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The Late Glacial and Holocene development of valley network in the Puck Morainic Plateau

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The authors analyse the relief of the Puck Morainic Plateau. This is one of the largest plateaux of the Kaszubian Coastland, characterised by a diversity of heights and forms. The plateau's relief is varied by its valley cuts, formed earlier and now transformed and used by the Gizdepka and the Potok Błądzikowski rivers.

The authors relate the development of the valley network at the end of the last glaciation to the processes occurring during the glaciation of the region as well as to changes in the erosion base-level in the Holocene.

Key words: quaternary geology, Pleistocene, valley network, Puck Morainic Plateau, Gdańsk Coastland

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INTRODUCTION

The area under study, called the Puck Morainic Plateau, constitutes the eastern part of the Kashubian Coastland (Fig. 1). The characteristic feature of the young glacial landscape of the western coast of the Gulf of Gdańsk, the so-called Kashubian Coastland, is a network of isolated morainic plateau patches separated by ice marginal valleys. The high diversity of the absolute and relative heights and the distinctiveness of forms result from many processes whose effect is combined with the exaration and accumulation activity of the Pleistocene glaciers and their meltwater.

GEOLOGICAL SETTING OF THE AREA

The Puck Morainic Plateau, also called the Puck Isolated Morainic Plateau (Kępa Pucka), is one of the largest isolated morainic plateaux of the Kashubian Coastland. The thickness of the Quaternary sediments ranges from 40 m in its eastern part to 95–100 m in the western part (Nosewicz, 1995). Such differences in the thickness of the Quaternary result mainly from the land relief of its basement (Jereczek-Korzeniewska, Olszak, 2007). According to the documentation presented by Skompski (2001, 2002) and Pikies (2000), denivelations of the top of the Quaternary basement in the study area reach values similar to those observed in the present relief of the area. The base of the Quaternary is the lowest in the areas of the Płutnica (80–100 m b. s. l.) and the Gizdepka (40–60 m b. s. l.) (Pikies, 2000) (Fig. 2).

These maximum depths of the sub-Quaternary surface coincide with the bottom of elongated depressions of a latitudinal direction. These depressions correspond to the subglacial channels of the surface relief. The valleys cutting the sub-Quaternary surface were formed as fluvial valleys by the end of the Neogene or in the lower Pleistocene. They were then deepened by the glacial and fluvioglacial activity of the first Pleistocene continental glaciers (Pikies, 2000). This is evidenced, among others, by the occurrence of the

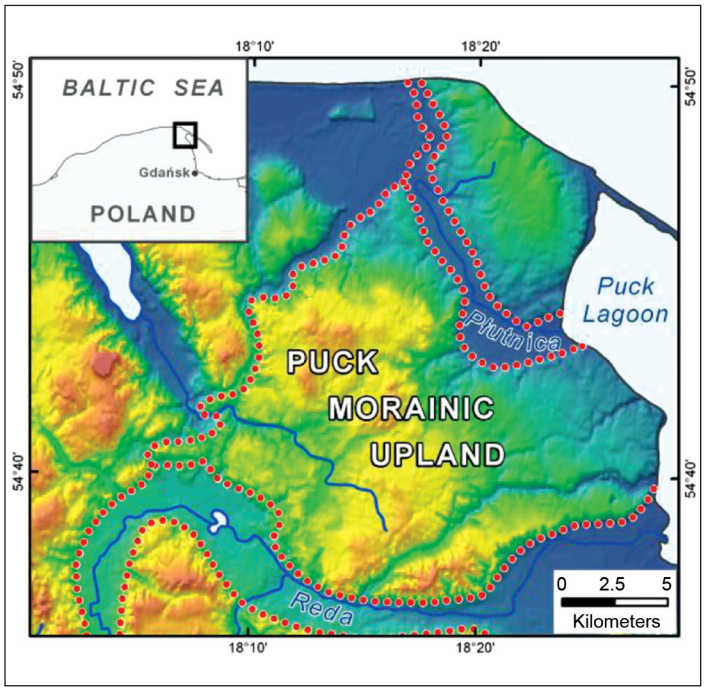

Fig. 1. Location of the Puck Morainic Plateau

1 pav. Pucko moreninės aukštumos padėtis

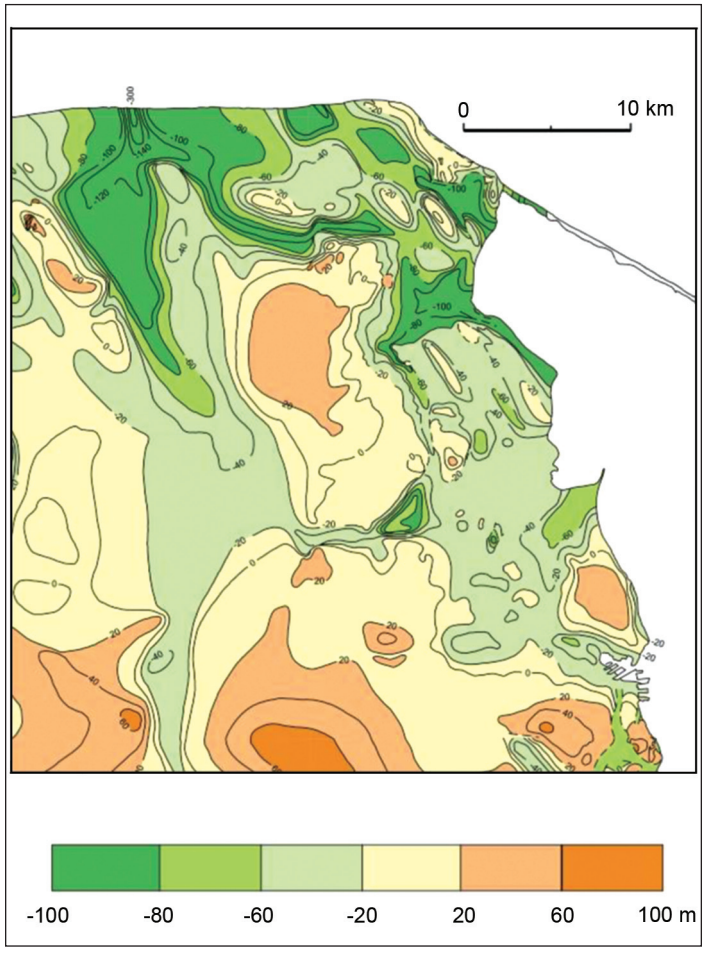

Fig. 2. The relief of the pre-Quaternary surface area (after Pikies, 2000)

2 pav. Prekvartero paviršiaus reljefas (pagal Pikies, 2000)

oldest sediments of the Narew and Nida glaciation in these depressions (Pikies, 2000). Most probably, in these places the negative forms were rejuvenated during the Pleistocene (younger levels) up to the youngest stadial of the last glaciation. Such rejuvenation of depressions, consistent with a particular direction, is attributed to the tectonic activity of faults along which the negative forms were formed. The pressure of the subsequent advancing glaciers activated the fault zones of the ground, and with the advancing deglaciation of the area, the individual horsts were elevated isostatically at different rates. As a result, considerable denivelations were revived. The relationships between the land relief and ground tectonics and movements in the Pleistocene in central and western Pomerania had been documented by other authors who observed similar dependencies (Dobracka, Piotrowski, 2002; Kurzawa, 2000, 2004).

The surface of the area under study is made up of till of the last glaciation. It is situated at the maximum altitude of about 100–110 m a. s. l. and slopes steeply towards the Reda (southern boundary) and the Płutnica (in the north) Ice Marginal Valley. It forms the Osłonino and Puck Cliffs from the side of the Puck Lagoon (Fig. 3).

LANDFORMS AND GEOMORPHOLOGICAL PROCESSES IN THE AREA

The forms of the postglacial relief and the sediments forming them were related to the youngest phases of the Wisła Glaciation. The relief of the Puck Morainic Plateau is diverse with its valley cuts, of which the two largest ones are now used by the Gizdepka and the Potok Błądzikowski rivers. The Gizdepka has a catchment area of 36.6 km^2, while the difference in altitude between its wellhead and outlet into the Puck Lagoon is over 100 m. The catchment area of the second watercourse – the Potok Błądzikowski – equals 21.8 km^2, with the difference in the altitude between the wellhead and mouth of approximately 50 m.

The development of the valley network, along with the hydrographic network, at the end of the last glaciation was related to the processes occurring during that period (the last glaciation); after deglaciation, in the Holocene, it was influenced by changes in the erosion base-level. However, recently a greater role in the shaping of the relief of this area has been ascribed also to tectonic conditions. The impact of neotectonic movements, occurring after the termination of the processes of glacioisostatic transformation, on the development of the relief remains an open question. According to

the map of recent vertical movements of the earth surface (Wyrzykowski, 1985), the area of the Puck Morainic Plateau is stable. It reveals slight positive movements (up to about 0.5 mm / year). If the area under study did not reveal any major neotectonic movements during most of the Holocene, the relief development should be attributed to changes in the erosion base-level (Fig. 4).

During the glaciation and deglaciation, subglacial channels and valley lowerings were formed. They were related to the route of water outflow which flowed from the retreating and melting continental glacier situated on the surface of the plateaux. The waters flowing to a lowering with a latitudinal course moved southwards to the most developed, deepest and widest channels as well as to the south-west towards the Reda-Łeba Ice Marginal Streamway. These channels are currently used by the present streams flowing into the Puck Bay, the Potok Błądzikowski and the Gizdepka, which discharge into the Puck Bay. During the deglaciation of the area, dead ice blocks filled these channels and prevented the outflow of water eastwards. Initially, water flowed on the surface of the dead ice blocks. Once the dead ice blocks in the channels of the Potok Błądzikowski and the Gizdepka melted, a new, eastern direction of the outflow developed towards the area of the present Puck Lagoon and farther towards the Gulf of Gdańsk. During melting, narrowings in the channels were cut, resulting in the formation of characteristic gorge sections. The present wide sections of the valleys, assuming the shape of basin forms, are traces of the melting ice blocks in which small stagnant water reservoirs formed (Jereczek-Korzeniewska, Olszak, 2007).

The subsequent development phase, at the final stage of melting and after the melting of the dead ice blocks, comprised intensive erosion processes. In the Preboreal periods, the area of the Puck Lagoon was covered by peat bogs and lakes (Kramarska et al., 1995), and the erosion base-level, related to the level of the Baltic Sea of that time (the Yoldia Sea), was situated about 50 m below the present sea level. In this period, the Gizdepka and the Potok Błądzikowski valleys could be significantly transformed (deepened). At that time, considerable quantities of sandy material were accumulated in the area of the present Puck Lagoon (local erosion base at that time) or carried farther to the Gulf of Gdańsk (final erosion base) (Fig. 5).

In the Boreal and Atlantic periods, as a result of the rising of the Baltic Sea level, erosion processes diminished, and the sandy material transported by the streams was deposited in the littoral zone of

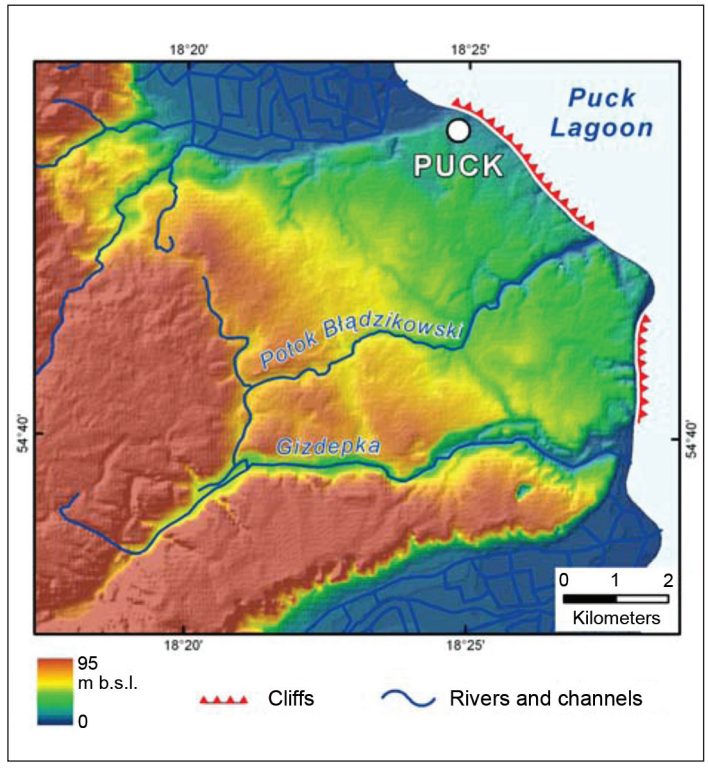

Fig. 3. The relief of the area under study

3 pav. Tirtos teritorijos reljefas

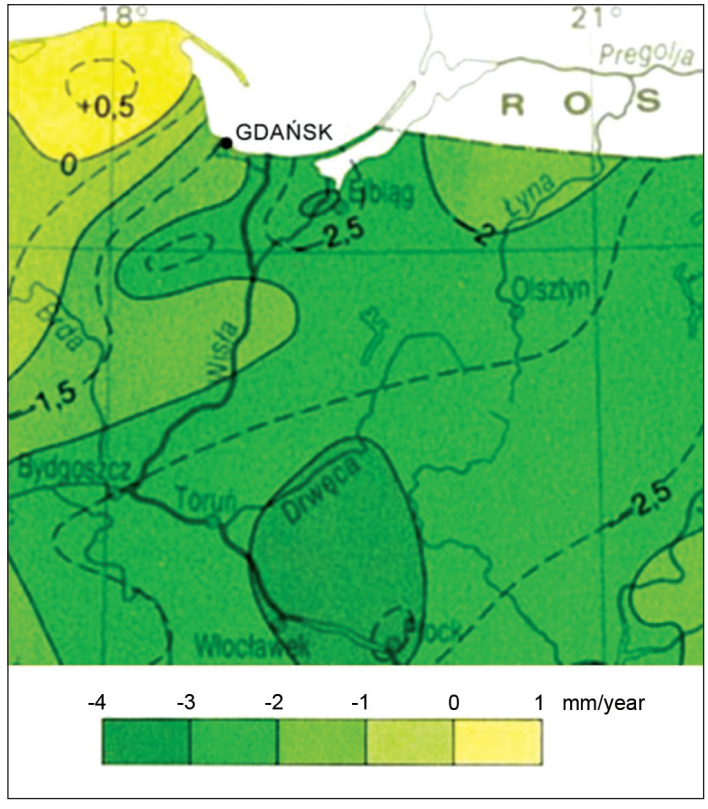

Fig. 4. Vertical movements of the Earth surface in the area of the Puck Morainic Plateau (after Wyrzykowski 1985)

4 pav. Vertikalūs žemės paviršiaus judesiai Pucko moreninės aukštumos teritorijoje (pagal Wyrzykowski, 1985)

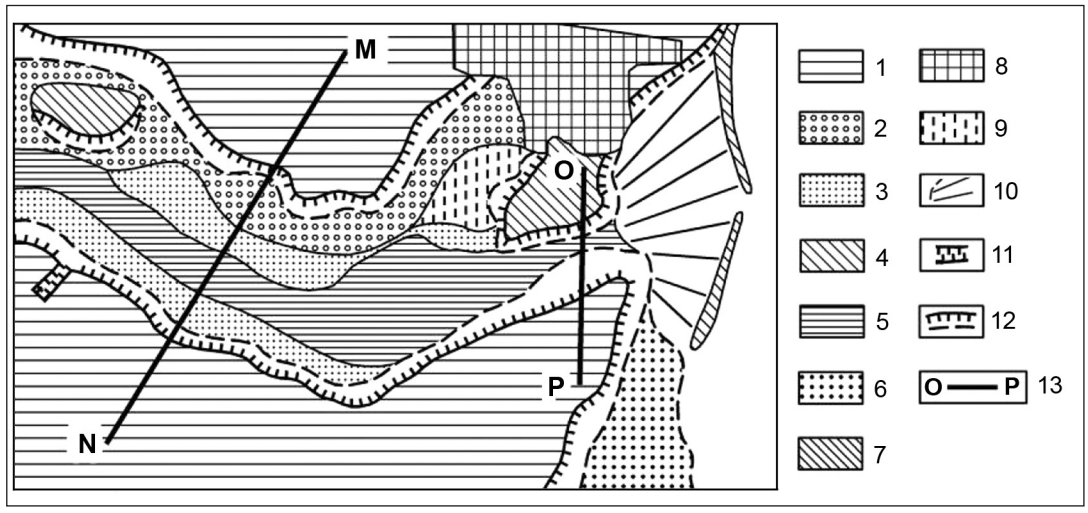

Fig. 5. Geomorphological sketch of the lower part of the Gizdepka valley
1 – morainic plateau; *2* – kame terrace; *3* – stream terrace; *4* – kames; *5* – valley bottom; *6* – beach; *7* – coastal berms; *8* – built-up area; *9* – stagnant water reservoirs; *10* – alluvial fan; *11* – gorges; *12* – edge; *13* – cross-sections

5 pav. Žemesniosios Gizdepkos upės slėnio dalies schema
1 – moreninė aukštuma, *2* – keimo terasa, *3* – upelio terasa, *4* – keimai, *5* – slėnio žemuma, *6* – paplūdimys, *7* – pajūrio bermos, *8* – apstatyta teritorija, *9* – skvinčio vandens telkiniai, *10* – aliuvinė sklaida, *11* – tarpekliai, *12* – pakraštys, *13* – pjūviai

the lake(s) which existed at that time in the Jama Rzucewska depression in the area of the Puck Lagoon (Witkowski, Witak, 1993; Kramarska et al., 1995; Uścinowicz, Miotk-Szpiganowicz, 2003). At the end of the Atlantic period, with the sea level lower by about 3.0–2.5 m from the present one, the lakes which then occupied the present area of the Puck Lagoon were transformed into a brackish lagoon of a shape resembling the present Puck Lagoon (Uścinowicz et al., 2007). In the Subboreal and Subatlantic periods, with a slow rise in the Baltic level, erosion in the Gizdepka and the Potok Błądzikowski valleys diminished, and sediments transported by the streams were deposited in the shore zone of the Puck Lagoon. Both streams formed a substantial estuary fan. The sands carried by the Potok Błądzikowski to the Puck Lagoon were transported in the southern direction, building up the Rzucewo Headland.

CONCLUSIONS

The location of subglacial channels of the surface relief correspond to the elongated depressions in the pre-Quaternary bedrock. The origin of the valley network was related to the erosional processes occurring during the last deglaciation. During the Holocene, the erosion of the valley bottom was related to changes in the local and regional erosion base-level. Erosion processes slowed down since the end of the Atlantic period when the local and the regional erosion base-levels became equal, i. e. the water level in the Gulf of Gdansk rose to the level of the Puck Lagoon area, and local lakes were transformed into a brackish lagoon. The impact of neotectonic movements that occurred after the termination of the last glaciation on the development of the relief remains an open question.

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SLĖNIŲ TINKLO FORMAVIMASIS PUCKO MORENINIAME PLATO VĖLYVUOJU LEDYNMEČIU IR HOLOCENE

S a n t r a u k a

Pucko aukštumoje esančių kvartero nuogulų storis kinta priklausomai nuo pokvartero paviršiaus reljefo formos. Maksimalūs pokvartero paviršiaus reljefo pažemėjimai sudaro pailgas, lygiagrečias formas. Slėnių sistemos vystymasis siejamas su ledynmečiu vykusiais procesais. Holoceno metu buvo svarbi kintanti erozijos bazė. Vis didesnę įtaką aukštumos reljefo formavimuisi turėjo tektoniniai procesai.

Subglacialinės rinos ir slėnių įrėžiai Pucko aukštumoje susidarė apledėjimo ir deglaciacijos metu. Visos šios formos yra rininės kilmės. Tirpstantis vanduo sutekėdavo į greta esančius giliausius ir plačiausius reljefo pažemėjimus. Pasinaudodamas senosiomis rinomis į Pucko įlanką suteka *Bladzikowski* ir *Gizdepka* upių vanduo. Deglaciacijos metu rinose buvo „mirusio", palaidoto, ledo luitai, kuriems ištirpus, pasikeitė nuotėkio kryptis – vanduo ėmė tekėti į rytus, į Pucko įlanką ir toliau į Gdansko įlanką. Preborealio metu Pucko įlankoje buvo durpynai, o erozijos bazė atitiko buvusį Joldijos jūros vandens lygį, apie 50 m žemesnį nei dabartinis jūros lygis. Preborealio ir borealio metu slėniai dar pagilėjo. Pucko įlankoje susikaupė didelis kiekis smėlingų nuosėdų. Atlančio laikotarpiu kylant Baltijos jūros lygiui erozijos procesas kiek susilpnėjo. Subborealio ir subatlančio metu Pucko aukštumoje vykusi erozija toliau silpo. *Gizdepka* ir *Bladzikowski* upėmis keliavusios nuogulos buvo akumuliuojamos Pucko įlankos priekrantėje.

Raktažodžiai: kvarteras, pleistocenas, Pucko moreninė aukštuma, Gdansko įlanka