

THE INFLUENCE OF AEOLIAN FACTOR ON CIRCULATION OF SANDY MATERIAL IN THE SANDPITS OF SILESIAN UPLAND (SOUTHERN POLAND)

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Abstract. Variability in time and space related with the main attribute of material mobility is one of the essential features of nature including relief. The aim of this study is to show the selected geomorphological and sedimentological results of sandy matter circulation (formation of new landforms and microforms) and to determine the importance of wind in this process within large active sandpits in the Silesian Upland in the southern part of Poland, which are areas of sand circulation, intensified by anthropogenic factor. The human impact very often entails certain changes of relief. Based on direct observations of variability of sandy landforms and microforms, it is assumed that an intensive circulation of sandy material has been taking place in the areas analysed. During the period of observation, repeated transitions of sandy material from one environment into another occurred, what resulted in the formation of new landforms, which, in their turn, underwent decay and were replaced by new forms. Frequent changes of particular driving forces of transport, i.e. sedimentation environment followed. Wind action is the prevailing natural factor shaping the sandpit bottoms and slopes. Aeolian processes in sandpits play a role of double importance. Firstly, they take part in the sandy material circulation in different sedimentation environments, secondly, wind causes quick devastation, masking or retouching of formerly existing landforms. References 20, Figs.13. In English, summary in Lithuanian.

Keywords: Poland, Silesian Upland, sandpit, Aeolian processes, sandy matter circulation.

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Introduction

Lability, i.e. changeability in time and space related with the movement as the main attribute of substances, predetermining their existence, is one of essential features of nature. Relief is a part of nature and develops in stages according to defined rules: from its beginning through maturity up to the moment of disappearance. Changeability of landforms means dynamics and circulation of building material. It is easiest to understand circulation patterns observing: 1) loose sandy material, easily transported by different exogenous factors: water, wind, slope processes etc., 2) in relatively small compact areas, including sandpits after sand exploitation.

The aim of this study is to show selected geomorphological (formation of new landforms and microforms) and sedimentological effects of sandy matter circulation (compare Nowaczyk, 1995) and to determine the role of wind in this process in the areas of widespread sandpits of Silesian Upland, which are a significant morphological landscape element in this area (Fig.1).

1. Regional Setting

Quaternary sand areas abound in the Silesian Upland of South Poland. This material mainly originated from fluvial accumulation under extra-glacial conditions in the period of Vistulian (Weichselian) glaciation (Sendobry, 1988; Lewandowski, Zielinski, 1990).

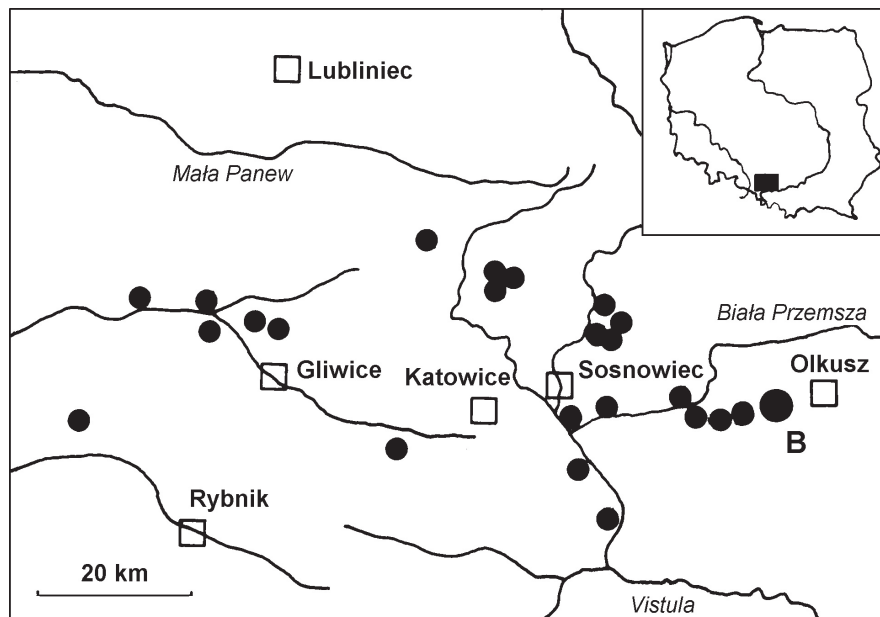


Fig.1. Location of main sandpits in the Silesian Upland; B – sandpit at Bukowno
1 pav. Pagrindiniai Silezijos aukštumų smėlio karjerai; B – Bukovno karjeras

Aeolian processes played an important role in this material accumulation. They also predetermined the morphoscopic features and mechanical abrasion of quartz grains (Pełka, 1992). At the end of Vistulian glaciation and in the beginning of Holocene, a dune relief was formed as a result of reworking of extra-glacial deposits by Aeolian processes (Fig. 2; Szczypek, 1988).

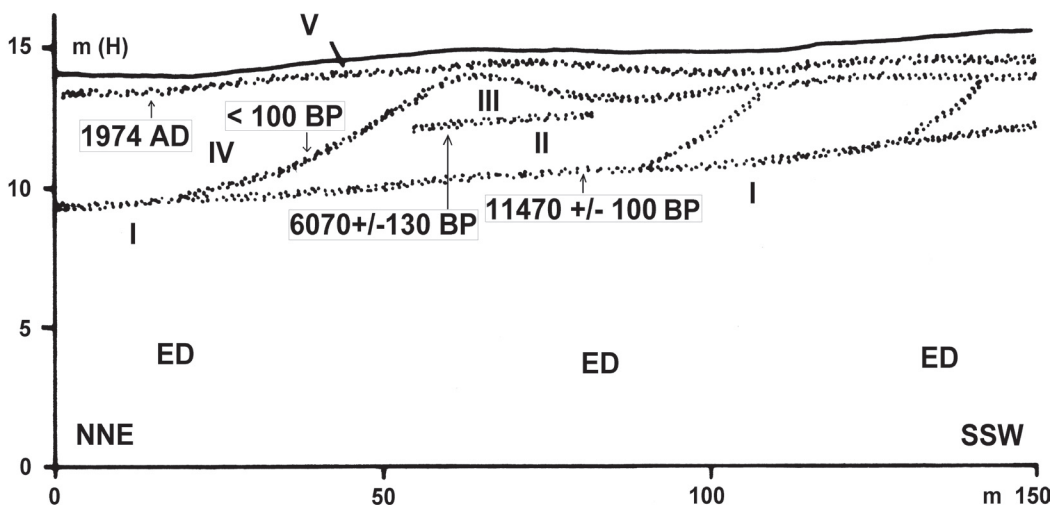


Fig.2. Late Glacial and Holocene dune series (I–V) uncovered at sandpit wall in Bukowno; ED – extra-glacial deposits
2 pav. Vėlyvojo ledynmečio ir holoceno kopų virtinės (I–V) atodanga Bukovno karjero šlaite; ED – priedėdyninės nuogulos

For many tens of years, the above-mentioned sandy areas of the Silesian Upland have been exploited for needs of black coal mining (the sand was used as stowing material to fill the empty places in mines after coal exploited; today, under the conditions of changing economic structure, the sand is used on a smaller scale as a material for building industry). The above-mentioned sandpits (from a few to about 40 sq km in area and at least a dozen metres in depth) are a result of morphological effects of sand exploitation. The eastern part of the largest sandpit "Szczakowa", situated in eastern part of Silesian Upland in Bukowno, is the best known one and was chosen as the base of analyses, although similar processes – though at a smaller scale – also take place in the remaining excavations.

2. Methods

Investigation of geomorphological and sedimentological effects of sandy matter circulation, conditioned by different factors, requires appropriate methods. These methods were as follows: direct long-term visual observations and measurements of changeability in landforms and microforms by means of e.g. geodetic methods as well as laboratory analyses of grain size distribution and the degree of mechanical abrasion of sandy deposits taken from proper forms. The following techniques were also used: 1) classic sieve method with sieve eyes changing per circa about 0.5 phi; on the base of direct results of analyses, main parameters of grain size distribution were determined: mean grain diameter M_z and sorting degree δ according to formulas proposed by Folk and Ward (1957); 2) method of mechanical graniformametry by Krygowski (1964) for determining the degree of mechanical abrasion of quartz grains 1.0-0.8 mm in diameter. Applying the equations of this author, the index of abrasion W_o and contents of rounded grains of γ type and angular grains of α were calculated.

3. Results

3.1. Morphological Effects of Aeolian Circulation of Sandy Matter

Direct anthropogenic interference – in the form of sand exploitation – into the environment of the study area, started in the middle of 1970-ties., caused uncovering of sandy extr-aglacial substratum and Late-Vistulian-Holocene Aeolian material. Moreover, this material was subject to the influence of different morphogenetic factors: natural and anthropogenic ones. Due to this, a renewal of sandy material circulation became possible; similarly to the one taking place under natural conditions thousand years ago yet more intensive and enriched as a result of human impact.

Among the most important actual relief-forming factors within sandpit discussed one should number: 1) direct anthropogenic processes in the form of formation of high excavation scarps, the heaping of artificial landforms from useless material for practical use (Szczypek, Snytko, 1998; Szczypek, Wach, 1998), formation of up and downs in the sandpit bottom owing to exploitation works, microforms being the effect of vehicle wheels activity and mechanical gentling of slopes as a result of land reclamation in some parts of the sandpit in forest direction, 2) anthropogenically induced, but naturally running processes of: a) fluvial transport and lateral erosion with inter-bed accumulation in channels draining sandpit bottoms, b) rill- and sheet- wash after more intensive rainfalls and c) sand sliding at sandpit slopes as well as d) Aeolian processes at co-operation of vegetation or without it. The role of these processes in the formation of morphological face of the bottom and slopes of sandpit is different, but the effects of wash are least noticeable.

The importance of direct anthropogenic processes is of supreme importance, because thanks to them we can observe large, very quickly formed concave landforms in the form of excavations, which under natural conditions cannot function. The creation of singular as well as whole complexes of convex relief landforms of different size in the form of hillocks is another essential direct morphological evidence of human activity.

The presence of initially rectilinear channels draining sandpit bottom, usually from some hundred m to some km long, is one more effect of direct human activity. It is obvious that immediately after these landforms formation they are influenced by natural processes. Initially rather steep sandy walls of excavations during a few a dozen or so weeks undergo gentling thanks to natural processes of sliding and material scattering. The same processes gentle slopes of anthropogenic hillocks, whereas in channel beds natural processes of fluvial transport, lateral erosion and accumulation of sandbars start to occur.

But the essential role in circulation of sandy matter within sandpit is played by the Aeolian factor. The intensity and effects of its influence (deflation, transport and accumulation), similarly to these occurring under completely natural conditions, depends on the amount of proper material, its dryness and degree of covering by vegetation, which was introduced by natural succession or by human being.

As official meteorological data indicate, and most of all the results of direct observations of the course of axes of Aeolian landforms and directions of tree inclination (Peřka, 1994) confirm, south-western winds predominate in the area investigated. Uncovered extra-glacial deposits at different exploitation levels, in terms of granulometric properties, almost immediately undergo wind influence, because the narrow and rather deep (15–20 m) form of excavation concentrates stream of flowing air and fulfils the function of specific aerodynamical tunnel.

The less or more widespread deflation areas and surfaces, and the areas of deflation pavement, composed of gravels and weathering crumbs of limestones and flints, which were here transported together with sandy mass by extra-glacial rivers, are a result of deflation. Under advantageous conditions, when in blown material on slopes among other compact illuvial horizons of fossil soils small niches occur or whole systems of different size deflation depressions originate (Fig. 3) the intensity of deflation is testified by the uncovering of roots of *Salix acutifolia* of 10 cm per year and the formation of deflation remnant of height of about 25 cm in the same period.

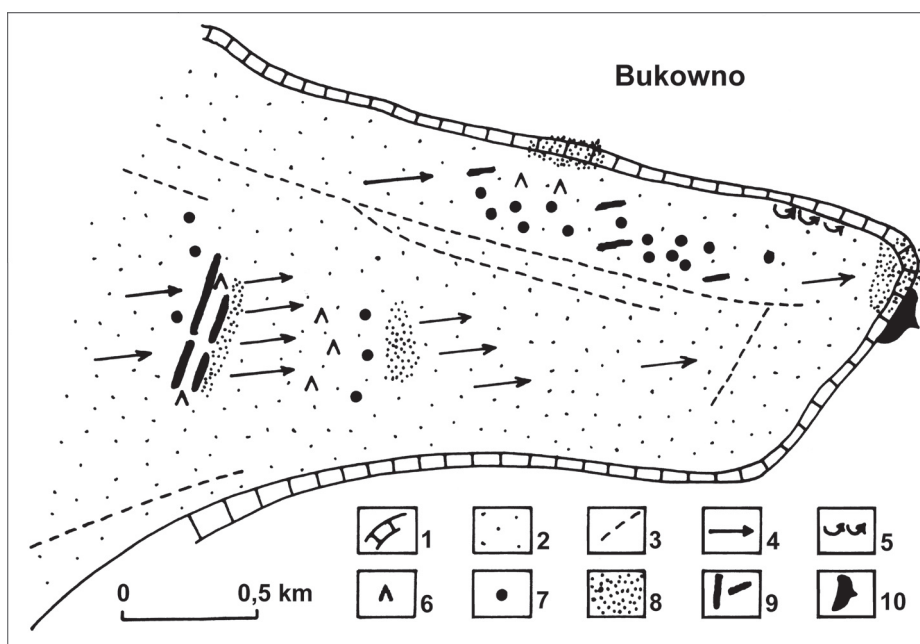


Fig. 3. L1 – slope of sandpit, 2 – sandy bottom of sandpit, 3 – ditches, 4 – deflation areas, 5 – system of small blow outs, 6 – deflation pavement, 7 – sandy shadows of nebkha type, 8 – aeolian cover sands, 9 – initial dunes, 10 – scarp dunes

3 pav. Dabartinės eolinės kraštovaizdžio formos Bukovno smėlio karjere:

1 – karjero šlaitas, 2 – smėlingas karjero dugnas, 3 – grioviai, 4 – defliacijos paveikti plotai, 5 – mažų defliacinių duburių sistema, 6 – defliacinė vaga, 7 – nebkhos tipo fitoakumuliaciniai kaubrai, 8 – eoliniai smėliai, 9 – pirminės kopos, 10 – kopos šlaitas

The blown out material is transported to small distances, mainly by the way of saltation and dragging. Sometimes in the summer time, it is also possible to observe here the development of small and rather quickly moving air vortexes (whirls), which also transport sandy material, throwing down it in any places, also including these in draining channels. Sand transported by deflation also gets here, and it is transported farther, but in the fluvial environment. It then can bars, which after warm and dry summer periods undergo intensive blowing out. It is undoubtedly the situation, which is at least partly similar to the one that existed during river extra-glacial accumulation.

Extra-glacial deposits, Aeolian ones in their majority, are in many places of sandpit bottom spontaneously fixed by grasses (e.g. *Calamagrostis epigejos*, *Koeleria glauca*, *Corynephorus canescens*). Thanks to it, the sand shadows of different size (from 5–15 up to 40–50 cm high and from 30–50 cm up to about 6–7 m long) and rather changing in time and space, clearly diversifying the monotonous flat substratum as well as slightly larger initial dunes, fixed by bushes of *Salix acutifolia* (Fig. 3), are here formed.

Accumulation of Aeolian sand also takes place at gentled by sliding and earlier deflation sandpit slopes as well as at morphological scarps. In the first case, not very mobile covers of blown material of the thickness of about 0.5 m and occupying 0.5–1 ha in area are formed. Some of them are artificially fixed by different bush species.

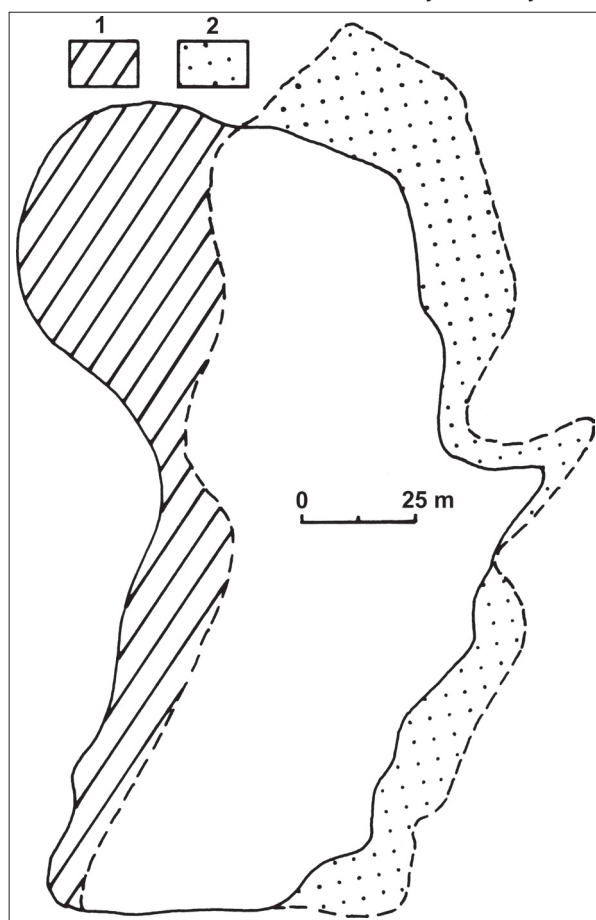


Fig. 4. Changes in scarp dune extent at Bukovno in the period 1986–1993: 1 – surface decrease, 2 – surface increase
4 pav. Pakopinės kopos apimties pokyčiai Bukovno karjere 1986–1993 metais: 1 – paviršiaus ploto sumažėjimas, 2 – paviršiaus ploto padidėjimas

As a result of the occurrence of morphological scarps – excavation scarp – a unique transverse dune was created at the eastern border of this concave landform. It was formed in a few stages: from small cover through to a dune with typical asymmetric slopes of deposits (up to more than 4 m in thickness occupying an area of more than 1 ha (Szczypek, Wach, 1991, 1993, 1999). In seven years, depending on the amount of material delivered from the sandpit bottom as well as from slope blown (the development of scarp dune according to K. Keilhack – compare Prusinkiewicz, 1971), predetermined by the slope foot angle and vegetation cover as well as by direct anthropogenic interference, this dune gradually moved towards the east at mean velocity from 2.3 do 3.9 m/year, whereas the mean annual increase in sand thickness amounted to 10–30 cm. It is a high value [comparable with 30–50 cm for the Aeolian cover on Kuybyshev water reservoir on the Volga River in Russia according to Klucharev (Ключарев, 1969)], because e.g. Reinhard (1953–1954) for the dune on Insel Hiddensee and Prusinkiewicz (1971) for the dune in Wolin Island gives the values, which amount only to 0.5 cm/year (Fig. 3 and 4).

At morphological scarps of lower exploitation levels, small Aeolian covers about 10–20 cm in thickness and up to some thousand meters in area are formed in an identical way, and they also undergo spatial transformation in time.

Wind activity within borders of the sandpit at Bukowno also modifies smaller landforms, which were directly created by human activity. E.g. the above-mentioned anthropogenic hillocks undergo such modification. On the one hand, sandy material is blown from them, what causes the intensive lowering in their height (up to 50% during 1 or 1 and 1/2 year), whereas on the other hand, they are covered by sand brought by wind. In the course of time the situation happens, that they are completely covered by the layer of Aeolian sand. Due to lack of knowledge of initial structure of such landform, when its development has not been directly observed, it can be wrongly classified as a typical Aeolian landform, although it is anthropogenic landform but transformed by wind activity. Ruts of heavy vehicles (lorries or tractors) may serve as another example of anthropogenic landform transformed by Aeolian activity. Initially they very clearly appear in the relief of sandpit bottom, but later the Aeolian factor starts gradually to gentle them and only general outlines of these forms allow following up their primary genesis.

3.2. *Sedimentological Effects of Aeolian Circulation of Sandy Material*

Apart from morphological effects, sedimentological effects of Aeolian sand circulation in the area of sandpit at Bukowno are also observed. They include changes in grain size distribution, features of sand grains abrasion as well as internal structure of dunes. In the given study, the attention is focused on the above-mentioned features of Aeolian material in relation to some selected small landforms: initial dune, large sand shadow and miniature sand shadow.

The grain size distribution of sandy deposits in the most detailed way was known on the example of initial dune. In the area of sandpit at Bukowno, these landforms are evidently created in co-operation with bushes *Salix acutifolia*, whose widespread root system with ease fixes mobile sands. The dune selected for analyses has the outline of prolate ellipse: its longer axe extending SW–NE equals to 10.5 m, whereas the transverse axe is about 7.8 m long. The height of the dune is about 55 cm. This form is characterized by noticeable slope asymmetry: the angle of windward slope is 8°, and the angle of leeward slope 3°, what proves the direct contribution of bushes in its development.

The above-mentioned form is a stationary dune. In its internal structure, one series of laminated sands is observed, overlying a 30 cm thick aeolian cover in the extra-glacial deposits, from which it is divided by a rather continuous layer of sand (4–5 cm thick) with small content of humus. Lamination of dune sands shows duality: it has the preserved structure of windward and leeward slopes; therefore sand within this form dips SW as well as NE at angles as follows: in the roof part 11–20°, in the middle part 8–15°, in the floor part 2–6°. Therefore there is disagreement between the deposits structure and contemporary slope inclination, what can be explained by wind erosion of this form.

Samples for analyses (the total of 33) were taken from artificially uncovered dune wall (together with cover sands) of course corresponding with the longer axe. Additionally, the substratum material was also sampled. Distribution of grain size distribution indices (Mz and σ) was presented in Figs 5 and 6.

Values of mean grain diameter Mz in dune investigated fluctuate between 0.233–0.398 mm (an average of 0.304 mm). The coarser material is mainly located within the windward slope and on top, whereas within the leeward slope it is finer. The calculated mean values of Mz for these three dune elements (0.314–0.311–0.295 mm) show clear tendency to material fining together with wind influence direction. It is confirmed by regression line: $y=0.323736-0.0036176x$ at $r=-0.63$). Simultaneously one should pay attention to the fact that as a result of wind influence the dune sand in general is finer than the source extra-glacial material.

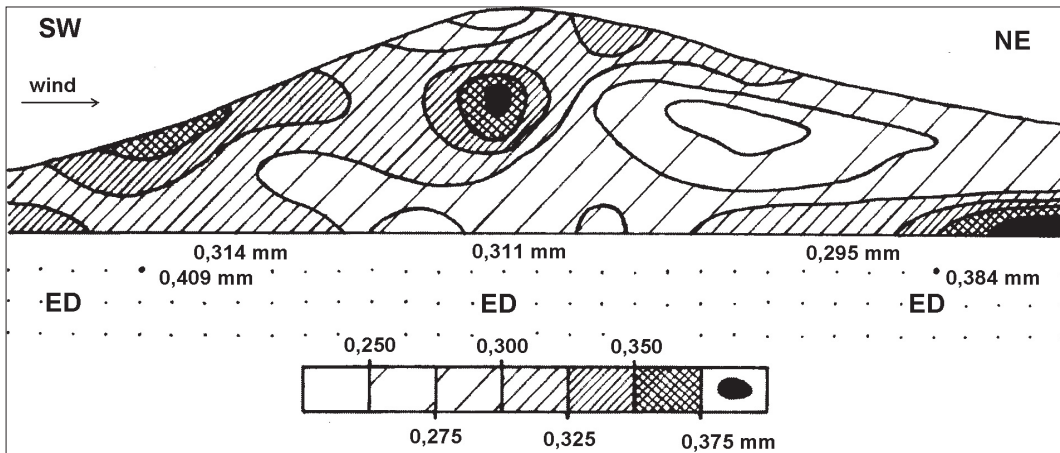


Fig. 5. Distribution of Mz value in longitudinal profile through initial dune in sandpit at Bukowno; ED – extra-glacial deposits

5 pav. Mz verčių pasiskirstymas išilginiame Bukowno karjero pirminės kopos profilyje; ED – priedėdinių nuogulos

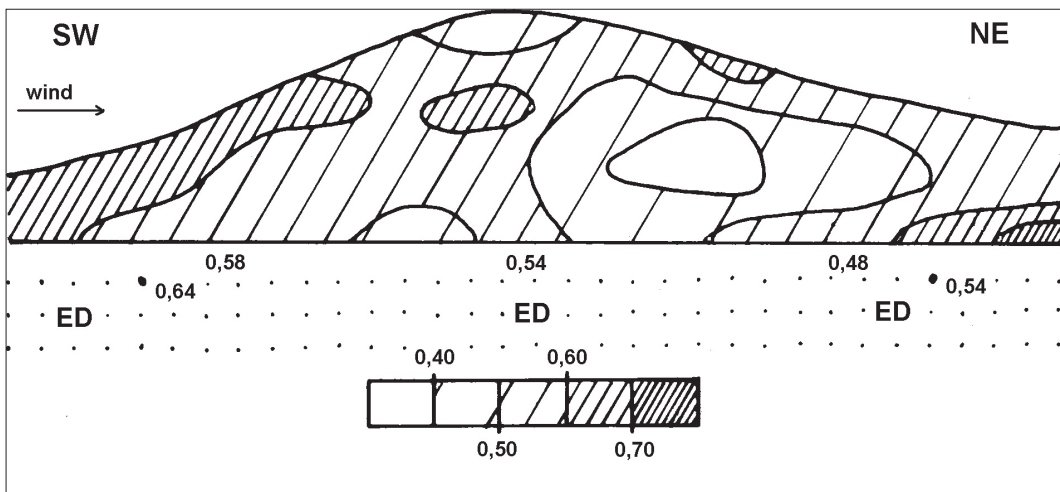


Fig. 6. Distribution of values of sorting degree index σ in longitudinal profile through initial dune in sandpit at Bukowno; ED – extra-glacial deposits

6 pav. Rūšiutumo indekso σ verčių pasiskirstymas Bukowno karjero pirminės kopos išilginiame profilyje; ED – priedėdinių nuogulos

Taking into account the sorting degree of these deposits it is possible to state that values of this parameter of grain size distribution are located within the range $\sigma = 0.39\text{--}0.71$ (on the average $\sigma = 0.54$). Fig. 6 clearly demonstrates the tendency of improving of sorting degree of deposits in the NE direction ($y = 0.594957 - 0.00956333x$ at $r = -0.48$) and the fact that dune sands in general are slightly better sorted than substratum material. Generalizing we could say that: 1) the given picture of grain size distribution of sands in the initial dune in this area is not a rule, because analyses of other such forms indicated completely undirected changes in grain size distribution features or almost its complete homogeneity, 2) surface sands of the mentioned scarp dune as an incomparably larger from the above-described, in different research periods were characterised by different degree of readability of proper changes in Mz and σ values.

The attention was also paid to the changeability in grain size distribution in miniature sand shadows, which were formed at the shadow of *Corynephorus canescens* (Fig. 7). They are 8–10 cm high and about 40 cm long. In this case, in spite of such small sizes of forms, the above-mentioned change in values of Mz and σ according to wind influence is simply school-bookish.

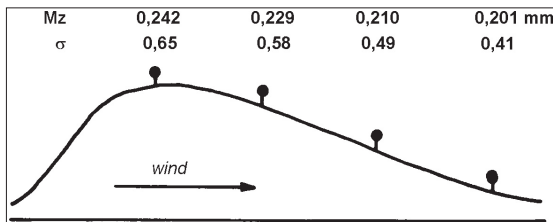


Fig. 7. Change in grain size distribution characteristics of initial sand shadows at Bukowno

7 pav. Bukovno karjero smėlio kauburų granulimetrinės sudėties pasiskirstymas

investigated form, the gradual decrease of contribution of grains of this type from windward slope (15.2%), through the top (14.0%) up to leeward slope (13.8% – fig. 8) is noticeable.

Deposits building the investigated initial dune are characterised by high degree of mechanical abrasion of quartz grains. The contribution of young angular grains of α type fluctuates within the limits of 3.0–26.5% (14.5% on the average). Herewith, one should notice, that in the direct dune substratum there are about 13 % of grains of α type on the average, i.e. almost similar portion to these in the dune. In longitudinal profile through the

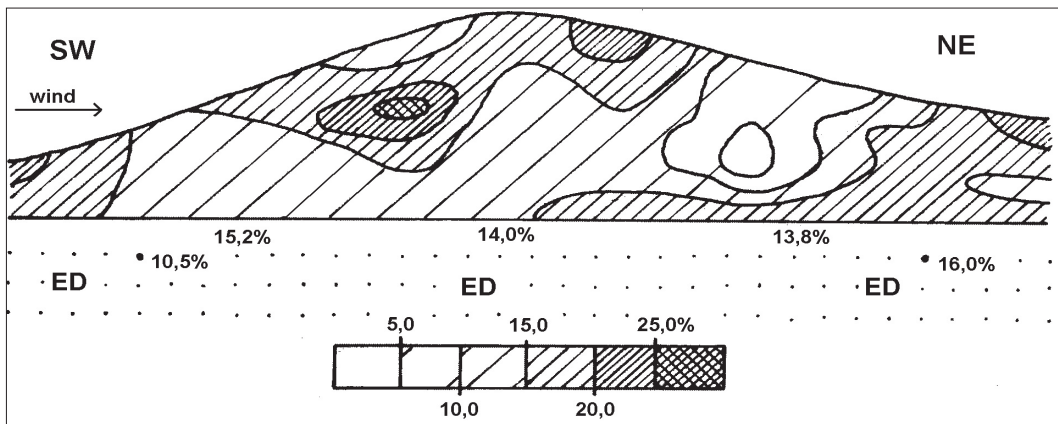


Fig. 8. Content of angular grains of α type in longitudinal profile through initial dune in sandpit at Bukowno; ED – extra-glacial deposits

8 pav. Neapzulinčių α tipo smėlio dalelių kiekis Bukovno karjero pirminės kopos išilginiame profilyje: ED – priešledyninės nuogulos

The contribution of grains of mature abrasion, of rounded γ type, typical for Aeolian deposits, amounts in the dune from 29.0 to as many as 79.0% (42.5% on the average). In substratum deposits, the average value is 41% as in the dune sands. But in the longitudinal profile, their similar contribution within windward slope and top (40.0%) and increase up to 45% in the leeward slope (Fig. 9) is observed.

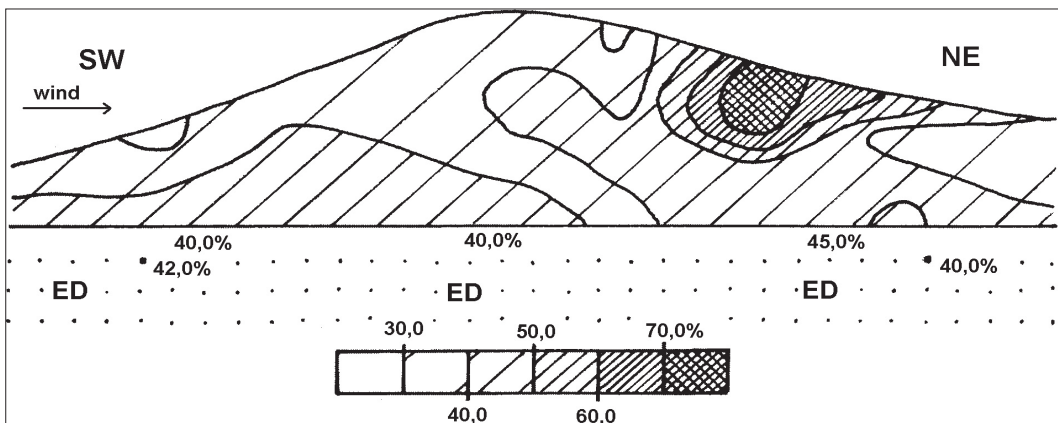


Fig. 9. Content of rounded grains of γ type in longitudinal profile through initial dune in sandpit at Bukowno; ED – extra-glacial deposits

9 pav. Apzulinčių γ tipo smėlio dalelių kiekis Bukovno karjero pirminės kopos išilginiame profilyje: ED – priešledyninės nuogulos

The total degree of material abrasion is presented by means of values of index W_o : the higher is the index, the better is abrasion. For mature Aeolian sands of Poland, it amounts on the average to 1200–1300. In the dune analysed, the above-mentioned values of W_o fluctuate between 1263 and 1709 (1425 on the average), whereas in the substratum material about 1438, therefore they are also approximated. In the longitudinal section (Fig. 10), the improvement of material abrasion degree is clearly noticeable: from $W_o = 1403$ on windward slope through the value 1427 in the summit up to 1439 within the leeward slope. But the regression equation ($y = 1398.26 + 4.33946x$) indicates that the tendency to improve the mechanical abrasion of material towards leeward slope is hardly readable and statistically unessential ($r = 0.20$). In general, one should state that very high degree of dune sands abrasion is a reflection of the same feature of extra-glacial sands, which in the whole area of investigation during its accumulation underwent strong wind influence, what was proved by Pełka (1992; compare also Goździk, 1980).

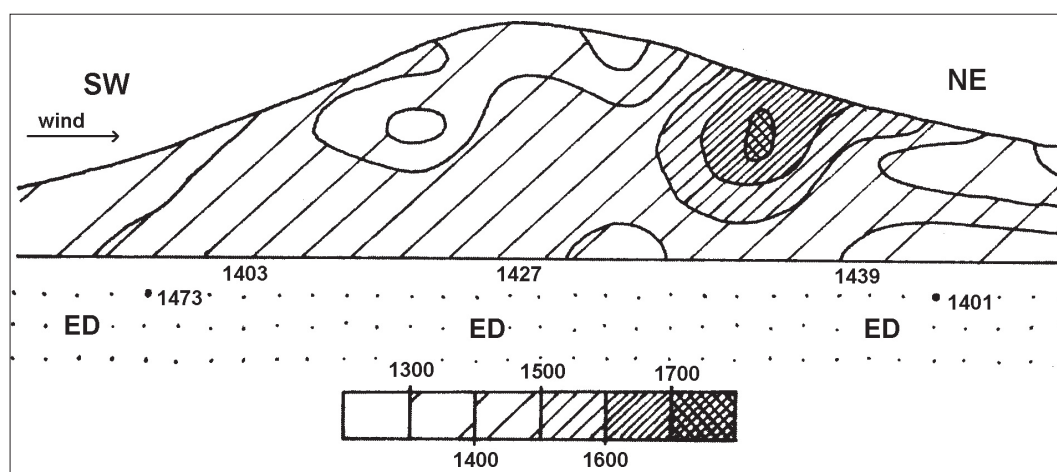


Fig. 10. Distribution of values of index of quartz grains abrasion degree W_o in longitudinal profile through initial dune in sandpit at Bukowno; ED – extra-glacial deposits

10 pav. Kvarco dalelių abrazijos indekso W_o verčių pasiskirstymas Bukovno karjero pirminės kopos išilginiame profilyje

On the margin of consideration on high abrasion degree of dune sands investigated one should state that exactly in this dune the highest (even in the world) known to the authors of this study values of W_o index, determined by means of mechanical method of Krygowski, occur: 1709 and 1699, at equally record content of grains of γ type: 79.0% and 78.0%. Slightly smaller, although also very high values of $W_o = 1554$ and $W_o = 1557$ for dune sands and for substratum deposits ($W_o = 1636$) from the neighbouring areas are given by Dulias (1994, 1996).

The internal structure of recently forming Aeolian landforms within sandpit at Bukowno was known on the example of sand shadows: the large and the miniature ones. It appears that in both cases, disregarding decided differences in size, it is almost identical: in the extra-glacial sands of substratum, the layer of grey humus sand 1 cm in thickness occurs, from which individuals of *Corynephorus canescens* responsible for the formation of miniature sand shadows grow (Fig. 11), or 10–20-cm sand layer with admixture of organic matter, to which – as a rule though not necessarily always – roots of *Calamagrostis epigejos* reach. This grass is responsible for the formation of large sand shadows (Fig. 12). Right above these humus sand layers, typical Aeolian sand occurs. In both cases it is laminated: in small shadows it is characterised by very simple structure, in large ones it is more complicated.

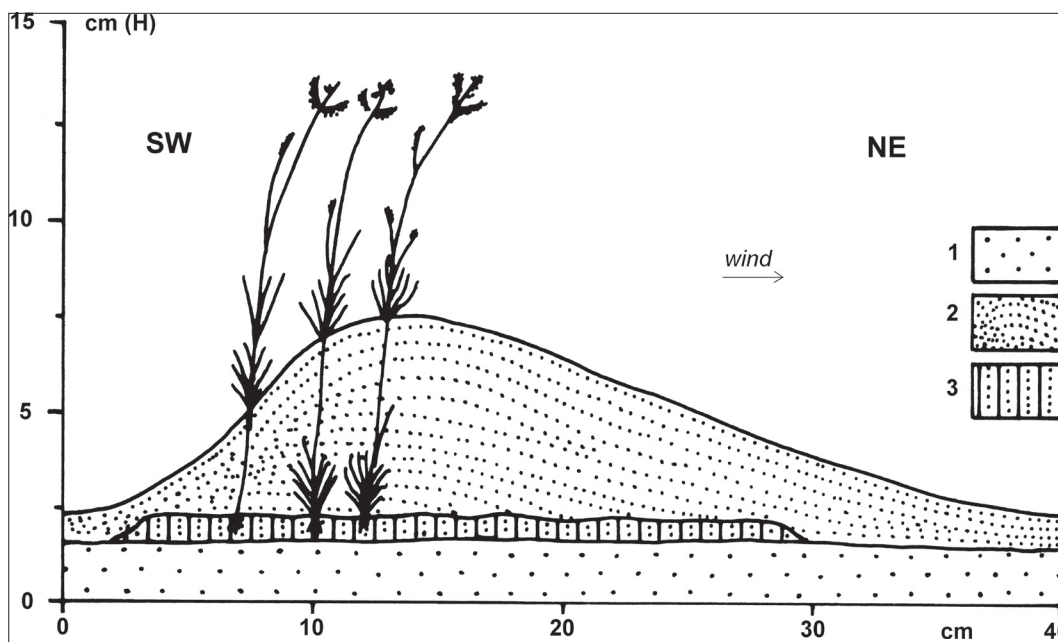


Fig. 11. Internal structure of typical initial miniature sand shadow in the sandpit at Bukowno:
1 – substratum deposits, 2 – aeolian sands, 3 – grey humus sand

11 pav. Bukovno karjero tipiško fitoakumuliacinio mikrokaubro vidinė struktūra: 1 – substratas, 2 – eoliniai smėliai, 3 – pilkas humusingas smėlis

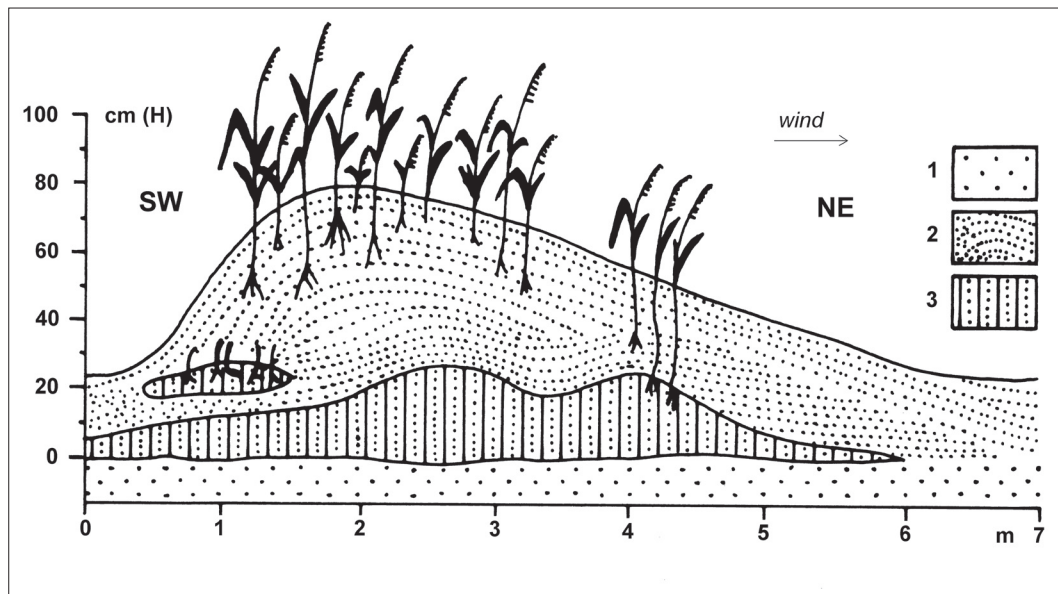
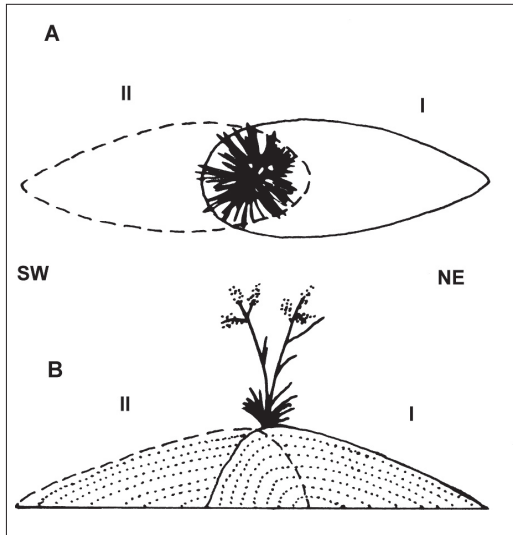


Fig. 12. Internal structure of sand shadow in the sandpit at Bukowno:
1 – substratum deposits, 2 – aeolian sands, 3 – grey humus sand

12 pav. Bukovno karjero tipiško fitoakumuliacinio kaubro vidinė struktūra: 1 – substratas, 2 – eoliniai smėliai, 3 – pilkas humusingas smėlis

Sand shadows are very changeable landforms, but miniature forms should be numbered among simply ephemeral. Our observations in the sandpit at Bukowno indicate that they can radically change under the influence of opposite winds. The majority of these microforms is created by the contribution of SW winds. Winds of opposite direction – NE –



appearing here from time to time, completely destroy them or completely remodel: at the place of microform with the axe directed NE, analogous microform with the axe directed SW appears. In this case, it is characterized by dual structure: within windward slope of new microform, the remnant lamination of the former microform exists, and it is divided by clear surface of discordance from lamination of leeward slope of new microform (Fig. 13).

Fig. 13. Evolution of initial sand shadows which have been originated under the influence of SW winds (I) and remodelled by eastern winds (II); A – plane, B – section

13 pav. Pietvakarių vėjų suformuotų (I) ir rytų vėjų performuotų (II) fitoakumuliacinių kaubry raida; A – vaizdas plokštumoje, B – pjūvis

Conclusions

The above-presented facts prove that an intensive circulation of sandy material, caused by anthropogenic factors as well as natural ones, among which the aeolian activity obviously predominates, takes place in the area of sandpits in the Silesian Upland. Sandy deposits many times are transported from environment to another, what results in the formation of new landforms and microforms, which afterwards disappear and are replaced by others. All anthropogenic landforms, independent of the size, quickly undergo intensive modelling and remodelling by natural processes, aeolian ones in particular. One should state that specific fight of anthropogenic factor with natural one takes place here. Therefore wind activity in the area of sandpits is not trifling and plays a double role: 1) it creates typical aeolian landforms and microforms, and material transported can be located in other environments, 2) it causes quick disturbance, masking or retouching of the formerly created landforms.

The above-described sandpit at Bukowno in the Silesian Upland with seemingly banal effects of aeolian activity can appear at first sight not very interesting for serious landscape or geomorphological researches. But natural processes, which started to influence the substratum completely prepared by human being can on a miniature scale create interesting landforms and favour the defined succession of vegetation. In the area of relatively small object, it is possible to include all these phenomena and to know mechanisms of processes, which under natural conditions, in incomparably larger spaces can be decidedly more complicated and not too readable. Therefore areas of sandpits can fulfil very important educational and scientific role as well-equipped natural laboratories of specific kind, and especially aeolian ones. Therefore areas of sandpits in the Silesian Upland are specific models of climatic deserts or other widespread terrains, in which morphological effects of wind activity are observed for a long time. But one should remember that climatic conditions occurring in the Central Europe favour rather quick introduction of vegetation, especially in small bare sandy areas, including also these prepared by humans. This fact limits their further applying as natural and very perspicuous educational laboratories.

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Eolinio veiksnio įtaka smėlio sąrašų dinamikai Silezijos aukštumos (Pietų Lenkija) smėlio karjeruose

Santrauka

Materijos nepastovumas, t.y. kitimas laike ir erdvėje, susijęs su jos gebėjimu judėti bei keistis, yra viena pagrindinių gamtos (ir reljefo) savybių. Šio straipsnio tikslas – parodyti kai kuriuos geomorfologinius (naujų reljefo formų (mikroformų) atsirasusidarymas) ir sedimentologinius smėlio apytakos rezultatus bei įvertinti vėjo vaidmenį tuose procesuose, remiantis didelių veikiančių smėlio karjerų Silezijos aukštumoje (Pietų Lenkija) pavyzdžiu. Minėtieji karjerai – dėl antropogeninio veiksnio poveikio sustiprėjusios smėlio apytakos arenos. Žmogaus ūkinė veikla dažnai tampa reljefo kaitos priežastimi. Tiesioginiai smėlingo reljefo formų (mikroformų) kaitos tyrimai parodė, kad tiriamojoje teritorijoje vyko intensyvi smėlio eolodinamika. Smėlis dažnai būdavo pernešamas iš vienos vietos į kitą. Dėl to susidarydavo naujų reljefo formų, kurios po kurio laiko išnykdavo, jas vėl keisdavo kitos. Smėlio pernašos veiksniai, t.y. sedimentacinė aplinka, taip pat kito dažnai. Vėjas yra pagrindinis smėlio karjerų dugną ir šlaitus formuojantis gamtinis veiksnys. Eoliniams procesams minėtuose tyrimo objektuose būdingas dvigubas vaidmuo. Vėjas: 1) dalyvauja smėlio apykaitoje, nes būtent dėl jo poveikio smėlis pernešamas ir nusodinamas skirtingose aplinkose, 2) sunaikina, užneša arba performuoja senąsias reljefo formas.

Mažoje smėlio karjerų erdvėje vykstantys natūralūs procesai sukuria įdomias reljefo formas. Tiriant minėtus procesus nedidelėje teritorijoje, lengviau suvokti jų mechanizmą. Natūraliomis sąlygomis žymiai didesnėse erdvėse vykstantys procesai yra silpnesni ir sudėtingesni. Taigi smėlio karjerai yra svarbūs mokomuoju ir moksliniu atžvilgiu – tai tarsi tam tikra, gerai įrengta eolinių procesų tyrimo gamtinė laboratorija. Silezijos aukštumų smėlio karjerų teritorija yra gamtinių dykumų arba kitokių ilgai vėjo veikiamų teritorijų (kintančio reljefo) specifinis morfologinis modelis. Pažymėtina, kad Vidurio Europoje vyraujančios klimatinės sąlygos yra palankios greitam augalijos įsitvirtinimui nedidelėse smėlingose teritorijose, būtent tose, kurios atsirado dėl žmogaus veiklos poveikio. Dėl šios priežasties smėlio karjerai yra neilgai egzistuojanti natūrali mokomoji arba mokslinė laboratorija.