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A method for measuring geometrical properties of ripple marks

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Eine Methode zur Erfassung der räumlichen Struktur von Rippelfeldern (Zusammenfassung): Es wird ein Meßverfahren zur Messung der Höhe und Länge trockengefallener Rippeln beschrieben, das Messungen auf langen Profilen ermöglicht. Als Referenzsystem wird ein Schlitten mit 2 Kufen benutzt, deren Länge sehr lang im Vergleich zur Rippelwellenlänge ist. Je nach Gewicht des Schlittens, der Kufenbreite und der Bodenbeschaffenheit ebnet diese Vorrichtung die Rippeln im Bereich der Kufen ein, so daß sie als Bezugssystem für detaillierte Messungen von Rippelformen dienen kann. Es werden einfache mechanische Abtaster in Verbindung mit handelsüblicher Trägerfrequenzmeßtechnik benutzt. Der Anwendungsbereich und mögliche Verbesserungen der Methode werden diskutiert und einige Meßbeispiele geschildert.

Summary: In order to apply statistical methods to the geometrical properties of sand ripples with high confidence very long records are necessary. For this purpose a device for measuring heights and wavelengths of drained ripple marks is described. The reference system is a sledge with a pair of skids with lengths very large compared with the wave lengths of the ripples. According to the weight of the sledge, the width of skids and the state of the sand bottom the device flattens the ripple crests in the range of the skids. With respect to this platform the geometrical properties of ripple fields are measured with mechanical profilers in connection with usual carrier frequency technique. Possible applications and the limits of this method are described and some examples of measurements are represented.

Introduction

Many efforts have been made in the past to investigate the complex interaction between water flow and erodible beds. Because of the long history of research in this field of hydrodynamics there exist a lot of methods and instruments for investigating flow parameters in the case of a rigid wall. In the case of erodible beds, however, there is a great lack of techniques to determine the variations of the spatial structure of the bed due to hydrodynamic forces (J. R. L. Allen, 1967).

The difficulties to measure the wavelength, waveheight and the shape of ripples in the field increase rapidly with decreasing dimensions of the bedforms. Megaripples can easily be recorded by an echosounder. Their spatial structure can be determined by side scan methods from shipboard. This method, however, is restricted to waves of sand having heights greater than 30 to 50 cm (J. Ulrich, 1972). Data from smallscale ripples can be obtained using stereo photography (e. g. R. W. Sternberg and J. S. Creager, 1965) or "ripple profilers" to be used by divers (R. S. Newton, 1968). The disadvantage of these methods is the very restricted number of ripple trains recorded by a single measurement. This does not allow to employ many of the powerful statistical methods such as correlation techniques or analysis by power spectra. Up to now this was only possible in a satisfactory manner with flume measurements as far as we know (C. C. Nordin and J. H. Algert, 1966).

Because of the technological difficulties encountered when measuring ripples under water in situ we restricted ourselves for the time being to measurements of drained ripple marks in the shore belt during low tide. We are aware of the fact that there are differences in shape between ripples under water and drained ripple marks. This holds mainly for the ripple heights but not so much for the wavelength. So we intend to apply statistical methods and other analyses especially to the second quantity. To obtain high confidence the first step is to get an array of long profiles with a great number of ripple trains, in order to compute directional distributions and other features of such a ripple field. Only the technical solution found for this problem, some examples of measurements and conclusions from field experiments are presented here whereas a detailed discussion of results will be published separately.

The measuring system

An essential supposition for measuring the shape of ripples is a suitable reference system. For this reason we used a sledge equipped with a pair of skids. The weight of the sledge flattens the ripple crests in the range of the skids (fig. 1) depending on the state of the sand bottom. Provided the length of the skids are large compared with the ripple length this method then makes the sledge to be a reference platform for measuring ripple data (fig. 2). This ripple profiling sledge is pulled by a winch which is connected to it by a twist-free steel rope with a length of 40 m. The winch to be seen in fig. 3 is driven by an AC-motor.

The sledge was equipped with sensors for measuring the ripple height, the distance covered and the inclination of the platform. In order to simplify the method as much as possible, we selected a mechanical method for sensing the ripple profile.

Fig. 4 shows a scetch of the ripple height sensor. A small wheel mounted on a rod follows the contours of the ripple. The rod is connected to the axis of an inductive transmitter for the rotation angle. Hence the ripple height is transformed into the measurement of an angle. With the length of the rod used the error in equalling the sine-function to the argument was neglegible. The bottom pressure of the wheel can be selected by sliding a counterweight. The electronical measurement of the angle is done by usual carrier frequency technique using integrated modules. The low costs for the mechanical as well as for the electronic equipment enable us to operate an array of 6 of these sensors (fig. 5). The inclination of the sledge was measured by a simple pendulum connected to the same type of inductive transmitter as used for the ripple height. The range of inclination was ± 5 degrees. The hauling distance was measured using a wheel running in one of the traces of the sledge. Its axis turned a 360°-potentiometer. With the aid of a constant voltage applied at the ends of the potentiometer the slider generates a saw-tooth voltage when the wheel turns.

Fig. 6 shows the block diagram of the equipment on board the sledge. All data were recorded on a 7-channel analogue magnetic tape unit.

The accuracy of the measuring system described here is limited by different sources of error. We have already mentioned the difference of ripple height between flooded and drained ripples as a general restriction of this investigation. The error of the height measurement can be nearly neglected. The resolution of this sensor was better than ± 0,05 cm.

An additional source of error can arise when sampling the ripple shape with the aid of a small wheel. For elevations there are nearly no restrictions. The shape of a depression, however, is only measured accurately if its radius of curvature is not less than the radius of the wheel. In our test area this condition was not always satisfied though we used a sample wheel with a radius of 1 cm only. The seize of this wheel was estimated from measurements of current ripples in a sediment flume. But in the case of wave-formed

Fig. 1 The traces of ripple profiling sledge

Fig. 2 The ripple profiling sledge with sensors

Tafel 2 (zu G. Krause u. I. Stander)

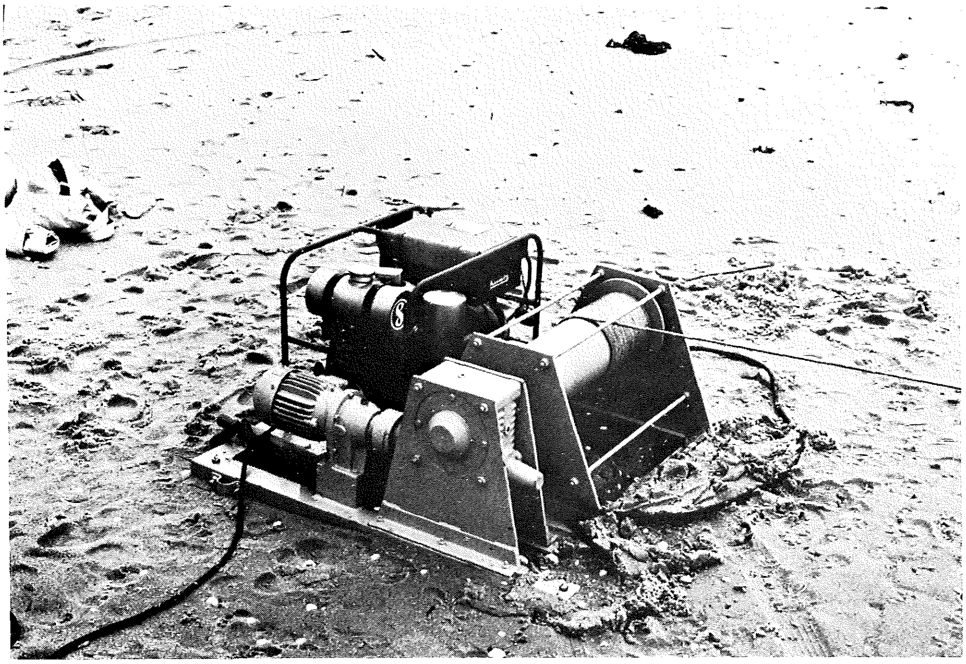

Fig. 3 The winch pulling the sledge

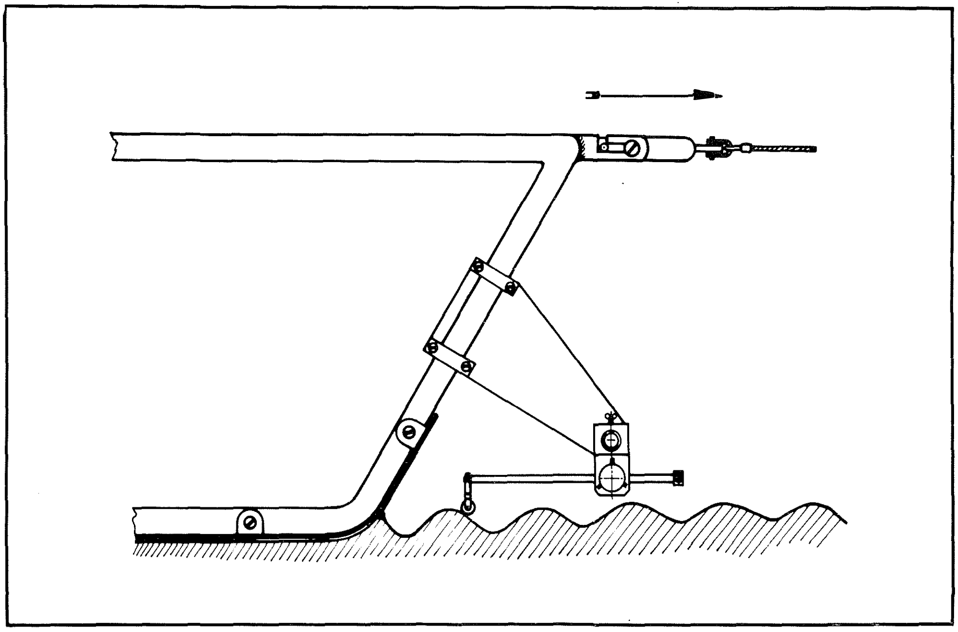

Fig. 4 Sketch of the ripple height sensor

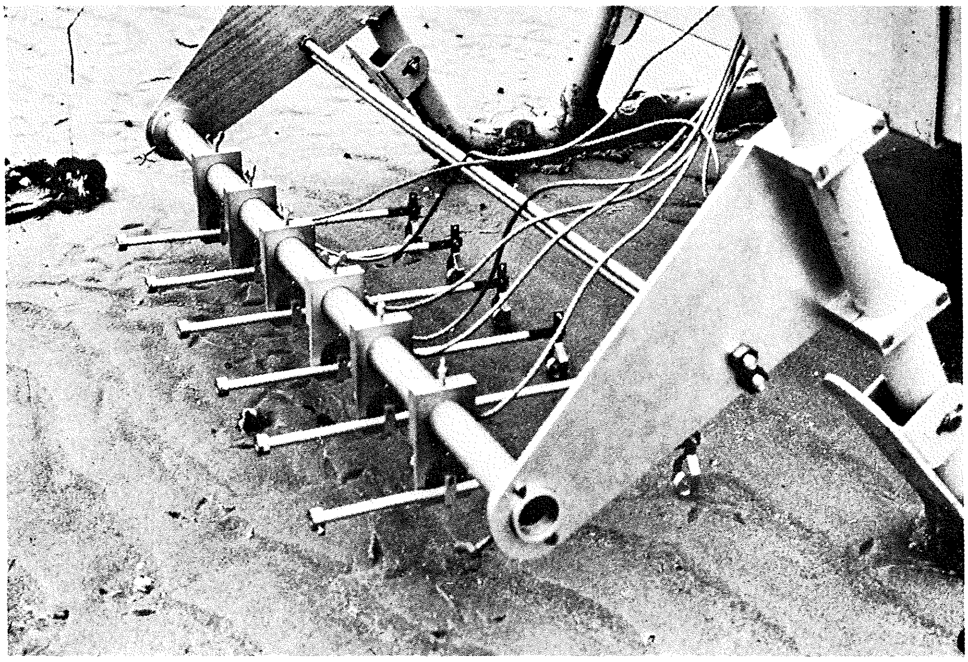

Fig. 5 An array of height sensors

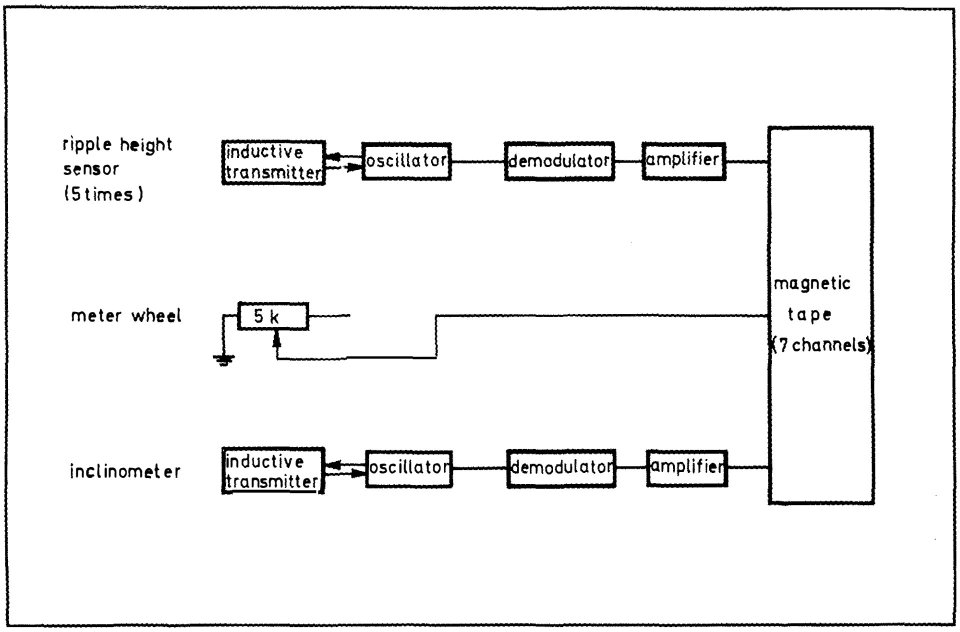

Fig. 6 Block diagram of the equipment

Tafel 4 (zu G. Krause u. I. Stander)

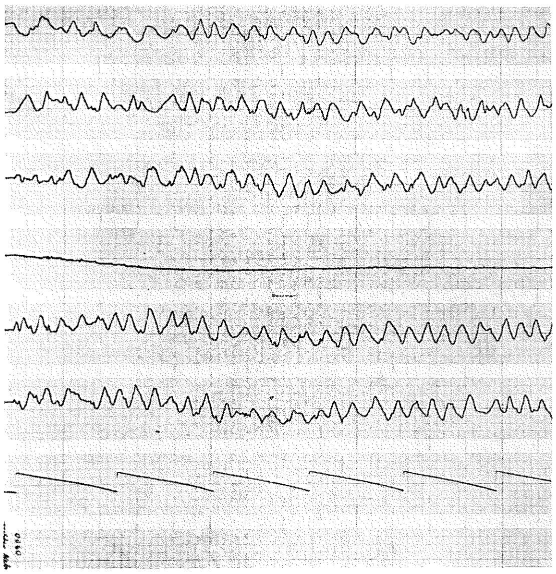

Fig. 7 Section of a record.
Lower trace: Output of the meter wheel.
Middle trace: Inclination of the sledge.
All other traces: Output of height sensors

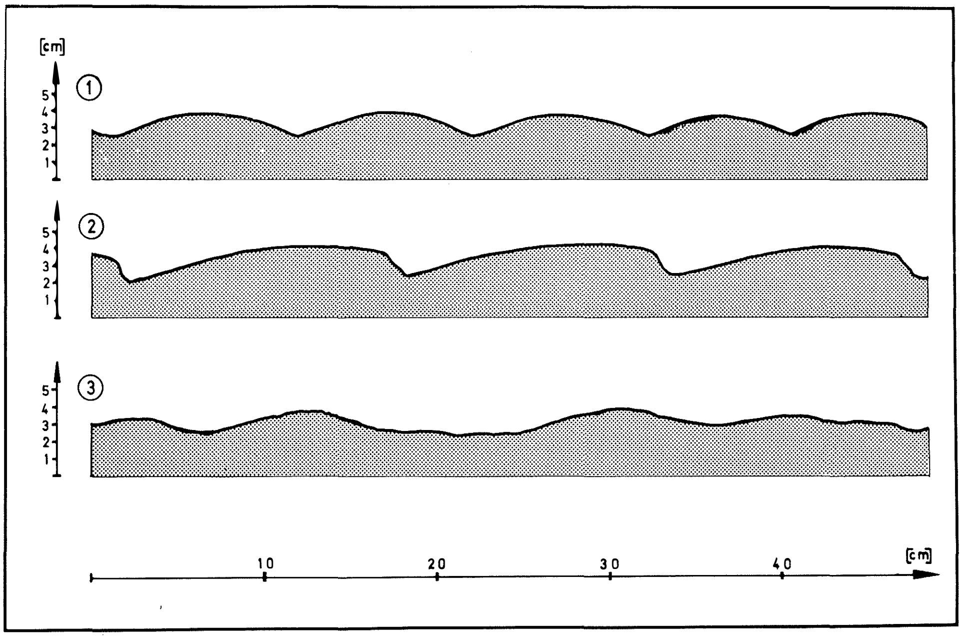

Fig. 8 (1) and (2): Ripples caused by oscillatory flow; (3): Current ripples

ripples more acute angles can occur when a through is formed by two slopes each with the angle of repose. The sinking-in of the wheel can easily be avoided by the counterweight, provided that the ripples are drained.

Measurements

The first tests of the measuring system have been performed at a tongue of land on the eastern shore of the island of Sylt near Hörnum from August 23nd until September 10th, 1971. This test area was selected because of its accessibility by motor vehicles, its gently sloping beach and its relatively uniform sediment properties. At low tide the measurements on drained ripples could be carried out for four hours. The lengths of the profiles measured, ranged between 20 to 40 meters. So one record contained up to 250 ripples. In order to include also directional properties of the ripple fields, three profiles were measured at every test area. The angles between them were 30 degrees. During the time of investigation 2000 meters of profiles with some thousands of ripples were recorded as a base for the shape analysis.

Fig. 7 shows a section of a record played back from the magnetic tape to a strip chart recorder. It represents the shape of the ripples as recorded by 5 height sensors, the changes of inclination of the sledge, and the output of the meter wheel as a measure for the distance.

As fig. 8 indicates, two different kinds of ripple marks were picked up by the measurements. The upper two profiles show longcrested ripples obviously caused by oscillatory flow. The irregular, short-crested ripple marks below taken at another area are due to unidirectional flow during the ebb tide. The grain size of the bottom material differed strongly in both test fields confirmed by the results of a sieving analysis.

Conclusions

The ripple profiling sledge has proved to be an adequate instrument to get easily quantitive knowledge of the geometrical properties of ripple marks. Its advantage is the uncomplicated rigid construction and its relatively low costs. Its disadvantage is the mechanical sensing of the ripple marks. This restricts its application to dry ripple fields but doesn't allow measuring underwater because of the lack of mechanical stability of ripples in water. For this purpose the sledge will have to be equipped with non-mechanical sensors, e. g. ultrasonic or optical profilers. However, these technical improvements will not change the methods of analysis but allow to investigate the ripple height also.

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