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Spatial Variability of Aeolian Sands on Starczynow "Desert" (Eastern Part of Silesian Upland)

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Introduction

The influence of wind on the substratum material is not only documented by changes in its features, but also in a form of segregation in space, i.e. territorial, according to wind direction, proper distribution of this material in respect of fraction (grain size), sorting, shape, degree of mechanical abrasion. Wind is characterized by a specific dynamic force, so the material should struggle with gravitation force during transport, even under the conditions of rather gentle airflow. Therefore, the clear differentiation of these deposits within whole sandy fields as well as in aeolian forms selected have been studied.
The aim of this paper is to know the spatial differentiation of textural features of sandy deposits in Starczynow desert in Silesian Upland in southern Poland.

Materials and Methods

To solve problem above-mentioned, a detailed field study was carried out during which 900 sand samples were collected from aeolian cover sands and selected dunes by using a series of knot points of a square net.
The whole material was subjected to laboratory investigation, which included standard analyses of grain size distribution according to equations of Folk and Ward (1957), quartz grain abrasion 1-0.8 mm, applying methods of morphoscopy by Cailleux (1942) and mechanical graniformametry by Krygowski (1964). Also the content of heavy minerals and feldspars was analyzed.
The statistics compilation of data allowed to map the textural parameters trends as well as spatial distribution. These data were also the base to make a complex estimation of these parameters anomalies. For a set of particular parameters smoothed by a movable mean, average values and their confidence intervals (at α =0.05) were calculated. It was assumed, that parameters within this interval characterize the average conditions of the analyzed sand, while those beyond the intervals (positive or negative anomalies) indicate a relative predominance of deposition (accumulation) or redeposition (deflation) processes. It was estimated that redeposition is described by positive anomalies of Mz (mm), δ, K_G and negative anomalies of Sk, while the opposite anomalies of these parameters indicate deposition (Pelka-Gosciniak, 1999).

Area of investigation

The Starczynow "Desert" is situated in the eastern part of Silesian Upland (Southern Poland) and it occupies an area located backward of the Middle Triassic cuesta and in front of the Upper Jurassic cuesta. It is a compact area of aeolian sand, which till the 60s was intensively blown out. It has a flat surface, sloping from the east to the west, varied by numerous different dunes in form of clear parallel belts. Aeolian coversands show changing thickness within the whole desert. They form monotonous, slightly waved area of little inclination (in the majority $0\text{-}2^0$) with weakly marked slopes and relative heights. Their surface is varied by small hillocks and flat, rather irregular depressions without drainage, where in some places signs of rill- and sheet wash occur (Pelka-Gosciniak, 2000a).

This desert is not a typical climatic dry area, but it is a result of human impact on the natural environment. The wind activity in the area investigated in the Late Vistulian and Holocene caused the transformation of sand features and the formation of numerous accumulative forms. Till the early Middle Ages this area was covered with dense forests. Tree cutting and uncovering of sandy substratum was a consequence of wood demand to heat in the contemporary lead and silver ironworks, which were located near Olkusz. Due to uncovering of material substratum, the hitherto fixed sand was removed and the remodelling of the earlier relief followed. The formation of aeolian relief is still going on (Pelka-Gosciniak, 2000b; Szczypek, 1995; Szczypek, Wach, 1991; 1999).

The origin of the sand of the Silesian Upland was subject of many investigations. The majority of authors connect the time of their formation with the Middle Polish Glaciation . Recent research connects the age of deposits of the Biala Przemsza valley with three glaciations: Oder, Warthe (Middle Polish) and Weichselian (Szczypek, Wach, 1989).

The genesis of sands in the eastern part of Silesian Upland can be defined as complicated, i.e. in different parts of this unit deposits of different origin occur: fluvioglacial, fluvial-proluvial, fluvial or proluvial-deluvial. It can be assumed that deposits located in the eastern part of sandy area of Starczynów "Desert" are of fluvial-proluvial origin (Pelka-Gosciniak, 1999, 2000a).

The anemological conditions of area investigated were analyzed by means of data supplied by the Institute of Meteorology and Water Management in Katowice from the nearest meteorological stations in Olewin, Zabkowice and Slawkow for the period 1961-1990. These data indicate that in the last 30 years winds from widely understood western sector (about 44% of cases) clearly predominate. Winds from these directions are also characterized by the largest mean velocities from 3 to 3.6 m/sec.

Taking into account the results of field measurements, i.e. observations of morphological axes and internal structure of aeolian forms selected and wind-shaped trees in the Starczynow "Desert" it can be also stated, that under real conditions the westerly winds predominated in area investigated (Pelka, 1994).

Results

Aeolian coversands in the Starczynow "Desert" exhibit a thickness of 1.5 m in the central and eastern parts to 2.5 m in the western part. Below thin series of structureless sands (30-50 cm), laminated sand deposits occur, where laminae dip generally in eastern or north-eastern direction at an angle of $6\text{-}8^0$. The substratum sand shows horizontal stratification. These sands are mostly built of medium-grained material (0.5-0.25 mm) (approximately to 56.4%). The content of the fraction>0.8 mm is rather small: 1.89%. The addition of dusty fraction is characterized by similar content and it amounts to 1.47%. The value of mean grain diameter Mz reaches 0.316 mm. The sorting of sands is moderate, the value of standard deviation δ equals 0.599. The deposits analyzed are characterized by good mechanical abrasion with the majority of well-rounded grains of γ type – on average 42.1%. Medium rounded grains of β type and angular grains of α type sum up relatively to 40.3% and 17.6%. Sands analyzed are characterized by the high share of mat-rounded grains of RM type – 44.7%, the value of abrasion degree parameter Wo amounts on average to 1376.

In the composition of aeolian covers 1.5-2% heavy minerals are present, among them garnet makes about 32% of the transparent fraction mass. The small amount of feldspars (about 2%) was also noticed

To know the more important textural parameters of dune sands, material from dunes: barkhan-like, transverse and longitudinal was collected.

From the observation of the basic textural features of aeolian sands on Starczynow "Desert" results that materials which build aeolian coversands and dunes are very similar. It refers to grain size distribution as well as to quartz grain abrasion because the material, which builds dunes is medium-grained (on average 59%), the value of Mz=0.315 mm. The share of fraction>0.8 mm amounts to 1.52%. It contains about 2.5% of additional dusty fraction. Dune sands are characterized by moderate

sorting (δ=0.56), they are also well abraded, grains of γ type is about 41.9%, β and α - relatively 32.08%, 26%. Value of Wo amounts on average to 1311 (Pelka-Gosciniak, 1999, 2000a).

Conclusions

The analysis of the aeolian coversands and dunes allows to state that even in relatively small areas and within rather small forms, a clear spatial segregation of sand is observed. First of all, the influence of wind on the character of aeolian sands on Starczynow "Desert" is reflected in the coarsening of sandy material, evident by the increase in Mz (in mm) value and the decrease in Sk value, less sorting degree as the Upper Jurassic cuesta comes near (the increase in δ values), the decrease in values of K_G, which means the pulsatory changes in the environment energetics during deposition and the improvement of the abrasion degree by the increase in values of both Wo and the content of well-rounded grains of γ type. The decrease of RM content together with direction of dune-forming wind is also typical of the analyzed area. The aeolian deposits are also characterized by the increasing share of garnets and the decreasing content of feldspars from west to east. Considering the tendencies of changes in the spatial distribution of dunes, it is evident to that the barkhan-like and longitudinal dunes are very similar, because their material becomes finer, better sorted and worse abraded. The transverse dune presents the opposite trend.

Therefore, the textural features connected with grain size distribution behave in a different way from the typical aeolian environment. The reason is the existence of an older relief in the form of the Upper Jurassic cuesta, which is a barrier on the route of wind. On one hand such a situation can be explained by the fact that wind, which blows over the obstacle decreases in its velocity, crating the conditions for coarser material to accumulate. But on the other hand it can be explained by the increase in velocity of air stream which overcomes the barrier and which is connected with the larger share of coarser material, transported by dragging. The size of grains decreases upward slope. Over the barrier only finer material is transported. It seems that the latter factor is of larger importance in the distribution of textural features of material in the vicinity of cuesta slope.

Another influence of older relief on sandy material textural features is observed in the vicinity of river valleys. At rivers which are natural barriers to the further development of wind transport as well sand translocation, accumulation prevails.

The second characteristic feature of aeolian sands occurring in the Starczynow "Desert", which results from the influence of wind on the texture of the deposits, is the clear zonality of areas with deposits in the phase of redeposition (deflative areas) and deposition (accumulative ones). This zonality of textural features is observed in both grain size distribution and quartz grain abrasion. It is concluded that areas with sands in the phase of redeposition (deflative) are characterized by the occurrence of material of weaker degree of abrasion, but the areas with the tendency to deposition by better abraded one (Pelka-Gosciniak, 1999, 2000a).

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