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SOME ASPECTS OF GLACIAL EROSION AND DEPOSITION IN NORTH GERMANY

by

Jürgen Ehlers

(Geologisches Landesamt Hamburg, Oberstr. 88, D-2000 Hamburg 13, West Germany)

ABSTRACT

In the marginal areas of the Pleistocene Scandinavian ice sheet in north Germany there are few signs of direct glacial erosion. Fine gravel analyses show that glacial reworking was not very important. This may be partly due to the fact that at least in the late phases of the glaciation the active parts of the ice sheet moved over dead ice and were not in direct contact with the underlying substratum. Buried tunnel valleys with a depth of more than 400 m show that considerable erosion by subglacial melt-water streams took place, at least during the Elsterian glaciation.

INTRODUCTION

Whereas in areas of modern glaciation processes of glacier erosion and deposition can be observed directly, in areas of Pleistocene glaciation they must be reconstructed from an interpretation of the sediments. Fortunately most of the ancient processes seem to be comparable to those now in progress today. In this paper, a type of glaciofluvial erosion which cannot be observed directly in present-day glacier processes,and which is not yet fully understood, is discussed, as well as the composition of tills from the Saalian and Elsterian glaciations in the Hamburg area, north-west Germany (Fig. 1).

As northern Germany was covered by the margins of the Scandinavian ice sheet, deposition was the prevailing process. The sediments are mainly composed of melt-water deposits, but also of deposits left by the glaciers themselves. The sediment cover of Pleistocene age which is found in the north German lowlands normally reaches a thickness of several metres. Two-thirds of this deposit consists of melt-water deposits; the rest is till material. In many cases a regular sequence of alternating glaciofluvial sands and tills can be found.

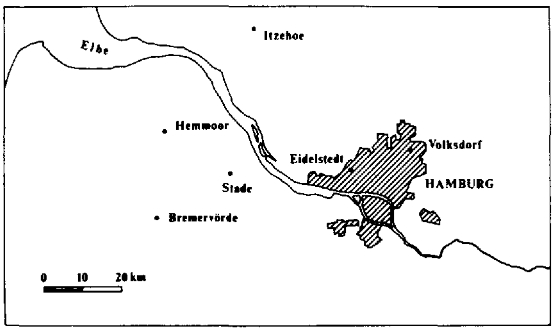

Fig. 1. Location map.

The interpretation of glacial sediments is complicated as in some places this simple layering was disturbed by glacial thrusting. It must be remembered that not only deposition took place but also erosion, and in most cases a certain proportion of the glacial sediments was removed after deposition. Indeed, there are very few places in which a full sequence of the Pleistocene strata can be found today.

It has been suggested that glacial sediments were subject to perpetual reworking by the advance of Pleistocene ice (Gillberg 1977, Marcussen 1978). Thus the latest deposits should comprise an almost total mixture of all older materials available. But in fact this is not the case. Although in some places reworking was important, normally tills and corresponding melt-water deposits have a characteristic composition which means that boulders may be counted or gravel analysed for stratigraphical purposes (Ehlers 1978).

TILL COMPOSITION

In Hemmoor (Fig. 2) an almost complete Pleistocene profile was exposed just on top of the upper chalk (Ehlers 1979). The fine-gravel diagram shows that the chalk material has affected the composition of the deposits very little. The Elsterian till, which lies directly on the soft white chalk, contains the lowest proportion of chalk and flint of all the exposed strata. In other places erosion and reworking were considerable, but this did not occur often. Figure 3 shows the fine-gravel analysis of a drilling in Hamburg-Eidelstedt, in which the Drenthe till of the Saalian glaciation was found directly on top of Pliocene sands. In the basal till, there are large amounts of the characteristic Pliocene quartz grains, which contain in some cases remnants of deeply weathered feldspars, but the concentration of quartz decreases rapidly from the lower to the higher parts of the profile.

MECHANISM OF DEPOSITION

Most of the deposits of the Scandinavian ice sheet in north Germany are interpreted as basal tills, although in some places flow tills, ablation tills, and waterlain tills seem to be present. Most of the morainic material which later formed the basal till was transported in

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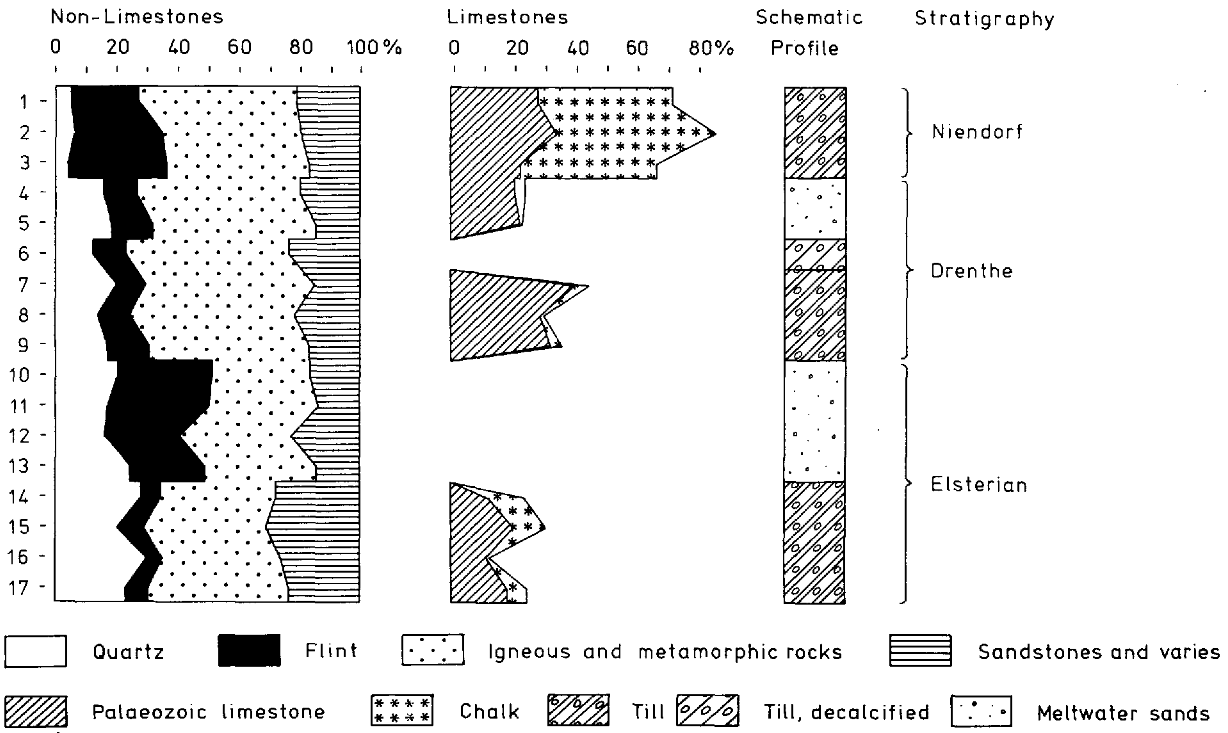

Fig. 2. Fine-gravel analysis of the Pleistocene sequence in the Hemmoor chalk quarry (fraction 3 to 5 mm). Almost no glacier erosion has taken place (Ehlers 1979).

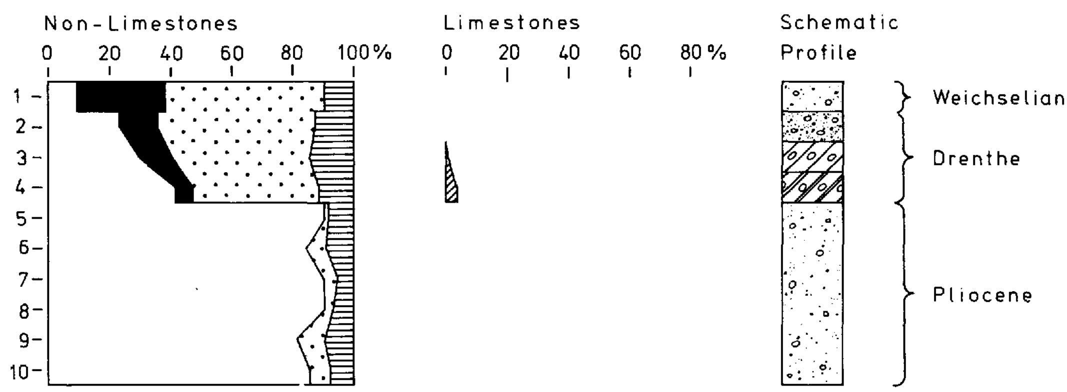

Fig. 3. Fine-gravel analysis of a drilling in Hamburg-Eidelstedt. The underlying Pliocene quartz sands have been considerably reworked and incorporated in the Drenthe till, which usually contains only about 10% quartz in this area.

the basal layers of the inland ice. During this transport a certain amount of underlying material was always incorporated in the ice. This must have been the case especially when the underlying sediments were taking part in the glacier movement as suggested by Boulton and Jones (1979). Thus the Elsterian tills always contain a certain amount of Tertiary material, and the younger tills always contain a certain amount of older till material. Despite this, tills of different ages can be distinguished as they all bear their individual characteristics.

In western parts of north Germany and in the northern Netherlands a type of red till occurs which is entirely composed of material that has been transported a considerable distance (Meyer 1976,Zandstra 1977, Höfle 1979, Meyer, unpublished). Investigation of the indicator boulders points to an eastern Baltic origin. This till is always found on top of the usual sandy till of the Drenthe (Saalian) ice advance. In some places the red till is mixed with the underlying sandy till, and the stratum is split up into a number of lenses which are more or less red and contain some clay. In its original composition this till contains neither quartz nor flint. This proves that the material must have been transported over hundreds of kilometres without any contact with the underlying sediments. It seems most likely that this transport took place englacially, and, perhaps, was accomplished by ice readvancing over dynamically-dead ice in an east-west direction during the late phase of the Drenthe advance (Fig. 4). As the same features can be seen, although less-pronounced, in late Elsterian and

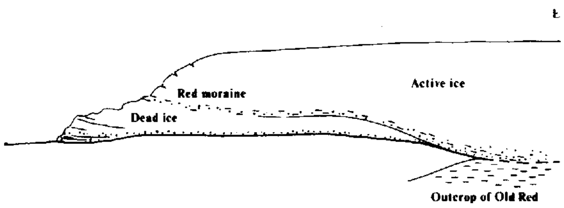

Fig. 4. The formation of the red Drenthe till. Distance between the areas of formation and deposition was more than 750 km.

late Weichselian deposits as well as in the tills of the Warthe (Saalian) ice advance, this type of englacial transport must have played an important part in the glaciation of north Europe. Similar types of till have been described from North America (Wickham and Johnson 1981).

MECHANISM OF EROSION

How did glacial erosion in north Germany take place? In some cases it may have been due to plucking or shearing (Dreimanis 1976), but in the area under consideration melt water was usually the main eroding agent, not the ice.

During the main glaciation vast amounts of melt water were released which ran off subglacially to the glacier margins. As this melt water was confined in ice tunnels (Shreve 1972), it had considerable erosive power. The largest features formed by glacial action are not the well-known push moraines but the buried tunnel valleys found in the subsurface of north Germany. These valleys have a depth of more than 400 m and a width of about 2 000 to 3 000 m. The courses of these fjord-like features can be followed from the coast of the Baltic Sea almost to the mid-German uplands. Valleys with a depth of more than 100 m (Fig. 5) are to be found only north of a line from Twistringen in the west to Celle in the east. Maps of these valleys were presented recently by Hinsch (1979) and Kuster and Meyer (1979).

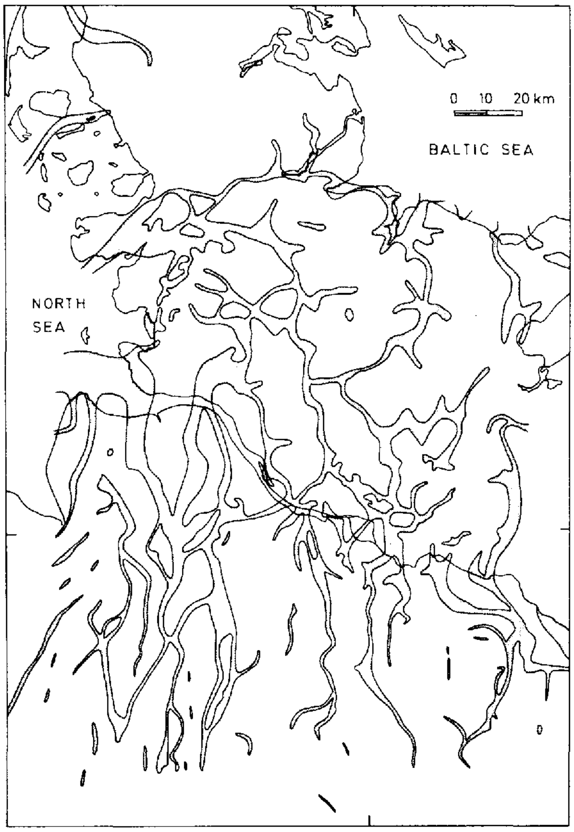

Fig. 5. Courses of the buried tunnel valleys deeper than 100 m below sea-level in the north German lowlands (compiled after Hinsch 1979, Kuster and Meyer 1979).

The origin of the valleys is not completely known. Their immense overdeepening and their net-like connections show that they were not formed as a fluvial system under subaerial conditions. Normally, till deposits are found only on top of the valley sediments and on the flanks, and not at the bottom. This indicates that these forms were probably built by subglacial melt water which was under high hydrostatic pressure. No explanation can be offered yet for the almost total absence of such features of Saalian age. All the big tunnel valleys seem to have been formed during the Elsterian glaciation.

In the Hamburg area, where the subsurface has been drilled many times and is therefore well known, a number of interesting features have been revealed. Profiles drawn through the tunnel valleys indicate that they are of a trough-like form (Fig. 6). The flanks are oversteepened,

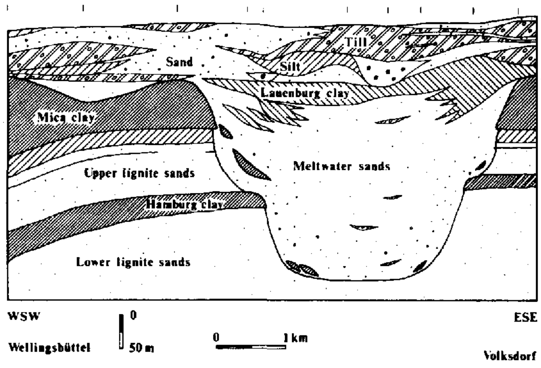

Fig. 6. Cross-section through a deeply incised tunnel valley in the Miocene mica clay and lignite sands in Hamburg-Volksdorf.

and in many places slumping of Tertiary material into the valleys occurred. Even where the flanks consist of the very stable mica clay of upper Miocene age, big blocks slid downwards, probably under the pressure of the overlying ice. The big tunnel valleys were rapidly re-filled with sandy deposits mainly during the Elsterian, before the glaciofluvial processes taking place at the end of this glaciation were replaced by glaciolimnic ones. The tunnel valleys were transformed into ice-dammed lakes, in which the so-called Lauenburg clay was deposited. After the Holsteinian interglacial the tunnel valleys were so completely filled with sediments that they could not be re-activated during the Saalian glaciation.

CONCLUDING REMARKS

In the marginal areas of the Scandinavian ice sheet in north Germany the glaciers themselves had only limited erosive power, perhaps because the active areas do not appear to have been in contact with the underlying substratum. Thus erosion was mainly effected by subglacial melt-water streams which formed fjord-like tunnel valleys, at least during the first major inland glaciation. Why this process was not repeated during succeeding glaciations remains an open question.

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