ANALYSIS OF SEDIMENTS IN THE NORTH-EAST MORAINIC UPLAND EDGE ZONE IN THE VICINITY OF PIASKI POMORSKIE (WEST POMERANIA, NW POLAND)

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Abstract: The aim of this article is the description of lithofacies characteristics of sediments forming the north-east part of the morainic upland edge zone in the vicinity of Piaski Pomorskie (West Pomerania). The paper undertake also an attempt to reconstruct paleogeographical conditions of the formation of moranic uppland edge. The diversification of glaciofluvial and fluvial processes during the phase of stagnation and recession of uppervistulian ice-sheet in the vicinity of Piaski Pomorskie (Western Pomerania) led to the formation of a morainic upland edge distinctly marked in morphology The edge zone separates the undulating moraine plateau from a lower situated Dębnica River Valley. This area is mostly formed by fine-grained sands with occasional layers of a coarser fraction of gravel and coarse- and medium-grained sands. The observed type of low-angle cross-stratification and trough cross-stratification indicates the dominance of diversified energy depositional environment with considerable power of water as transporting medium. The research area was formed at the front of the ice-sheet, which receded from the nearby reach of the Pomeranian Phase of the Weichselian glaciation.

Keywords: morainic upland edge zone, lithofacies analysis, the Pomeranian Phase, West Pomerania

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Introduction

Variability and dynamics of depositional processes related to glacier and meltwater activity is visible in both the morphology of studied areas and in lithofacies record of sediments forming individual parts of the region. Qualitative and quantitative characteristics of sediments in selected areas allows the determination of paleogeographic conditions during the individual development stages of the Pomeranian Phase ice-sheet snout. On the basis of interpretation of the results of laboratory analyses of mineral sediments, an attempt can be made to define the genesis and dynamics of the environment of the analysed area of the morainic upland edge zone in the vicinity of Piaski Pomorskie (West Pomerania). Moreover the attention was paid on lithofacial and lithogenetic analyses of forms and deposits of the studied area. Fundamental aim of research was then the to reconstruct paleogeographical conditions of glaciofluvial and fluvial processes intensity during the recession of uppervistulian ice-sheet in the Parsęta lobe, in the area of morainic upland edge of Piaski Pomorskie surroundings.

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Study area

The study site was established at the marginal zone, within the recession area from the reach of the Pomeranian Phase of the Weichselian glaciation (Karczewski 1968). According to the regional division of Poland (Kondracki 1998), the research area is situated in the Drawsko Lake District (Fig. 1).

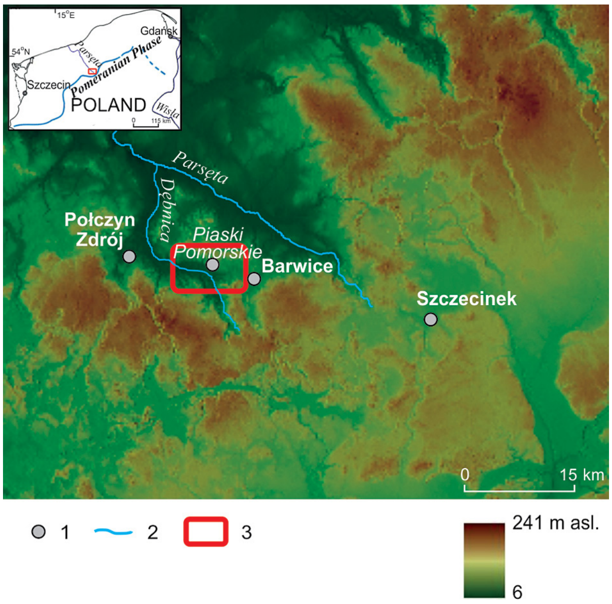

Fig. 1. The location of the research area.
1 – towns, 2 – rivers 3 – research area.

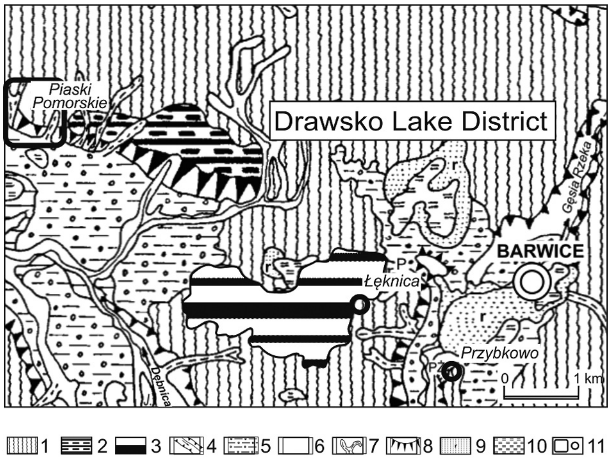

Fig. 2. Geomorphology of the research area (on the basis of the geomorphological sketch, Barwice sheet 1:100,000 Popielski 2000, changed).
1 – undulating morainic plateau, 2 – dead-ice morainic hills, 3 – kames, 4 – subglacial troughs, 5 – cut-and-built valleys and plains of meltwater, 6 – floors of river valleys and floodplain terraces 0–2 m above stream level, 7 – valleys, ravines, young erosional dissections or valleys in general, 8 – long slopes, 9 – lacustrine plains, 10 – peat plains, 11 – research area.

Undulating moraine plateau is the dominant element of the layout of the land with denivelations of 2–5 m and slope inclinations of up to 5°. The monotonous surface of the moraine plateau is diversified by formations of crevace-filling accumulation landforms and vast kames in the area of Białowąs (159 m a.s.l.), Ostrowąsy (Góra Krucza 114.9 m a.s.l.), Koprzywno (160.8 m a.s.l.) and Łęknica (167 m a.s.l.). The Piaski Pomorskie morainic upland edge zone separates the undulating morainic plateau from a lower situated Dębnica River Valley. Terrain absolute height range from 90 to 125 m a.s.l. In accordance with subzones of the Parsęta lobe designated by Karczewski (1989), the research area should be classified as the highest 7th level of the morainic plateau of the northern Pomeranian slope. The northern part of the slope is cut by erosional-denundational valleys of varyious lengths and depths of the bed. The majority of them are dry formations, only some of them have a permanent outflow (Paluszkiewicz 2007, 2009) (Fig. 2).

The research area is located in the Piaski Pomorskie morainic upland edge zone. In the southern part, it is limited by the lowering of the Dębnica furrow, which cut the undulating moraine plateau, filled with sand and gravel sediments of glaciofluvial and fluvial origin. The large crevace-filling form (Łęknica) is situated in the south-eastern part of the research area, on the borderline between the lowering of the glacial furrow and morainic upland edge (Paluszkiewicz 2008, 2011).

The geological structure layout of the area is dominated by glacial gravel and silty sands, glacial tills and glaciofluvial sands (Popielski 2000, Fig. 3).

Research methods

Research methods used in the elaboration included field works, laboratory analysis and data processing. Field works included analysis of outcrops of total depth down to over 7 m (Fig. 4). In the outcrops sediment samples for laboratory analysis were collected. A total number of achieved samples reached 11. Apart from lithological analysis, also structural and textural features of sediments were examined. According to the procedure proposed by Gołąb (1951) and Stankowski (1961) the azimuth and dip of layers and lamins were measured. Further research procedure was connected with laboratory and deskwork, as well as the study of archive material analyses. The elaborations included:

- in granulometric description of sediments the classification according to the Polish Geological Institute (Instruction 2004) was used,
- an analysis of the mechanical composition of deposits using Cassagrande's areometric-sieve method modified by Prószyński (Racinowski 1973; Płochniewski 1986),
- determination of the calcium carbonate ($CaCO_3$) content using Scheibler's apparatus
- an analysis of the abrasion grade of quartz grains using Krygowski's (1964) mechanical graniformametry method for the fractions of 1.25–1.0 mm and 1.0–0.8 mm (Drzymała et al. 1980, Bednarek et al. 2004),
- grain size indices were calculated using the Folk and Ward method (1957), with the use of the Gradistat software (Blott, Pye 2001),
- Miall's lithofacies code (1977, 1978) modified by Zieliński (1992) was used for the genetic interpretation of sediments.

Site-specific works included preparation of drawings and diagrams based on collected documentation.

As cartographic materials used in the study served: topographic maps at a scale of 1:10,000,

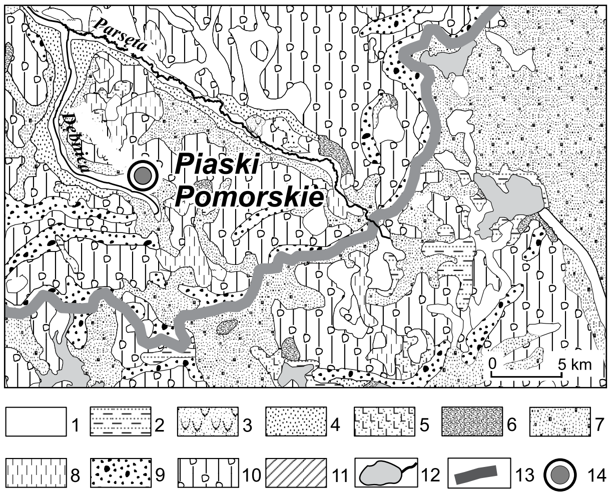

Fig. 3. Lithology of surface sediments of the research area. Prepared on the basis of Poland's geological map at a scale of 1:500,000 (http://www.pgi.gov.pl/mapy/mpgp500/MGP500_main.html,2006).
1 – alluvia, peats and organic soil, 2 – lake sands, silts, clays and gytjas, 3 – eolian sands, 4 – fluvial sands, gravels and silts, 5 – lake sands and silts, 6 – ice-dam clays, silts and gravels, 7 – outwash sands and gravels, 8 – kame sands and silts, 9 – end moraine gravels, sands, boulders and tills, 10 – tills, weathered tills, glacial sands and gravels, 11 – sands locally containing amber, silts, clays and ignite, 12 – river network, lakes, 13 – the Pomeranian Phase of Vistulian Glaciation limit, 14 – study site.

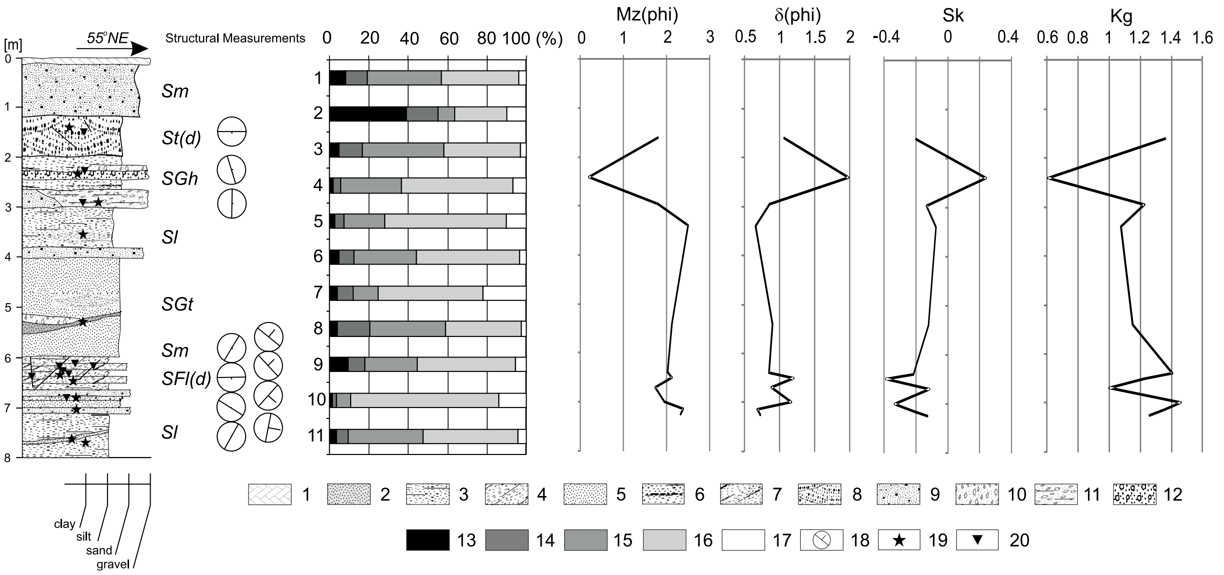

Fig. 4. The lithofacies structure of the Piaski Pomorskie site. The percentage content of primary fractions, the value of granulation indices.
1 – soil, 2 – fine-grained silty sands with iron precipitates 3 – fine-grained silty sands 4 – low-angle cross-stratification fine-grained sands with silt, 5 – fine-grained sands, 6 – fine-grained sands with horizontal lamination, 7 – fine-grained sands with low-angle cross-stratification, 8 – fine-grained sands with trough cross-stratification, 9 – varied-grain sands, 10 – coarse-grained sands and fine-grained gravel, 11 – coarse-grained sands and coarse-grained gravel with horizontal lamination, 12 – gravel pebble, 13 – 10–1 mm, 14 – 1.0–0.5 mm, 15 – 0.5–0.25 mm, 16 – 0.25–0.1 mm, 17 – 0.1–0.02 mm, 18 – structural measurements, 19 – sample collection sites 20 – structural measurement sites.

detailed geological map of Poland (SMGP) at a scale of 1:50,000 and a geomorphological sketch – Barwice sheet at a scale of 1:100,000 (Popielski 2000).

Results

Lithofacies analysis of sediments at the Piaski Pomorskie test site

Characteristics of sediments forming the north-western part of the morainic upland edge zone were determined based on the analysis of an outcrop located 2 km NW of the village Piaski Pomorskie (Fig. 1). The arrangement of sediments was examined down to a total depth of over 7 m. The division into granulometric groups was applied (standard BN–78/9180–11 1979). It showed considerable predominance of fine-grained sand fractions (0.1–0.05 mm, Fig. 4). The bottom of the profile is composed of fined-grained sand (Mz = 2.3 phi) with a moderately degree of sorting (δ = 0.68–0.7 phi). A negative obliquity value (Sk = –0.213––0.126) indicates the presence of coarser fractions. This series reaches a thickness of 0.3 m. Within this layer, traces of iron compound rinsing can be seen in the form of small interbeddings. The presence of iron compound rinsing should be associated with post-sedimentational processes. This series show a type of low-angle cross-stratification (Sl), indicating the participation of flowing water in the sediment deposition process. Above, i.e. at a depth of 7 m a.s.l., an interbedding of fine-grained sand occurs (Mz = 1.95 phi) with a significant share of coarser fractions: gravel (9.4%), coarse- (8.4%) and medium-grained sands (26.7%) (SGm). The above mentioned serie reaches a thickness of 0.2 m and is characterised by a poor degree of sorting (δ = 1.16 phi). It shows a higher energy of the sediment-transporting environment, as compared to the lower layer. Above, a layer of fine-grained sand (Mz = 1.74–2.12 phi) is situated, showing a low and moderate degree of sorting (δ = 0.85–1.2 phi). This series reaches a thickness of 1.8 m and is representing low-angle cross-stratification (SFl). Interbeddings, with finer material, with a considerable amount of coarse-grained silt (over 21%) are characteristic for this layer. The presence of finer material indicates decreasing energy of the transporting environment. The occurrence of fine rigid structures was observed in the upper part of this layer in the form of normal fault (SFd). The dump of the material was slightly above 0.07 m. Above, i.e. at a depth of 5.4 m below ground, a serie of fine-grained massive sand occurs (Mz = 2.3 phi) showing a moderate degree of sorting (δ = 0.7 phi) (Sm). This layer reaches a thickness value of 0.5 m. Above, a layer of coarse-grained sand with gravel is deposited. This series reaches a thickness of 1.2 m and it is characterised by the occurrence of trough cross-stratification (SGt). The stratification type indicates the influence of flowing water with considerable energy during the sediment deposition. Above, i.e. at a depth of 3.80–3.40 m, i.e. 4 m below ground, the occurrence of fine-grained sand sediments was noticed, which constituted over 56% of sediments. This series is characterised by low-angle cross stratification with a moderate degree of sorting (δ = 0.66 phi) (Sl). Above, i.e. at depths ranging from 2.95 to 2.00 m a.s.l., lithofacies with textural characteristics indicating a type of coarsening upward cycle was found. Namely, a gradual transformation of sediments from fine-grained sands through coarse-grained sands and to the gravel fraction was observed. The gravel fraction in the upper part amounts to over 38% of the entire sample weight (Mz = 0.21 phi). This serie is characterised by a low degree of sorting (δ = 1.99 phi) and positive obliquity values (Sk = 0.24), and represents a type of horizontal lamination (SGh). In the uppermost part of the analysed outcrop, a serie of fine-grained sands is deposited (Mz = 1.8 phi) with a low degree of sorting (δ = 1.06 phi) and negative obliqueness values (Sk = –0.2). This serie is characterised by trough cross-lamination deformed by stiff structures of normal faults (Std).

The calcium carbonate content of deposits is low and ranges from 2.2 to 4.1%.

The frequency curves (Fig. 5A), which were analysed for the outcrop sediments, show the greatest frequency (maximum up to 20 units) of two fractions: 3 and 2 phi, indicating the dominance of fine- and medium-grained sands. Two samples (no. 2 and 11), showed a higher frequency of coarser fractions: –1.5 phi and 0 phi, thus showing the predominance of gravel and coarse-grained sands. The curves indicate a bimodal character manifested by a considerable share of fine- and medium-grained sands. Only for samples representing coarser sediment (samples no. 2 and 11), single-mode curves are observed.

A comparison of Mz-δ indicators shows a tendency for more limited sorting (δ), together with an

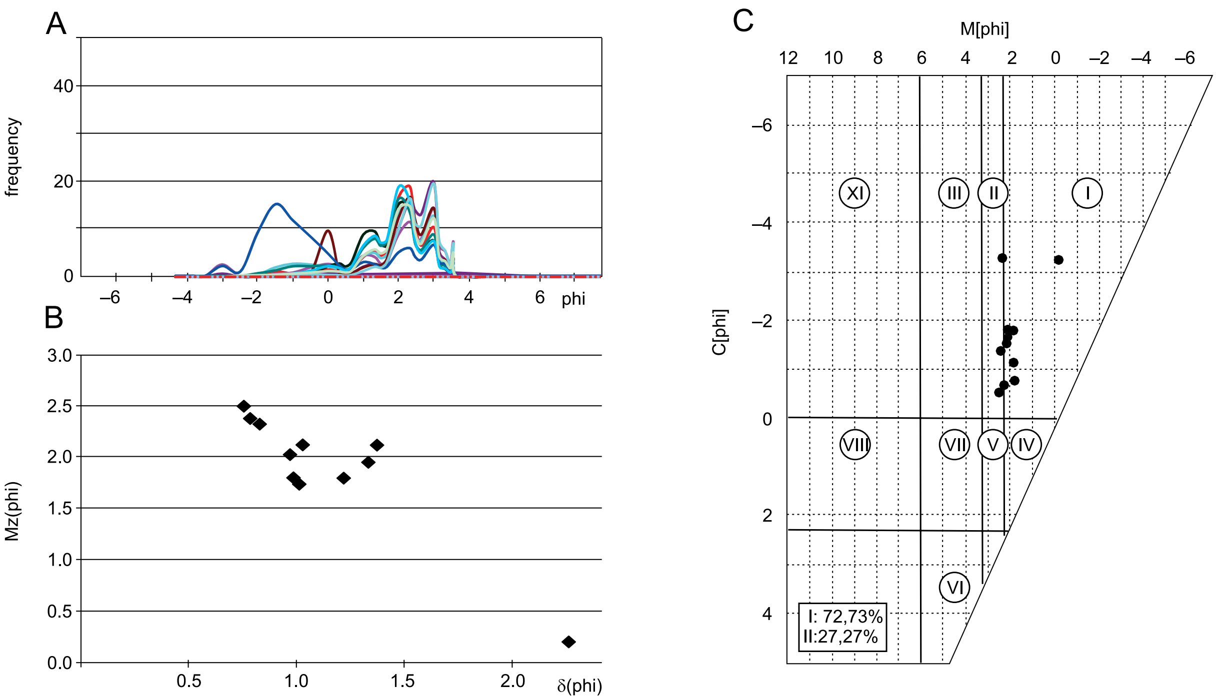

Fig. 5. A. Frequency curves of sediments in the Piaski Pomorskie test stand, B. Comparison of granulation indices Mz-δ for samples of sediments in the Piaski Pomorskie stand, C. Passega diagram for sediments in the Piaski Pomorskie test stand.

increase in the average grain diameter (Mz) (Fig. 5B). Sediments characterized by such a trend are formed in an environment with diversified dynamics, with saltation interrupted with a predominance of better sorting periods of increased flow with deposition of coarse-grained material. The above setting is typical for environments with varied dynamics and high variability of the sediment-transporting power and it is characteristic for fluvial and glaciofluvial trough sediments (Mycielska-Dowgiałło 1980, 1995).

Analysis of sample distribution in the C/M Passega diagram (1957, 1964) allows to assess the conditions of sediments accumulation. The sample distribution in the C/M Passega diagram (Fig. 5C) indicates formations shifted as a result of traction in the environment with high dynamic activity, which do not have favorable conditions for precipitation of the load from the suspension (Racinowski, Szczypek 1985). Sediments with a C value, of more than 1 mm, are mostly deposited during bedload transport. The highest percentage share of samples were observed for sector I – over 72% and for sector II – over 27%. The sector of diagram C/M I and II includes the coarsest grains with a diameter of over 1 mm. It is an arrangement that is characteristic of sediments formed with a share of grains rolled over the bottom (traction) with a low share of the suspension. The majority of the mineral material was tractioned over the bottom.

The measurements of the azimuth and dip of layers indicate that sediments were deposited from the N sector (Fig. 4).

Lithofacies analyses of morainic upland edge zone were supplied with studies in earlier elaborated site Przybkowo/Barwice, located 3 km south-east from the town Barwice (Paluszkiewicz 2013, Fig. 3). Detailed researches were done in the zone of morainic upland edge in the top part of a hill 150 m a.s.l. As it was stated mineral series are representing a typical setting, characteristic for outer kame moraine zone (Karczewski 1989). Two basic lithofacies were described in the inner structure: glacial one, represented by top and bottom series and fluvioglacial one between them. Morainic tills are representing ablation type and are showing big homogeneity, despite the division by 4.5 m thick glaciofluvial deposits (Wierzbicki et al. 2008). Contacts of tils represent erosive character both in the case of lower as upper ones (Paluszkiewicz 2008)

Analysis of quartz grain processing

An analysis of the degree of quartz grain abrasion using Krygowski's mechanical graniformametry

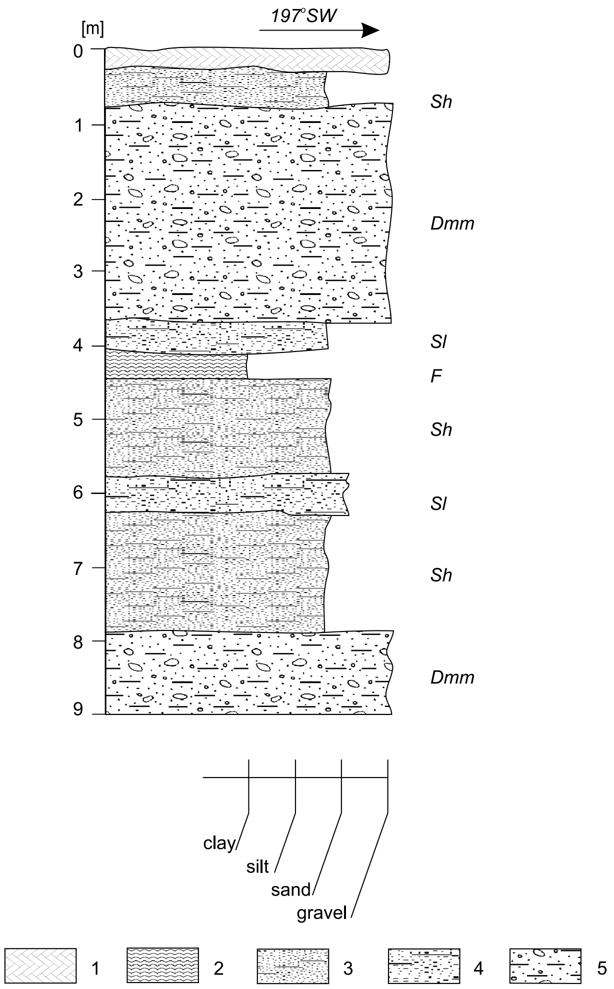

Fig. 6. The lithofacies structure of the Przybkowo/Barwice site.
1 – soil, 2 – clay, 3 – fine-grained sands with horizontal lamination, 4 – fine-grained sands with trough cross-stratification, 5 – massive diamicton.

method (1964) for the 0.8–1.0 mm and 1.0–1.25 mm fractions was applied. In accordance with the procedure proposed by Krygowski (1964), three types of grains were distinguished: α – angular grains, β – grains with an intermediate degree of abrasion, γ – grains with a good and very good degree of abrasion. The percentage share of individual types of grains for the fractions of 0.8–1.0 mm and 1.0–1.25 mm is similar. Within the fractions 0.8–10 mm and 1.0–1.25 mm, considerable predominance of β type grains as compared to the other two types: α and γ. In the 0.8–1.0 mm fraction, the percentage of individual types is as follows: α – 18%, β – 56%, γ – 17%; while for the 1.0–1.25 mm fraction, the percentage of individual types reaches: α – 13%, β – 74%, γ – 12%. A relatively high content of type-β grains with an intermediate type of abrasion can indicate the influence of the glacial and glaciofluvial environment and it can indicate the influence of frost weathering (Kostrzewski 1971, Paluszkiewicz 2009). Considerable predominance of β type grains over the other types may also indicate an increase in the degree of abrasion A considerable amount of type-γ grains of 12% for the 1.0–1.25 mm fraction and 17% for the 0.8–1.0 mm fraction may indicate severe weathering of superficial formations, and thus the influence of aeolian environment processes on the shaping of the edge zone in the vicinity of Piaski Pomorskie. The observed higher share of γ type grains in the finer fraction can be explained in accordance with Goździk and Mycielska-Dowgiałło (1982) by grains preservation in a glacial environment.

The presented characteristics pertaining to the degree of quartz grain abrasion using Krygowski's mechanical graniformametry (1964) indicated a higher amount of β type grains in two analysed fractions.

Conclusions

Interpretation of results of laboratory analyses allows to make an attempt to define the genesis of the analised area. Edge zones of the morainic upland plateau surrounding troughs or post-glacial depressions are characterised by high morphogenetic and lithological diversity. The Piaski Pomorskie edge zone is an area formed at the front of the ice sheet, which receded from the reach of the Pomeranian Phase of the Weichselian glaciation 15.2 ka BP (Marks 2002). This area is approx. 6 km long and its arrangement is close to latitudinal. After the Pomeranian Phase ice-sheet recession, water from the melting of dead ice blocks and the thawing of ground ice caused deep cuts in the plateaux (Dobracka, Lewandowski 2002, Maksiak, Mróz 1978, Marsz 1973).

An analysis of the southern part of the edge zone of the plateau (using the example of sediments in Przybkowo, Paluszkiewicz 2013), which surrounds the depression of the Dębnica valley, shows the occurrence of alternate glacial and glaciofluvial sediments. The internal structure described on the basis of test sites in Piaski Pomorskie (edge zone of the northern part of the Dębnica depression) shows the occurrence of fine-fraction glaciofluvial sediments. The predominant distribution of fractions, fine- and medium-grained sands as well as the structure and texture of sediments indicate low, but variable energy of the environment and constant deposition. A considerable load of mineral materials in proglacial watercourses led mostly to the accumulation of series of fined grained sands with low-angle or trough cross-stratification, occasionally showing a type of horizontal or massive lamination. Sediments were most probably deposited in conditions of transportation by traction and saltation.

Both the distribution of primary structures and secondary sedimentation structures occurring within the tested sediments imply considerable lithogenetic similarity to the mineral material occurring within sediments of the crevasse fillings formation in the area of Łęknica (Paluszkiewicz 2013). Thus, it can be stated that, just like in the case of the crevasse fillings formation, sediments present in the proglacial streams of the ice-sheet were also deposited here. The degree of quartz grain abrasion of the tested samples of sandy sediments indicates that quartz grains stayed long enough in a high-energy aquatic environment to acquire surface features typical of this environment.

Ablation waters discharging from plateau areas, apart from other directions, contributed to the overflow in the Dębnica valley. The meridional subglacial Dębnica trough is currently used by the upper section of the Dębnica River and Dębno and Koprzywno Lakes. Melting of ice blocks buried in sediment covers took place from the oldest Dryas through Bölling-Alleröd to the Preboreal period (Gołębiewski 1981, Florek 1991, Florek et al. 1999, Nowaczyk 1994, Błaszkiewicz 2003, 2005). This period was accompanied by changes in hydrogeological conditions. Slopes of larger river valleys and glacial structural basins, edges of moraine plateaux were cut by systems of erosion and denundation valleys and erosion slits (gullies). Aside of other places they were also formed on the slope of the Dębnica Valley in the area of Piaski Pomorskie and Buślarki villages (Paluszkiewicz 2009, 2013).

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References

Bednarek R., Dziadowie, H., Pokojska U., Prusinkiewicz Z., 2004. *Badania ekologiczno-gleboznawcze*. Wyd. Nauk. PWN, Warszawa. 344.

Blott S.J., Pye K., 2001. Gradistat: a grain size distribution and statistics package for the analsis of unconsolidated sediments. *Eearth Surf. Processes Landf.*, 26:1237–1248.

Błaszkiewicz M., 2003. Wybrane problemy późnoglacjalnej i wczesnoholoceńskiej ewolucji mis jeziornych na wschodnim Pomorzu. *Przegl. Geogr.*, 75, 4: 569–600.

Błaszkiewicz M., 2005. *Późnoglacjalna i wczesnoholoceńska ewolucja obniżeń jeziornych na Pojezierzu Kociewskim* (*wschodnia część Pomorza*). Pr. Geogr. PAN IGiPZ, 201: 192.

Dobracka E., Lewandowski J., 2002. Strefa marginalna fazy pomorskiej. In: Dobracki R., Lewandowski J., Zieliński T., (eds), *Plejstocen Pomorza Środkowego i strefa marginalna lobu Parsęty. IX Konferencja: Stratygrafia plejstocenu Polski*, PIG Oddz. Pomorski, Szczecin i UŚ WNoZ, Sosnowiec: 109–117.

Drzymała S., Maszner P., Michałek K., Mocek A., 1980. Właściwości chemiczne gleb. In: Dzięciołowski W. (ed.), *Ćwiczenia z gleboznawstwa, Skrypty Akad. Roln. W Poznaniu*, Wyd. Akad. Roln., Poznań: 123–130.

Florek W., 1991. *Postglacjalny rozwój dolin rzek środkowej części północnego skłonu Pomorza.* WSP, Słupsk: 238.

Florek W., Alexandrowicz S.W., Pazdur A., 1999. Zmiany poziomu wody w jeziorze Jasień na tle ewolucji środowiska w późnym vistulianie i holocenie. In: Pazdur A. (ed.), *Geochronologia górnego czwartorzędu Polski w świetle datowania radiowęglowego i luminescencyjnego.* WIND, Wrocław: 199–214.

Folk R. L., Ward W. C., 1957. Brazos river bar: a study of the significance of grain size parameters. *Journal of Sedim. Petrol.* 27; 3–26.

Gołąb J., 1951. *Zasady zdjęć geologicznych.* PWT, Katowice.

Gołębiewski R., 1981. *Kierunki i intensywność denudacji na obszarze zlewni górnej Raduni w późnym würmie i holocenie.* Zesz. Nauk., 26, Uniw. Gdański, Gdańsk: 165.

Goździk J., Mycielska–Dowgiałło E., 1982. Badania wpływu niektórych procesów geologicznych na przekształcenia powierzchni ziarn kwarcowych. *Przegl. Geol.* 54(3): 219–241.

Instrukcja opracowania i wydania Szczegółowej mapy geologicznej Polski w skali 1: 50 000 – zbiór wymagań formalnych i merytorycznych dotyczących sporządzania tego typu mapy, 2004. PIG, Warszawa: 127.

Karczewski A., 1968. *Wpływ recesji lobu Odry na powstanie i rozwój sieci dolinnej Pojezierza Myśliborskiego i Niziny Szczecińskiej.* Pr. Kom. Geogr.-Geol., 8(3), PTPN, Poznań: 105.

Karczewski A., 1989. *Morfogeneza strefy marginalnej fazy pomorskiej na obszarze lobu Parsęty w vistulianie* (*Pomorze Środkowe*). Wyd. Nauk. UAM, Poznań: 48.

Kondracki J., 1998. *Geografia regionalna Polski*. Wyd. Nauk. PWN, Warszawa: 440.

Kostrzewski A., 1971. Niecki denudacyjne w krawędzi wysokiej terasy ujściowego odcinka doliny Bobru. *Bad. Fizjogr. nad Pol. Zach.*, 24 A: 77–95.

Krygowski B., 1964. *Graniformametria mechaniczna, teoria, zastosowanie.* PTPN, Prace Kom. Geogr.-Geol., 2, 4: 112.

Marsz A., 1973. Niektóre zagadnienia geomorfologii bezpośredniego przedpola zasięgu stadiału pomorskiego na Pojezierzu Drawskim (na przykładzie obrzeżenia rynny marginalnej Drawsko–Pile). *Bad. Fizjogr. nad Polską Zach.*, ser. A, 26: 97–143.

Maksiak S., Mróz W., 1978. Czwartorzęd środkowej części Pojezierza Pomorskiego. *Biul. Inst. Geol.*, 300: 97–152.

Marks L., 2002. Last Glacial Maximum in Poland. *Quat. Sci. Rev.*, 21: 103–110.

Miall A. D., 1977. A review of braided River depositional environment. *Earth. Sci. Rev.*, vol. 13.

Miall A. D., 1978. Lithofacies types and vertical profile models in braided River deposits: a summary. In: Miall A.D. (ed.), *Fluvial Sedimntology*, Can. Soc. Petrol. Geol., Memoir, 5, 597–604.

Mycielska-Dowgiałło E, 1980. *Wstęp do sedymentologii (dla geografów*). WSP w Kielcach, Kielce.

Mycielska-Dowgiałło E., 1995. Wybrane cechy tekstualne osadów i ich wartość interpretacyjna. In: Mycielska-Dowgiałło E., Rutkowski J. (eds), *Badania osadów czwartorzędowych. Wybrane metody i interpretacja wyników*. Warszawa: 29–105.

Nowaczyk B., 1994. Wiek jezior i problemy zaniku brył pogrzebanego lodu na przykładzie sandru Brdy w okolicy Charzykowy. *Act. Univ. Nicolai Copernici, Geogr.*, 27(92): 97–110.

Paluszkiewicz Re., 2007. Charakterystyka geomorfologiczna strefy krawędziowej w obrębie Pomorza Zachodniego (na przykładzie okolic Piaski Pomorskie). In: Smolska E., Swarczewski P. (eds) *Zapis działalności człowieka w środowisku przyrodniczym.* 4: 105–108.

Paluszkiewicz Re., 2009. Zróżnicowanie litologiczne osadów dolinek erozyjno-denudacyjnych (Pomorze Zachodnie). In: Kostrzewski A., Paluszkiewicz R. (eds) *Geneza, litologia i stratygrafia utworów czwartorzędowych* 5, Seria Geografia 88, Poznań: 383–406.

Paluszkiewicz Re., 2013. The Developmental Stages of An Accumulative Cone of Dry Valley as an Indication of Change in Natural Environment Conditions (Western Pomerania). *Quaestiones Geographicae.* 32(1): 15–20.

Paluszkiewicz Ry., 2008. Rozwój morfogenetyczny centralnej części lobu Parsęty na podstawie analizy cech osadów okolic Barwic (Pomorze Zachodnie). *Landform Analysis.* Vol. 9: 164–167.

Paluszkiewicz Ry., 2011. Zapis procesów glacjalnych i glacifluwialnych w osadach wysoczyznowych centralnej części lobu Parsęty (Pomorze Zachodnie). In: *Georóżnorodność rzeźby Polski.* IX Zjazd Geomorfologów Polskich. Poznań, 20–22.09.2011, 118.

Paluszkiewicz Ry., 2013. Architektura osadów zaplecza centralnej części strefy marginalnej lobu Parsęty na przykładzie stanowiska Przybkowo (Pomorze Zachodnie). In: *Ogólnopolska Konferencja Funkcjonowanie geoekosystemów zlewni rzecznych w Luboradzy* 2013.

Passega R., 1957. Texture as characyeristic of plastic deposition. *Bull. Am. Assoc. Petrol. Geol.*, 41,9:1952–1984.

Passega R., 1964. Grain-size representation by CM patterns as a geological tool. *J. Sedim. Petrol.*, 34:830–847.

Płochniewski Z., 1986. Hydrogeologia i geologia inżynierska. *Wyd. Geol.*, Warszawa: 124 ss.

Popielski W., 2000. *Objaśnienia do Szczegółowej mapy geologicznej Polski w skali 1:50 000, arkusz Barwice.* PIG, Kielce.

Racinowski R., 1973. Analiza uziarnienia. In: E. Rühle (ed.): *Metodyka badań osadów czwartorzędowych.* Wyd. Geol. Warszawa, 331–335.

Racinowski R., Szczypek T., 1985. *Prezentacja i interpretacja wyników badań osadów czwartorzędowych.* Skrypty Uniw. Śląskiego, 359. Katowice: 143.

Stankowski W., 1961. Z metodyki badań nad wydmami na przykładzie Basenu Szczecińskiego. *Czas. Geogr.*, 32, 1: 57–76.

Wierzbicki J., Paluszkiewicz R., Paluszkiewicz R. 2008: Wytrzymałość mechaniczna osadu a jego geneza, na przykładzie wybranych utworów strefy marginalnej fazy pomorskiej zlodowacenia Wisły. *Landform Analysis,* 9: 390–393.

Zieliński T., 1992. Kod litofacjalny – zapis podstawowych faktów litologicznych. In: Mycielska-Dowgiałło E. (ed.), *Badania sedymentologiczne osadów czwartorzędowych.* Letnia Szkoła Sedymentologiczna, Murzynowo k. Płocka. UŁ, 297–301.