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Boundary conditions of barchans development on a tideless sand beach

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Aeolian bedforms formed on sandy beaches include ubiquitous aeolian ripples and less common sand patches which sometimes may evolve into barchans. Except for small ripples, which are the quick response of a dry sandy surface to wind above the threshold speed, the formation of even small dunes on the beach requires the interaction of many factors. The aim of the study was to determine the boundary conditions and the time necessary for the development of small barchans on a tideless beach. The research was carried out on the beach of Łeba Barrier, the South Baltic coast, within the Słowiński National Park (Poland), in May 2020. The field work included GPS RTK survey of 1-km-long fragment of coast where barchans developed as well as sampling of surface and subsurface sands for the assessment of sand moisture. Based on obtained Digital Elevation Model main morphometric parameters of barchans and sand patches, foredune height and inclination of its seaward slope, the width and height of the beach, and the length of the potential available fetch were determined. Additionally, hourly data from the meteorological station located on the foredune, 2.5 km from the study site, and from the two nearby mareographs (in Łeba and Ustka) were used. Parameters such as wind speed and direction (including the angle of wind attack in relation to the shoreline), the amount and intensity of precipitation, air temperature and humidity, and sea level were analysed in three periods, i.e. before barchans formation, and at the time of their development and then destruction. The obtained values were considered representative for the conditions favourable for the development of barchans. To confirm the obtained results these parameters were also analysed in selected periods between 2000 and 2020, when the occurrence of such barchans was documented.

The studied barchans were 0.54-1.09 m high, their windward slopes were 9.0-12.03 m long, and a total length equalled to 9.4-17.6 m. Their volume was estimated at 116.5-284.8 m³. They formed a chain of bedforms with crest perpendicular to the shoreline and migrated alongshore. Boundary wind conditions of their formation have been determined as follow: the minimum potential wind energy (DP) is 1.9, minimum potential resultant wind energy (RDP) - 1.5 and wind direction variability (RDP/DP) - not greater than 0.83. The results also indicate that such barchans may also develop during oblique onshore wind whose angle of attack is up to 45° to the coastline. In such a case, the near surface air flow can be deflected in the alongshore direction when the seaward slope of the foredune is inclined more than 20° and foredune relative height is greater than 10 m. Under favourable conditions the time needed for the development of barchans is less than 24 hours. The results also shows that barchans form in spring and summer, when events of beach flooding by storm waves are rare and surface layer of dry sand is thick enough to supply the right amount of

sand.

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