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C. Area between the Scandinavian and the Alpine Glaciation

1. Periglacial Sediments and their Stratigraphy

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With 1 figure

1. Introduction

"Former periglacial areas" refers to that part of the Federal Republic of Germany which neither was covered by Scandinavian or Alpine ice during the Pleistocene nor affected by glaciofluvial processes. Essentially this is the region of the central German hill country (Mittelgebirge) excluding its highest parts which have been glaciated. [1])

This region also is of special interest for stratigraphical Quaternary research because it is the link between the Northern and Alpine glaciated areas. It is from here that important contributions might be given for synchronizing Northern and Alpine glacial advances. At present, however, there is no answer at hand to this question because the difficulties in achieving a reliable stratigraphy e.g. of the terraces all along the Rhein still prove to be too great. In spite of the enormous ammount of work done during the past years these problems much rather increased than decreased.

Such a sceptical view seems to be surprizing taking into consideration the great amount of well preserved periglacial products that can be found at numerous places together with interglacial products. But this view is mainly due to the vast variety of products which dims the chronology of periglacial events. The following pages shall show the present state of Pleistocene research in the area between the Alpine and the Northern glaciation. Also the most important questions which still cannot be answered shall be discussed.

2. Stratigraphy of the Typical Periglacial Deposits

Here typical periglacial sediments are loess eolian sand, solifluction deposits, and gravel terraces. They occur in most parts of the hill country and the internal basins and mostly they are definitely of periglacial origin. In some places they reach a great depth and they can often be classified by interglacial products they contain.

2.1. Loess

In recent times the most intensive research on periglacial deposits in the Federal Republic of Germany has been done on loess. The initiative resulted from investigations by FREISING (1951, cit. SEMMEL 1968) in the north of Württemberg and by SCHÖNHALS

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[1]) ROTHER (1971) summarizes the results of investigations dealing with the Pleistocene glaciation of the Harz, Bayerischer Wald, and Schwarzwald. Studies by FEZER (1971) and PAUL (1969) have been published later. MENSCHING (1960) finds different explanations for forms in the Hohe Rhön which used to be interpreted as being of glacial origin.

(1950, cit. SEMMEL 1968) in the Rheingau. From then on special attention has been paid to the Wuerm loess, because FREISING and SCHÖNHALS had worked out different results. More problems were created by profiles from Bayern, published by BRUNNACKER (e.g. 1959, cit. SEMMEL 1968). Later it was found that BRUNNACKERS main horizons also occur in the Wuerm loess of Hessen, Niedersachsen, and Württemberg (SEMMEL 1963, cit. 1968; ROHDENBURG & MEYER 1966; ROHDENBURG 1968). A stratigraphically important correction has been necessary only in so far as BRUNNACKER equated his "Braunen Verwitterungshorizont" with FREISINGS "Nassboden III". For FINK (e.g. 1961, cit. SEMMEL 1968) the former one normally is a stratigraphical equivalent of "Stillfried B". It had become apparent that this "Nassboden" lies above the "Braune Verwitterungshorizont" (SEMMEL 1963).

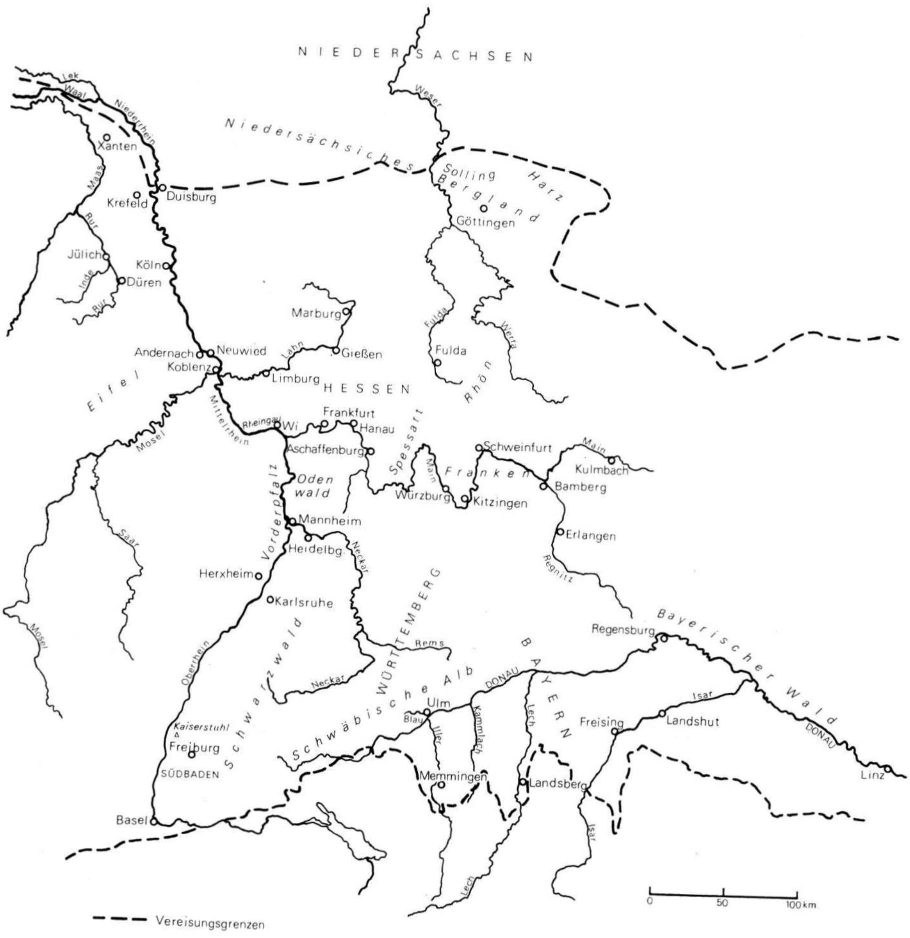

Fig. 1. Topographical situation of the sites discussed.

According to recent investigations in Niedersachsen, Hessen, Wuerttemberg, and Bayern a schematic collective profile can be constructed. Thus the base of the Wuerm loess is formed by an intensive B_t-horizon (in more humid areas a pseudogley soil), which developed from an older loess during the last interglacial era.[2]) On top of it solifluction, Schwemmlöss or loess alternate with several (often up to three) humuszones, chernozem-like soils. They belong to warmer periods of the early Wuerm and probably correspond to the interstadials Amersfoort, Broerup, and Odderade. At times a tendency to develop B_t-horizons can be noticed. The loess on top produced a soil called "Braune Verwitterungshorizont", "Lohner Boden", or the slightly differently developed "Hainerberger Boden". Commonly this is regarded as the most distinguished horizon in the upper Wuerm loess and is supposed to be the base of the Late Wuerm loess. Leached brown soils or pseudogley-like leached brown soils as climax soils generally developed on top of the Late Wuerm loess. It is only in small less humid areas (Rheinhessen, Wetterau) that we find chernozems.

Beside this collective profile of course there are many individual soil profiles with a simpler structure. Especially in Niedersachsen and Hessen, however, more complex soil profiles are known where poorly developed soil horizons (e.g. "Nassboden" according to FREISING) and tuff horizons (SEMMEL 1967, cit. SEMMEL and STÄBLEIN 1971) have a special significance. Finding several generations of ice wedges ROHDENBURG (1966, cit. 1968) could demonstrate a repeated freeze-thaw process in the soil during the Wuerm glacial.

A still greater difficulty presents the integration of Wuerm loess profiles from southern Baden and Niederrhein into this scheme. That is why BRONGER's (1966, cit. 1969) parallelization (published with all reserves) of two "Verbraunungszonen" in the profile of Heitersheim with Broerup-Amersfoort- and Paudorf-Arcy (=Stillfried-B)-Interstadial has not yet been achieved completely.[3])

The most complicated stratigraphical situation can be found on the Niederrhein. Only in the most recent past a definite equivalent of the "Lohner Boden" (=Stillfried-B) has been found (ROHDENBURG & SEMMEL 1971). Before that investigations undertaken by PAAS (e.g. 1968) introduced many profiles which showed brown forest soil-like material and tundra gley soils above leached brown soils and humus zones of the last interglacial not corresponding typologically to the "Lohner Boden" (Stillfried-B). BRUNNACKER (e.g. 1967, cit. 1969) also could not find any definite equivalents of this soil in the many profiles he had analysed. Probably it is missing as a result of erosion and displacement during the early Late Wuerm (SEMMEL 1968). According to our research on many profiles tundra gley that had been compared with the "Stillfried-B" (formerly called Paudorf-Interstadial) certainly belongs to Late Wuerm loess (ROHDENBURG & SEMMEL 1971). This fact should be kept in mind when interpreting the publication of FINK et al. (1967) who discuss the parallelization of Wuerm loess from the Niederrhein and Belgian and Dutch profiles.

Profiles from Hessen and the Niederrhein cannot be regarded as equivalents mainly because the deep loesses of the basin of Neuwied (on the Mittelrhein) still present a number of unsolved problems. The discussion mainly deals with the Pleistocene profile of the clay pit Kärlich (recent literature BRUNNACKER, STREIT & SCHIRMER 1969). BRUNNACKER (1968, cit. 1969) identified main horizons up to then unknown, and SCHIRMER (1970) analysed the Wuerm loess. Unfortunately, however, the equivalent of the "Lohner Boden" still cannot be definitely traced in the profile of Kärlich (SCHIRMER 1970, 276 f.). In my opinion merely some shifted material of this soil can be found in a shallow depression (ROHDENBURG & SEMMEL 1971, Abb. 1).

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[2]) LESER (1967, cit. 1970) discusses the question whether the last interglacial soil in the present-day chernozem area of Rheinhessen has been a chernozem.

[3]) According to my own investigations (March 1972) in the exposure Heitersheim Wuerm loess shows the "Lohner Boden" (=Stillfried-B) and above it a well developed „Nassboden" (probably corresponding to E 2 of the scheme of Hessen).

It is much easier to synchronize the collective profile (p. 294 f.) with some Wuerm loess profiles from the German Democratic Republic (e.g. LIEBEROTH 1963, cit. SEMMEL 1968), from the CSSR (e.g. KUKLA 1969, cit. ROHDENBURG & SEMMEL 1971), and from Austria (e.g. FINK 1961) (for details see SEMMEL 1968, 10 ff.). There facies and age of the main horizons are undoubtedly identical.

The Wuerm loess stratigraphy outlined above is mainly based on pedological criterions. In our area rarely any other criteria are at hand (e.g. REMY 1969). Also palynological investigations did not lead to stratigraphical results (e.g. FRENZEL 1964). According to recent research charcoal lying just above the B_t-horizon of the last interglacial age belongs to climatologically indifferent species (e.g. ROHDENBURG & MEYER 1966, 135; SEMMEL 1968, 32). Recent ^{14}C-datings indicate the doubtful figure of about 20 000 a.b.p., and all ^{14}C-datings of humus material brought about 28 000 a.b.p. (max.), a figure much too small. Should these results be correct then the whole Wuerm loess stratigraphy in middle Europe would be incorrect. A plausible ^{14}C-dating, however, was achieved in the loess province on the Niederrhein. A humus layer in the loess profile at Erkelenz shows a ^{14}C-age of at least 49 000 $\pm$ 2000/ $\pm$ 1700 a.b.p. (cit. according to SCHIRMER & STREIT 1967, 87, cit. BRUNNACKER et al. 1969). PAAS (1968, 36) equates this sample (gro 2675) with his brown forest soil-like "Frimmersdorfer Bodenbildung" which he thinks to be an equivalent of the "Paudorf-Interstadial" (= Stillfried-B).

In contrast to the many Wuerm loess profiles there are relatively few pre-Wuerm loess exposures that could be distinctly analysed. These profiles show loess resp. loess loam beneath the more or less well developed Wuerm loess and the basal soil of the last interglacial age. This loess resp. loess loam contains one or several (max. 8) fossil B_t-horizons (leached brown soils) or S_d-horizons (pseudogley soils). Additionally there are sometimes soils of less intensity (humus zones and "Nassboden"). The greatest number of fossil soils (Type: leached brown soils) is found in the profile of the pit at Bad Soden, south of the Taunus (SEMMEL 1967, cit. SEMMEL & STÄBLEIN 1971). Starting from below this profile shows white Pliocene clay, an early Pleistocene terrace (stratigraphically between Tegelen- and Waal-Interglacial age), loess loam, then pseudogley soil, loess loam, five B_t-horizons, calcareous loess, and four B_t-horizons (including the present top soil). Charcoal as relics of willows and poplars is found on top of most of the fossil soils. However no pollen could be extracted from these substrata.

Sedimentpetrographically and soiltypologically in the whole profile above the Pseudogley no stratigraphically relevant distinction could be found. The fossil soils often lie immediately one above the other or they are interrelated, on the other hand they can be separated by several meters of loess or loess loam.

Therefore a "Doppelung" of certain soils as described for Čeverný Kopeč (KUKLA 1969, cit. ROHDENBURG & SEMMEL 1971) and a coordination of such "Doppelböden" and certain interglacial ages is not feasable. Paleomagnetic studies (carried out by Dr. FUJIWARA at the Department of Geology, University of Sapporo) showed the partly reverse orientation of the loess loam which lies above the pseudogley. Consequently it has an age of no less than about 700 000 years. At the present time more paleomagnetic experiments are in process and some are carried out in the profiles of Ostheim, north of Hanau and Reinheim in the northern Odenwald. At both locations several fossil B_t-horizons lie above a very intense pseudogley soil. BOENIGK et al. (1972, 155) give information about loess which lies beneath "Tegelen"-peat in the Wetterau.

In southern Baden BRONGER (1969) found a sequence of loess with five B_t-horizons on top of (presumably) early Pleistocene gravel. Here as well there are no remarkable differences between older and younger fossil soils. In Austria, northern Italy, and ČSSR, however, there have been findings which suggest that the soils of the early Pleistocene are rotlehm-like products (see SEMMEL 1972, 19 ff.). In my opinion BRONGER is right by saying that it is impossible for him to correlate his fossil soils with specific interglacial ages. Some years ago (BRONGER 1966, Tab. 6, cit. 1969) the three uppermost soils had been compared with the "classical" interglacial ages; accordingly the fossil leached brown soil on top was a product of the Riss/Wuerm-Interglacial, the soil in the middle a product of the Riss I/Riss II-Interglacial, and the lower soil a product of the Mindel/Riss-Interglacial.

According to BRUNNACKER et al. (1969) the loess profile of the pit at Kärlich shows four fossil leached brown soils. In my opinion, however, the youngest of these soils is not a fully developed leached brown soil but rather a brown forest soil of interglacial character (see SCHIRMER 1970). On the other hand the soil that was compared with "Stillfried-B" by BRUNNACKER et al. (i.b., 127) is a remainder of a B_t-horizon which needed a similar climate as the older B_t-horizons in order to develop (see ROHDENBURG & SEMMEL 1971). On the eastern slope of the Kaiserstuhl KHODARY-EISSA (1968) describes loess with four remainders of leached brown soils; the oldest but one has developed especially well.

Loess profiles with four fossil B_t-horizons have been found in Franken (SEMMEL & STÄBLEIN 1971) and northern Hessen (SEMMEL 1972). Profiles with three remainders of fossil leached brown soils are very frequently found. PAAS e.g. (1968), SCHIRMER & STREIT (1967, cit. SCHIRMER 1970) describe such profiles of the Niederrhein. The loess layers on the lower Middle Terraces of Maas and Rhein have been studied by PAAS and are especially important. As this terrace supposedly has been developed during the Drenthe (see p. 302) the formation of leached brown soils must also have been possible during the Eem-Interglacial age as well as during two post-Drenthe-periods. Recent studies (still unpublished) by SCHIRMER show that this terrace even holds four fossil leached brown soils at Frimmersdorf-West which follow each other closely in pairs. The profile at Riegel (Kaiserstuhl) holds 3 B_t-remainders (GUENTHER 1961) as well. At Marktheidenfeld and Mosbach near Wiesbaden-Biebrich there are loess layers with three remainders of fossil leached brown soils on top of paleontologically analysed fluvial deposits. In both pits differences occur between loess-stratigraphical and paleontological datings (SEMMEL 1968, cit. 1972 a). These problems shall be dealt with a length on page 299 ff.

All in all it can be stated that it is still impossible to apply any of the present Pleistocene chronologies used in the Federal Republic of Germany to the sequence of B_t-horizons beneath the fossil soil of the last interglacial age. The comparison of the soils of the many exposures is still very difficult. In my opinion the scientific methods used in this field of investigation proved to be incorrect in the long run. This is also true for BRUNNACKER's (e.g. 1970 and HÄDRICH 1970) definition of the iron content and also for METZGER's (cit. BRUNNACKER 1970) definition of the "Steighöhe". The division and the correlation of the loesses with the aid of tuff has been very successful in the Wuerm loess (SCHÖNHALS 1959, cit. 1964); in older loesses, however, this methods often fails (SEMMEL 1967, cit. SEMMEL & STÄBLEIN 1971). Recent studies by BIBUS (1973) in the Wetterau can be mentioned here as well.

2.2. Eolian sand

The former periglacial area covered with eolian sand in the Federal Republic of Germany is much smaller than the area now veiled by loess. Eolian sand is found in the Oberrhein Valley, in the Donau Valley, and the valley system of the Main (Würzburg, Kitzingen, Schweinfurt, and Erlangen). Here BRUNNACKER (1959) distinguishes three different eolian sands; the two older ones have been developed during the late Wuerm, the youngest one developed as a consequence of clearing woodlands in prehistoric times. BECKER (1967) made a more detailed study of the eolian sands in the northern Oberrhein

Valley. He separated a very much stratified basal complex from a much younger body of sand. Sometimes Laacher pumice tuff (Allerød) is found between both bodies of sand. It had also been found by SONNE & STÖHR (1959) in the eolian sand north of Mainz. Recent surveys show that Laacher pumic tuff normally can only be found in the upper 50 cm of the eolian sand (SEMMEL 1969, cit. 1972 a). Post-Pleistocene (historical) eolian sand covers only some small areas.

The position of eolian sand beneath the Laacher pumice tuff still lacks a stratigraphical explanation. Probably this eolian sand dates back to the dry cold phase that according to SCHÖNHALS, ROHDENBURG & SEMMEL (1964) began about 20,000 a.b.p. (middle Late Wuerm). A definite synchronization even with nearby loess profiles has not yet been possible (see SEMMEL 1969, 88, cit. 1972 a).

2.3. Solifluction Deposits

Periglacial solifluction was very frequently found in the German hill country. Generally there is no outcropping of pre-Pleistocene rock but it is covered by several layers of solifluction material. Consequently, these deposits are the original soilforming material and their analysis is rather important for the soil scientist. The deposits mainly contain solifluction material as well as alluvial deposits. According to the topic of this report all those recent publications shall be discussed which deal with both solifluction layers and their stratigraphical analysis.

In the hill country of Niedersachsen ROHDENBURG (1965, cit. 1968) and BARTELS (1967) studied debris layers that had been developed in the transitional zone of Röt/Muschelkalk. On top the series of solifluction deposits frequently show alluvial sediments consisting of loess, Muschelkalk- and Röt-material. These sediments are underlaing the present flood plain. Consequently, they should date back to the Wuerm glaciation. The overlying stratum consists of Röt-Muschelkalk-solifluction and of Muschelkalk debris rich with loess. On top there are Röt-solifluction, Muschelkalk debris without loess, and solifluctionloess. On the eastern slope of the Solling ROHDENBURG (1965 a, cit. 1968) discovered a two-cyclic series of the three-sectional sequence Röt-solifluction, Muschelkalk-solifluction, and loess. The underlying sequence is supposed to date back to the early and middle Wuerm (referring to SCHÖNHALS et al. 1964), the top sequence to the late Wuerm (ROHDENBURG 1968, 83).

This division lacks the youngest periglacial solifluction layer of the Late Dryas age (SEMMEL 1964, cit. 1968). In all other areas it is present unless it has been washed off by Holocene soil erosion. ROHDENBURG (ib.) equates the loess veil with the "Mittelschutt", and the underlying solifluction layer with the basal debris free of loess (according to SEMMEL 1968). Such three-sectional solifluction deposits are very frequently found in the hill country. The "Mittelschutt" however, is often restricted to favourable positions. This sequence does not always lead to definite stratigraphical conclusions. Such a body of solifluction deposits could only have been deposited in the Late Wuerm. On the other hand individual layers (except the top debris layer = "Deckschutt") can be older indeed (SEMMEL 1968, 66 f.).

The difference between the three-sectional division of the solifluction layers according to SEMMEL (1968) and the division into "Basis-, Haupt- and Deckfolge" as it has been introduced by SCHILLING & WIEFEL (1962, cit. SEMMEL 1968) for the hill country of the German Demokratic Republic is based on the stratigraphically often uncertain position of the deposits. These authors also have a different opinion concerning the regional distribution of the "Deckschutt" (=Deckfolge). According to SCHILLING & WIEFEL "Deckschutt" only exists in the highest regions of the mountains. In the FRG, however, "Deckschutt" also occurs in basins. For example in the lower Main Valley (in less than 100 m O.D.) it can be related to ice wedges and cryoturbations that developed in the Laacher pumic tuff of the Alleröd. Other forms of permafrost are filled with "Deckschutt" that largely consists of pumic tuff (SEMMEL 1969, cit. 1972 a). It developed a brown forest soil and shows all qualities of a "Lockerbraunerde". Its relation to Laacher pumice tuff has been discussed by SCHÖNHALS (1959) and STÖHR (1963). Judging from all recent results this material is in fact Laacher pumice tuff and not an older tuff the age of which lately has been identified by ERLENKEUSER, STRAKA & WILLKOMM (1970). Apart from the tuff content these "Lockerbraunerden" mostly are additionally characterized by loess loam components. These can also be found in the top soil of many other profiles, such as in the leached brown soils of the Schwäbische Alb (HEMME 1970).

2.4. Gravel Terraces

Pleistocene gravel terraces in the FRG frequently have been the object of quaternary geological and -geomorphological studies. The terraces of the Rhein-system have been of major interest. Their division is also the main object of the following chapter. A summary of Pleistocene valley development in the area of the drainage divide between Main and Donau and the hill country of Fulda-Werra is given by SCHRÖDER (1971) and SEMMEL (1972 and 1973).

According to KAISER (1961) in the basin of the Niederrhein fluvial gravel with typical Pleistocene minerals is found on top of Pliocene sediments. This gravel contains several interglacial clay layers. Following the Dutch division of the Quaternary the oldest clay is supposed to be a deposit of the Tegelen-Interglacial. The gravel layers below Tegelen-clay are supposed to be part of the Older Main Terrace of the Rhein (see QUITZOW 1962). Based on sedimentpetrographical investigations BOENICK (1970, cit. 1972) concludes that the change from "Pliocene" to "early Pleistocene" sediment facies does not occur at the base of the gravel but already in the underlying clay, called Reuver. KOWALCZYK (1971, 8 ,cit. BOENIGK et al. 1972), however, still uses the traditional separation according to which coarse-grained coloured gravel (=Pleistocene) lies above light gravel rich with quartz or clay rich with humus (=Pliocene). According to the Dutch division sediments rich with clay (=Cromer) are the last layers of the early Pleistocene sediment sequence. The gravel between Tegelen clay and Cromer material supposedly belong to the Younger Main Terrace which also contains clay of the Waal-Interglacial (KAISER 1961).

The difficulties of connecting the different late Pleistocene gravels and clays in the Niederrhein area are discussed by BOENIGK, KOWALCZYK & BRUNNACKER (1972). Presently there is no satisfactory solution at hand. Even paleomagnetic methods could not solve the problem completely.

Indications of a periglacial climate in this area have often been described (e.g.AHORNER & KAISER 1964). In the field of investigation of KOWALCZYK drift blocks are only found in the gravel above the Tegelen clay, synsedimentary ice wedges only in the overlying stratum of the Younger Main Terrace.

In the Rhein-Main area, however, drift blocks are already found embedded in the gravel beneath clay layers of the Tegelen-Interglacial (SEMMEL 1972 a, 63). Such blocks are missing in the underlying Pliocene. In contrast to the Pliocene sediments which contain only resistent rocks and minerals the gravel between the Tegelen clay holds many components easily to be weathered. On top of the Tegelen clay which is said to be the oldest interglacial product a gravel series containing drift blocks follows. This gravel series contains three more interglacial clay layers which according to their pollen contents should be older than the Holstein-Interglacial. The whole sequence is part of the "Kelsterbacher Terrace" between Aschaffenburg and Frankfurt/M.; towards the west it merges into the complex of the "Mosbacher Sande" south of Wiesbaden. It is part of an enormous gravel accumulation which is frequently found in the upper Rhein system. The early Pleistocene deposits of Herxheim, Jockgrim, and Rheinzabern in the Vorderpfalz (PETERS 1965, cit. SEMMEL 1972), and of Marktheidenfeld in Unterfranken (KÖRBER 1962) are part of it as well as valley fill in the Odenwald (SEMMEL 1961, cit. 1968), in the area of Würzburg (RUTTE 1971), and the sand of Mauer near Heidelberg (KÖRBER 1962). Further down the Rhein early Pleistocene gravels in the basin of Neuwied (BRUNNACKER 1971) is also part of these gravel accumulations.

It is very difficult, however, to compare the stratigraphy of these different exposures. These difficulties shall be discussed below analysing some exposures. Because of its fauna contents the greatest part of the Mosbacher Sand is mostly dated back to the later Pleistocene (Cromer to Elster or Mindel; see e.g. ADAM 1964). Referring to palynological results most of the sediments of the Kelsterbacher Terrace, however, are older than the "Cromer" (pollen analysis by V. D. BRELIE, BORGER, SONDEY, still unpublished; see SEMMEL 1972 a). GUENTHER (1969) found *Archidiskodon meridionalis* in the lower section of the three-divisional Mosbacher Sand. Therefore he suggests a greater age. In contrast to the different paleontological interpretations fieldgeological findings suggest that the Mosbacher and Kelsterbacher deposits are stratigraphically identical (SEMMEL 1969, cit. 1972a). In V. D. BRELIE's opinion (written information from May 5, 1972) it is possible to connect the horizons of the Kelsterbacher Terrace and the Dutch division of the early Pleistocene by ZAGWIJN, MONTFRANS & ZANDSTRA (1971). Accordinly, the following interglacial ages can be named (starting from below): Tegelen, Waalien, Interglacial I, Interglacial II. The "Cromer-Komplex" is divided by the last two interglacial ages. The Elster glaciation starts above the Interglacial II. According to the present state of research the Kelsterbacher Terrace mainly consisting of deposits of the $t_{(1)}$-Terrace (SEMMEL 1972a) could be divided in the following way:

$t_{(2)}$ - Terrace ≡ 5^{th} Glaciation
4^{th} Interglacial (Interglacial II)
$t_{(1)d}$ - Terrace ≡ 4^{th} Glaciation
3^{rd} Interglacial (Interglacial I)
$t_{(1)c}$ - Terrace ≡ 3^{rd} Glaciation
2^{nd} Interglacial (Waalien)
$t_{(1)b}$ - Terrace ≡ 2^{nd} Glaciation
1^{st} Interglacial (Tegelen)
$t_{(1)a}$ - Terrace ≡ 1^{st} Glaciation
Pliocene

Within the deposits of the type "Mosbachium" BRUNNACKER (1971) sets aside profiles with five top layers from those with four top layers. The latter type is characterized by a younger body of gravel incised in the older deposits. According to BRUNNACKER at least the older section of the fluvial sediments in the pit of Kärlich in the basin of Neuwied is part of the Main-Terraces (probably Young Main Terrace), though presumably the earliest Pleistocene is missing.

The K-Ar-determination by FRECHEN & LIPPOLT (1965, cit. FRECHEN 1971) is based on the assumption that the earliest Pleistocene is older than the Main Terraces of the Mittelrhein which themselves should be younger than the Waal-Interglacial, and possibly they are of minor K-Ar-age. Assuming that the Tegelen-Interglacial is the oldest Pleistocene interglacial the Kelsterbacher Terrace is differently structured. Here the earliest Pleistocene is represented by the gravel beneath the Tegelen clay. In Marktheidenfeld as well the earliest Pleistocene seems to be missing; in the Main Valley, however, it is represented by high-level terraces called Upper, Middle, and Lower Main Terrace (KÖRBER 1962). On the Untermain such high-level terraces are equivalents of the Kelsterbacher Terrace from the Rhein-Graben region (SEMMEL 1969, cit. 1972 a). In spite of its greater number of top layers the fluvial complex of the profile of Kärlich can be well connected with the profiles of Mosbach and Marktheidenfeld, because the "obere Schotter" (according to BRUNNACKER et al. 1969, Abb.7) surely corresponds to the E-Terrace of KÖRBER ($\equiv t_{(2)}$-Terrace of SEMMEL, 1969), resp. the "Haupt-Schotter" corresponds to the A-Terrace ($\equiv t_{(1)}$-Terrace). In spite of some obvious similarities the differences within the sequence of the top layers might well be coincidental (SEMMEL 1972 a).

Recently it has been discussed at length under which climatic conditions these early Pleistocene sediments were deposited. Palynological findings (v. D. BRELIE 1966) and the occurrence of anorganic remnants of frost climate suggest glacial-age conditions for the colder sections. Recent faunistic investigations, however, yielded different and contradictory results (see ANDRES 1971; BRÜNING 1970; RUTTE 1971; SEMMEL 1969; HEIM 1970).

Thus the stratigraphical division of the early Pleistocene fluvial sediments is rather difficult; the stratigraphical analysis of the younger gravel terraces, however, is subject to even more uncertainty. Due to palynological findings v. D. BRELIE (1966) suggests that deposits of the Cromer-, Holstein-, and Eem-Interglacial lie above the early Pleistocene in the Oberrhein-Graben near Karlsruhe. These interglacial deposits are separated from one another by glacial-age gravel bodies. KAISER (1961) published similar sequences for the Niederrhein area, and summarized the terraces of the Mittelrhein Valley. According to this author there are below the Main Terraces three Upper Middle Terraces, the Middle and the Lower Middle Terrace as well as an Older and Younger Lower Terrace. The different terrace groups can be distinguished by heavy minerals that reflect the Pleistocene volcanism of the Schiefergebirge.

In the Limburger Basin ANDRES (1967) suggests another set of five younger terraces beneath the terraces that probably correspond to the Rhein-Haupt-Terraces (slightly different interpretation by BIRKENHAUER 1971). In the upper Lahn Valley, however, HEINE (1970, cit. 1971) suggests only three terraces beneath the Main Terraces. KÖRBER (1962) often describes at least five terraces in the Main Valley that are younger than the "early Pleistocene Mosbachium". In the Untermain area south of the Taunus a terrace complex holds six sections which are younger than the Mosbach sands. The two youngest ones date back to the last glaciation. The upper one is covered by loess (see KANDLER 1970, SEMMEL 1972 a). The terrace $t_{(5)}$ is covered by loess including a fossil B_t-horizon; the loess on top of the terraces $t_{(4)}$ and $t_{(3)}$ holds two fossil B_t-horizons, and the oldest $t_{(2)}$-terrace above the Mosbachium is veiled by loess which includes three fossil B_t-horizons. Thus at least nine individual gravel terraces can be specified in the Untermain area. Apart from the two oldest layers synsedimentary ice wedges were found in all other gravel layers. This terrace sequence is also visible in the narrow Main Valley cutting through the Spessart. Therefore its formation seems to be due to climatic rather than tectonic influences.

A similar amount of separate terraces can be seen in the area of the Mittelrhein and southern Niederrhein. Recently WINTER (1968) disputed the existence of the "Krefelder Middle Terrace" that is supposed to be developed between the Lower Middle Terrace and the Older Low Terrace. According to FRECHEN & v. D. BOOM (1959, cit. BRUNNACKER et al. 1969) the Older Low Terrace is built up by the layers Wuerm I, II, and III. This division, based on sedimentpetrographical studies, (see also FRECHEN & HEINE 1969, cit. FRECHEN 1971), seems to be subject to further discussion because of the dubious stratigraphical position of the "Brocken tuff" of Kärlich (BRUNNACKER et al. 1969). Already the younger section of the Low Terrace contains gravel of Laacher pumice tuff dating back to the Allerød.

The great amount of Pleistocene terraces in the valleys of the Rhein system causes doubts whether the stratigraphical findings of V. D. BRELIE (see p. 301) are really valid for the whole Rhein system. Presently no scheme of Pleistocene stratigraphy seems to be at hand to suffice this sequence of terraces.

This problem has already been discussed thoroughly by SEMMEL (1969, cit. 1972 a) and BRUNNACKER (1971). Furthermore it is still rather difficult to connect periglacial and glacial terraces. DONGUS (1963) e.g. stresses that the terraces in the valleys of the Schwäbische Alb do not correspond to the terraces of the Alpenvorland. And at the northern frontier of the periglacial area the connection of periglacial and glacifluvial terraces still holds many a problem (see e.g. KEMPF 1966; MIOTKE 1971; SEMMEL 1972 and the chapter Norddeutschland).

Initiating conditions of sedimentation or erosion in the periglacial area need further investigation. To ROHDENBURG's mind (1968, cit. 1971) a general Pleistocene sea level regression caused the great Quaternary fluvial erosion. BÜDEL (1969) on the other hand presumes that the wet early glacial phases mainly stimulated erosion; accumulation, however, occurred during the dry cold main glacialphase. The results of my own investigations (SEMMEL 1972 b) suggest gravel accumulation e.g. during the early wet cold Late Wuerm, followed by an incision of many rivers. Again accumulation was dominant during the later phases of the Late Wuerm. According to my results, only changes of the climate conditions can be held responsible for the alternating erosion and accumulation, even though it is doubtful whether this change of events also occurred during the Older Glaciations.

The following matter is still lacking a plausible explanation: After an intensive incision during the earliest Pleistocene, some of the valleys were filled up again (Talverschüttung). This can be shown both in the Rhein system (e.g. KÖRBER 1962; SCHRÖDER 1971; SEMMEL 1961, cit. 1972) and the Donau system (BRUNNACKER 1964). In many areas tectonic movements which influenced the Pleistocene fluvial processes are probably still not sufficiently known. BIRKENHAUER (1971) and HEINE (1971) discuss this matter with reference to the Rhein system.

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