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3. On the Pleistocene Vegetation History

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With 2 figures

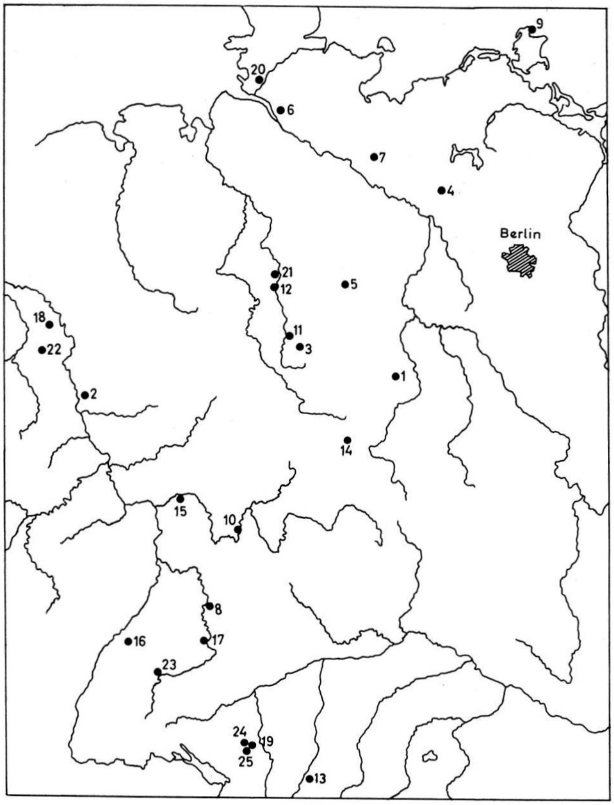
1. Introduction

When it was widely accepted that the Pleistocene of Northern and Central Germany comprised three glacial periods only, i.e. from oldest to youngest the Elsterian, Saalian, and Weichselian glaciations, it seemed to be an easy task to reconstruct the Pleistocene vegetation history, since only the Holsteinian and the Eemian warmperiods had to be taken into consideration. Difficulties arose, when in East Anglia the sediments of the Cromerian warmperiod were seen to belong to the Pleistocene and when it became increasingly clear, that this warmperiod consisted of two phases with warm and one with cold climate conditions. Moreover the observations in the Netherlands as to an even much more complicated older part of the Pleistocene were a challenge to Quaternary geologists and paleobotanists. As to Central Western Germany the situation was still worse since here in general a correlation of warmperiod sediments with river terraces, outwash plains or glacial sediments is only seldom possible. So the following remarks can only afford a glimpse of that what happened there during the Pleistocene.

2. How many warmperiods did exist?

Attempting to evaluate the number of Pleistocene warmperiods in the mountainous part of Western Germany between the areas of former Scandinavian and Alpine glaciations I refer to the following papers: ERD 1970: Artern, Voigtstedt, Dömnitz, Granzin, Pritzwalk, Kap Arcona; KAISER & SCHÜTRUMPF 1960: Bensberg; MÜLLER 1965: Bilshausen; GOEDECKE, GRÜGER & BEUG 1966: Elm; MENKE 1969: Ellerhoop, Nordende, Tornesch; MENKE 1968: Wacken; VODIČKOVA, unpubl.: Heilbronn, Pfefferbichl, Stuttgart-B 8, Stuttgart-Lauster, Winzeln; HEYDENREICH 1959: Marktheidenfeld; CHANDA 1962: Northeim; GRÜGER 1967: Osterholz; MAI, MAJEWSKI & UNGER 1963: Rippersroda; BAAS 1932: Schwanheim; KOLUMBE 1963: Steinbach; KEMPF 1966: Tönisberg; GÖTTLICH & WERNER, unpubl.: Unterpfauzenwald und Ziegelberg; RABIEN 1953: Wallensen; VON DER BRELIE, MÜCKENHAUSEN & REIN 1955: Weeze. In this list papers concerning adjacent regions are included, too, for better understanding the problems discussed below (see moreover FRENZEL 1968). The situation of the sites is given in fig. 1. Attempting to compare the pollen diagrams of the papers cited as to their relative age soon serious difficulties are met with. The reason for this is that

a) different types of sediments have been investigated which don't preserve the fossil pollen flora equally well,
b) the aim of the investigations differed from oneanother (geological dating or botanical investigation);
c) within the last twenty to thirty years much progress in pollen diagnosis has been achieved rendering a comparison of papers the age of which is different extremely difficult.



Artern u. Voigtstedt	1	Rippersroda	14
Bensberg	2	Schwanheim	15
Bilshausen	3	Steinbach	16
Dömnitz u. Pritzwalk	4	Stuttgart-Lauster }	17
Elm	5	Stuttgart - B 8 }	17
Ellerhoop, Nordende, Tornesch	6	Tönisberg	18
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Heilbronn	8	Unterpfauzenwald	19
Kap Arkona	9	Voigtstedt	1
Marktheidenfeld	10	Wacken	20
Nordende	6	Wallensen	21
Northeim	11	Weeze	22
Osterholz	12	Winzeln	23
Pfefferbichl	13	Wurzach	24
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Fig. 1. Topographical situation of the sites discussed

But in spite of this the pollen diagrams cited here must be compared with oneanother if the various warmperiod sediments should be grouped according to their relative age (always bearing in mind the difficulties just mentioned). Doing so (fig. 2) the following can be stated. There seem to exist some groups of warmperiod sediments, for instance thus:

a) Wallensen and Weeze;

b) Kap Arkona;

c) Dömnitz and Wacken;

d) Pritzwalk, Granzin, Wurzach, Pfefferbichl, Stuttgart-Lauster? Northeim? Unterpfauzenwald?

e) Winzeln, Tönisberg, Bensberg, Ziegelberg ?
f) Voigtstedt, Marktheidenfeld, Bilshausen (younger part);
g) Elm, Osterholz, Artern ?
h) Tornesch;
i) Ellerhoop;
k) Nordende;
l) Schwanheim and Rippersroda ?
m) Steinbach and Stuttgart — B 8
n) Heilbronn.

	Artern	Bensberg	Bilshausen	Dömnitz	?Elm	Ellerhoop	Granzin	Heilbronn	Kap Arkona	Marktheidenfeld	Nordende	Northeim	?Osterholz	Pfefferbichl	Pritzwalk	Rippersroda	Schwanheim	Steinbach	Stuttgart B 8	Stuttgart-Lauster	Tönisberg	Tornesch	Unterpfauzenwald	Voigtstedt	Wacken	Wallensen	Winzeln	Wurzach	Ziegelberg	Weeze
Artern		-	-	-	?	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bensberg	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	?	-
Bilshausen	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Dömnitz	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Elm	?	-	-	-		-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ellerhoop	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Granzin	-	-	-	-	-	-		-	-	-	-	?	-	+	+	-	-	-	-	?	-	-	-	-	-	-	-	+	-	-
Heilbronn	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kap Arkona	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marktheidenfeld	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Nordende	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northeim	-	-	-	-	-	-	?	-	-	-	-		-	-	?	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Osterholz	?	-	-	-	+	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pfefferbichl	-	-	-	-	-	-	+	-	-	-	-	-	-		+	-	-	-	-	?	-	-	?	-	-	-	-	+	-	-
Pritzwalk	-	-	-	-	-	-	+	-	-	-	-	?	-	+		-	-	-	-	?	-	-	-	-	-	-	-	+	-	-
Rippersroda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		?	-	-	-	-	-	-	-	-	-	-	-	-	-
Schwanheim	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?"		-	-	-	-	-	-	-	-	-	-	-	-	-
Steinbach	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		?	-	-	-	-	-	-	-	-	-	-	-
Stuttgart-B 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?		-	-	-	-	-	-	-	-	-	-	-
Stuttgart-Lauster	-	-	-	-	-	-	+	-	-	-	-	+	-	?	+	-	-	-	-		-	-	-	-	-	-	-	-	-	-
Tönisberg	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	+	-	?	-
Tornesch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-
Unterpfauzenwald	-	-	-	-	-	-	-	-	-	-	-	-	-	?'	-	-	-	-	-	-	-	-		-	-	-	-	?'	-	-
Voigtstedt	-	-	+"	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-
Wacken	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
Wallensen	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	+
Winzeln	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-		-	?	-
Wurzach	-	-	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	?	-	-	-	-		-	-
Ziegelberg	-	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-	-	-	?	-		-
Weeze	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	

+ correlation well established
? correlation open to debate
- correlation impossible

' = younger part
" = older part

Fig. 2. A comparison of the warmperiods discussed as to their vegetation history

With this grouping nothing is said as to the climatic conditions prevailing during the different warmperiods; it is only the aim of fig. 2 to see what warmperiod sediments can be lumped together as to their relative age.

The picture given here may surprise since it seems to indicate that the number of Pleistocene warmperiods was much greater than was hitherto held in Central Western Germany.

3. The character of the warmperiod vegetation

MENKE & BEHRE (1973) have discussed the character and some interesting details of Northern Germany warmperiods at some length. So here only some contributions are necessary.

a) Type Wallensen and Weeze

Without any doubt these warmperiods belong to the Eemian "interglacial" of Northern Germany. Details see in MENKE & BEHRE (1973).

b) Type Kap Arkona

In the area investigated only the description of warmperiod sediments of the type section of Kap Arkona on the Isle of Rügen are available (ERD 1970). Very early and rapidly *Quercus, Corylus* and *Taxus* were able to spread. *Ulmus, Fraxinus, Tilia* and *Alnus* could spread early, too, but their amount within the then pollenflora was appreciably small. *Carpinus* and *Picea* appeared astonishingly late. *Abies* was lacking.

c) Type Dömnitz and Wacken

In general *Pinus* and *Alnus* contributed much to the pollenrain. *Quercus, Ulmus, Fraxinus* and *Tilia* immigrated early at the beginning of the warmperiod. Only during its second part *Taxus, Corylus,* some *Carpinus* and *Picea* spread, *Picea* being the latest of all. *Abies* was lacking or its pollen could not be detected, since the last phases of this warmperiod are not represented in the diagrams. According to MENKE & BEHRE (1973) this warmperiod resembled strongly the Kap Arkona warmperiod. But there did exist some differences between both these warmperiods, the most significant of them being the very early immigration and strong amounts of *Taxus* and *Corylus* during the Kap Arkona warmperiod as compared with the Dömnitzian warmperiod.

d) Type Pritzwalk and Granzin

These warmperiod sediments belong to one of those types of warmperiods which are well known in Central Europe, i.e. to the Holsteinian warmperiod. MENKE & BEHRE (1973) described it at some length. Certainly the warmperiod sediments of the socalled Pfefferbichl and of the Wurzacher Becken (at about — 95 m) belonged to this "interglacial", too (FRENZEL 1973).

In the pollendiagram of Stuttgart—Lauster only the first part of a warmperiod is represented, together with the lateglacial of the preceding coldperiod. The warmperiod spectra are dominated by the pollen of *Picea, Pinus* and *Betula. Ulmus, Quercus, Tilia* and *Corylus* contributed only little to the pollenrain. The single pollengrains of *Carpinus* and *Abies* seem to originate from longdistance transport, but their amount rises at the end of the diagram so that it might be argued that soon the *Abies-Carpinus*-phase might have begun. All these facts point to a Holsteinian age of sediments, though alder was only weekly represented.

According to CHANDA (1962) the lacustrine clays of Northeim belong to the same warmperiod, too. The always remarkable contribution of *Picea, Ulmus, Tilia* and *Alnus* to the pollenrain seems to warrant this interpretation. But the Holsteinian age of these clays is not proven, since only a very short lapse of time of the warmperiod proper is represented in the diagram.

To the east of the Wurzacher Becken, some years ago warmperiod sediments were found near Unterpfauzenwald (lacustrine clays and fenpeat). Without anticipating a detailed paper by GÖTTLICH & WERNER it may be stated that the pollenflora between 1670 cm and 1740 cm seems to fit into the picture of the pollendiagrams of Wurzacher Becken and Pfefferbichl. The same does not hold true for the upper levels of Unterpfauzenwald. Here future investigations must clarify whether we have to deal with autochtonous or redeposited pollenfloras.

e) Type Winzeln and Tönisberg

The warmperiod sediments of Tönisberg and Bensberg are held to be of Holsteinian age, since the pollenflora was dominated by *Abies* (KEMPF 1966; KAISER & SCHÜTRUMPF 1960). But it is striking to see that *Carpinus* was lacking at the same time. This is in contrast to Holsteinian pollendiagrams. Moreover *Corylus* strongly contributed to the pollenrain, which is unlike the Holsteinian *Abies-Carpinus*-phase, too (Tönisberg). By these facts the warmperiod of Tönisberg and Bensberg strongly differed from Holsteinian type, but they resembled those of Winzeln and Ziegelberg (VODIČKOVA, unpubl.). Recently the Ziegelberg warmperiod was held by GÖTTLICH & WERNER (1967) to be of Holsteinian age but then only few pollen samples could be counted.

f) Type Voigtstedt and Bilshausen

At Voigtstedt only the end of a warmperiod was met with, characterized by the sudden and simultaneous decline of the pollencurves of *Ulmus, Abies, Carpinus, Alnus* and *Tilia*. These woody species seem to have dominated the forest a little earlier. Only when they had retreated *Picea* and *Pinus* spread. The same seems to hold true for the pollendiagram of Marktheidenfeld (HEYDENREICH 1959) and for the younger part of the Bilshausen warmperiod (zones i to k, MÜLLER 1965). To me it is questionable, whether the whole of the Bilshausen warmperiod, the socalled "Rhume warmperiod" (zones c to k, MÜLLER 1965) indeed belong to one warmperiod only since the older and the younger parts are devided from oneanother by a phase with dominating nonarboreal pollen, pine and birch.

g) Type Osterholz

According to the careful investigations by GRÜGER (1967 and GOEDECKE, GRÜGER & BEUG, 1966) the warmperiod sediments of Osterholz and the Elm Mt. were accumulated in one warmperiod only. It began after the end of the preceding lateglacial with the strong dominance of *Ulmus* and *Quercus*. Other woody species seem to have contributed only little. One point of interest is that *Corylus* only very late in the warmperiod began to spread and that its contribution to the pollenrain was even then always very weak. At the same time, when *Corylus* began to spread *Carpinus* began to dominate, accompanied by *Eucommia*. At the very beginning and the end of the warmperiod proper *Picea* was of some importance, together with the strongly dominating pine trees. By the very late spread of *Corylus*, by the presence of *Eucommia* and by the fact that *Abies* was lacking, this warmperiod strongly differed from both parts of the Rhume warmperiod but it resembled the Arterian warmperiod (ERD 1970), though *Carpinus* was lacking in Artern. But this may be caused by to small a number of levels being analyzed at Artern.

h) Types Tornesch, Ellerhoop, Nordende

These warmperiods have been described by MENKE & BEHRE (1973) so that a discussion is not neccessary here.

i) Type Schwanheim

According to BAAS (1932) the pollenflora of the warmperiod sediments of Schwanheim is dominated by *Tsuga, Carpinus* and species of the mixed oak forest, together with *Abies* and *Pterocarya*. Many plants characteristic for the Tertiary could be found, too. It is striking to see that none of the warmperiods discussed hitherto seems to have been the equivalent of the Schwanheim warmperiod. But the fossil flora of Rippersroda (MAI, Majewski & Unger 1963) resembled it strongly as far as the younger part of this profile is concerned (depth of 11,5 to 16,0 m). Perhaps the warmperiod of the socalled Uhlenberg (Zusamplatte, Southern Germany) resembled it, too, by its strong amount of the pollen of *Pterocarya* and *Tsuga* (Frenzel 1973). But it is not clear whether these similarites suffice to synchronize the three warmperiods discussed.

k) Type Steinbach

Kolumbe (1963) felt that the warmperiod sediments of Steinbach near Baden-Baden belong to the Holsteinian warmperiod. Since plant species characteristic of the Tertiary or of the older part of the Pleistocene are lacking it seems to be sure that the Steinbach flora belonged to some time of the Middle or to the younger part of the Older Pleistocene. But I am not convinced that Kolumbe was right, since the older part of the Steinbach warmperiod was characterized by strong amounts of *Carpinus* and *Quercus* (some 30 % each). *Abies, Ulmus* and *Tilia* were lacking then. The role of *Picea* was very unimportant. Only at the end of the *Carpinus-Quercus* pollen assemblage *Picea* and *Abies* were able to spread. These facts are in contrast to all pollendiagrams hitherto known from Holsteinian time. Moreover at that time, when in Holsteinian pollendiagrams *Carpinus* had contributed much to the pollenflora, i.e. during the *Abies-(Picea-)*phase, hornbeam was nearly lacking at Steinbach. During both these phases just discussed the rôle of *Corylus* was negligible. In view of these facts it seems to me impossible to synchronize the Steinbach and the Holsteinian warmperiods. It is true that it is nearly impossible to compare the Steinbach pollenflora with all the other pollenfloras just mentioned, too. But there seem to exist similarities to the fossil pollenflora of Stuttgart B 8 (Vodičkova, unpubl.), if at Steinbach the levels at about 11,64 m depth are considered: In both these diagrams the pollenflora was dominated by *Abies* and *Picea.* The rôle of *Quercus, Tilia, Carpinus* and *Ulmus* could nearly be neglected. Yet the pollendiagram from Stuttgart B 8 is too short as to render a reliable synchronization possible.

l) Type Heilbronn

The Heilbronn warmperiod seems to have been only of interstadial rank (Vodičkova, unpubl.). This is shown by an always high percentage of nonarboreal pollen (30—40 % of the general pollen sum) and the predominance of pine, birch and oak in the forested area. *Corylus* and other thermophilous tree species were nearly lacking. The same holds true for spruce and for shade demanding plants.

4. The age of the warmperiods

As already mentioned there can be no doubt as to the Eemian age of the warmperiod sediments of Wallensen and Weeze.

The Holsteinian warmperiod is clearly represented by the pollendiagrams of Pritzwalk, Granzin, Wurzach, Pfefferbichl and perhaps of Stuttgart-Lauster, Unterpfauzenwald and Northeim, too.

According to Erd (1970) and Cepek (1968) the sediments of the Kap Arkona warmperiod were found lying between two tills of Saalian age (Saale 2 and 3), being covered by the Weichselian tills.

Erd (1970) and Menke (1968) observed that the sediments of the Dömnitzian warmperiod were accumulated only after the end of the Holsteinian warmperiod. Between both these periods lay a time of extremely cold climate. It must be stressed that according to ERD and MENKE the Dömnitzian sediments were found on top of the cold climate sediments and the Holsteinian layers in one exposure or borehole only. So it is proven that the Dömnitzian warmperiod followed the Holsteinian. But it was older than the Eemian warmperiod and the Saalian glaciation.

The warmperiods of Tönisberg and Bensberg were obviously of the same age. They may be looked upon here as belonging to the "Tönisberg warmperiod", since KEMPF (1966) gave a valid description of this site. At Tönisberg the warmperiod sediments are situated on top of the socalled Mittlere Mittelterrasse (Rinnenschotter), but are covered by the sediments of the Untere Mittelterrasse. The "interglacial" sediments are called by KEMPF "Kempen-Krefelder Schichten". These layers and those of the Untere Mittelterrasse were folded and dislocated by a glacier advance. From this KEMPF concluded that the Kempen-Krefelder Schichten belong to the Holsteinian warmperiod. As has been already stressed this is not corroborated by the pollenflora. Moreover it should be borne in mind that according to KOWALCZYK (1969) the real age of the middle terraces of the river Rhine is open to debate. Last not least BRUNNACKER (1967a) stated that on top of the Untere Mittelterrasse fossil soils of two warmperiods of interglacial rank can be found.

From this it follows that according to pollenanalysis and geomorphology the Tönisberg warmperiod is probably older than the Holsteinian. The geological setting of the warmperiod sediments described by KAISER & SCHÜTRUMPF equals those of Tönisberg. It must be regretted that the geological setting of the Winzeln and Ziegelberg warmperiod sediments is of little value as to the stratigraphical position of the Tönisberg warmperiod: The Winzeln sediments fill a karstic sink-hole, being covered by loess loam. Those of Ziegelberg were found lying between two tills the sediment petrography of which was different from oneanother. The upper one was held to be of Rissian age, the lower one of Mindelian age. So it was thought that the warmperiod sediments were accumulated during the Mindel/Rissian warmperiod, which was held to be the equivalent of the Holsteinian. Whether this synchronization is possible may be doubted (FRENZEL 1973). At any rate the evolution of the Ziegelberg fossil flora is not matched by that of Holsteinian type.

As has been shown the warmperiod sediments of Voigtstedt (Voigtstedt-Warmzeit, *sensu* ERD), of Marktheidenfeld and of Bilshausen (younger part) may be lumped together as belonging to the "Rhume warmperiod". The sediments of this warmperiod are found at Bilshausen lying below layers and soil horizons of two warmperiods of presumably interglacial rank. It must be regretted that the Bilshausen loess profile seems not to have been investigated as to its fossil soils. The site of Marktheidenfeld is covered according to BRUNNACKER (1964) by sediments with three fossil "interglacial" soils. The warmperiod sediments of Voigtstedt lie under till of the Elsterian glaciation (ERD 1970; CEPEK 1968; RUSKE 1965). So the Rhume warmperiod must be older than the Elsterian glaciation and it must be appreciably older than the Holsteinian warmperiod, too. But from a botanical point of view the Rhume warmperiod is not identical with the Tönisberg warmperiod. In my opinion it should be older than this.

As to its geological consequences the Osterholz warmperiod has become a stumbling block for quaternary geologists (Osterholz, Elm, and presumably Artern, too). This is caused by the fact that the warmperiod sediments of the Elm Mt. were found between two tills. On the other hand the sediments of the Elm Mt. and those of Osterholz were accumulated simultaneously, those of Osterholz having been covered lateron by till of the Elsterian glaciation (GRÜGER 1967). From this it follows that the Elsterian glaciation was preceded by a still older one, which reached the Central German mountains. It was already stated that the sediments of the Osterholz and the Rhume warmperiods were not accumulated simultaneously. If it be possible to synchronize the Osterholz and the Arternian warmperiods it must be concluded that the Osterholz warmperiod was older than the Rhume warmperiod since the Arternian warmperiod is older than the Voigtstedtian warmperiod which can be synchronized with the Rhume warmperiod.

The geological setting of the Nordende, Ellerhoop and Tornesch warmperiods has been discussed by MENKE & BEHRE (1973) sufficiently. It could be seen that the vegetation history of these warmperiods did not resemble that of the Schwanheim and Rippersroda fossil floras. On the other hand the fossil floras of Schwanheim and of Rippersroda resemble each other. The organogenic sediments at Schwanheim ware found lying on top of fluviatile sediments containing big boulders the corners of which were not rounded. From this BAAS (1932) concluded that the Schwanheim warmperiod was preceded by a coldperiod, and MAI, MAJEWSKI & UNGER (1963) feel that it might be possible that the same holds true for the Rippersroda flora, too. As long as the climatic conditions of the preceding coldperiod cannot be evaluated sufficiently it is impossible to judge whether both these fossil floras still belonged to the Pliocene or were already of Pleistocene age. At any rate it must be stressed that the fossil flora of Schwanheim and Rippersroda held an intermediate position between those of the Reuverian and the Tiglian. In my opinion the fossil floras of Schwanheim and Rippersroda already belonged to the Pleistocene. Perhaps the name "Schwanheim warmperiod" is quite appropriate.

Reliable hints as to the age of the Steinbach and Stuttgart B 8 fossil floras seem to be lacking. As was already shown it seems to be impossible to synchronize the Steinbach warmperiod sediments with those of the Holsteinian. On the contrary there do exist clear divergencies between the trend of vegetation history of these two warmperiods. On the other hand plant species indicative of Pliocene or Early Pleistocene time are lacking. The sediments of Stuttgart B 8 (fluviatile clay and silt) were found at the base of travertine which in turn was covered by loess (Höfersche Ziegelei, SOERGEL 1919). According to observations made by REIFF & FRENZEL (unpubl.) in this loess at least two fossil Parabraunerde soils can be found. The lower one was formed on still older loess, which lies on solifluction material (1,65 m thick). This sediment covers a third strongly developed Parabraunerde. It can be suggested that the travertine just mentioned was situated under this third fossil soil. Moreover it must be stressed that the Stuttgart B 8 sediments are covering an old terrace of the river Neckar, some 22 m above its present level and some 15—17 m above the sediments of Stuttgart-Lauster which presumably date from early Holsteinian time. On the other hand it seems to be impossible to think of very old sediments as Stuttgart B 8 is concerned, since exotic plants are lacking there. As has been stated already it seems to be possible to correlate the Stuttgart B 8 sediments with those of Steinbach (depth of 11.64 m). But there a geological dating is rather difficult since the thick sediments covering the warmperiod "Moorkohle" have not been investigated recently. According to older observations (KOLUMBE 1963) on top of the "coal layer" gravels of the socalled Mittel- and of the Hochterrasse were found, being covered by loess and loess loam of several meters thickness. If so, it must be admitted that the Holsteinian age of the Steinbach warmperiod from a geological point of view is not sure, rather it might be much older. The age of the Heilbronn interstadial (VODIČKOVA, unpubl.) cannot be given with certainty. The warmperiod sediments are situated here on an old terrace of the river Neckar, being covered by 14 m of gravels and loam. Perhaps one may think of middle-pleistocene age.

As could be seen our knowledge of the Pleistocene history of Central Western Germany is still very bad. Yet the question must be answered whether this uncertainty is only the consequence of former strong regional differences in warmperiod-vegetation. This would mean that in reality the number of warmperiods might have been small but that strong regional differences in flora and vegetation gave the fallacious picture of much more warm periods. In this connection the following must be stressed: Without any doubt the Schwanheim warmperiod was older than all the other warmperiods discussed here. The warmperiod sediments of Tornesch, Ellerhoop and Nordende near Lieth can be observed in one exposure, only, lying on top of each other. Moreover the warmperiod sediments of Artern and Voigtstedt were found in one borehole only, lying on top of eachother, too. The same holds true for the Pritzwalk and Dömnitz warmperiods. The sites of Bilshausen, Osterholz and of the Elm Mt. are situated very close to eachother so that the possibility can be ruled out that local differences in vegetation caused the fallacious picture of different warmperiods. Last not least it is quite clear that the Eemian and the Holsteinian warmperiods differed from eachother strongly. So it must be admitted that the number of pleistocene warmperiods was appreciably great. Their stratigraphical position is given — hypothetically — in table 1.

Table 1.

An attempt for a stratigraphical division of the pleistocene

			MENKE & BEHRE (1973)
Postglacial			Postglacial
Weichselian coldperiod			Weichselian coldperiod
Eemian warmperiod			Eemian warmperiod
Kap Arkona warmperiod		Saalian	coldperiod
Dömnitzian warmperiod			Wacken-Dömnitzian warmperiod
Fuhne coldperiod			Mehlbeck coldperiod
Holsteinian warmperiod			Holsteinian warmperiod
Steinbach warmperiod	Elsterian		Harreskov warmperiod ?
Tönisberg warmperiod	coldperiod ?		? coldperiod B
Rhume warmperiod			Rhume warmperiod
?			coldperiod A
Osterholz warmperiod			Osterholz warmperiod
Elbe coldperiod			Elbe coldperiod
?			Pinneberg warmperiod
?			Elmshorn coldperiod
?			Uetersen warmperiod
?			Pinnau coldperiod
?			Tornesch warmperiod
?			Lieth coldperiod
?			Ellerhoop warmperiod
?			Krückau coldperiod
?			Nordende warmperiod
?			Ekholt coldperiod
Schwanheim warmperiod			?
?			Barmstedt Stufe
Pliocene			Pliocene

Comparing both these attempts it is striking to see that in Northern Germany the Kenocene (as defined by MENKE) was composed of much more cold and warmperiods respectively than in Central Western Germany. On the other hand here seem to exist more hints as to a finer stratigraphic division of the older pleistocene *(sensu* MENKE) than in Northern Germany. If both these attempts approached somewhat reality, the Kenocene and the Pleistocene should have been divided by a very great number of warmperiods. Comparing this with the stratigraphical division of the pleistocene as revealed by loess and fossil soil stratigraphy of Central Europe it may be seen that the division given here is not entirely impossible. Moreover SEMMEL (1973), BRUNNACKER (1967) and BRUNNACKER, HELLER & LOŽEK (1971) have stressed that the division of the Pleistocene was much more complicated than it was thought previously. It might be argued that one or the other of the old Pleistocene warmperiods *(sensu* MENKE) in reality belonged to the Kenocene, thus reducing the number of warmperiods. But it must be remembered that the character of flora and vegetation as well as the geological position at least of the Tönisberg warmperiod does not favour this.

It seems to me that not only the Kenocene was much more complicated than was hitherto thought (MENKE & BEHRE 1973), but that the same holds true for the Older Pleistocene and Middle Pleistocene as well.

5. Coldperiod vegetation

The oldest coldperiod vegetation and flora of Northern Germany has been described already by MENKE & BEHRE (1973). In the mountainous area of Central Germany comparable observations are lacking. Here the oldest hints as to cold climate vegetation and flora date from the lateglacial of the Elbian coldperiod. The vegetation of that time was roughly comparable to that of lateglacial phases of younger coldperiods. The vegetation was dominated by *Gramineae, Juniperus, Salix, Artemisia, Chenopodiaceae, Filipendula, Thalictrum* and *Ephedra distachya.* The rôle of ericaceous plants seems to have been astonishingly small (in general only *Calluna,* GRÜGER 1967). The significance of *Empetrum* was still less. This plant, together with *Selaginella* and *Helianthemum* seems to have appeared only some time before the beginning of the Rhume warmperiod. Yet it is questionable whether the socalled steppe-tundra which was so characteristic of later coldperiods began to form only then or whether it existed already for a long time but the remains of it were not yet found. In this connection it must be stressed that some finds of *Myrica* date from lateglacial times of the Elbian glaciation indicating that the climate was much more oceanic than during later coldperiods.

The fullglacial vegetation of much younger coldperiods was investigated by VODIČKOVA (unpubl.) and by FRENZEL (1968). The fullglacial sediments of Mühlacker (to the northwest of Stuttgart, VODIČKOVA; presumably from the last but one glaciation) contained a rich nonarboreal pollenflora being dominated by *Centaurea scabiosa, Plantago media, Helianthemum, Scabiosa, Gentiana, Daucaceae, Heracleum*-Type, *Artemisia, Thalictrum, Bupleurum* and *Botrychium,* together with quite a lot of other interesting plants. Comparable with this was the herb flora near Kitzingen on the river Main (FRENZEL) in which loess was accumulated during the last coldperiod.

Investigations of the interstadial vegetation in the area under discussion have begun only. As was already said the climate during the Middle-Pleistocene (?) Heilbronn interstadial must have been relatively warm as may be seen from the high amount of *Quercus* pollen (about 15 %), accompanied by a rich aquatic flora being dominated by *Sparganium*-type, together with *Sagittaria, Myriophyllum, Nuphar, Potamogeton* and others. On dry habitats amongst the copses of pine, birch and oak *Daucaceae, Artemisia, Silenaceae, Thalictrum, Centaurea, Rosaceae* and others seem to have thrived abundantly (VODIČKOVA, unpubl.). Presumably still older are warmperiod sediments of interstadial rank, found near Jockgrim, Rheinzabern, and Herxheim (Vorderpfalz; PETERS 1965). Moreover it seems to be questionable whether all the warmperiod sediments discussed earlier were formed within periods of interglacial character. The scepticism is caused by the essential rôle having been played by light-demanding trees as for instance during the Kap Arkona and Dömnitz warmperiods.

Presumably from the beginning of the last coldperiod, perhaps being equivalents of the Amersfoort or Brørup interstadials, date organic sediments filling fossil karstic sink holes (VODIČKOVA, unpubl., Stuttgart, Hauptstätterstraße). During these interstadials besides the riverine alder thickets *Picea* and *Abies* seem to have dominated the forests within the Stuttgart basin which is so warm today. Pine, birch and hazel shared only little to the pollenrain. It must be suggested that pollen grains of oak, hornbeam, linden, maple, elm and others were either redeposited or originated from long distance transport. It is not possible to give reliable indications as to the age of these sediments nor is it possible to synchronize them with the interstadial observed in the socalled Wellheimer Trockental, near Neuburg on the river Donau by SCHÜTRUMPF (1951) and being reinvestigated now by BRANDE.

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