Schirmer, W. (2002): Compendium of the Rhein loess sequence. –
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1. Compendium of the Rhein loess sequence

Wolfgang Schirmer

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Interglacial solcomplexes embracing breviglacials

A loess and fossil soil record of the Lower Mittelrhein and Niederrhein-Maas area (Fig. 1) covers four fossil interglacial soil complexes (solcomplexes) separated by thick loess stacks. The solcomplexes should belong at least to MIS 5, 7 , 9 and 11. In case major unconformities would be hidden within the stack the lower solcomplexes would become older (Schirmer 1999a).

The interglacial solcomplexes are mostly named after rivers of the Niederrhein area, Erft, Rur and Niers (Fig. 2).

The solcomplexes comprise each 2-5 Bt horizons, humic soils (Humuszonen) and sometimes gelic gleysols (Nassböden) each separated by thin loess layers. In case of the Rocourt Solcomplex (MIS 5) it can be demonstrated that this solcomplex covers an interglacial (Eemian) represented by the Rocourt Bt horizon followed by very mature interstadials (Brørup and Odderade) likewise represented by Bt horizons. There is also a topping fourth Bt horizon representing an even younger interstadial. In addition, each Bt horizons is followed by a separate humus zone (Humuszone) which represent certain warming phases (Schirmer 2000a and b).

From this follows: An interglacial solcomplex is a cluster of preferably terrestric and minor semiterrestric soils that comprises at least one interglacial period, sometimes two or more, and a range of interstadial periods. These warm periods are separated by thin loess layers representing short cold periods with loess deposition, called breviglacials sensu Schirmer 1999a. As a whole the solcomplex with its soils and breviglacial loesses forms a long period of quiescence of the landscape. There occurs neither thick essential accumulation nor greater erosion during the long period of duration of a solcomplex (Schirmer 1999a).

Euglacials

In contrast, the individual solcomplexes themselves are separated by thicker loess stacks subdivided and interrupted by large erosional phases that reorganize the landscape sometimes to a high degree. These loess units represent euglacials sensu Schirmer 1999a.

The loess stacks are named after early medieval landscapes called gouw, gowe, gau or pagus (Fig. 2), following the way of A. Dumont (1839), who gave the name Hesbayen and A. Rutot 1899 who named the Brabant Loess.

For example, the period since the last interglacial comprises two euglacials, the last one ranging from ca. 30 ka to ca. 14 ka leaving behind the important Würmian/Weichselian glacial landforms, and the penultimate one from ca. 67-60 ka the landforms and deposits of which are mostly destroyed or covered by the last euglacial. Both are separated by a long period of an interstadial solcomplex, the Ahr Interstadial Complex comprising the Remagen and Sinzig Soils (Fig. 3).

The third euglacial before present (MIS 6) is essentially marked by the Wetterau Discordance (Fig. 1) that reorganizes the whole landscape by deep and far extended erosion of thick beds of prior deposited complete euglacial loess stacks and solcomplexes. Rarely and only in

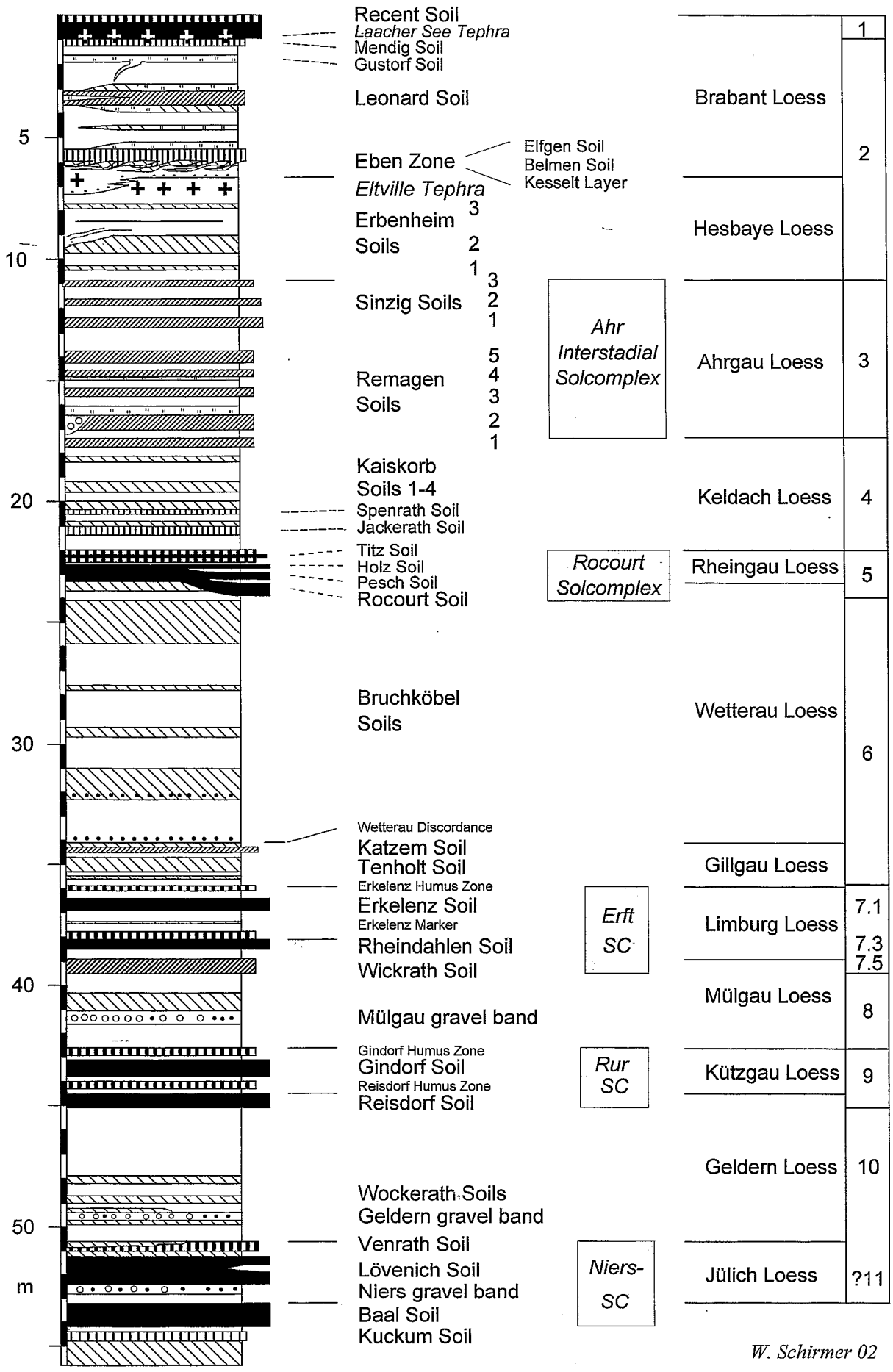

Fig. 1: Loess-soil sequence of the Niederrhein area.

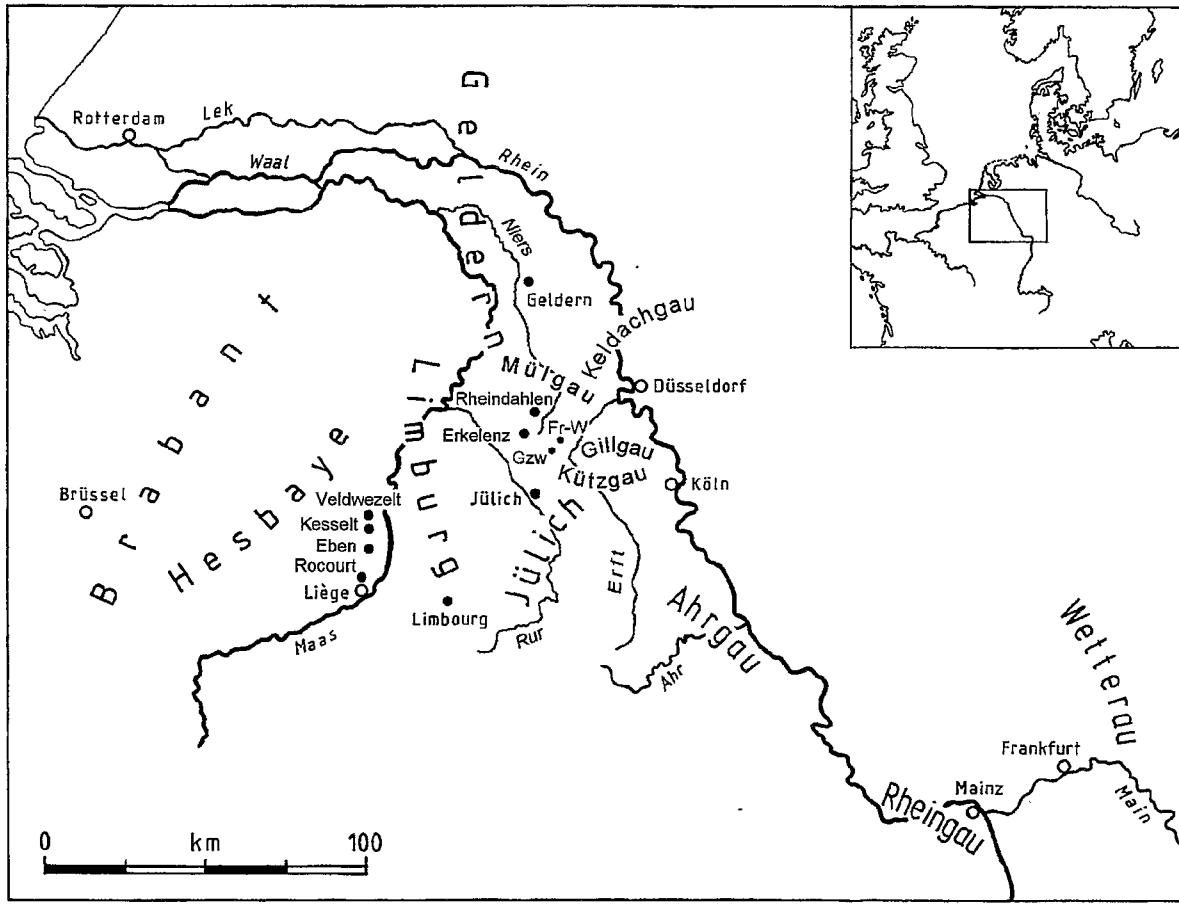

Fig. 2: Location map.

protected positions those euglacial loess stacks and solcomplexes are preserved, as it is the case in Frimmersdorf-West and Erkelenz (Figs. 2 and 4).

Therefore is is not quite sure whether the Rhein loess record presented here is free of major gaps.

Of course, the loess stack deposited since the last interglacial solcomplex, the Rocourt Solcomplex, is best preserved and shown in most outcrops. Only in few places it is completely eroded, as it is the case along the northern rim of loess deposition towards the large eolian sand belt of northern Central Europe (cf. SCHIRMER 1999b). As good examples of this type serves the Rheindahlen site (Figs. 2 and 4).

Gelic gleysols (Nassböden)

A conspicuous feature of the Rhein loess stack are the numerous gelic gleysols (Nassböden), that show several types (SCHIRMER 2000a: 312 and b: 30):

Morphologically they can be grouped into a
- ***speckled gelic gleysol*** **(Gefleckter Nassboden)** with grey and rusty speckles and a
- ***grey gelic gleysol*** **(Grauer Nassboden)** with homogenous grey colour.

Texturally two types can be identified:

- ***Synchronic gelic gleysols*** **(Synchrone Nassböden)** mark - as all normal fossil soils do - a certain standstill within the depositional sequence. They occur as speckled as well as grey gelic gleysol.

- ***Diachronic gelic gleysols*** **(Diachrone Nassböden)** cross the stratification under low angle. They appear only as grey gelic gleysol. They are suggested to represent standstill phases of downward prograding dissipation of permafrost within the sediment. Diachro-

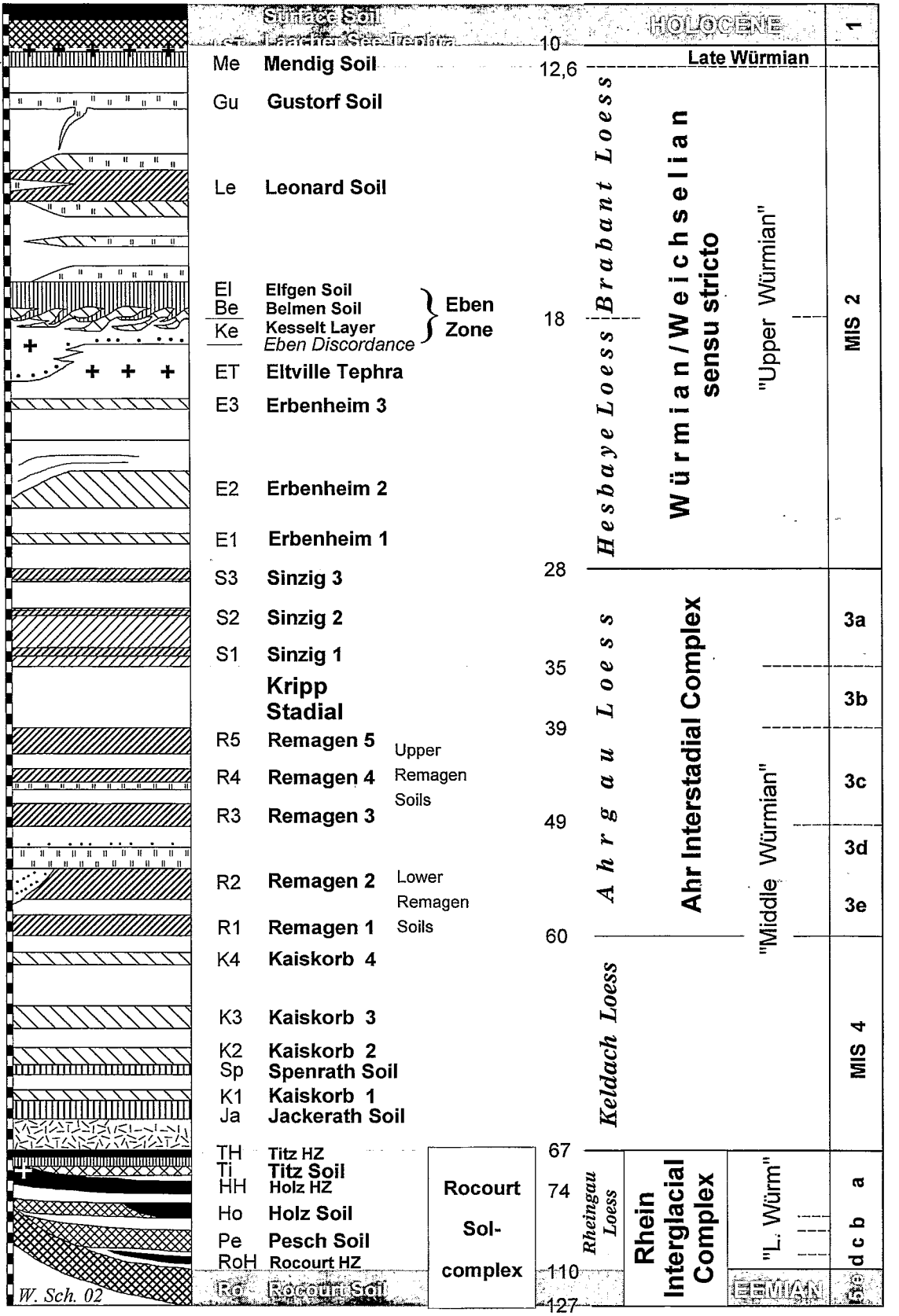

Fig. 3: The Upper Pleistocene Rhein-Maas loess-soil sequence. From left to right hand: The meter scale represents an average thickness as far exhibited; for symbols see Fig. 4; characteristic soils and sediment deposits and their abbreviations; some important ages in ka BP; italics: lithological loess units; subunits of the Upper Pleistocene; marine isotopic stages (MIS) = O-isotope stages.

nic gelic gleysols are not shown in the stratigraphical sections of this paper.

Definition and description of the loess units and solcomplexes

Unless it is particularly mentioned the names of the loess units and interglacial solcompolexes are given by SCHIRMER (1999a: 91).

1 Niers Solkomplex

Definition: Solcomplex presenting a characteristic sequence of two to three Bt horizons (Baal Soil and Lövenich Soil, the latter locally biparted). Only the Lövenich Soil exhibited a humus zone up to now. All soils are separated by thin loess layers. The Bt horizons show more or less pseudogleying, the overlying thin loess layers then forming Sw horizons.

Pedostratigraphically the solcomplex starts with the Baal Soil and ends with the uppermost humus zone, the Venrath Soil. Lithostratigraphically it covers the loess substratum of the Baal Soil and the Jülich Loess. Its chronostratigraphic position is MIS 11 or older as it is overlain in Erkelenz by the Rur, Erft and Rocourt Solcomplexes.

Type locality: Brickyard pit GILLRATH in Erkelenz/Niederrhein.

Characteristics and subdivision:

In Erkelenz the 3,25 m thick solcomplex is subdivided in:

The Baal Soil is preserved up to 2m thick. Its deeper subsoil veils the humic **Kuckum Soil**, that sometimes can be recognized by its darker humic colour. Normally the Baal Soil is topped by a bleached horizon (Sw horizon), but in places the unconformity below the **Niers gravel band** cuts down into the Baal Bt horizon. The **Lövenich Soil** is up to 1,25 cm thick preserved. The topping Sw horizon is locally rich in charcoal. The humic **Venrath Soil** turns towards depressions into a gleyic phaeozem (Anmoorgley) the Aa horizon of which grows up to 40 cm thickness.

2 Jülich Loess

The Jülich Loess is a breviglacial loess within the Niers Solcomplex separating the individual soils of this solcomplex. It starts with the Niers gravel band and ends with the substratum of the Venrath Soil. Generally it is poorer in coarse silt than the Geldern loess above it.

3 Geldern Loess

1. Definition: Euglacial loess unit represented by loess loam and solifluction loess loam decalcified by the soil formation of the topping Rur Solcomplex. In its lower part there occur the Wockerath Soils, grey gelic gleysols and inmidst of them the Geldern gravel band. The lithostratigraphical range of the Geldern Loess starts with the upper contact of the Venrath Soil and ends together with the substratum of the Reisdorf Soil below the Kützgau Loess. Its chronostratigraphic position is within MIS 10, as it is overlain by the interglacial Rur, Erft and

Venrath Soil: Humus zone to gleyic phaeozem	Jülich Loess
bleached horizon (Sw horizon)	
Lövenich Soil, sometimes biparted: pseudogleyed luvisol	
Niers gravel band	
bleached horizon (Sw horizon)	
Baal Soil: luvisol-pseudogley	loess

Rocourt Solcomplexes, or it is older in case of hidden stratigraphical gaps.
Type locality: Brickyard pit GILLRATH in Erkelenz/Niederrhein.

Characteristics and subdivision:
The basaly occuring **Wockerath Soils** form within a vertical distance of 3 m up to five grey gelic gleysols. The **Geldern gravel band** lies between the second and third gelic gleysol forming a sandy-gravelly band of 25 cm in maximum thickness. The Wockerath Soils are synchronous grey gelic gleysols. In addition, within their range occurrence of diachronous gelic gleysols starts to augment upwards towards the banded B horizon of the Rur Solcomplex.

4 Rur Solkomplex

Definition: Solcomplex embracing a characteristic sequence of two Bt horizons each bearing a dark humus zone. All soils are separated by thin loess layers. The Bt horizons show more or less pseudogleying, the overlying thin loess layers then forming Sw horizons.

Pedostratigraphically the Rur Solcomplex starts with the Reisdorf Soil and ends with the uppermost humus zone, the Gindorf Humus Zone. Lithostratigraphically it covers the Kützgau Loess. Its chronostratigraphic position is MIS 9 or older as it is overlain in Frimmersdorf-West and Erkelenz at least by the Erft and Rocourt Solcomplexes.

Type locality: Browncoal opencast mine Frimmersdorf-West/Niederrhein.

Characteristics and subdivision: The type locality showed the following subdivision from above to below:

The type locality was mined in 1974 and the opencast mine prograded towards its recent state called opencast mine Garzweiler. In recent times only the loess pit of Erkelenz exhibits the lower part of the Rur Solcomplex, the Reisdorf Soil.

5 Kützgau Loess

Definition: Breviglacial loess loam, mostly in the facies of silt-lens loam, completely disguised by the Bt horizons of the Gindorf and Reisdorf Soils. Lithostratigraphcally the Kützgau Loess represents an intra-solcomplex loess within the Rur Solcomplex. It starts above the Reisdorf Soil and ends with the substratum of the Gindorf Humus Zone below the Mülgau Loess. Its chronostratigraphic position is within MIS 9 or older as it is overlain in Frimmersdorf-West and Erkelenz at least by the Erft and Rocourt Solcomplex.

Type locality: Browncoal opencast mine Frimmersdorf-West/Niederrhein.

6 Mülgau Loess
(for.6-10 cf. also SCHIRMER 2002a)

Definition: Euglacial loess unit represented by loess loam and solifluction loess loam decalcified by the soil formation of the topping Erft Solcomplex. In its deeper part the Mülgau gravel band occurs. The lithostratigraphical range of the Mülgau Loess starts with the upper contact of the Gindorf Humus Zone and ends together with the substratum of the Wickrath Soil below the Limburg Loess. Its chronostratigraphic position is within MIS 8, as it is overlain by the interglacial Erft and Rocourt Solcomplexes.
Type locality: Brickyard GILLRATH in Erkelenz/Niederrhein.

Gindorf Humus Zone	Kützgau Loess
bleached horizon (Sw horizon), silt-lens loam	
Gindorf Soil: pseudogleyed luvisol	
silt-lens loam	
Reisdorf Humus Zone	
bleached horizon (Sw horizon), silt-lens loam	
Reisdorf Soil: pseudogleyed luvisol	Geldern Loess

Characteristics and subdivision:

In Erkelenz the base is marked by the **Mülgau Discordance** that cuts the bulk of the Rur Solcomplex. In Erkelenz the whole loess loam comes up to a thickness of 2,2 m. Inmidst a 15 cm thick well bedded fluvial gravelly sand layer forms the **Mülgau gravel band**. Upward it is followed by a grey gelic gleysol. The upper region of the Mülgau loess towards the Wickrath Soil exhibits a speckled gelic gleysol. BRUNNACKER (1966: 347) called this loess and soil type "Staublehm" in Rheindahlen. In addition, within the whole Mülgau Loess diachronous gelic gleysols occur. Their diachronous nature becomes obvious especially at the level of the Mülgau gravel layer, where they locally run diagonally across this band to change their position sometimes from above to below this gravel band.

7 Erft Solcomplex

Definition: Interglacial solcomplex embracing a characteristic sequence of Bt horizons (Wickrath, Rheindahlen and Erkelenz Soil) with humus zones and with a grey gelic gleysol (Erkelenz Marker). All soils are separated by thin but loess layers distinct in thickness. The Bt horizons show more or less pseudogleying, the overlying thin loess layers then forming Sw horizons.

Pedostratigraphically the Erft Solcomplex starts with the Wickrath Soil and ends with the uppermost humus zone, the Erkelenz Humus Zone. Lithostratigraphically it covers the uppermost Mülgau Loess and the whole Limburg Loess. Its chronostratigraphic position is MIS 7 as it is overlain in Frimmersdorf-West and Erkelenz by the Rocourt Solcomplex.

Type locality: Brickyard DREESEN in Rheindahlen/Niederrhein. Paratype locality is the brickyard GILLRATH in Erkelenz/ Niederrhein. Both localities exhibit the same strata and features.

Characteristics and subdivision:

At the type locality the Erft Solcomplex is subdivided from above to below as follows:

The soil type of the **Wickrath Soil** is a luvisol. As the Wickrath Soil lies within the lower part of the Bt horizon of the Rheindahlen Soil and above the Wickrath Soil there is no weakening of the Bt features it is argued that the original soil type of the Wickrath Soil was a mere Bv horizon of a cambisol or a Btv horizon of an initial luvisol.

The loess between the Wickrath Soil and the Rheindahlen Soil (PAAS 1961: 212) shows beyond the Bt horizon the character of a speckled gelic gleysol, or it is silt lens loam. The whole B horizon of the **Rheindahlen Soil** covering the Wickrath Soil comes up to at least 3.5 m, the Bt up to 1.7 m in Erkelenz, 1.4 m in Rheindahlen. In all outcrops the **Rheindahlen Humus Zone** follows immediately the Bt horizon. Only within the lowest part of the humic horizon there occur traces of a bleached Sw horizon.

Between the Rheindahlen and Erkelenz Soil there is distinct small grey band, the **Erkelenz-**

Erkelenz Humus Zone	Upper Limburg Loess	
bleached horizon (Sw horizon)		
Erkelenz Soil: pseudogleyed luvisol		MIS 7.1
silt lens loam		
Erkelenz Marker: grey gelic gleysol	Middle Limburg Loess	
silt lens loam		
Rheindahlen Humus Zone	Lower Limburg Loess	
Rheindahlen Soil: pseudogleyed luvisol		MIS 7.3
loess with speckled gelic gleysol or silt lens loam		
Wickrath Soil: cambisol or initial luvisol transformed to a luvisol	Mülgau Loess	MIS 7.5

Marker, a grey gelic gleysol, sometimes supported by a black manganese band.

The **Erkelenz Soil** (PAAS 1961: 189, 221) is preserved as Bt horizon up to 1.3 m thickness. Its whole B horizons passes into the B horizon of the Rheindahlen Soil. In contrast to the Rheindahlen Humus Zone the **Erkelenz Humus Zone** is separated from the Erkelenz Bt horizon by a distinct light bleached Sw horizon, in Rheindahlen called "Helles Band" (light seam) (cf. SCHIRMER 2002b: 47). The humic degree of the Erkelenz Humus Zone is continually higher than that of the Rheindahlen Humus Zone.

In the Rhein-Main area the solcomplex ending with two Weilbach Humus Zones (SEMMEL 1968: 19, 117) underlies the Rocourt Solcomplex. In case it is a chronostratigraphical equivalent of the Erft Solcomplex this equivalent would represent a soil facies with domination of Humus Zones instead of the soil facies with luvisol domination in the Rhein-Maas area (cf. Rocourt Solcomplex).

Dating: TL dates from this solcomplex turn out to give too young ages. ZÖLLER (1989) found data between 137 ka (above the Erkelenz Soil) und 239 ka (below the Wickrath Soil). Ages given by FRECHEN et al. (1992) lie in-between (vgl. Tab. 1 in SCHIRMER 2002e: 23). From the Bt horizon below the Ostheim Zone (cf. Gillgau Loess) in Böckingen/Württemberg ZÖLLER found an age of 168 ± 28 ka (BIBUS 1989: 9), from the range of the Weilbach Humus Zones in Mainz-Weisenau an age of 106 ± 11 ka (SEMMEL 1996: 13).

8 Limburg Loess

Definition: Breviglacial loess loam, mostly in the facies of silt-lens loam, completely disguised by the Bt horizons of the Erkelenz and Rheindahlen Soils. Lithostratigraphcally the Limburg Loess represents an intra-solcomplex loess within the Erft Solcomplex. It starts above the Wickrath Soil and ends with the substratum of the Erkelenz Humus Zone below the Gillgau Loess. It is subdivided by soil horizons into three parts, the Lower, Middle and Upper Limburg Loess. Its chronostratigraphic position is within MIS 7 as it is overlain in Frimmersdorf-West and Erkelenz by the Rocourt Solcomplex.

Type locality: Brickyard DREESEN in Rheindahlen/Niederrhein. Paratype locality is the brickyard GILLRATH in Erkelenz/ Niederrhein. Both localities exhibit the same strata and features.

Characteristics and subdivision:
Lower Limburg Loess: It starts with the upper contact of the Wickrath Soil and ends with the substratum of the Rheindahlen Soil. Locally the loess type is a silt lens loam.
Middle Limburg Loess: It runs from the top of the Rheindahlen Soil till the top of the Erkelenz Marker. The loess type is a silt lens loam.
Upper Limburg Loess: It runs from the top of the Erkelenz Marker till the top of the Erkelenz Humus Zone. The loess type is a silt lens loam.

9 Gillgau Loess

Definition: Euglacial loess und solifluctional loess subdivided by speckled and grey gelic gleysols and a brown soil. Lithostratigraphically the Gillgau Loess starts on top of the Erkelenz Humus Zone and ends with the Wetterau Discordance. This is the most important discordance before today. As it is visible in Erkelenz it cuts the older deposits down to the Geldern Loess (Fig. 5). The sedimentary stack between the Gillgau Loess known so far and the Wetterau Discordance possibly hidden behind this discordance is unknown. But up to now it is assumed that the Gillgau Loess has ist position within the older part of MIS 6. This is supported by the paleomagnetic investigation of COFFLET (see chapter 4.3) who found a minimum of the relative paleointensity curve within the upper Erft Solcomplex and basal Gillgau Loess that corresponds to the Jamaica Event (190.000 BP).

Type locality is the brickyard pit GILLRATH in

Erkelenz/Rheinland

Characteristics and subdivision: In Erkelenz the Gillgau Loess is represented by a 1,8 m thick loess sequence above the Erft Solcomplex interrupted by a thin and a thick speckled gelic gleysol, the **Tenholt Soil** and a brown cambisol, the **Katzem Soil**. As the latter lies within the decalcification front of the surface soil, its original soil type is difficult to identify. A grey gelic gleysol tops this loess unit below the great Wetterau Discordance.

In the Wetterau (location see Fig. 2) the loess equivalent beween the Upper Weilbach Humus Zone and the Wetterau Discordance is formed by a solifluctional loess loam with intermixed brown and dark brown soil material, called the Ostheim Zone (Bibus 1974: 174).

Age: According to the loess-soil stratigraphy and the paleomagnetic results the Gillgau Loess should represent the early MIS 6.

10 Wetterau Loess

Definition: This euglacial loess unit consists preferably of solifluidal and colluvial loess with strong and characteristic grey gelic gleysols their colour with a tint to blue, the Bruchköbel Soils (Bibus 1974: 168). In the Niederrhein-Maas area its lithostratigraphical base is the great Wetterau Discordance forming a deep erosional relief. It ends with the substratum of the Rocourt Soil. Chronostratigraphically it represents the younger MIS 6, corresponding to the Saale or Jungriss glaciation.

Type region is the Wetterau landscape from where Bibus (1973, 1974) gave a first detailed subdivision of this loess unit.

Characteristics and subdivision: In the Wetterau an unconformity is recorded above the Ostheim Zone sometimes cutting the whole solcomplex at its base (Bibus 1974: 179). The same role takes the **Wetterau Discordance** at the Niederrhein. On the large loess plateau of the Hauptterrasse between the Rhein and Maas rivers the thick loess stack recorded here is often reduced to mainly the loess above the Wetterau Discordance. In depressions of this erosional unconformity mainly laminated colluvial loesses are deposited. Within this facies and above occur the blue-grey **Bruchköbel Soils** up to six in the Wetterau area, in Erkelenz and Kesselt up to five. These grey gelic gleysols show strong reduction with striking rusty seams on top and below, thus contrasting to all younger grey gelic soils within the higher loess cover that appear to be weaker.

Age: As the sedimentation of the Wetterau Loess terminates with the Rocourt Solcomplex (MIS 5) it represents MIS 6. In addition in Erkelenz and Rheindahlen the Wetterau Loess overlies the Gillgau Loess the base of which bears the characteristic minimum of the NRM paleointensity curve. TL dating of the Wetterau Loess yielded the ages of 77-120 ka after Zöller et al. (1988) and Zöller (1989). The TL ages described by Frechen et al. (1992) lie in-between this range. These ages, however, seem to be too young.

11 Rocourt Solkomplex

Definition: Interglacial solcomplex embracing a characteristic sequence of Bt horizons (Rocourt, Pesch, Holz and Titz Soils) with humus zones respectively regosols (pararendzina). All soils are either separated by thin loess layers or they are condensed to soil stacks. The Bt horizons show more or less pseudogleying, the overlying thin loess layers then forming bleached Sw horizons.

Pedostratigraphically the Rocourt Solcomplex starts with the Rocourt Soil (Gullentops 1954) and terminates with the uppermost humus zone, the Titz regosol of the Niederhein area and the Upper Mosbach Humus Zone (Semmel 1995) of the Rhein-Main area. Lithostratigraphically it comprises the uppermost Wetterau Loess and the whole Rheingau Loess. Its chronostratigraphic position is MIS 5e-a.
Type locality is the opencast mine Garzweiler/

Niederrhein. Paratype region is the Maas valley around Maastricht, especially the outcrop Veldwezelt. Paratype region should also be the Rheingau with the Mosbach Humus Zones (SCHÖNHALS et al. 1964).

Characteristics and subdivision:

The browncoal opencast mine Garzweiler exhibited the following sequence:

Titz Humus Zone: regosol	Rheingau Loess	MIS 5a
bleached horizon: Sw horizon		
Titz Soil: weak pseudogleyed luvisol		
Holz Humus Zone: regosol		
bleached horizon: Sw horizon		
Holz Soil: pseudogleyed luvisol to greysem: Bht horizon		
bleached horizon: Sw horizon		
Pesch Soil: pseudogleyed luvisol		Mis 5 c
Rocourt Humus Zone		
bleached horizon: Sw horizon		
Rocourt Soil: pseudogleyed luvisol	Wetterau Loess	MIS 5 e

In the Niederrhein area there normally occurs a solcomplex consisting of only one luvisol followed by a bleached horizon and a twin humic soil (SCHIRMER & STREIT 1967). In the Maas valley GULLENTOPS (1954) designated this luvisol **Rocourt Soil**. In morphological depressions - as in the site Garzweiler 4 (SCHIRMER 1999c) - this solcomplex is vertically spread showing at most four Bt horizons of luvisols each followed by an own bleached horizon and a humus zone (Garzweiler 4 shows three Bt horizons, see Figs. 23, 25). The lowest one, the Rocourt Soil, is the strongest Bt, its colour of a deep red to yellow red. The Bt of the **Pesch Soil** exhibits a darker, more brownish red, that of the **Holz Soil** a grey-brown red, that of the **Titz Soil** a yellow-brown colour. The polyedric components of the Holz Soil are coated by red clay and dark brown humus (greysem). In the very depression (right side in Fig. 23) the Holz Soil changes its type to a pseudochernozem. The Titz Soil has the weakest Bt horizon. The difference in colour among the four Bt horizons is due to the carbon content that increases from the Rocourt Soil toward the Holz Soil (Fig. 26). Vice versa the preserved thickness of the Bt horizons decreases towards the top.

Fig. 23 shows that the normal luvisol developed in plateau position is the Rocourt Soil. The Pesch Soil is fully developed only in depressions, in plateau position it is condensed with the Rocourt Soil or eroded. The Holz Soil can be identified due to its darker slightly humic B horizon (Bht) that is preserved as a thin dark seam sometimes topping the Rocourt Soil even in plateau position. In normal morphological position the Titz Soil is mostly incorporated into the Holz Humus Zone. Only in depressions it separates from the Holz Humus Zone by a silty humic thin-bedded colluvium and from the Titz Humus Zone by a bleached Sw horizon.

The Rocourt Humus Zone is exposed only in depressions, a Pesch Humus Zone was not observed up to now, the Holz Humus Zone is dark grey-brown and strikingly white spotted. In Titz Humus Zone starts with a humic synpedogenetic grey brown silt layer (Ah2) and terminates with a black brown regosol (Ah1). This sequence contrasts to the sequence described from the Rhein-Main area and Niedersachsen (SCHÖNHALS et al. 1964, RICKEN

1983, SEMMEL 1996, BIBUS et al. 1996). It shows that the Rocourt Solcomplex occurs in two different kinds of facies: 1. Bt-Facies of the Niederrhein-Maas area and 2. Humus Zone Facies in the Mittelgebirge joining the Niederrhein–Maas area towards east and south.

The striking characteristics of the Bt facies are up to four Bt horizons. The Humus Zones represent predominantly regosols (pararendzinas). In contrast the Humus Zone Facies shows above the Rocourt Bt horizon prevailingly Humus Zones (e. g. Mosbach Humus Zones in the Rhein-Main area). Additional Bt horizons recede. Towards the continental belt the humus zones gain more and more chernosem nature with only local features of B horizons.

Equivalents to the Rocourt Soil are the Erbach Soil and Homburg Soil (SCHÖNHALS et al. 1964). Possibly the Lower, Middle and Upper Mosbach Humus Zones correlate with the humus zones of the Pesch, Holz and Titz Soil, especially since the Lower and Middle Mosbach Humus Zones locally show basal B horizons.

Age: Mean TL-ages from loess just below the Rocourt Soil yielded 110 ka or more. Those from within the Rocourt Solcomplex and just above it yielded ages between 110 und 65 ka (ZÖLLER & SEMMEL 2001: 25). ^{14}C-dates of this age are always minimum ages with little information.

Equivalents of the Rocourt Solcomplex are the Naumburg Solcomplex of the Saale-Unstrut area (RUSKE & WÜNSCHE 1961: 26), the Lommatzsch Solcomplex in Sachsen (LIEBEROTH 1963: 178) and the Bilshausen plus Niedervellmar Solcomplex in Niedersachsen and Hessen (ROHDENBURG & MEYER 1966: 26 and 120).

12 Rheingau Loess

Definition: Thin solifluctional loess layers rich in reworked soil material in-between the tightly superimposed soils of the Rocourt Solcomplex, also serving as substratum of the soil horizons. This breviglacial intra-solcomplex loess is completely disguised by the Bt horizons of the Pesch, Holz and Titz Soils. Lithostratigraphically it starts above the Rocourt Soil and terminates with the Titz Humus Zone below the Keldach Loess. Its chronostratigraphic position is within MIS 5 b-a. It represents the eolian deposit of the chronostratigraphical period called Lower Würmian/Weichselian.

Type region is the Rheingau (location see Fig. 2) where the Mosbach Humus Zones (SCHÖNHALS et al. 1964) subdivide this loess: the DYCKERHOFF quarry at Mainz-Amöneburg (description by SEMMEL 1995) as well as the Heidelberger Zement-AG quarry in Mainz-Weisenau (description by SEMMEL 1996, BIBUS et al. 1996). As paratype locality may serve the browncoal opencast mine Garzweiler/ Niederrhein (description by SCHIRMER 2000a: 315, 2000b: 32).

Recommendation: This intra-solcomplex loess represents typical breviglacial phases within a warm climate complex, or - with other words – it is part of a soil-dominated landscape stability phase of the long duration of ca. 60 ka (cf. SCHIRMER 1999a: 88, 95). As consequence it is recommended here to exclude this deposit (and climate period) from the Würmian/ Weichselian stage and to join it together with the Eemian represented by the Rocourt Soil to an interglacial complex, that may be called Rhein Interglacial Complex. This Rhein Interglacial Complex then is the climate complex producing the Rocourt Solcomplex with Rheingau Loess in-between.

13 Keldach Loess (nom. nov.)

The Keldach Loess and its soils are separated from the Ahrgau Loess as an own loess unit.
Definition: This euglacial loess unit consists preferably of solifluidal and colluvial loess. Lithostratigraphically it starts above the uppermost Humus Zone of the Rocourt Solcomplex and terminates with the substratum of the lowest Remagen Soil. In all areas its basal part shows large masses of solifluidal loess intermixed with soil material of the reworked Rocourt Solcomplex and/or younger soils. This solifluctional loess is called **Niedereschbach Zone** (SEMMEL 1968: 30). It appears as dark humic and red to brown B material. Above it in the Niederrhein area the loess is subdivided by two humic regosols, the **Jackerath Soil** (nom. nov.) and the **Spenrath Soil** (nom. nov.) and four grey gelic gleysols, the **Kaiskorb Soils 1-4** (nom. nov.). It terminates with the substratum of the Remagen Soil 1. Chronostratigraphically it represents the MIS 4 (corresponding to the Middle Würmian 1 sensu SCHIRMER 1991: 77).

Type locality is the browncoal opencast mine Garzweiler/Niederrhein.

Characteristics and subdivision:

Kaiskorb 4 Soil: grey gelic gleysol	Keldach Loess	MIS 4
Kaiskorb 3 Soil: grey gelic gleysol		
Kaiskorb 2 Soil: grey gelic gleysol		
Spenrath Soil: regosol (pararendzina)		
Kaiskorb 1 Soil: grey gelic gleysol		
Jackerath Soil: regosol to cambisol (braunerde-pararendzina)		
Niedereschbach Zone (solifluidal reworking layer with soil material)		

In the Mittelrhein and Niederrhein area the Niedereschbach Zone is characterised by reworked soil material of the Rocourt Soil. Towards south and east the Niedereschbach Zone may comprise the whole Keldach Loess (or even higher stratigraphical strata) incorporating material of the brown and grey soils of the Keldach Loess (or even the Ahrgau-Loess). In the Schwalbenberg section/Mittelrhein in the deeper part of the Keldach Loess the **Reisberg Soil** (SCHIRMER 2000a: 319, 2000b: 35) occurs as parautochthonous brown interstadial soil.

14 Ahr Interstadial Complex (nom. nov.)

Definition: Interstadial solcomplex embracing a characteristic sequence of B horizons, the **Remagen Soils 1-5** and **Sinzig Soils 1-3** (SCHIRMER 1990: 106; 1995: 531. These eight calcic cambisols are each separated by thin solifluctional loess layers. However, two of these loess layers are somewhat thicker thus forming three groups of soil clusters, two Lower Remagen Soils, three Upper Remagen Soils and three Sinzig Soils (Fig. 3).

Pedostratigraphically the Ahr Solcomplex starts with the Remagen 1 Soil and terminates with the Sinzig 3 Soil. Lithostratigraphically it comprises the uppermost Keldach Loess and the whole Ahrgau Loess. Its chronostratigraphic position is MIS 3.

Type locality is the Schwalbenberg section/ Mittelrhein (SCHIRMER 1990, 1991, 1995: 530).

Characteristics and subdivision: For subdivision see. Fig. 2. Amongst the Remagen Soils the second soil (R2) is the thickest and shows the highest C content. Amongst the Sinzig Soils the first, Sinzig 1, is the strongest with the highest C content. The solifluctual loess layers inbetween are formed as gleysols, speckled and grey ones.

The Schwalbenberg site is unique for its broadly vertically spread Ahr Interstadial Complex.

Normally the "Middle Würmian" sites in Central Europe present only one, two or three soils of this kind. E. g. in the Rhein-Main-Neckar area there occur three soils at maximum in superposition: the brown Gräselberg Soil (SCHÖNHALS et al. 1964), Böckingen Soil (BIBUS 1989: 8), and the Lohne Soil (SCHÖNHALS et al. 1964), only one soil has been found in the Saale-Unstrut area, the Kösen Soil (RUSKE & WÜNSCHE 1961) and in Sachsen the Gleina Soil (LIEBEROTH 1963). Hence it is difficult to decide how to correlate this smaller number of soils with the nine Schwalbenberg soils. The question is whether the minority of soil presence is caused by erosion or by condension of single soil groups. In case of erosion the additional question rises where the erosional unconformities are to be sought. This is the reason why the soils of the Schwalbenberg site cannot be correlated with terms like Lohne or Böckingen Soil.

All in all the amount of soils within the Ahr Interstadial Complex decreases from the Rheinland towards the areas with more continental climate.

Age and correlation: TL-data of the locus typicus, the Schwalbenberg, date the Remagen Soils from 48-40 ka, the Kripp Stadial and the Sinzig Soils from 40-30 ka. The upper part of the Sinzig Soils yielded a TL age of 31,3 ± 2,6 ka and a ^{14}C age on mullusc shales of 27.890 ± 440 (Pta-2722) and 28.080 ± 530 (Pta-2721) (ZÖLLER & WAGNER 1989).

The MIS 3 of The Netherlands presents three peaty interstadials, Moershoofd, Hengelo and Denekamp. In no place they occur in superposition; their stratigraphical position has been fixed by ^{14}C dates. In addition, VANDENBERGHE (1985: 33, 35) stresses that peat does not necessarily need interstadial climate. It is restricted to wet depressions. Also BEHRE (1989: 41) points out that during this milder climate of the higher Middle Würmian, tundra vegetation could establish here and there at edaphically favourable places thus causing humic or peaty horizons that may not necessarily reflect climatic improvement. However, interstadial horizons of various European areas, he continues, are correlated with the three Dutch interstadials only on the basis of their ^{14}C dates of varying reliability. Finally, he states, there is a lack of marked phases of climatic improvements to be correlated over large distances.

In contrast the Rhein loess sequence exhibits all its nine interstadial periods of the Ahr Interstadial Complex in clear superposition. Moreover the sequence seems to offer good correlation over large areas to deep sea and glacier curves by distinct characteristics pointed out for the tripartite soil cluster on the one hand and for outstanding individual soils on the other hand, e. g. the Remagen 2 or the Sinzig 1 Soils (SCHIRMER 2000a).

15 Ahrgau Loess

It is the prevalently solifluctional loess forming the interstices between the Ahr Interstadial Soils. Lithostratigraphically it starts above the deepest brown soil of the Ahr Solcomplex, that is at the locus typicus the Remagen 1 Soil. It terminates with the substratum of the highest brown soil of the Ahr Solcomplex, which is at the locus typicus the Sinzig 3 Soil. The thickest loess layer therein growing up to 1,4 m is that between the Remagen and Sinzig Soils representing the **Kripp** stadial period. Chronostratigraphically it represents the MIS 3 (corresponding to the Middle Würmian 2-4 sensu SCHIRMER 1991: 77).

16 Hesbaye Loess (DUMONT 1839, redefined by GULLENTOPS 1954: 164)

Definition: This thick euglacial loess loess shows a tendency of fine lamination and is intercalated by three grey gelic gleysols (Nassböden), the Erbenheim Soils 1-3 (SCHÖNHALS et al. 1964). Above the Erbenheim 3 Soil the Eltville Tephra (SEMMEL 1967) forms the most reliable stratigraphic layer of the Upper Würmian or Würmian s.str. This tephra is closely followed by the Eben Discordance, that widely extends over the Niederrhein-Maas-Sambre

area. Its reworking activity produced a bed incorporating reworked older loesses and soils, the Kesselt Layer.
Lithostratigraphically the Hesbaye Loess starts above the uppermost brown soil of the Ahr Interstadial Complex, in the Rheinland the Sinzig 3 Soil. It terminates with the top of the Kesselt Layer below the Belmen Soil. Chronostratigraphically it represents the early part of the last glaciation, the Würmian/ Weichselian glaciation sensu stricto or the lower part of the MIS 2. Chronologically it embraces the time range from about 28-18 ka. The upper part of the Kesselt Layer is suggested to host the LGM (SCHIRMER 2000a: 324).

Type region is Hesbaye or Haspengau in Belgium, as well as the Rheinland. In the Rheinland the former brickyard pit of Wiesbaden-Erbenheim functions as type locality.

Characteristics and subdivision:

Kesselt Layer: reworking layer Eben Discordance	Hesbaye Loess	ca. 18 ka
fine laminated loess		
Eltville Tephra		
laminated loess or soliflutional loess		
Erbenheim Soil 3 resp. j3β: gelic gleysol		MIS 2 lower part
soliflutional loess		
Erbenheim Soil 2 bzw. j2β: gelic gleysol		
soliflutional loess		
Erbenheim Soil 1 bzw. j1γ: gelic gleysol		
soliflutional loess with Rambach Tephra		ca. 28 ka

The typical fine laminated loess is suggsted to be of niveo-eolian origin. The basal black **Rambach Tephra** (SEMMEL 1967) occurs only in the southern Rheinland. Amongst the Erbenheim Soils the Erbenheim Soil 2 is considered as the best developed. The black **Eltville Tephra** is up to some cm thick and locally it may split up into six fine layers at most. The **Eben Discordance** (SCHIRMER 2000a: 322) is one of the most important morphological planes in the atlantic region of the loess area sometimes cutting down into old loess units. In different places this erosion commences from prior to the deposition of the Eltville Tephra until after its deposition. This erosion causes wide denudation, along valleys also linear erosion. It spreads along the northern rim of the European loess belt at least from France into western Germany. The erosion reworked older loess deposits redepositing a var iegated mixture of loess, decalcified loess and soil material, sand and gravel to form thereby the **Kesselt Layer** (SCHIRMER 2000a: 322), a red to orange red to yellow coloured product of intensive reworking up to 1 m in thickness. During the formation of the Kesselt Layer influx of fresh loess ceased, which can be recognized by the broadly missing carbonate content.
The Erbenheim Soils 1-3' correlate with the gelic gleysols j1*g*, j2*b* und j3*b* (SCHÖNHALS et al. 1964) in northern Hesssen and Niedersachsen.

The Hesbaye Loess has very often been removed below the Eben Discordance and is preserved mostly in depressions of the relief or in lee position. Moreover in the Niederrhein-Maas area the denudational erosion along the Eben Discordance has decimated most parts of the Ahrgau Loess sometimes the Ahrgau Loess, Keldach Loess and also the Rocourt Solcomplex. On the plateau between the Rhein and Maas the Kesselt Layers occurs in wide areas as the only representant of the Hesbaye Loess.

Age: After FRECHEN & PREUSSER (1996: 65) mean TL-data from the top of the Hesbaye

Loess yield ages around 20 ka. Hence they infer quick sedimentation of this loess unit. ZÖLLER & SEMMEL (2001: 25) report mean TL ages between 28 and 21 ka for the Hesbaye Loess. From its base at the Schwalbenberg/ Mittelrhein ZÖLLER & WAGNER (1989) yielded a TL-age of 29,6 ± 2,7 ka.

17 Brabant Loess (RUTOT 1899, redefined by GULLENTOPS 1954: 165)

Definition: Euglacial deposit of eolian loess, mostly homogenous and light yellow-grey in colour, the uppermost loess unit of the Rhein loess sequence that covers the landscape with a rather constant thickness of about 5-6 m. It includes at the base a calcic regosol, the Elfgen Soil (PAAS 1968: 194, redefined by SCHIRMER 2002c) and in its upper part a calcic cambisol, the Leonard Soil (SCHIRMER 2000a: 322) as well as several gelic gleysols of both types the grey and the speckled. Lithostratigraphically the Brabant Loess starts above the Kesselt Layer with the Belmen Soil (SCHIRMER 2000a: 322), a grey gelic gleysol. It terminates with the formation of recent surface soil. Chronostratigraphically it represents the late part of the last glaciation, the Würmian/ Weichselian glaciation sensu stricto, or the upper part of the MIS 2. It ends before the Meiendorf Interstadial. Chronologically it embraces the time range from about 18-12.6 ^{14}C ka.

The Brabant Loess represents the continuation of the euglacial Hesbaye Loess after the reworking break that formed the Kesselt Layer.

Type region is the loess area of Belgium, dutch Limburg and the Niederrhein.

Characteristics and subdivision: This youngest eolian cover shows the best subdivision along the northwestern border of the loess belt (ROHDENBURG & MEYER 1966, GEHRT 1998, SCHIRMER 2000a, b).

Surface soil			
eolian loess			12, 7 ^{14}C ka
Gustorf Soil : gelic gleysol			
eolian loess			
Leonard Soil: calcic cambisol, accompanied by gelic gleysols		Brabant Loess	MIS 2 upper part
eolian loess with gleysols			
speckled gelic gleysol			
Elfgen Soil B: calcic regosol, weaker			
Elfgen Soil A: calcic regosol, stronger	Eben Zone		
Belmen Soil: grey gelic gleysol			
Kesselt Layer		Hesbaye Loess	18 ^{14}C ka

After the interruption of the Kesselt Layer new eolian loess deposition started with the beginning of the Brabant Loess. Thus, the carbonate content increases abruptly with the beginning of the Brabant Loess. This mostly homogenous and light yellow-grey coloured loess covers the landscape with a rather constant thickness of about 5-6 m. The basal **Belmen Soil** starts to form short after deposition of the first decimeters of Brabant Loess. It is a calcic grey gleyic gelisol weakly humic, mostly deformed to long solifluctional tailes, a conspicuous tailed soil. It is closely followed by the **Elfgen Soil**, a humic grey-brown calcic regosol, sometimes speckled gleyic or grey gleyic and likewise succeedingly transformed by solifluction into a tailed soil. Thus the light grey tails of the Belmen Soil and the brown grey tails of the Elfgen Soil both grabbing into the yellow-orange Kesselt Layer form together with the Kesselt Layer a conspicuous entity, the **Eben Zone** (SCHIRMER 2000a: 322), a marker hori-

zon visible in many outcrops of the Rhein-Maas loess area. This zone brackets the uppermost Hesbaye Loess and lowermost Brabant Loess. It incorporates horizons formerly named Kesselt Soil (GULLENTOPS 1954) or Nagelbeek horizon (HAESAERTS et al. 1981), the history of which is broadly treated in SCHIRMER (2002c).

The **Leonard Soil** of the higher Brabant Loess is a brown soil, a calcic cambisol, resembling the soils of the Ahr Interstadial Complex. In the open cast mines of Frimmersdorf-West (Fig. 20) and that of Garzweiler (HENZE 1998 and Fig. 27), both the Eben Zone and the Leonard Soil form two wet parallely running bands following the walls of the open cast mines for kilometers. In many places, however, the soil formation of the recent surface (luvisol) conceals the much weaker Leonard Soil, whereas the Eben Zone is mainly preserved.

From the Eben Zone upward there occur at least eight synchronic **gelic gleysols** within the Brabant Loess. The first is the small tailed Belmen Soil, the second often occurs as a wet addition to the Elfgen Soil. The third follows tightly above the Elfgen Soil as speckled gelic gleysol, but can be absent as well. The following gelic gleysols may but need not occur and appear as both speckled and grey gelic gleysols. The fourth is positioned in the midst between the Elfgen and Leonard Soil within loess that is formed to frost pillows. The fifth occurs at the base of the Leonard Soil; in one case its base is cut as channel two meters deep into the older deposits. The sixth may occur as sandwiched soil in-between a split Leonard Soil. The seventh tops the Leonard Soil, and, finally, the eighth, the **Gustorf Soil**, pretty often occurs as fill of strong ice-wedges emerging below the lower contact of the recent soil formation.

In addition to these eight gelic gleysols in all stratigraphical positions of the Brabant Loess there occur gelic gleysols of **diachronic** nature. Their typical character to be identified is that by swinging up and down they cross strata and synchronic soils by a certain low angle. They exceptionally occur as grey gelic gleysols with reductional feature strongest on top and downward slowly tapering off. The top is steadily marked by a thin fine rusty line. They occur pretty often as cluster of few bands each a decimeter or so in thickness. As mentioned in Chapter 1 these soil types are not depicted in the figures.

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