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WIND-POLISHED STONES WITHIN THE MAXIMUM LIMIT OF THE VISTULIAN ICE-SHEET IN SOUTHERN GREAT POLAND LOWLAND, POLAND

Abstract

The process of corrasion is recorded in the area of the pleistocene glaciation mainly in the form of the ventifacts. This event was study in the marginal zone of the last glaciation in the Leszno Till Plateau. The wind-polished stones occur there on the surface of the ground and in the fossil deflation horizon. Above this horizon the series of aeolian cover sand was studied. In the till underlying the horizon one can observe fossil structures of epigenetic frost fissures. Detailed studies of the ventifacts' morphology were carried out as well as the simple statistical and petrographical analysis, and the comparison of these features of the wind polished stones in different morphological situations.

INTRODUCTION

Corrasion is a process mainly recorded in solid rocks. However, traces of this process are generally found in post-glacial areas. These are mainly wind-polished stones occurring in different geomorphological situations. These events are found outside sedimentation, i.e. they are related to genetically different forms and deposits. Their sites are known, both from areas of older moraine till plains, from outwash plains, rivers and pro-glacial marginal valleys terraces. As was stated by KOZARSKI and NOWACZYK (1992), they occur in the top parts of the upperpleni-Vistulian and late-Vistulian series and are formed as a series of ventifacts.

Likewise, in series older than the Vistulian their sites are commonly found, particularly in the fossil levels of the deflation horizons (NITZ, 1965, KUBIŚ, 1978, ANTCZAK-GÓRKA, 1995).

STUDY SITE

Corrasion in the maximum zone of last glaciation in the Leszno and Poznań till Plateau is mainly related to the recession period from the maximum phase although, undoubtedly, its results are the consequences of processes probably older than the last glaciation too. The time of peri-

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glacial climatic conditions which formed the periglacial series is also difficult to define. However, the maximum of corrasion processes was in the period of most severe periglacial desert. Conditions for extensive distribution of this periglacial domain existed in Wielkopolska throughout the period of Vistulian deglaciation (KOZARSKI, 1993). The research covered the area of immediate hinterland and foreland of the vistulian ice-sheet limit (Fig. 1). It was carried out in genetically different areas – ground moraine plateaux and outwash plains in order to check what effect the potential supply of clasts resulting from the area's origin may have on the phenomenon in question. The research terrain is morphologically diversified and the moraine plateaux and outwash plains were the main objecst of studies.

THE VENTIFACTS' MORPHOLOGY

At the hinterland and foreland zone of the vistulian ice sheet the detailed analysis of the shape and size of rocks was made. The rocks were divided into basic groups in which wind-polished stones occurred. This analysis was made both in the deflation pavement series where rocks modeled by the wind occur *in situ*, and on the surface in forest and farmed areas (Pl. 1). This research procedure was intended to find out to what extent the variability of ventifacts found in test fields located on the surface differs in comparison with the surface which was not anthropogenically changed. Results of this analysis are given in Tables I, II and III.

Table I.

Population of eologlyptoliths in different morphological situations

	ground surface	deflational horizon
Clasts	376	461
Wind–polished stones (%)	26	64
Ventifacts (%)	17	49

One- and two-faceted ventifacts are dominant both within the test fields located on the surface and in the stone horizon; only three- and multifaced ventifacts occur approximately 6% more often in the deflation horizon than on the surface. This may be an indication of a more advanced corrasion at the pavement level or of a greater dynamics of clasts, as is stated by DYLIK (1952). One- and two-edged ventifacts with one polished

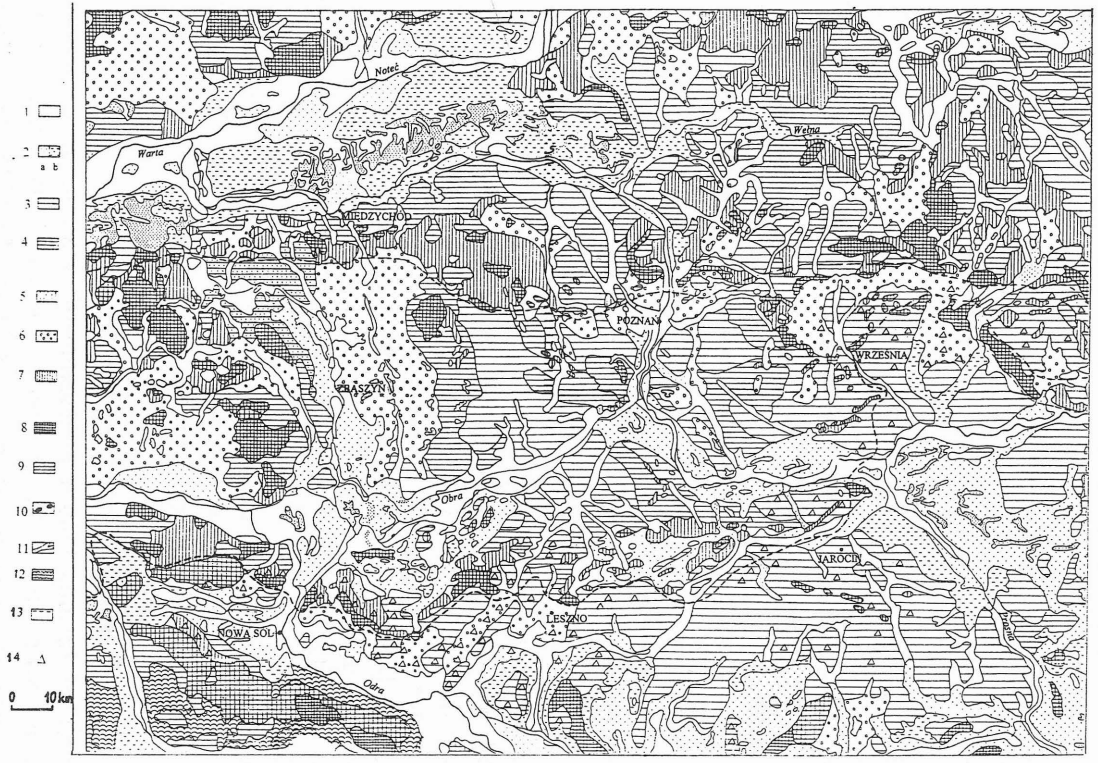

Fig. 1: Localisation of the study site on geomorphological map

Explanation: 1. bottom terrace, bottoms of the lake channels; 2. terraces: a – middle, b – high; 3. dunes; 4. flat ground moraine plateau; 5. undulated ground moraine plateau; 6. out wash plains; 7. hillocky ground moraine plateau; 8. end moraine; 9. kame hillocks; 10. eskers; 11. channels and channel lakes; 12. ground moraine plateau strongly undulated; 13. limit of the vistulian ice sheet; 14. wind-polished stones sites

Table II

Variety of ventifact shapes in different morphological situations (in %)

	1 – faceted	2 – faceted	3 – faceted	multi–feceted
Deflational horizon	46,2	24,9	20,8	8,1
Ground surface	52,5	23,2	14,9	9,4

Table III

Range of ventifact diameters in different geomorphological situations (in %).

	0 cm to 4 cm	4cm to 8 cm	≥8 cm
Deflational horizon	34,2	29,8	36,0
Ground surface	47,1	30,6	23,3

wall are dominant on the surface whereas in the stone horizon the number of polished walls increases insignificantly (4.7%). In both horizons simple edges are dominant, arch-like ones are less frequent, and s-shaped ones are least frequent.

Ventifacts of a diamater up to 4 cm are dominant on the surface, whereas the percentage of ventifacts of a diameter larger than 8 cm clearly increases (by 12.7%) in the stone horizon. This is undoubtedly an effect of farming.

Wind polished stones are mainly found among porphyrites, sandstones, granodiorites, granites and gneisses. No differences between the surface and the fossil deflation horizon were found.

THE VENTIFACT MICRORELIEF

On the surface of farmed land a population of wind-polished stones is found, constituting over 60% of the population of all clasts – it is comparable to the number of wind-polished stones in the fossil deflation horizon. This particularly large intensity of aeolian transformation of small stones was also recorded in a very rich aeolian microrelief. The most frequent forms are holes and grooves (Pl. 2). However, over half of the forms have well formed flutes and cupules. Obviously the degree to which microrelief was formed is closely related to the mineral composition of

rocks. Polymineral rocks are characterized by more complex microrelief. Laminated stones and ventifacts with concave surfaces are indicating very advanced process of aeolian weathering (DYLIK, 1952), are common at this site. Like at the adjacent site, ventifacts are mainly formed here in porphyritic rocks, sandstones, granodiorites, granites and gneisses and single forms in quartzites.

QUANTITATIVE DIFFERENCES

The frequency of occurrence of wind-polished stones and ventifacts was studied in the foreland and hinterland of the maximum limit of the vistu- lian glaciation in the Great Poland Lowland. A total of 187 test plots (10 sqare meters in area) were examined. This plots provided the data for statistical analysis of the representativeness of samples, their variation, the analysis of variance and correlation and significance tests. As in the previous work of the present author (ANTCZAK-GÓRKA, 1995) use was made of Snedecor's F-test which allows an evaluation of variance between samples as random or greater than the random value (GREGORY, 1976). This procedure helps to establish whether there are statistically signi- ficant differences between the zones under study, given the criterion of the frequency of occurence of wind-polished stones.

The asseses to realiability of the statistical parameters obtained from the samples, the standard deviation method was used on the assumption that a sample was a true representative of the entire population to the extent by its size (NORDCLIFF, 1986). The condition was met by 96,1 % of the samples examined, which meant that they were situable for further statistical analysis.

The research was carried out in litologically diversified terrain – ground moraine plateaux and outwash plains. To estimate population diversity in originally different areas a simple measure – standard deviation was used. In each case the areas were of this same age. The differences are shown in table IV.

Table IV

Differences in standard deviation in various aresas

Area	Wind-polished stones	Ventifacts
Ground moraine plateau	2.67	3,11
outwash plain	2,87	3,66

The out wash plains were found to display greater standard deviations, both the wind-polished stones and ventifact populations, which may result

from a bigger potential supply of clasts there and their greater diversification than on the till palteaux.

The next step in the statistical analysis was a correlation calculus, which give an estimation of whether, and to what extent, a variable in one set can change another set. The correlation was calculated between the total size of the ventifacts population and that of the multifaceted ventifact population. This relationship according to DYLIK (1952) is supposed to give an insight into the dynamic of the periglacial environment, the mobility of the specimens examined and possibility of their involvement in congelifluction movements. The value of this coefficient means the longer history and mobility in the oldest periglacial zone (Tab. V).

Table V

Correlation coefficients

Relationship	Foreland of max.phase	Hinterland of max. phase
Ventifacts/multi faceted ventif.	0,71	0,98

To determine the similarity or diversity of the sets studied, Snedecors F-test was used. This test was chosen for the set of variables involved, because they the best satisfy the criteria for its application. The F-statistic shown that the foreland and hinterland zone of the maximum limit of the vistulian glaciation are different as far as the frequency of apperance of the wind-faceted stones is concerned and it is a significant differentiation. At the 5% F-ratio level of the hypotheses has confirmed, which means that there is statistically significant difference between the zones under study.

THE STRUCTURES OF THE FROST FISSURES

Below this series we observe the layer of the till connected genetically with the maximum of the last glaciation (KASPRZAK, 1988) The structures of the fossil ice wedge were found there. There were 1,3 m in depth and in the top part about 24 centimeters in width in Radomierz site but there were bigger structures founded too (KASPRZAK, 1988). Thes structures are filled by fine sands similar to aeolian cover sands lying above in their grain-size distribution and abrasion coefficients. There were the structures of the epigenetic ice-wedges, typical in this region (KASPRZAK, 1988).

AEOLIAN COVER SANDS

Very common in this area are aeolian cover sands with an average thickness of 1.0 to 1.5 m. There are fine sands with the admixture of

medium ones. The thickness of this series is 1.3 m. Under this layer one finds a transient zone formed as medium grain sand with singular stones of 3 cm in diameter. At a depth of 1.5 m a series of fossil deflation pavement with a thickness of up to 30 cm was found. In the transient zone only single small stones with traces of eolian microrelief are found, whereas in the deflation horizon the number of ventifacts increases to 64% of the entire clast population. This is illustrated in table I.

THE QUARTZ GRAIN SHAPES

The degree to which quartz grains from aeolian cover sands were examined by the graniformametry method (KRYGOWSKI 1964). The results are given in table VI. They are mainly sands in which half angular grains (type) are dominant. This type of quartz grains is also dominant at the base. The loss of young angular grains compared to the base is insignificant. No clear vertical differentiation in the roundness of the eolian cover sands was observed. On this basis one can conclude that aeolian processes did not have much impact on the modelling of quartz grains in this series.

Table VI

Abrasion of quartz grains

	type α	type β	typ γ	Wo index of abrasion
Aeolian cover sands	17,0	59,6	23,4	1063
Substratum	22,4	50,9	25,8	1079

Wo – coefficient of abrasion after KRYGOWSKI

CONCLUSIONS

The corrasion process in the area under discussion was recorded as a series of the wind-polished stones occurring both on the surface and in the fossil deflation levels. It was found that after a phase of intensive deflation and corrasion there was a phase of eolian accumulation, which is evidenced by the series of aeolian cover sands.

The choice of samples, justified above suffices to confirm the realiability of the conclusions following from the statistical analysis. The difference between the frequencies of occurrence of wind-polished stones in the foreland and hinterland of the maximum limit of the vistulian glaciation in the Great Poland Lowland is statistically significant and the criterion proposed in this work, viz. the frequency of occurrence of wind polished stones, can be additional source of information in researches on the limits of various morphogenetic zones affected by periglacial processes.

Pl. 1. Wind polished stones on the ground moraine plateau surface

Pl. 2. Microrelief of the wind-polished stones

The question of the variation and the timespan of the periglacial processes activity is still an open problem. On the basis of studies of the wind created periglacial processes and the events connected with them we can state that after the recession of the last ice-sheet from the maximum phase the conditions of very serverely cold desert were present. Evidence these conditions for is the epigenetic ice-wedges developed in the till deposits of the last glaciation, the ventifacts and the rather thick layers of aeolian cover sands. All these events occurred in conditions of cold desert without plants or with very poor plant cover.

In conclusion, the results presented show that after the recession of the ice-sheet from the maximum there existed conditions favouring permafrost development, and the intensive process of corrasion and probably deflation. After this period, the process of aeolian accumulation activity took place. This model is similar to one presented by KOZARSKI (1993).

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