Temporary River and Meltwater Channels during the Saalian Glaciation in the Westphalian Bight, Germany - A Scenario -

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雑誌名	The science reports of the Tohoku University. 7th series, Geography
巻	49
号	2
ページ	215-225
発行年	1999-12
URL	http://hdl.handle.net/10097/45244

Temporary River and Meltwater Channels during the Saalian Glaciation in the Westphalian Bight, Germany
—— A Scenario ——

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Abstract Fluvial sediments and structures that cannot be connected with others to reconstruct the accompanying river course have been found in several locations in the River Lippe catchment, Westphalian Bight of NW-Germany. By combination with the proglacial fluvial dynamics of the advancing Scandinavian ice-sheet that reached and crossed the Lippe valley during the Saalian glaciation, a scenario of temporary ice marginal channels is developed. These channels were fed by meltwater from the ice-sheet and took several temporary courses. The important difference of this study compared with ice marginal channels described before is the temporary character of the Lippe valley channels as they do not necessarily belong to a stable ice margin. Temporary lakes are suspected too, even if no lacustrine sediments are found, because of the blocked river courses. A focus is placed on the suspected processes while aspects of mainly regional interest are presented elsewhere.

Key words: proglacial fluvial dynamics, ice marginal channels, proglacial lakes, Saalian glaciation, River Lippe valley, Central Europe

1. Introduction

During studies on the development of the Lippe valley, a tributary of the lower Rhine River in NW-Germany (Fig. 1), the influence of the glaciation of the area on the course of the river was one key issue (Herget, 1997). Without dicussing problems of only local interest, an explanation for the distribution of several isolated fluvial sediments and features is presented in this paper. In this scenario the glacio-fluvial dynamic at the margin of the glaciation that has reached the area is the key-factor for the explanation for the unsolved questions about isolated fluvial sediments and features.

After some simplified background information about the Quaternary glaciations of the investigation area, four selected examples of temporary river and meltwater

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Science Reports of Tohoku University, 7th Series (Geography)
Vol. 49, No. 2 (Special Issue on GLOCOPH '98), December, 1999, 215-225

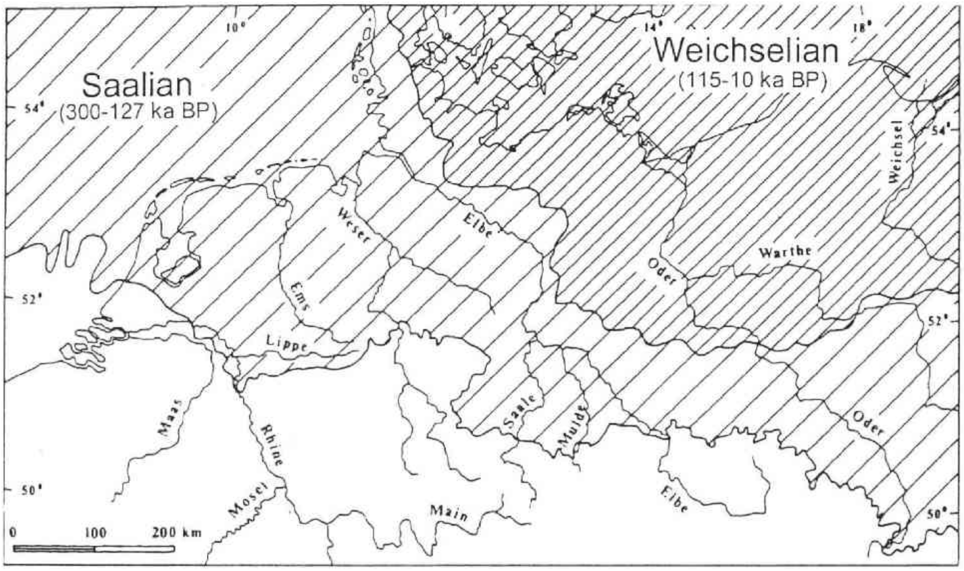

Fig. 1 Maximum extension of the Saalian (or older) and Weichselian glaciations in Central Europe (modified after Ehlers, 1994)

channels will be presented. Finally a comparision with other proglacial fluvial phenomena will be given.

2. Glaciations of northern Germany

In a simplified overview, the glaciations of northern Germany can be summarized as follows (Fig. 1). Further details can be found in e.g. Brunnacker (1986), Grube *et al.* (1986), Ehlers (1994), Skupin *et al.* (1993) and Skupin und Staude (1995).

The Saalian glaciation, which is connected to the oxygene-istope stages 8-6 and lasted between 300-127 ka BP, had its maximum extension in the western parts of Central Europe during OI-stage 8, which is traditionally called the Drenthe-stadial. In the eastern parts of Germany and in areas of Poland the Elsterian, an older glaciation, represents the maximum extension of the Scandinavian ice sheet. The last or Weichselian glaciation did not cross the Elbe-valley anywhere. In the Westphalian Bight the ice sheet exceeded somewhat south of the recent Lippe valley and extended to the northern rim of the Central European hill country. The Scandinavian ice-sheet carried sediments of Nordic provenance of granite, gneiss and quarzite (Smed and Ehlers, 1994) into northwestern Germany where rocks of those facies are not exposed at the surface. The Scandinavian ice-sheet is the only primary source for those rocks in the Westphalian Bight and therefore the occurence of those gravels is an important timemarker of the Drenthe-stadial of the Saalian glaciation in the area.

The Scandinavian ice-sheet reached the Westphalian Bight between the Teutoburger Wald and the Haarstrang from the northwest and crossed surrounding mountains of the Wiehengebirge and the Teutoburger Wald later (Fig. 2).

The ice blocked northwestward flowing river channels and forced the rivers to a course in a western direction towards the lower Rhine River because of the surrounding chains of mountains (Gibbard, 1988). While the glacial lake in the Weser valley, with its spillways into the Westphalian Bight (Thome, 1983) and several diversions of the river Weser (Rohde, 1994), are generally accepted, the proglacial environment within the Westphalian Bight is unknown and the dynamics are unproven (Herget, 1997).

While the ice was moving south to its maximum extension, the temporary ice margins must have been at several different locations until the maximum extension

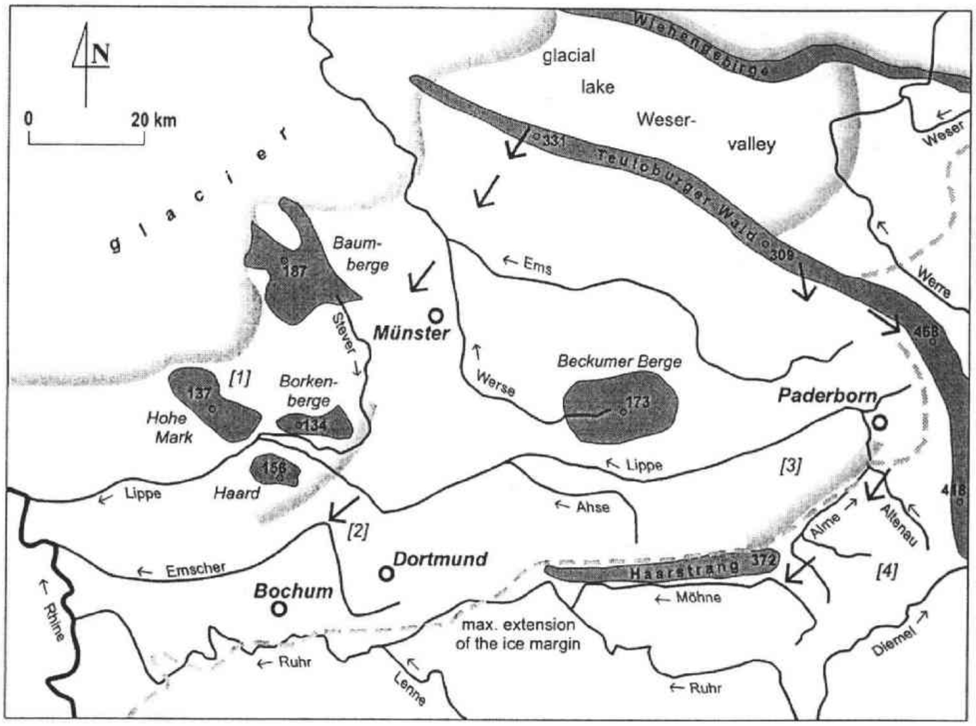

Fig. 2 Advancing Scandinavian ice-sheet during the Saalian glaciation in the Westphalian Bight
The four selected locations of temporary proglacial fluvial features are marked by numbers [1]-[4]. The named groups of hills in the lowland area of the Westphalian Bight are drawn in a shaded style and their maximum heights are indicated.

during the Saalian glaciation. These ice margins do not have to belong to a temporary stop of the forward moving ice or even an interstadial, but caused many individual temporary ice marginal channels.

3. Examples of the temporary proglacial fluvial environment

At the four marked locations (Fig. 2) examples of the influence of the temporary ice margins on the fluvial environment are shown in detail. Due to limited space in this paper and the mainly regional importance of the controversial ideas about the locations, the interpretation of the sediments as parts of unconnectable river terraces are discussed elsewhere (Herget, 1997).

3.1. Nordic sediments at the Hohe Mark

At the northern and north-eastern rim of the Hohe Mark, Braun (1975) mentions fluvial sediments which are interpreted as Old-Pleistocene terrace of the River Lippe (location no. 1 in Fig. 2). During the time of sedimentation the River Lippe should have taken a course which led along the northern rim of the Hohe Mark. The altitude of the sediments of 60 m a.s.l., which is comparable with terrace sediments of the lower Rhine River of this age, provides the only support for this interpretation.

During a verification of the description Braun (1975) has given, Nordic gravels where found among the sediments of the suggested Old-Pleistocene river terrace (Herget, 1997). Therefore the sediments cannot be older than the Drenthe-stadial of the Saalian glaciation and this interpretation must be wrong. On the other hand these sediments can neither be interpreted as a Drenthe-stadial river terrace, because all other fluvial sediments of this age are found in lower altitudes of about 50 m a.s.l., which is an important difference in a lowland area.

An explanation can be found in the fluvial processes that occur in front of the forward moving ice-sheet. As shown in Fig. 2, the valleys of the Rivers Weser and Ems among many others in Central Europe have been blocked from the northward against the ice-sheet, such that flowing water was forced to flow together with the meltwater of the glacier in a western direction. The advancing ice-sheet was slightly influenced by the mountains but sooner or later reached the northern rim of the Hohe Mark. During this situation the collected river water and meltwater had to pass between the ice margin and the mountains. This temporary river and meltwater channel was in use until the ice-sheet reached and blocked it. Until that point of time water was flowing more or less parallel along the northern slope of the Hohe Mark and might have left fluvial sediments that contain Northern Gravels as the meltwater from the Scandinavian ice-sheet was a suitable source. The altitude of these proglacial fluvial sediments is not of any significance because the ice-sheet displaced the marginal channels as it was moving southward. This displacement continued even upward on the northern slopes of the Hohe Mark until the water formed a submarginal channel or used another spillway south of the ice-margin.

3.2. Divide between the Emscher and Lippe valley

In the lower Lippe valley south-east of the Mountains of the Haard and Borkenberge a suspected ice-margin of an uncertain position must once have blocked the River Lippe during the forward movement to its maximum extension (location no. 2 in Fig. 2). A lake developed until the divide between the Rivers Lippe and Emscher was reached and used as spillway into the Emscher valley. At an altitude of 67 m a.s.l. a channel with a width of 20-40 m and up to 2 m depth was formed. The several hundreds of metres of visible channel was filled with gravels containing Nordic sediments and was covered by till. It is described by Fricke *et al.* (1949) but unfortunately was destroyed during the advance of quarrying in the clay-pit where it was exposed in the 1940's.

According to the interpretation of Fricke, *et al.* (1949), the channel is a former channel of the river Lippe leading into the valley of the Emscher. This should have been the course of the river until the Saalian glaciation. The problem on this interpretation is the explanation of the process which made the Lippe change course out of the Emscher valley into northwestern direction later. For example an accumulation of sediments during the last glacial can be excluded, because the Weichselian Lower Terrace does not reach the altitude of the channel. Therefore the development of the course of the Lippe has to be seen as leading in a north-western direction before the glaciation, a temporary blocking by the ice-sheet, a diversion into the Emscher valley and a return to the former course after the ice retreated.

Other fluvial sediments close to the location of the temporary spillway channel can be seen in this connection too. The fluvial sands at an altitude of 77 m a.s.l., which consist of bedded medium and fine sands, cannot be connected with other fluvial sediments to reconstruct a former river course (Bode und Udluft, 1939 ; Herget, 1997).

In this scenario, the proglacial fluvial dynamic, controlled by the forward moving ice-sheet, can be compared with that described for the Hohe Mark, except that Nordic sediments are absent.

3.3. Exogenic fluvial deposits

In the south-eastern part of the Westphalian Bight, exogenic fluvial deposits are found among the sediments of the Pöppelsche, a small creek on the northern slope of the Haarstrang (location no. 3 in Fig. 2). The whole catchment area of the creek is incised into Cretaceous limestones and carries water only episodically due to the karstification.

The problem is the explanation for the gravels of lydite among the limestone sediments that must have crossed the divide to the catchments of the upper Möhne and Alme River, where Palaeozoic lydite is exposed to fluvial erosion. The lydite belongs to the underlying Palaeozoic sediments below the Cretaceous limestones (Fig. 3).

According to the scenario of temporary marginal channels the sediments of the Alme River might be displaced by the ice marginal drainage of the area. In the marginal channel there is also a contribution of water from the catchment of the River Weser which is blocked by the ice and developed spillways which sent their water into the Westphalian Bight. This water was displacing older fluvial sediments, that contain the lydite !, and might have found a way to cross the divide to the north, because it was running in relative high altitudes above the valley floor. After the Scandinavian ice-sheet was melted down, the lydite was displaced inside the catchment of the Poppelsche and was deposited again among the autochthonous sediments of

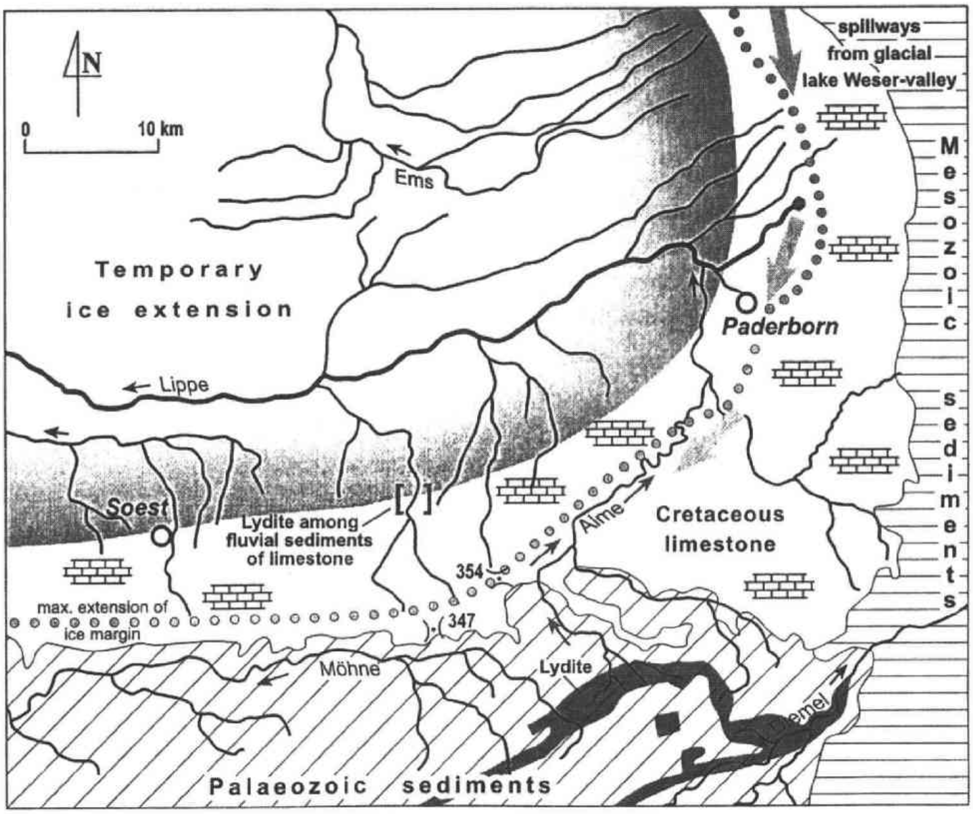

Fig. 3 Exogenic fluvial deposits of lydite in the catchment of the Pöppelsche Creek (simplified from Herget, 1997, geology from various sources)

limestone.

An alternative interpretation is given by Skupin (pers. comment). According to him, the lydite might be interpreted as glacially displaced older sediments from the catchment of the River Ems. The lydite from the catchment of the River Alme is found by Lotze (1953) and is interpretated as an indicator for a former course of the Alme into the recent catchment of the Ems. If this interpretation were true, Nordic sediments should have been found in the Pöppelsche catchment, too. But even in the Drenthe-stadial terrace of the Pöppelsche, which contains 5% of Palaeozoic sediments, no Nordic gravels are mentioned by Skupin (1995).

3.4. Nordic sediments beyond the maximum ice extension

At several other locations on top of the Eiler Berg at an altitude of 364 m a.s.l.

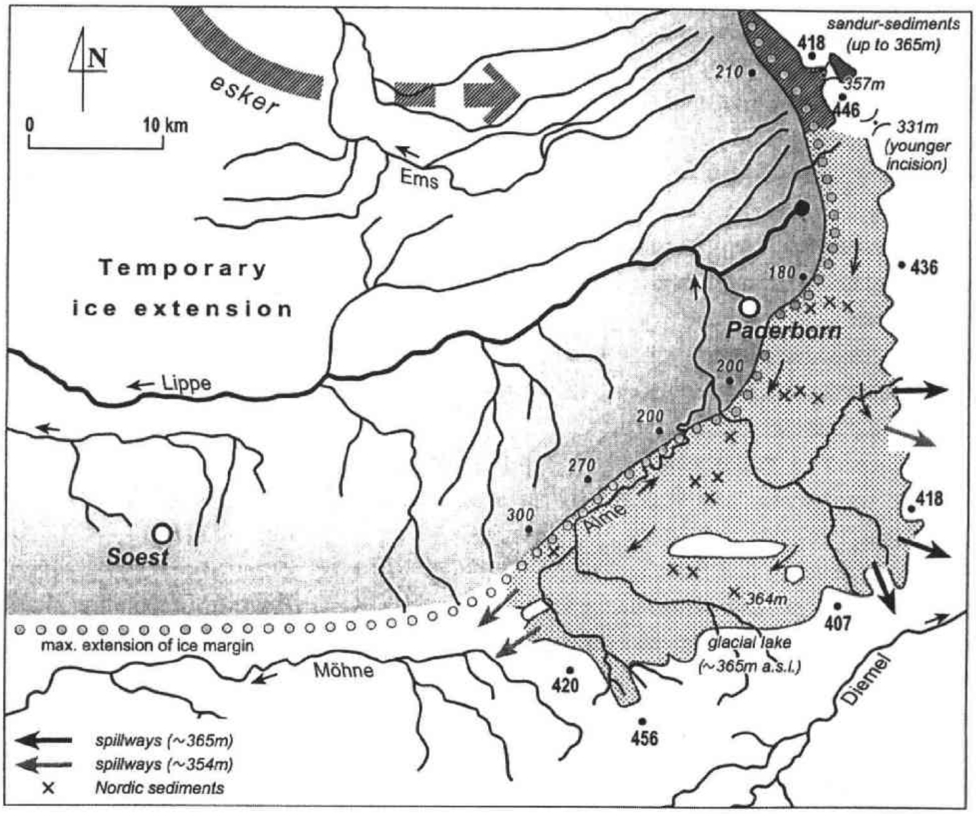

Fig. 4 Nordic sediments beyond the maximum ice extension south of Paderborn (Distribution of Nordic sediments after Stille (1904, 1935a, 1935b), Hiss (1989), Skupin (1989) and this investigation)

Nordic sediments are deposited (location no. 4 in Fig. 2) (Fig. 4). The problem with those sediments with diameters up to 10 cm is the location that lies more than 10 km beyond the maximum extension of the Scandinavian ice-sheet. The gravels of Nordic sediments at the Eiler Berg are located nearly 100 m higher than the nearest former ice margin. An anthropogenic origin, such as agricultural activities can be excluded because of the size of the sediments involved and their early identification (e.g. by Stille, 1904).

Until now the Nordic sediments of this region are unexplained. Without considering detailed arguments, these gravels have been used to argue for an extension of the maximum ice limit (Deutloff, 1976), ideas about a short time advance of the ice-sheet during the Saalian glaciation (Skupin, 1989) or speculations about an Elsterian glaciation of the area (Skupin, 1989).

Connected with the scenario of temporary ice marginal channels, a proglacial lake from blocked channels might have existed in the area south of Paderborn (Fig. 4). It reached a level of 365 m a.s.l. to let the Nordic gravels be deposited from icebergs melt out. These icebergs drifted on the surface of the lake and ran aground or loose the drift blocks by melting out and be deposited as dropstones. According to Benn and Evans (1998) they belong to the category of ice-rafted debris. The former lake might have had several spillways at elevations of 365 m a.s.l., according to the recent morphology. The elevation of these spillways corresponds to the altitude of the Eiler Berg with the Nordic sediments on its top. Two possible main spillways on lower elevations (354 m today) might have been in use: one to the east, which is broad, but without incision, and one separated into two parallel channels in a south-western direction into the Möhne valley, which is sharply incised and large compared to the valleys of the surrounding area. It is possible that the eastern spillway belongs to younger periglacial erosion like the divide to the north-east at an altitude of 331 m a.s.l. north-east of Paderborn.

The temporary lake was fed by an esker which ran below the ice sheet of the Westphalian Bight and shows a direction towards sandur sediments north of Paderborn (Skupin and Staude, 1995). These sandur sediments also reach an altitude up to 365 m a.s.l. (Farrenschon, 1990) and therefore even cross the surrounding chain of mountains locally. But more important than this is their corresponding altitude with the suspected temporary proglacial lake. Unfortunately, no lacustrine sediments of the lake are identified until today, on the other hand no one really expects to find them after two following ice-ages with periglacial erosion processes which, without any doubt, have destroyed lacustrine sediment structures of the short-time temporary lake.

4. Discussion of the scenario

The scenario of the temporary river and meltwater channels in the proglacial environment of the Westphalian Bight during the Saalian glaciation should be seen as an explanation for otherwise unconnectable fluvial sediments in the area. The scenario is the key for combining the individual locations which individually cannot reveal the accuracy of the proglacial fluvial dynamics given in a broad outline. The scenario is not a distinct fact but a plausible explanation for the problem of the course of the meltwater fed rivers between the advancing Scandinavian ice-sheet and the slopes of the southern margin of the Westphalian Bight. Recent studies indicate an important influence of ice marginal channels even in the central lowland areas of the Westphalian Bight (Speetzen und Weber, 1999).

Ice marginal channels and proglacial lakes are described in different scales from nearly all areas of Pleistocene and Recent glaciations (e.g. Benn and Evans, 1998 ; Elson, 1992 ; Baker and Bunker, 1985 ; Grosswald, 1998 ; Teller, 1995). An important new aspect of the temporary ice marginal channels is that they do not belong to a more or less stationary ice margin like the "Urstromtäler" (Liedtke, 1981) or other structures discussed in Benn and Evans (1998) and Herget (1998). Therefore they typically did not leave large structures like channels or terraces but rather left disjointed traces which are difficult to interpret, especially on a regional rather than local scale.

The suspected temporary channels belong to the the second last glaciation. Their modification in the periglacial environment of the last glaciation is uncertain. Their uncertain distribution, the coverage by younger sediments and the lack of exposure makes their systematic investigation difficult. Typical characteristics of those deductive developed river courses are impossible to list completely at this point, first few indicators are mentioned in the selected examples discribed above. Further examples are noted in Herget (1997).

Acknowledgements

I thank P. Carling, H. Liedtke, K. Skupin and K. Thome for important discussions and comments. Financial support for the studies was kindly provided by the "Deutsche Forschungsgemeinschaft" (German Research Foundation) (Li 86/21-1). R. Wieland and S. Steinert have improved the maps and helped to give them a presentable style. G. Fornari and P. Carling have checked the text for correct English.

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