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MID-PLEISTOCENE GRAVEL AGGRADATIONS AND THEIR COVER-LOESSES IN THE SOUTHERN LOWER RHINE BASIN

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Along the Lower Rhine, stratified accumulations of gravel with intercalated interglacial deposits have long been known from within the Mittelterrassen sequence. In the Köln-Krefeld region, where such gravel deposits have been studied most frequently /see Kaiser&Schütrumpf, 1960, Kempf, 1966/, they have been assigned, wherever they occur in a concordant succession, to that sequence of sedimentation terminating in the Untere Mittelterrasse. Thus from Kempf /1966/:

Untere Mittelterrasse	Drenthe
Kempen-Krefelder Schichten	Holstein
"Rinnenschotter"	Elster/Holstein

Here the Untere Mittelterrasse refers to that of the Grevenbroich-Krefeld district, which is not necessarily identical to the Untere Mittelterrasse of other areas, cf. Winter, 1968/, that is to Mittelterrasse III /MT 3/ in the terminology of the Köln school.

The age-determination of this gravel aggradation is concluded from the interrelationship between the Untere Mittelterrasse and the Drenthe-age ice advance into the Lower Rhine valley /see Kaiser, 1961/, and from the interglacial nature of the Kempen-Krefelder Schichten /most recent references Kempf, 1966/.

One of the localities, where this gravel aggradation is present, is the Braunkohlen-Tagebau Frimmersdorf West, north-west of koln.

GRAVEL DEPOSITS AND COVER-LOESSES IN THE TAGEBAU FRIMMERSDORF-WEST

The gravel strata exposed in the pit at Frimmersdorf West near Grevenbroich are subdivided into two by freshwater pond sediments /Frimmersdorfer Schichten/. These occur in the lower part of the gravels in association with a channel which, at the base of the gravels, is cut down into the underlying, lignite-bearing Miocene strata /figure 1/. According to v.d. Brelie, Kilpper and Teichmüller /1959/ the peaty silts yield pollen spectra of interglacial type. Of particular note is the occurrence in abundance of Juglans, Pterocary and also Keteleeria-like /coniferous/ pollen.

The basal gravels of this terrace aggradation formerly showed well-developed cryoturbation structures /see v.d.Brelie et al, 1959/ table 1/. Within the gravels above the interglacial strata, towards the top where fine-grained sediments occur, ice-wedge casts and

again cryoturbation structures can be recognized. Above the redeposited, water-lain loess and flood loam which complete this sequence of terrace sedimentation, a fossil soil complex is developed. The terrace carries a 15 m thick sequence of cover deposits, which consists of three loess beds of glacial age, each separated by a fossil interglacial soil complex.

According to v.d.Brelie et al., /1959/, the upper gravel of the Frimmersdorf aggradation being Drenthe in age, then the cover-loesses belong in their entirety to the Würm glacial period, but according to Paas /1968 a,b/, the loesses are ascribed to both Saale and Weichsel glacial periods /see further discussion in §5/.

However, since there are three cold climate cover loesses which post-date the gravel aggradation and since these are separated not only from the gravel but also from each other by interglacial soil complexes, then the upper part of the gravel must be ascribed at least to the fourth-last glacial period and the Frimmersdorf interglacial beds at least to the fourth-last interglacial /see table. 1/.

Consequently, the Frimmersdorf gravel aggradation can no longer be correlated with the Untere Mittelterrasse of the Grevenbroich area /MT 3/. From the terrace succession, from the maximum number of cover deposits, likewise from its relationship with the advan ce of the northern inland ice, the MT 3 gravel aggradation must be younger in age. The only profile of cover deposits described from that terrace surface occurs at Rheydt-Giesenkirchen and there, according to Brunnacker /1967/, shows two cold climate beds above the terrace.

MIDDLE PLEISTOCENE GRAVEL AGGRADATIONS ALONG THE SOUTHERN LOWER RHINE

From this it appears that there are at least two Mittelterrassen along the Lower Rhine, each with a gravel aggradation consisting of a relatively thin lower gravel. a fine-grained interglacial middle horizon and a well developed upper gravel. As far as the climatic indications for the upper and lower gravels are concerned, at Frimmersdorf the upper gravels show obvious cold-climate features: ice-wedge casts, cryoturbation and festooning. At present at most only c.1.5 m of deposits with festooning are exposed at the base of the lower gravel. In fact, from their position and the sediments involved /with, at the margin of the channel, reworked lignite pocketed down into fine-grained Tertiary sand/ these latter features could just as well be interpreted as load-cast phenomena without any cold climate implications. However, in the Tagebau Fortuna-Garsdorf, where again a fluviatile aggradation occurs, equivalent in its appearence and height relationships to the gravel aggradation at Frimmersdorf /see Heller & Brunnacker, 1966/, a synsedimentary ice-wedge cast was exposed in the basal gravel in 1969.

If every lower and upper gravel stratum of such an aggradation were to represent an individual glacial period, then this would imply a very large number of such cold periods, in agreement neither with the maximum number of cover deposits found overlying the terraces, nor with the terrace subdivision of other areas, for example of the

Middle Rhine. Thus, the answer must be that the basal gravel of an aggradation must at times represent the final stages of the glacial period associated primarily with the upper gravel of the next gravel terrace up, i.e. the basal gravels form a transition to the succeeding interglacial /Schirmer, 1969/. In that case the main interval of erosion takes place towards the end of a glacial period. Šibrava /1972/, from a study of terrace aggradations in the ČSSR and from comparable studies elsewhere in Europe, comes to the conclusion that the main erosion, generally associated with the maximum extent of glaciation, takes place in the second half, i.e. towards the end of glacial periods.

If we accept this erosion-accumulation hypothesis, then the lower three Mittelterrassen /MT 2-4/ correspond successively to the second to fourth glacial periods before present, and the maximum proved number of their associated cover-beds and interglacial soils corresponds to the number of cover.beds expectable for terraces of those ages /see table 1/.

THE SUBDIVISION OF THE COVER-BEDS IN THE TAGEBAU FRIMMERSDORF WEST

The cover-beds in the Frimmersdorf West pit, which are exposed along a face almost 4 km long, are subdivided by soil complexes /see figure 1/.

The lower soil complex which can be traced over a distance of c. 1,500 m rests directly on the fluviatile top stratum on the Frimmersdorf gravel aggradation. A Parabraunerde soil has been formed on heavily gleyed, reworked loess and flood loam; laterally this passes at a slightly higher level into pseudogley and gley soils; this soil is capped by a humus zone. Above this, with a barely perceptible discordance, follow sandy, silty flood-wash sediments on which a partly pseudogleyed Parabraunerde soil has formed. Again this is succeeded by a humus zone and above that by a well developed loess.

The middle soil complex is only preserved where formerly a gentle slope occurred. In two sections of the wall of the pit some 2 km apart, it could be traced for distances of 300 m and 200 m respectively. Regularly separated by a depth apart of 1.5-2 m, B_t horizons of two Parabraunerde soils rest one above the other, the upper soil being weakly pseudogleyed. The lower soil is succeeded by a very weak humus horizon, the upper by a more distinct one and then by a well developed loess.

The upper soil complex is only present on the edge of a dell, 500-600 m east of the former farmstead St. Leonard. It consists of a pseudogleyed B_t horizon of a Parabraunerde soil, overlain by a remarkably dark, thick humus zone.

For the soils of both the lower and middle complexes the significance of the individual B_t horizons and their intervening layers is in question. Because the soils lie over such long distances virtually parallel and close together, the possibility that the interval between the two B_t horizons conceals a full glacial period seems highly unlikely. Had that been the case, then, from our present

knowledge of the behaviour of fossil soils, one would not expect the upper soil in each case to reflect the relief of the lower so constantly. After the upheaval of a glacial period with, in turn, soilwash, solifluction and drifting of loess, there should develop - especially here at the foot of the Rhine Hauptterrasse - a relief which has been quite altered in detail before the onset of the next interglacial.

Thus it can only be assumed that between the B_t horizons /i.e. their soil equivalents/ there is represented a rather drastic cold oscillation within an interglacial period, when the closed vegetation cover and the soil development gave way to reworking, even to short periods of loess accumulation.

THE EVALUATION OF THE INTERGLACIAL SOIL COMPLEXES

Similar relationships prevail in the west German region to those already known for some years from the ČSSR, namely that an interglacial period is represented in the soils/cover beds series by a soil complex with paired closely spaced soils usually of interglacial type, such as Parabraunerde /see Kukla, 1969, and older refs. cited there/. Both soils may show a more or less similar development, as for example in the younger soil complexes of the ČSSR, PK IV and PK V, which are assigned to the penultimate and antepenultimate interglacial periods.

In the Frimmersdorf West pit it is the two lower soil complexes which show similarly developed soils, in each case of interglacial type. According to the terrace and cover-bed succession shown in table 1, these too from their minimum age belong to the penultimate and antepenultimate interglacials. This then presents a good analogue to the Czechoslovakian cover-beds subdivision.

The evidence from such interglacial soil complexes is a reminder that, where cover-bed profiles are reckoned up with every soil of interglacial type ascribed to an individual interglacial period, they or their underlying sediments appear to be much too old. To set up a glacial-interglacial sequence it is necessary to present evidence not only of interglacial soil type but also of periglacial sediment sequences characterized in loess profiles by solifluction phenomena, slopewash sediments, loesses and intercalated interstadial soils amd being represented by a reasonable thickness of sediment. As the Frimmersdorf exposures and also many Czechoslovakian examples show /Kukla, 1969/, the presence of thin loess beds, even of frost cracks and small cryoturbation features, is not sufficient to demonstrate that two interglacial soils are separated by a glacial period. That is to say, under unfavourable circumstances two discordant soils from distinct interglacial periods, lying closely associated, might be almost indistinguishable from two successive more or less concordant soils belonging to a single interglacial soil complex. In sich cases the profiles are not suitable for stratigraphical subdivision of the Quaternary period. Often, however, the study of laterally extensive profiles and the morphological behaviour of the soils, as opposed to the usual columnar profiles which get described, can yield more information about the relationship of two soils of interglacial type.

COMMENTS ON EARLIER ACCOUNTS OF THE COVER-DEPOSITS IN THE TAGEBAU FRIMMERSDORF WEST AND ALONG THE LOWER RHINE

Paas in his dissertation /1961/ studies a 1 km long section of the 4 km face showing the cover-deposits in the Frimmersdorf West pit. Further consideration of the same data appears in his later papers /Paas 1968 a,b/. Of the five soils of interglacial type described in the present work and forming the three soil complexes shown in figure 1, Paas in his papers described three. These are the two soils of the middle complex - the Erkelenzer and Rheindahlener soils in Paas's terminology - and the upper soil of the lower complex - Paas's Wegberger soil.

The type profiles for these soils, at Erkelenz, Rheindahlen and Wegberg, are all to be found overlying the Early Pleistocene Jüngere Hauptterrasse of the Rhine. From Paas's account these localities show very incomplete cover-deposit profiles with at most three soil horizons overlying the Early Pleistocene strata. Therefore, at their type localities, no evidence of any kind can be obtained for the age of these soils. Consequently, Paas /1968 a,b/ correlated the soils of the Frimmersdorf West pit as follows: assuming that the fluviatile gravels below the cover-deposits at this site to be the Untere Mittelterrasse of Drenthe age and a complete succession of cover-deposits to be present, then the Wegberger and Rheindahlener soils are assigned an intra-Saalian age and the Erkelenzer soil an Eemian one. Recently the Rheindahlener soil has also been assigned to the Treene interglacial, the Wegberger soil to the "younger Holstein interglacial" and thus the "Untere Mittelterrasse" into some cold phase within the Holstein interglacial /Maas et al, 1971, p. 337/.

Since, as already described in this article, the soil/cover-loess sequence at Frimmersdorf West is more complicated than Paas suggests, and therefore the fluviatile strata below the cover deposits rather older, then the basis for Paas's conception of the time-stratigraphy of the loesses of the Lower Rhine falls to pieces.

CONCLUSIONS

On the basis of investigations in the Tagebau Frimmersdorf West, at least two terraces with gravel aggradations of Middle Pleistocene age can be demonstrated. An older gravel aggradation, within which are intercalated the Frimmersdorf interglacial beds, has its uppermost fluviatile strata dating to at least the fourth glacial period before present. On the next terrace level down follows the younger gravel aggradation, in which are intercalated the Kempen-Krefeld interglacial beds /Kempf, 1966/, and here fluviatile aggradation terminated during at least the third glacial period before present /see table 1/. Its uppermost gravels are believed to involved with the Drenthe-age advance of the inland ice into the Lower Rhine valley.

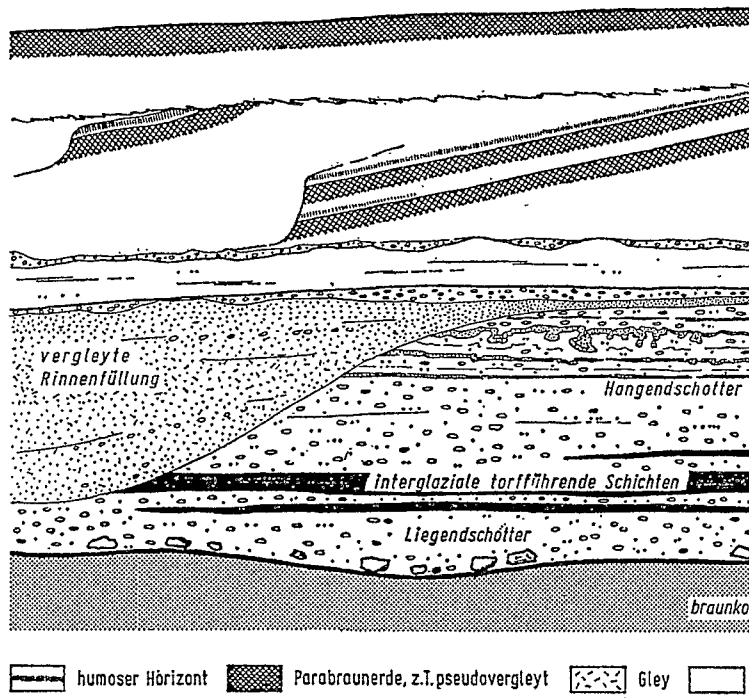
From the construction and age of the gravel aggradations, it is concluded that the erodional phase preceding the development of terrace aggradations of this sort takes place during the latter part of

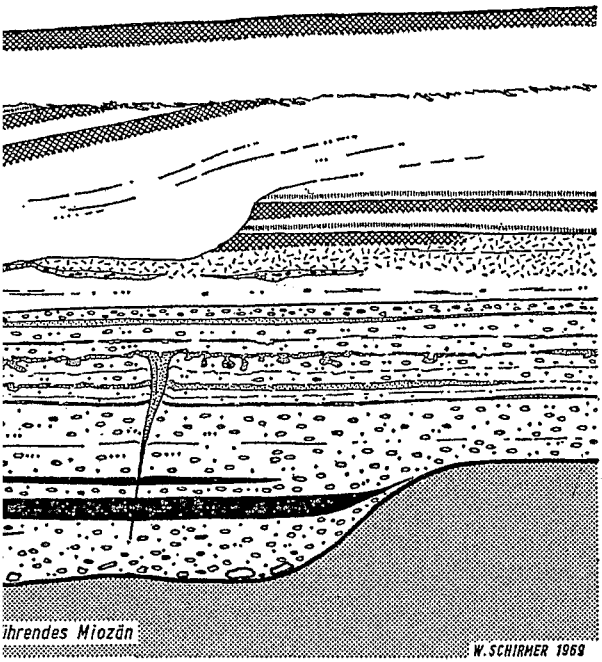
a glacial period and, therefore, the basal gravel of such a terrace represents the final phase of a glacial period or even the onset of the succeeding interglacial.

Within the cover-loess deposits of the Tagebau Frimmersdorf West, there occur interglacial soil complexes each containing two equally developed soils of interglacial type /figure 1/. From their appearance and stratigraphical position they appear to be the equivalents of the PK IV and PK V soil complexes of Czechoslovakia /Kukla, 1969/, which again supports the correlation suggested above for the Frimmersdorf fluviatile and cover-deposit series.

The evidence for these interglacial soil complexes containing several stratigraphic units, developed under such favourable regional conditions in the Rhineland, stressed the necessity of interpreting the Quaternary stratigraphy of complex, multibedded loess profiles not only from the number of soil horizons they show, but also by demonstrating that the intervening horizons are unquestionably of glacial age.

Fig. 1


vergleyte
Rinnenfüllung
Hangendschotter
interglaziale torfführende Schichten
Liegendschotter
braunkohl
humoser Horizont
Parabraunerde, z.T. pseudovergleyt
Gley



Sand und feinklastische Sedimente · Schotter

Table 1:

Position of the Frimmersdorf interglacial within the Mittelterrassen system of the Lower Rhine

Terraces	Subdivision	Glacial periods before present	Cover-beds
Niederterrasse		1st glacial period B.P.	no cover-beds
MT IV Krefelder Mittelterrasse		Eem 2nd glacial period B.P.	at most 1 present
MT III	Hangendschotter /Untere Mittelterrasse/	Interglacial 3rd glacial period B.P.	at most 2 present
	Kempen-Krefelder Schichten	Holstein	
	Liegendschotter /"Rinnenschotter"/		
MT II	Hangendschotter	4th glacial period B.P.+	at most 3 present
	Frimmersdorfer Schichten	Frimmersdorf Interglacial	
	Liegendschotter		
MT I /Mittelterrasse I/		5th glacial period B.P.+	cover-beds sequence incomplete

+ Minimum age

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