SOME SEDIMENTOLOGICAL ASPECTS OF THE FLUVIOGLACIAL OUTWASH PLAIN NEAR SOESTERBERG (THE NETHERLANDS)

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SUMMARY

The fluvioglacial outwash plain near Soesterberg (The Netherlands) is a deposit, built up during the melting of the Saalian ice, by a braiding river system on the ice-free side of the ice-pushed ridge of Amersfoort.

The variation in the grain-size distribution of the sediment is great. Sorting is very poor to moderate. This indicates a high stream velocity, though fluctuating, combined with a huge supply of debris.

The parallel to the principal stratification plane bedded strata alternate frequently with depressions, which are filled up laterally, showing a "festoon lamination".

INTRODUCTION

The present investigation deals with the sedimentological characteristics of a sandur, located in the neighbourhood of Soesterberg. A sandur is a huge fanshaped body, laid down in front of an end moraine or an ice-pushed ridge by usually braided meltwater streams. The fluvioglacial outwash plain was formed during the Saalian glacial, Amersfoort stage. It is situated in front of the ice-pushed ridge SW of Amersfoort and has been studied in three sand pits (fig. 1).

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GRANULOMETRIC COMPOSITION

The outwash-plain sediments range from fine sand to coarse gravel. The rapid vertical alternation of well, moderately, poorly and very poorly sorted sets of strata is characteristic (photogr. 5). This changing and the poor sorting within one set may be attributed to fluctuations in current velocities of the braiding river branches. These fluctuations are, among

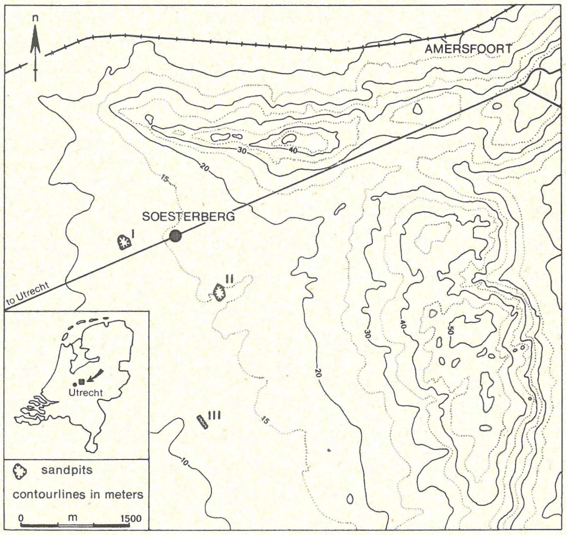


Fig. 1
Sketch map of the Soesterberg area, giving the location of the three sand pits (I, II and III). The gently sloping fluvioglacial outwash plain at the west side of the ice-pushed ridge can be recognized from the contour pattern.

Photo 1
Picture of the general type of sedimentary structures of the sandur deposits near Soesterberg (The Netherlands). The parallel bedded, subhorizontal strata are locally interrupted by channels. The trough in the centre of the photograph was filled up from the left, slightly flatter side of the channel, resulting in a festoon lamination. The laminae show a longitudinal and vertical grading into fine material.

other things, due to processes initiated by meteorological influences and to shifting of the anabranches. The sudden drainage of subglacial and intraglacial basins may intensify the variation in discharge. The sandur deposits were found to decrease in grain-size in downstream direction. A consistent fining upward tendency, as reported from some other brading river systems (D o e g l a s, 1962) was found in one location (sandpit II) only.

A general impression of grain-size distribution and sedimentary structures of sandpit II is given in fig. 2. Grain-size distributions of samples collected from successive units in this pit are given in fig. 3. Large

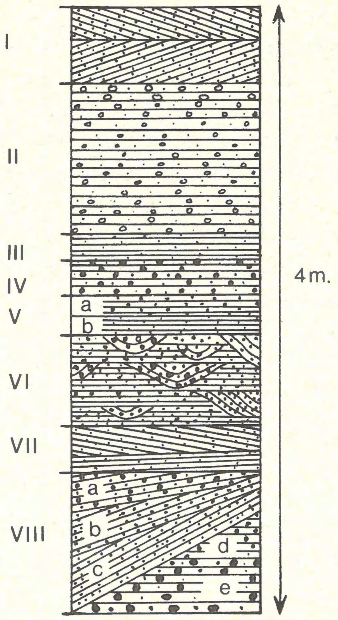


Fig. 2
Vertical section through the sedimentary structures of the outwash plain deposits in sand pit II, together with the grain-size distribution.

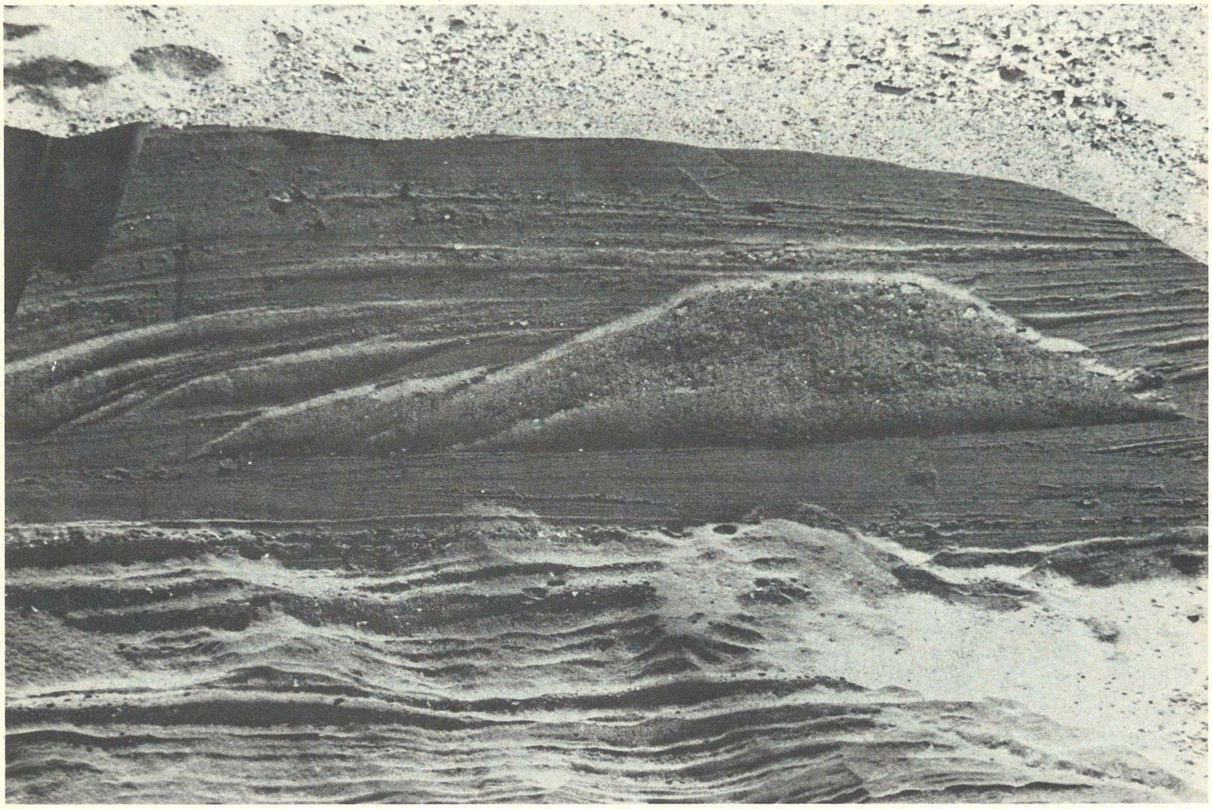
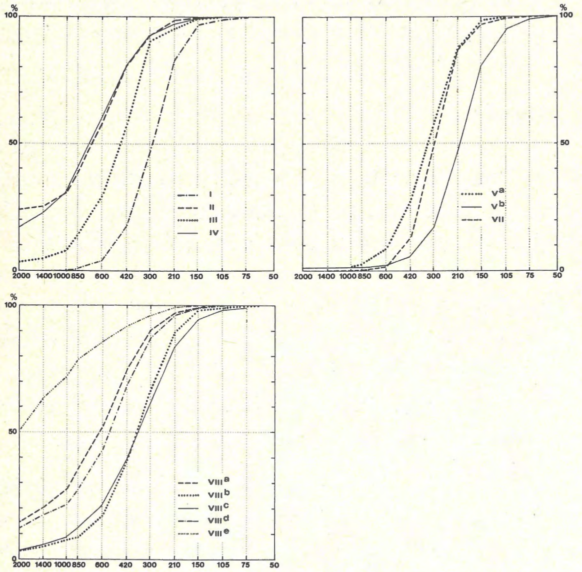


Photo 2
Intricate structure resulting from repeated scour and fill at approximately the same place. The youngest channel is superimposed on an older one. Remnants of the older channel banks are seen at the right.



Sample	T_I	
I	0,57	moderately well sorted
II	> 1,01	poorly sorted *)
III	0,73	moderately sorted
IV	> 1,04	poorly sorted *)
V^a	0,64	moderately well sorted
V^b	0,64	moderately well sorted
VII	0,40	well sorted
$VIII^a$	> 1,02	poorly sorted *)
$VIII^b$	0,82	moderately sorted
$VIII^c$	0,99	moderately sorted
$VIII^d$	> 1,15	poorly sorted *)
$VIII^e$	> 1,06	poorly sorted *)

*) possibly ranging to very poorly sorted

Sorting parameters according to Folk and Ward.

$$T_I = \frac{\varphi_{84} - \varphi_{16}}{4} + \frac{\varphi_{95} - \varphi_5}{6,6}$$

Fig. 3
Grain size distributions and sorting parameters of samples collected from the successive units of the vertical section in sand pit II, shown in fig. 2.

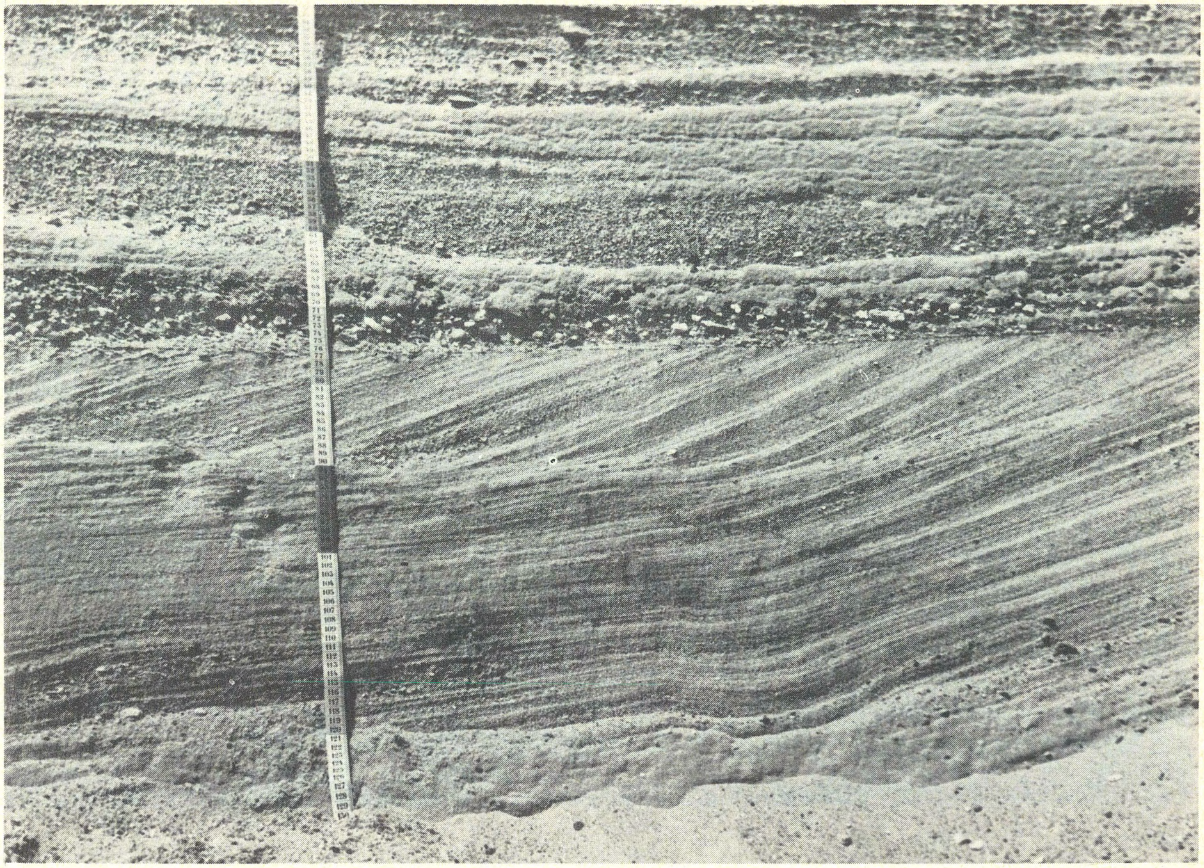


Photo 3
Subhorizontal, parallel bedded strata, overlying two filled-up channels. The lowermost unit (90-130 cm) displays a current or festoon lamination, whereas the unit immediately underlying the imbricated pebble layer shows a gradual decrease in foreset dip from right to left.

boulders, deposited within well or moderately sorted sets (photo 6) are probably ice-rafted.

SEDIMENTARY STRUCTURES

The principal sedimentary structure in these sandur deposits was low angle inclined to horizontal (= parallel to the principal stratification plane) bedding, frequently interrupted by short sets of large scale cross-stratification, formed by channel infilling.

The lateral extension of the horizontally bedded strata generally was in the order of a few meters; in some cases however, the extension amounted to some tens of meters. The set thickness of these horizontally bedded units varied from a few millimeters up to 70 centimeters. The boundaries were erosive and often discordant.

The channel infilling is related to the orientation of the channels in connection with the general direction of flow on the fanshaped sandur body. The channels appeared to be more or less perpendicular to the common direction of flow, as deduced from the general slope direction of the sandur cone; this implies that the depressions were filled up laterally.

Within these filled up channels two types of sedimentary structures could be observed (fig. 4), dependent on the form and size of the depressions.

1. In shallow depressions (up to 70 cm), especially when the gently sloping part was on the upstream side, the laminae ran more or less parallel to the channel profile (fig. 4a). This type of sedimentary structure is called "festoon or current lamination" (D o e g l a s, 1962).

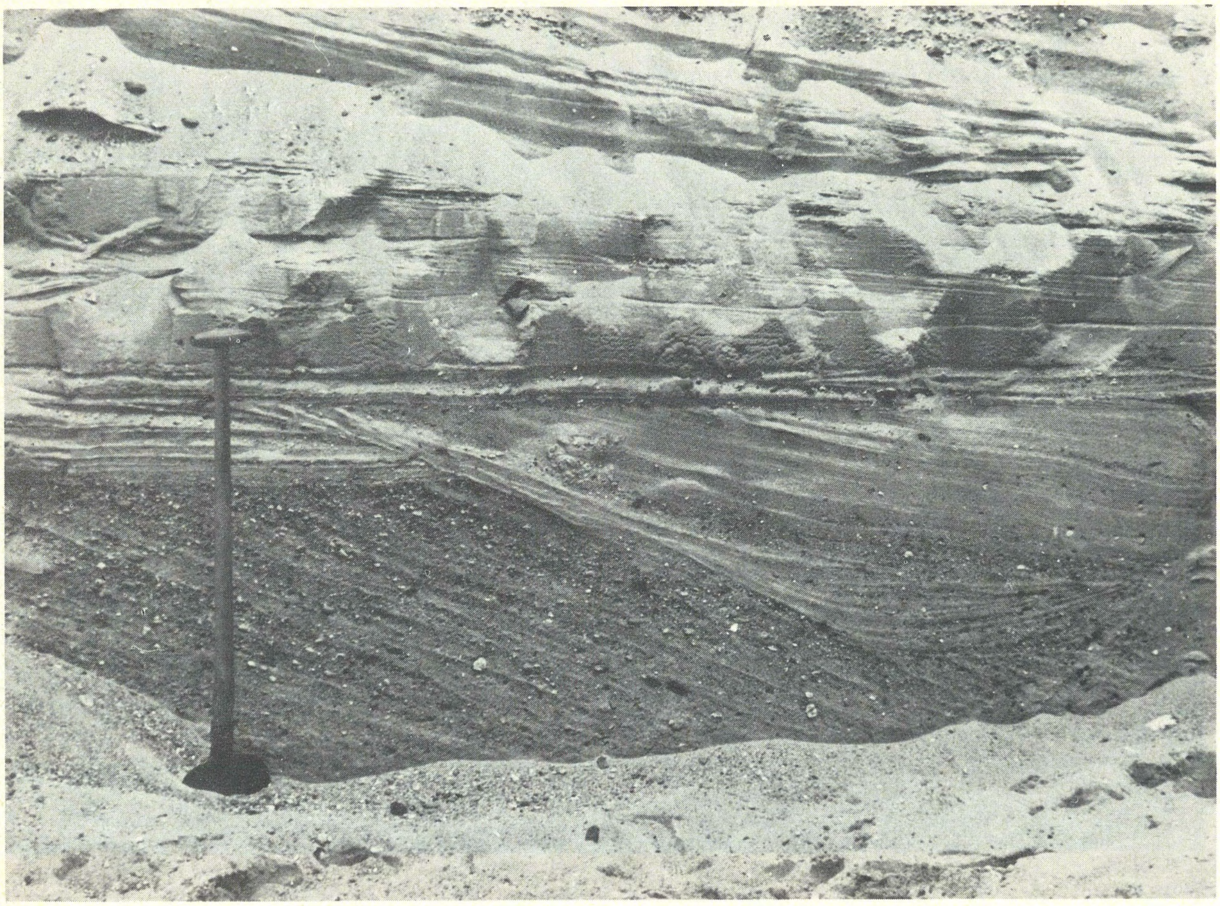


Photo 4
The true foreset lamination in a deep channel on the former outwash plain has been eroded by a small trough which has been filled up laterally from the left.

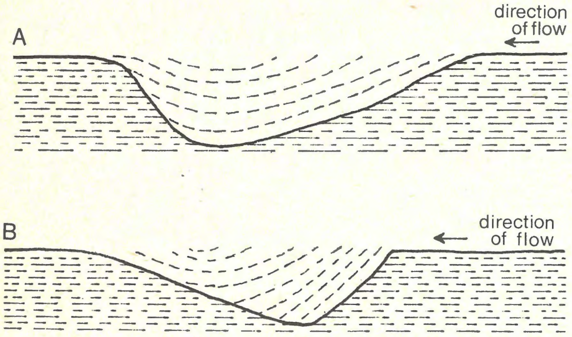


Fig. 4
The lateral filling up of a channel; a) especially when the gently sloping part is at the upstream side. This type of large-scale cross-stratification is called "festoon or current lamination" (Doeglas, 1962).
b) especially when the steep side is upstream.

2. In deeper channels (deeper than 100 cm) and especially when the steep side of the profile was upstream, a foreset lamination was present. This type of structure gradually passed into a festoon lamination (fig. 4b).

Frequently a new channel was cut into an already "sanded up" one, leaving behind only part of the original structure. The new-cut channel then was filled-up laterally too. Where this process of scour and fill repeated itself several times at approximately the same place an intricately cross-stratified structure was built (photo 2, 3 and 4). The shallow channels were found to be of a more frequent occurrence than the deep ones. A very broad (15 m) and deep (1,20 m) channel was found in one case only. It could be followed over a length of 62 m and showed a true foreset lamination. There must have been a vortex

Photo 5
The variability of sedimentary structures together with variations in the grade of sorting within the sets of strata as well as the individual laminae, ranging from very poor to well sorted is characteristic for the sediment of the fluvioglacial outwash plain.

that could maintain a dip slope of, in this case, 22° to 25° (photo 4).

Dip and dip-direction measurements of the structural units as performed in two of the three sand pits sustained the idea of a fan-like outbuilding of the outwash plain. In pit I the sets were found to dip in a direction ranging between N 40° E and N 300° E, while in sandpit II the direction of dip was found to vary between N 150° E and N 210° E (fig. 5). In pit I the angle of dip was between 2° and 5° ; in sand pit II the bedding parallel to the principal stratification plane was less discordant. From these measurements the authors concluded that the outwash plain had indeed a fan-like form and that the sand pits I and II are situated respectively N and S of the highest longitudinal profile of the outwash plain (fig. 5).

As for sedimentary structures there were only

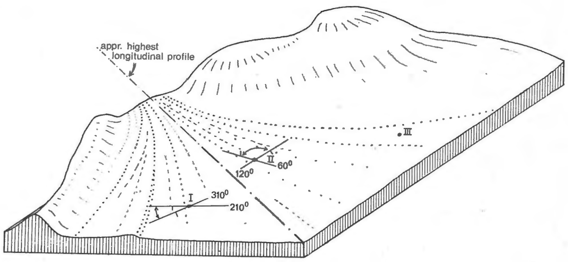


Fig. 5
Block diagram of the fanshaped sandur near Soesterberg (The Netherlands) at the west side of the ice-pushed ridge. The dip directions of the sets of strata lead to the conclusion that the sand pits I and II were on either side of the highest longitudinal profile of the outwash fan.

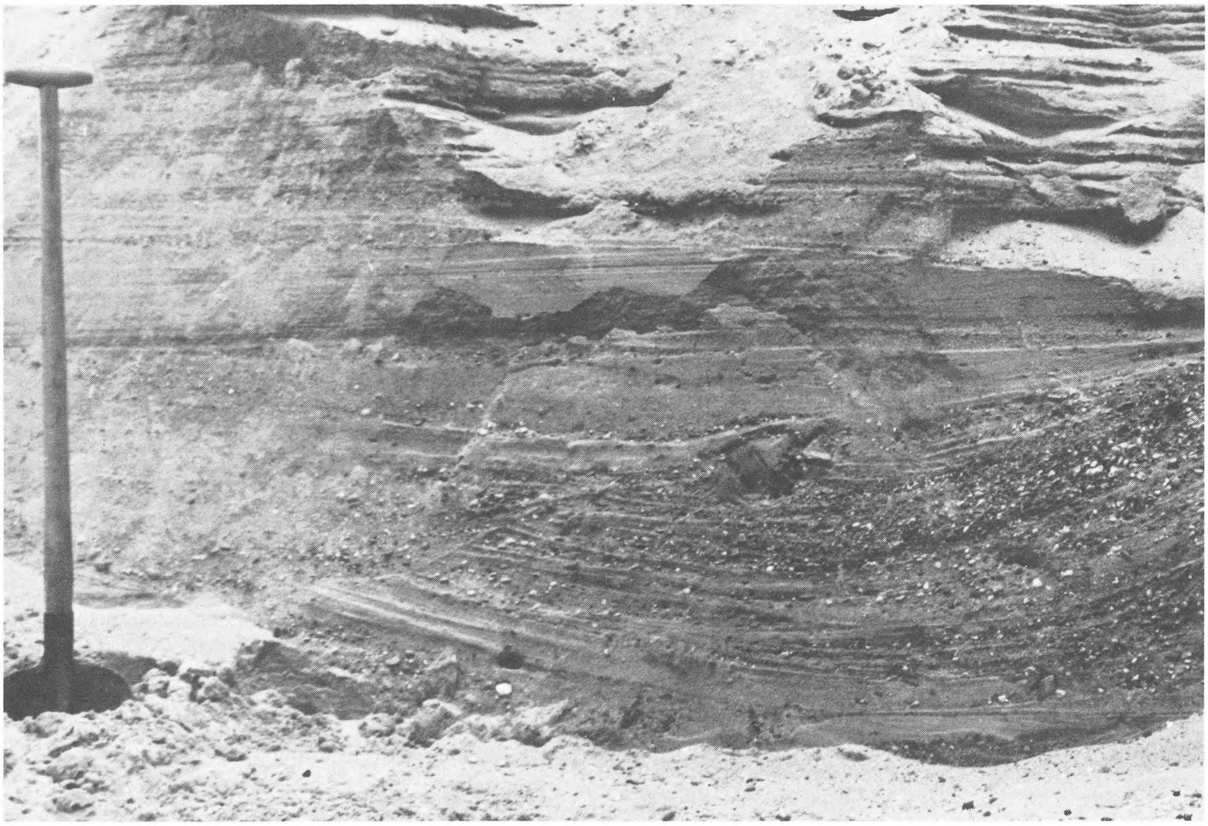


Photo 6
Large boulders, occurring within poorly sorted sets and consisting of well sorted loamy material, have probably been transported when frozen. The boulder, shown in the photograph had an ellipsoid form with axes of 30 and 12 cm. The lamination of the fine material of the cigar-like boulder showed a definite difference as compared with the surrounding structure.

slight differences between the sand pits I, II and III.

However, greater differences were found in the grain-size distribution. In pit I gravel was present in thin layers with a great horizontal extension. In pit II, on the contrary, in thick layers with a small horizontal extension. In the more downstream situated pit III gravel was almost absent.

Finally it is interesting to notice that in some places the sedimentary structures were disturbed. Glacial involutions, caused by alternating freezing and thawing resulted sometimes in loadcast-like features while frost cracks were also present.

DISCUSSION

Hjulström (1952), studying sandurs in Iceland, distinguishes 3 stages in the water movement.

1st stage: Low water; water movement is confined to preëxisting, anastomosing channels.

2nd stage: Rising water; the water overflows the banks of the channels. There is some erosion and consequently lowering of the bars between the channels. At the same time lateral filling up of the channels, which run more or less perpendicular to the overall direction of flow, will start. It seems very likely that the lateral infilling is responsible for the observed cross-stratified structures of the festoon and true foreset type.

3rd stage: High water; the water mass, overloaded with debris, flows as a sheet flood over the plain, breaking through barriers and filling up depressions. On the somewhat levelled surface of the outwash plain, where rapid flow conditions exist, the sediment may be deposited from suspension, resulting in more or less horizontal parallel bedded strata.

It should be noticed that the authors did not observe any small or large-scale cross-bedding due to current ripples.

Since the parallel bedded strata have a rather restricted extension it is quite probable that there was a rapid change in the conditions of sedimentation and erosion. This is in accordance with the findings of Hjulström who, observing the Hoffelssandur, noticed a rapid change, in time as well as in space, of the sedimentation and erosion (Hjulström, 1954). (Sundborg, 1954), reporting on the same sandur, observed differences in height of several meters. Therefore, even during high water the whole fan needs not to be inundated, which could be another factor restricting the extension of the parallel bedded strata.

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