic structures.

In Brzozów site Blockpackung is covered with the variously grained gravels and the glacial till. The deformations can be seen first of all in the gravels underlaying the glacial till. These are faults, mainly overcast ones. They dip northward, orientated to the northern east–southern west. Apart from this small drag folds have been noticed. In the gravels their original structure is preserved – cross-stratification. The gravels are covered with the variously grained sand with gravel also with the deformations in the form of faults. They make the continuation of the faults occurring in the gravels. Besides in this series the fluidal structures can be found – the sandy-gravelly stripes. Above them there is more than half a metre layer of hardly sorted, massive gravel. The entirety is covered with the argillaceous, dark brown till. The structural elements in the till indicate that most probably this is the lodgement till.

In Mielno site there is the glacial lodgement till in the roof. The variously grained sands lay downward. These sediments are deformed by the faults network. They are normal faults first of all. The incorporations of loams and argils as well as brown coal have been observed. The angle of faults strike is oriented to the northerneast — southern west, they generally dip southward with the deviations to the east or west. The faults of the northwestern — southeastern strike have most probably originated as a result of tensions arising due to the continental glacier activity whereas the faults of the northeastern–south western strike are the relaxation ones.

Among the fluvioglacial deposits there is the predominance of medium-grained sands with the coarse-grained one, light, mainly massive. In places the original, horizontal lamination can be seen, in places it is the cross-lamination particularly in the medium and coarse sand. Apart from the faults other deformational structures have been noticed – folds, especially in the bottom part of the glacial till as well as argillaceous and loamy fluidal structures.

The Nabłoto site: in this site the outcrops are located in the vicinities of Nabłoto village situated in the eastern part of the Brody-Drewitz Rampart. The sandy-gravelly, glaciotectonically deformated sediments are exposed in pits which are in the escarpment of the rampart in its northeastern part. The sediments dip to the southern east at an angle from 28 to 44 degrees. Among the deformated deposits there are the medium - and coarse-grained sands, light and rust coloured, horizontal- and cross-stratified. The xenoliths of black or black and dark brown loam as well as clayey silt are numerous. Rare faults are oriented to the northern west – southern east and they dip to the northern east. The sandy diapir has been observed here. The diapir range limits are outlined with the loamy intercalations of grey loam. This structure dips to the east and southern east at an angle of about 50 degrees. Round the diapir there is the medium gravel with the massive sand from medium to coarse. In the overlay of the diapir there are the medium-grained sands with the loam with numerous small dragged folds.

Dipping to the southern east, the dark brown loams with fine-grained sand intercalations occur in the pit about 2 — 3 kilometres away from those two mentioned above.

Interpretation various directions of the deformational structures indicate two different directions of the ice-front activity – from the northern west in the northern part of the Rampart and from northern east in its eastern part. The sites location on two ends of the Rampart suggests that this form consists of at least two different forms.

DIGITAL ELEVATION MODEL (DEM)

Digital Elevation Models (DEM) are used more and more often in the researches into the glaciations of the marginal zones (EWERTOWSKI et al. 2006; EWERTOWSKI and RZESZEWSKI 2006, 2007). One of the methods in the marginal zones researches is to set apart and analyse the lineaments raised most often as a result of the manual interpretation of shaded relief maps (EWERTOWSKI and RZESZEWSKI 2006, 2007). The manual analysis of shaded relief maps is burdened with a huge amount of subjectivity what may influence the conclusive interpretation of the researches.

In order to verify the results of the researches that have been produced so far in pits lo-

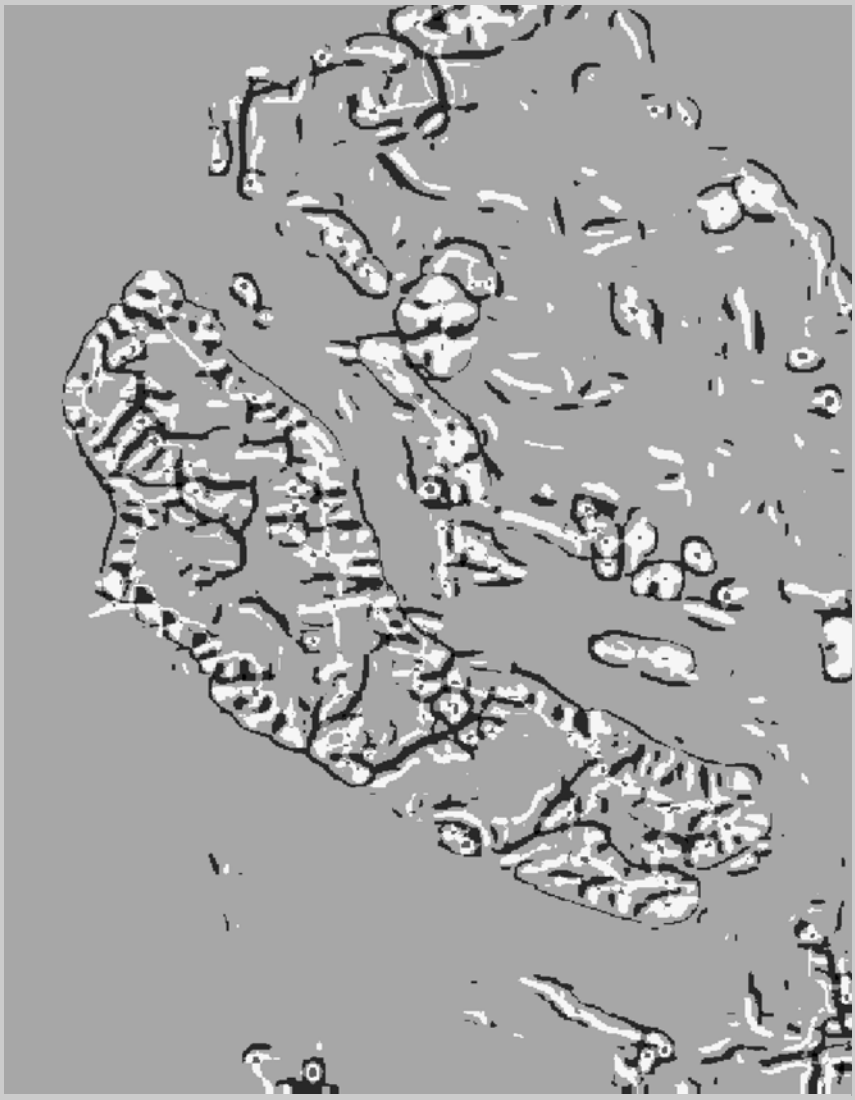

Fig. 4. Features of the morphology of the Brody-Drewitz Rampart

cated only in the escarpment of the Brody-Drewitz Rampart the digital terrain models (DTM) have been applied. An attempt has been made at marking off the morphologically different components of the rampart. The analysis was carried out with the aid of GRASS GIS (Grass Development Team) programme, R (R Development Team) and PostgreSQL. Each of these programmes is available free in the Internet under licence GNU Open Source.

The Brody-Drewitz Rampart has been analysed on the basis of the elevation model of horizontal 5x5 m and vertical 10 cm resolutions acquired on the basis of the digitization of the contour-lines of the topographic maps in the scale of 1:10 000 (**Fig. 2**).

With the help of the tools offered by GRASS GIS the areas of the inclination bigger than 2,4 degrees have been allocated (such angle was accepted after the histogram analysis); morphometric features have been analysed: peaks, ridges, passes, channels, pits and planes (**Fig. 4**); the entropy (**Fig. 6**) – the disorder measure of relief has been applied. Synthesis of these analyses allowed to section off 9 areas distinctly different in relief as well as to calculate the trends for these areas.

The Rampart escarpments are marked very clearly in each of these analyses. The entropy and the slope inclination analyses show that the northern escarpments are much more prevailing in the surface structure than the southern ones (**Fig. 5, 6**). Maps presenting the slopes inclinations (**Fig. 5**), entropy (**Fig. 6**) and the morphometrical features (**Fig. 4**) revealed such rampart relief elements which are difficult to notice during the analysis of the hypsometric

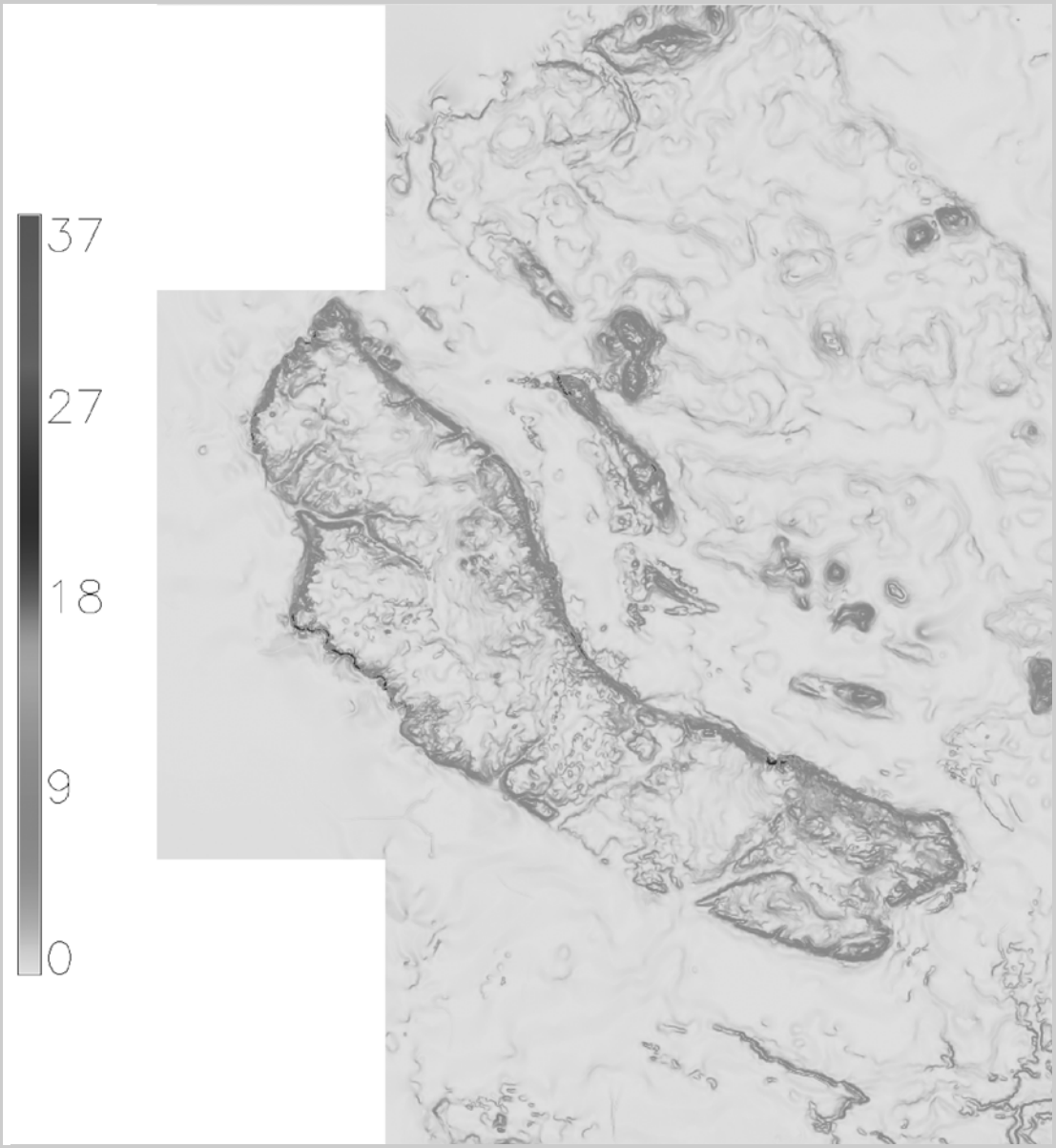

Fig. 5 Slopes of the morphology of the Brody-Drewitz Rampart

maps. The linear elements are marked in the northern part of the Rampart. Ridges and channels runs perpendicularly to the Rampart main axis there (**Fig. 4**). They are distinct particularly in the middle of the Rampart, right next to its northern escarpment (Brzozów site is situated near there) as well as on the eastern end of the Rampart (Nabłoto site). The analysis of prepared maps (maps of shaded relief, slope inclination, entropy, morphometrical features) provided a basis for the allocation of the areas on the rampart which differ from one another in the degree of the relief variety. Nine objects have been marked off for which the trends have been calculated. The 3 degree trend produced the best results (**Fig. 7**). The slightest degree of the relief variety is characteristic for the area number 1 (the sites of Strzegów and Późna) and the highest on - number 9 (Nabłoto) (**Fig. 7**).

CONCLUSIONS

The field researches conducted on the Brody-Drewitz Rampart in the exposures in the Rampart escarpments as well as the mechanical probes on the Rampart indicated highly heterogeneous structure inside that form. The great diversity of the deposition types and the struc-

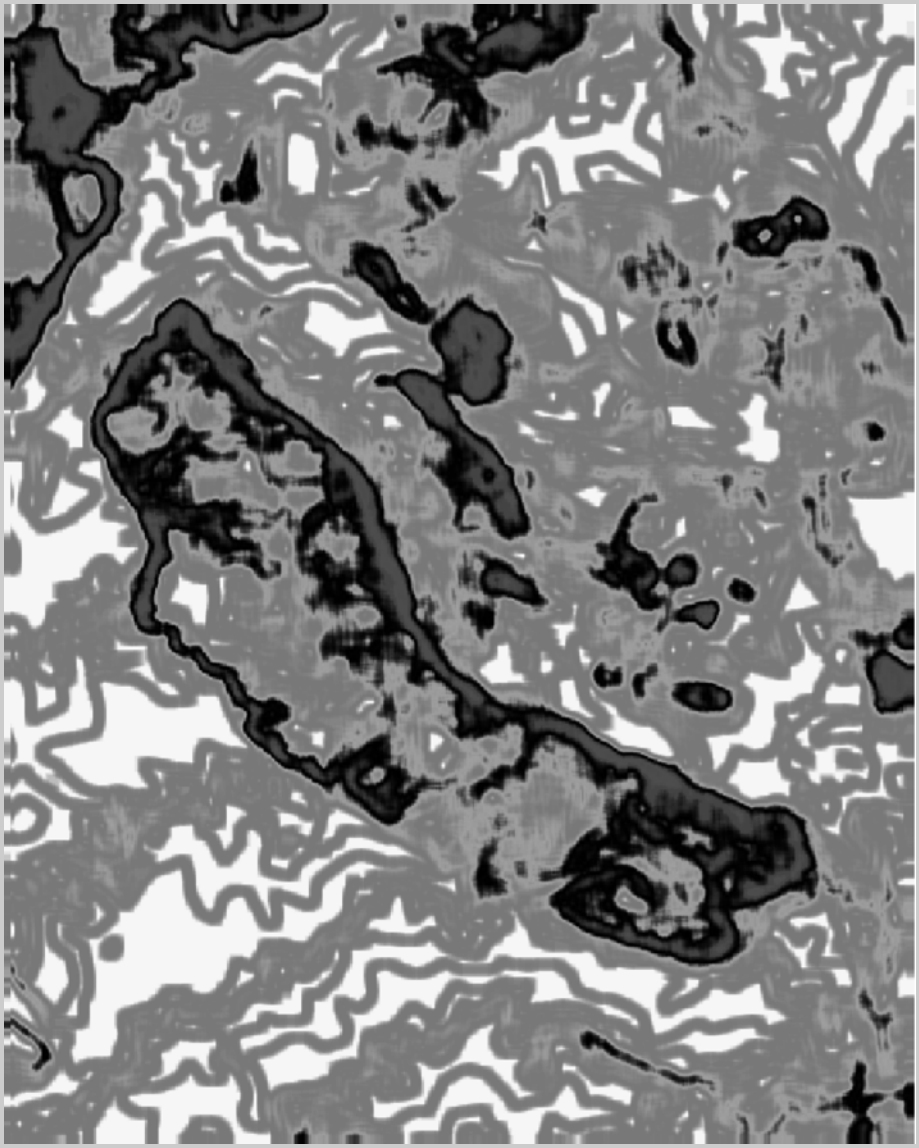

Fig. 6 Entropy of the morphology of the Brody-Drewitz Rampart

tures characteristic of forms of the different origin (glacial or fluvioglacial) have been observed. The glacio-tectonically deformed sediments occur in the middle part of the Rampart, at its northern escarpment, in the Rampart parts near the western escarpment and in the eastern part of the form. The analyses of the digital elevation model (DEM) of these parts allowed to notice small, slightly marked on the present surface of the Rampart, still distinct on the digital elevation model maps, components of the morphology (ridges and channels running perpendicularly to the Rampart main axis, great entropy). These parts of the Rampart are most probably the result of the ice-front dynamic activity. The Ramparts fragments where the fluvioglacial sediments and structures were observed (the sites of Późna and Strzegów) are hardly varied on the surface. That was revealed in the analyses of the morphometrical features, slope inclination and entropy. Analysing the Rampart morphology, the influence of the denudation processes on the present relief of the studied form was taken into consideration.

The researches that have been conducted so far suggest that the Brody-Drewitz Rampart, being a compact form at present, is a polygenetic form.

The applying simple techniques of the surface features analysis builds hopes on the help in the researches of the areas hardly varied at present as well as difficult for the field researches owing to the low number of pits. Digital elevation models (DEM) allow to carry out a very thorough analysis of the forms – the glacial and glaciofluvial form in that case.

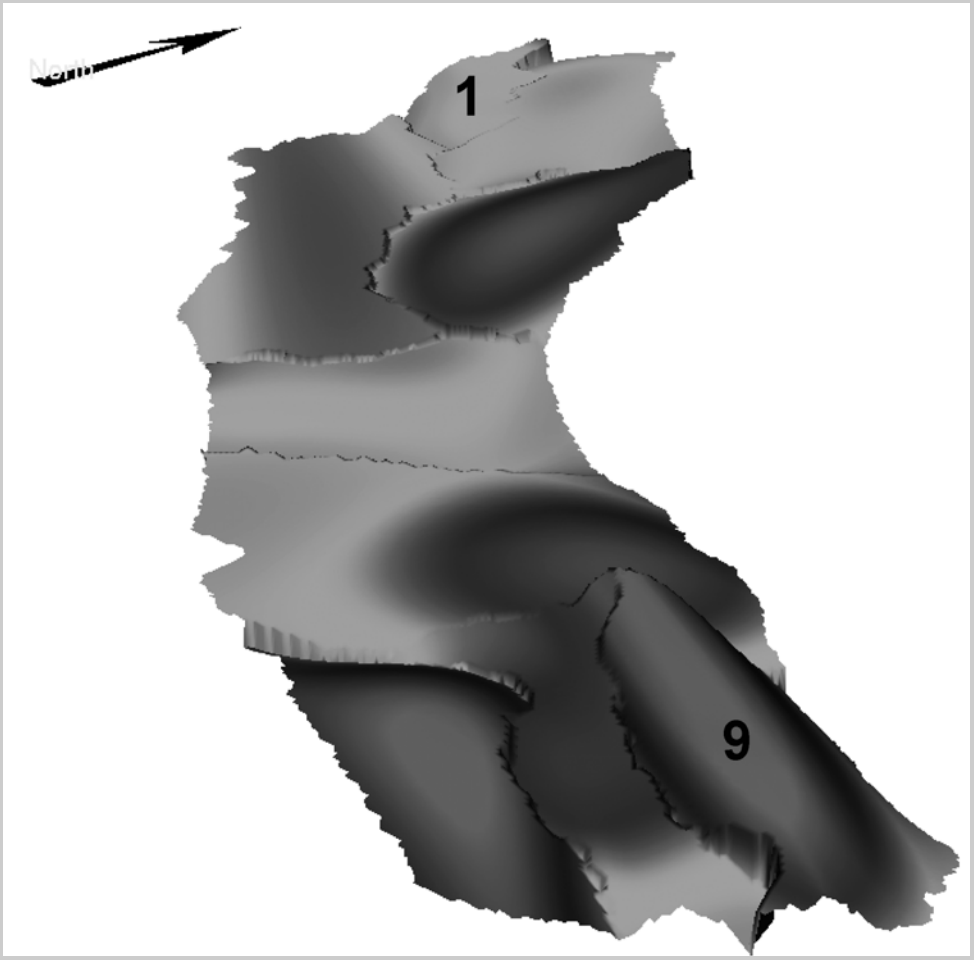

Fig. 7 Trends of the morphology of the Brody-Drewitz Rampart

REFERENCES

BARTKOWSKI, T. (1961). O granicy zlodowacenia bałtyckiego w okolicy Lubska (północna krawędź Wysoczyzny Żarskiej). Pozn. Tow. Przyj. Nauk, *Sprawozdania,* 63, 1, p. 102-107.

BARTKOWSKI, T. (1963). O formach rozcięcia marginalnego i niektórych formach strefy marginalnej na Nizinie Wielkopolskiej. *Bad. Fizjograf. nad Polską Zach*., 11, 7-45.

BARTKOWSKI, T. (1967). O formach strefy marginalnej na Nizinie Wielkopolskiej. *Prace Kom. Geogr.-Geol.*, PTPN, 7, 1, 260 p.

CEPEK, A. G. et al. (1973). *Geologische Karte der DDR 1:500 000*, Karte der quartaren Bildungen, Zentr geol. Inst., Berlin.

CEPEK, A. G., NOWEL, W. (1991). Zum Pleistozän im Raum Klinge – Dubrau (östliche Niederlausitz), ein Typusgebiet für den Saale-Komplex. *Zeitschrift Geol. Wiss*., 19, 3, 289-316.

CZŁOPA, K., ŁABUS, A., SZAŁAJDOWICZ, J. (1976). *Mapa Geologiczna Polski 1:200 000* A - Utworów Powierzchniowych w skali 1:50 000, arkusz Zielona Góra; Instytut Geologiczny, Mojski, J.E. (ed.), Warszawa.

EWERTOWSKI, M., RZESZEWSKI, M., SZUMAN, I. (2006). Zróżnicowanie form i osadów marginalnych fazy poznańskiej ostatniego zlodowacenia w okolicach Poznania – wyniki wstępnych badań geomorfologicznych. In Kostrzewski A., Czerniawska J., eds. *Przemiany Środowiska Geograficznego Polski Północno-Zachodniej*, Bogucki Wydawnictwo Naukowe, Poznań, 25-36.

EWERTOWSKI, M., RZESZEWSKI, M. (2006). Using DEM to recognize Possible Minor Stays of Vistualian (Weichselian) ice-sheet margin in the Wielkopolska Lowland. *Proceedings of International Symposium on Terrain*

Analysis and Digital Terrain Modelling, 2006, Nanjing.

EWERTOWSKI, M., RZESZEWSKI, M. (2007). Changes Of Glacier Extent: Using Gis To Integration Maps, Remote Sensing Material And Field Surveying. Petuaniabukta, Central Spitsbergen Case Study. In Wachowicz, M., Bodum, L. *10th AGILE International Conference on Geographic Information Science (Proceedings)*, 2007, Aalborg University, Denmark.

KASPRZAK L., KOZARSKI S. (1984). Analiza facjalna osadów strefy marginalnej fazy poznańskiej ostatniego zlodowacenia w środkowej Wielkopolsce. *Seria Geografia* 29, Wydawnictwo Naukowe Uniwersytetu im. A. Mickiewicza, Poznań, 1-54.

KŁYSZ, P. (1990). Mechanizmy kształtowania się strefy marginalnej fazy pomorskiej na obszarze Pojezierza Draw skiego. *Seria Geografia,* 47, Wydawnictwo Naukowe Uniwersytetu im. Adama Mickiewicza, Poznań, 194 p.

KOZARSKI S. (1965). Zagadnienie drogi odpływu wód pradolinnych z zachodniej części pradoliny Noteci-Warty. *Prace Komisji Geograficzno-Geologicznej*, 5, 1, Poznańskie Towarzystwo Przyjaciół Nauk, Wydział Matematyczno-Przyrodniczy, 1-98.

KRYGOWSKI, B., ed. (1953). *Mapa Geomorfologiczna Niziny Wielkopolsko-Kujawskiej*. Adam Mickiewicz University (digital version 2007).

KRYGOWSKI, B. (1961). Geografia fizyczna Niziny Wielkopolskiej, cz. I, Geomorfologia, Mapa Geomorfologiczna Niziny Wielkopolsko-Kujawskiej, http://geoinfo.amu.edu.pl/wngig/ipig/files/Krygowski_mapa.pdf.

LIPPSTREU, L., HERMSDORF, N., SONNTAG, A. (1995). Zur Gliederung der quartären Sedimentabfolgen im Niederlausitzer Braunkohlentagebau Greifenhain (LAUBAG) und in seinem Umfeld. *Kleinmachnow*, 2, 1, Brandenburgische Goewiss. Beitr., p. 61-67.

MILEWICZ, J. (1976). *Mapa Geologiczna Polski 1:200 000* A- Utworów Powierzchniowych w skali 1:50 000, arkusz Gubin; Instytut Geologiczny, Mojski, J. E. ed., Warszawa.

MOJSKI J. E. ed. (1976). Mapa geologiczna Polski 1:200 000, A – Mapa Utworów Powierzchniowych w skali 1: 50 000, Instytu. Geol., Warszawa; arkusz Gubin (J. Milewicz), arkusz Zielona Góra (J. Szałajdowicz, K. Czop, A. Łabus).

NOWACZYK, B. (1996). Wiek wydm w Polsce. *Seria Geografia,* 28, Wydawnictwo Naukowe Uniwersytetu im. Adama Mickiewicza, Poznań, 245 p.

TIETZE, O. (1911). Die Endmoränen zwischen Oder und Neiße und der Os von Kalke. *Jahrbuch der Königlich Preufsischen Geologischen Landesanstalt zu Berlin für das Jahr 1911*, 32, 11, 1, 160-181.