Erosional-denudational valleys on the Wolin Island cliff coast (Southern Baltic) and their impact on the morphological development of the coast

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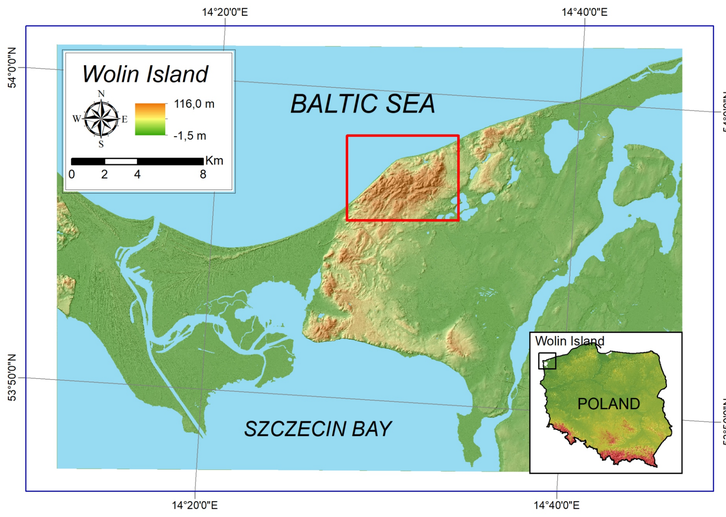
INTRODUCTION

A characteristic feature of the contemporary cliff morphology of the Southern Baltic Baltic are erosional-denudational valleys, which are an important element of the contemporary morphogenetic system. Detailed observations combined with the use of GIS methods were carried out on the Wolin Island. Over a length of about 4 km, several landforms have been distinguished, which are clearly marked in the relief. These forms show the course of NW-SE and are characterized by various morphometric features. Within the studied area, types of valleys with postglacial assumptions as well as fresh erosive cuts were identified. At the turn of the Pleistocene / Holocene, forms of late-glacial genesis were transformed by flushing and erosion processes. Progressive abrasion (cliff top recession rate of 0.22 m / year) has an impact on the further development of the valleys, whose bottoms are currently suspended in relation to the foot of the clif.

The aim of the study is to present detailed morphometry, lithology of sediments as well as the genesis of separated erosion and denudation valleys.

MATERIAL, METHODS AND STUDY AREA



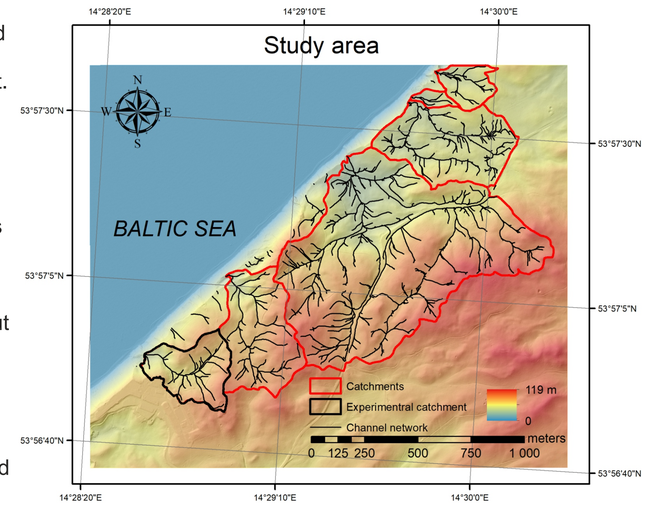
The research is carried out on the Wolin Island cliff coast, which is located in northwestern Poland. The analyzed area is part of the western section of the Southern Baltic coast (Pomeranian Bay). The analyzed erosional-denudational valley was formed within the northern part of the frontal-moraine embankment called the Wolin Belt. The Wolin Belt is the most important and characteristic element of the Wolin island relief. It stretches from the Szczecin Bay through Międzyzdroje to Świętouście, located at the base of the Dziwnów Peninsula. The main morphological axis of the moraine has the direction NE - SW. The Wolin Belt is morphologically diverse, it is formed by separate hills, often of the nature of isolated hills and depressions (Grzywacz 116 m a.s.l., Gosań 93 m a.s.l.).

An extremely important feature of the Wolin Belt morphology is the presence of numerous drainage depressions and deeply indented erosional-denudational valleys. They sometimes reach considerable sizes - up to 1000 m long, 300 m wide and 30 m deep.

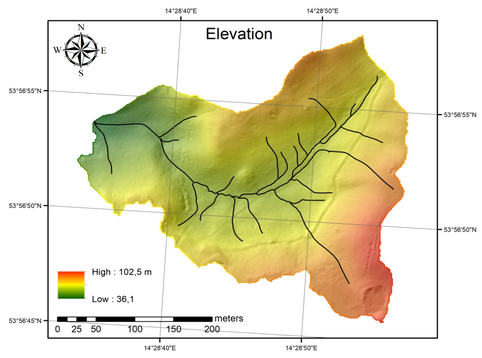
Conducted research included fieldwork, laboratory analysis, and data processing. During morpholithological mapping, manual drilling up to a maximum depth of 3 m above sea level was performed along the longitudinal cut profile. The collected samples were subjected to laboratory analyzes to recognize, among others features of sediments that build the studied form.

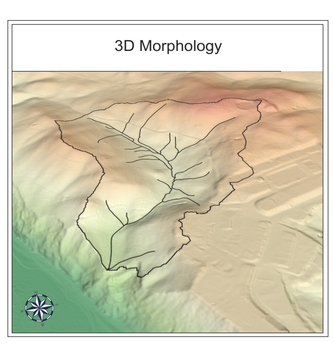
The main source of data used to determine the morphology and morphometry of the erosion-denudation valley was the point cloud from aerial laser scanning (ALS). On its basis, the Digital Elevation Model was developed, which was the basis for morphometric (3D elevation model, Slope, Aspect and Valley depth) and hydrological (catchment area, channel network, flow direction, flow accumulation, convergence index, stream power index and topographic wetness index).

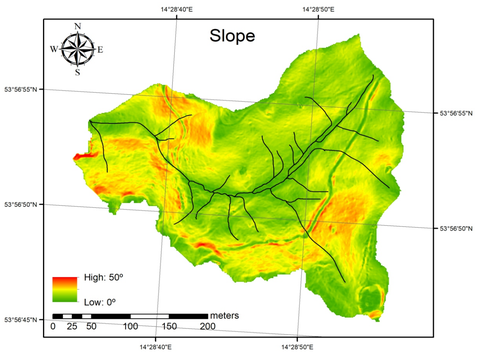
As part of morphological analyzes, valley bottom cross-sections and valley cross-sections were also developed.

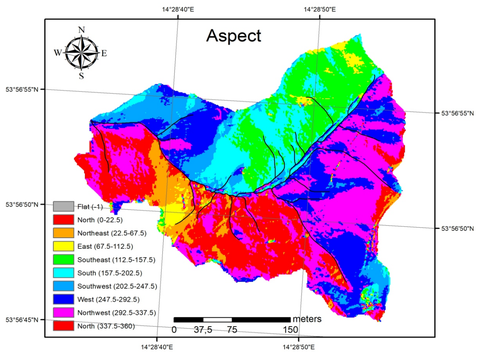


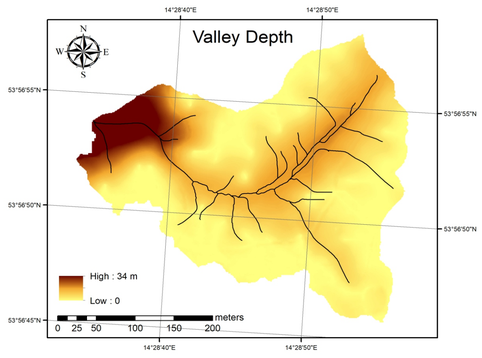
MORPHOLOGICAL AND HYDROLOGICAL CONDITIONS OF EXPERIMENTAL CATCHMENT

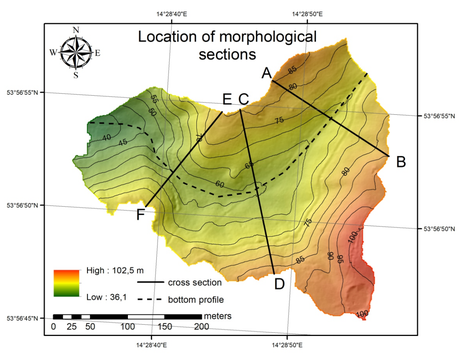




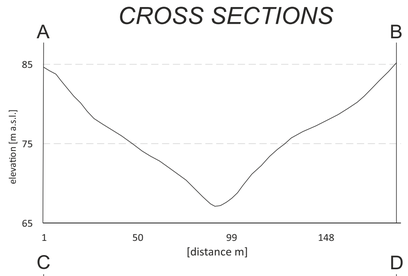


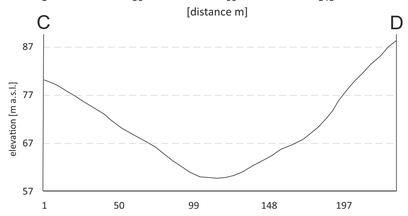


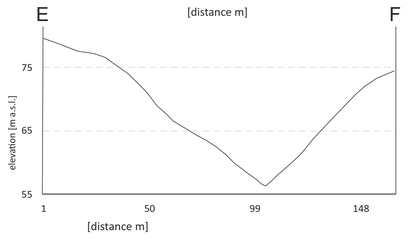




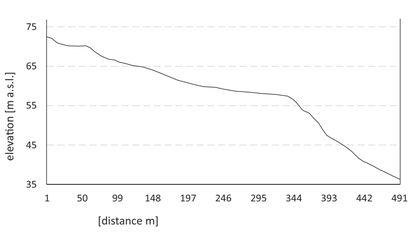
CROSS SECTIONS







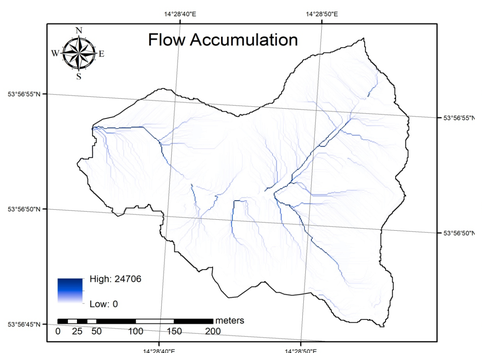
VALLEY BOTTOM PROFILE

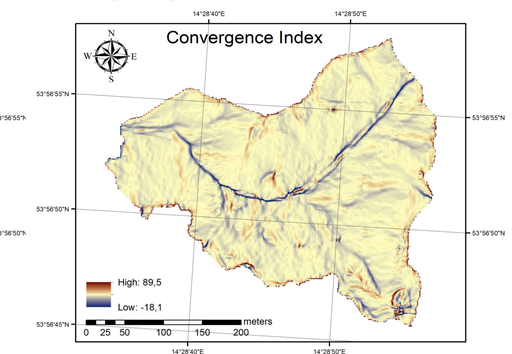


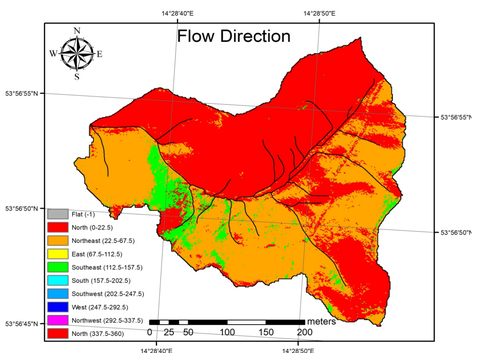
The area of the experimental catchment is about 97 542 m2. The valley length (measured along its bottom) is 490 m. The valley reveals the course of NE-SW-NW. The upper part is located in the back of the cliff and the lower part is on the top of the cliff. The denivelation of catchment area is about 65 m. The highest elevation occur in the SE part of the catchment. The slope measured along the longitudinal cut profile is 7.3%. At a length of about 344 m a clear drop in the valley bottom is visible. At the outlet of the valley, a rotational landslide system was formed within the cliff top as a result of increased dynamics of landslide processes. The longitudinal profile is concave-convex and the maximum depth of the valley reaches a value of over 34 m. The shape of the transverse profiles is characterized by a mostly symmetrical arrangement, only at the valley outlet the asymmetrical course of the transverse profile is observed. The valley bottom has a varied character: The largest width occurs in the middle of the valley and the smallest in the bottom.

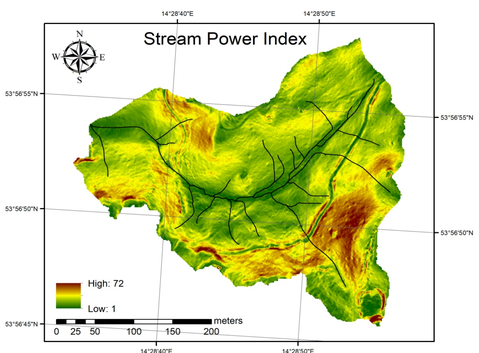
The largest slopes inclination in the catchment are were observed in the north-west and southern parts of the catchment, where their values reach up to 50º. Aspect analysis shows a great diversity (as many as 9 classes have been separated within the studied catchment area).

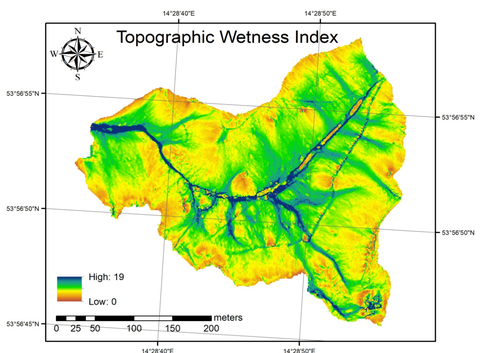
Topographic wetness index characterizes the distribution of soil moisture in the catchment. In the study area, the bottom of the valley is characterized by the highest moisture indicator. This indicator reaches the lowest values in the western part of the catchment, where steep slopes generate a high degree of surface runoff. Therefore, the highest indicator values indicate potential places for water concentration. The performed water flow analysis allows to generate the flow within the examined catchment. The places with the highest water flow coincide with the bottom of the cut and slopes within the western part of the cut within the cliff crown (the lowest point). The high flow is the result of a significant slope inclination in this part of the catchment, moreover, it is characteristic for the slopes in the southern part of the cut. Currently, this form does not create a geomorphological system in which high activity of sculpting processes is observed. The above analyzes show that the western part of the drainage basin was under the influence of intensive slope processes.



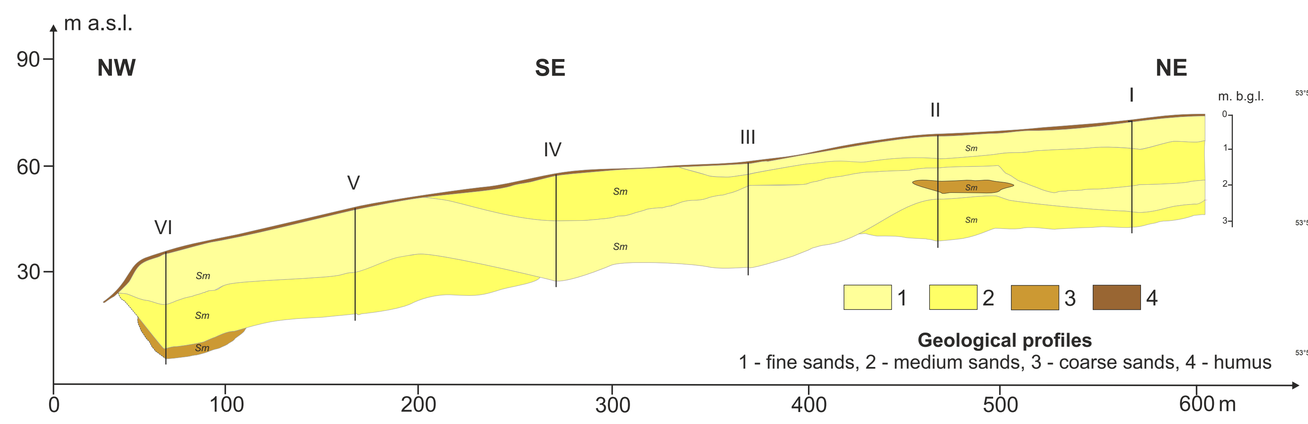


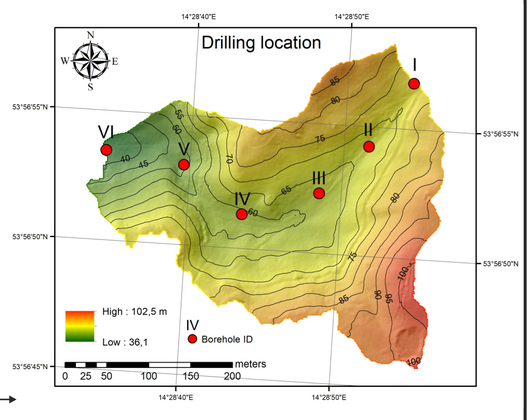






LITHOLOGY OF EXPERIMENTAL CATCHMENT





In the lithostratigraphic profile, the upper layer of the moraine embankment is made of aeolian cover sands, the thickness of which can reach up to 15 m. These deposits were deposited on the sand-gravel fluvioglacial series, which thickness reaches 40 m. The lithostratigraphic profile also has a layer of brown clay, which is characterized by local occurrence, and its thickness does not exceed several meters (glaciation of the Vistula). The lower floor of cliff is formed by gray clay, which is about 40 m thick (Warta Glaciation).

A detailed recognition of sediment features within the representative catchment was made along the longitudinal valley profile at a length of about 0.5 km. The geological structure is dominated by a series of Quaternary sediments mainly represented by massive fine- and medium-grained sands interlaced with coarse-grained sands. The thickness of the sediments was recognized up to 3 m deep. The sediment is characterized by a moderate degree of sorting, which indicates a moderate dynamics of the deposit environment. The share of coarser fraction, coarse sand is evidence of changes in the dynamics of the deposit environment (Borówka R. K. at. all. 1992, Kostrzewski A., 1985).

CONCLUSIONS

Based on the research on a selected experimental catchment (recognized as a representative form) located in the edge zone of the cliff, detailed morphological and lithological studies were carried out. In the longitudinal profile of the analyzed valleys, landslides were found in the lower part, which is an effect of an increased dynamics of abrasive processes, while the upper part of the valleys has erosive and denudative character. Based on the conducted experimental research, it is possible to separate in the longitudinal profile of the valleys the zone of impact of coastal processes from the zone which is shaping by erosion and denudation processes. Separated erosion and denudation valleys affect both the morphology of the coast and modify the contemporary morphogenetic system of the cliff coast of the Southern Baltic.

Planned, organized monitoring in the presented experimental valley will allow to state qualitative and quantitative interaction between the erosive-denudative and abrasive system and their role in the development of valleys on the cliff coast of the Wolin Island.