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YOUNG PLEISTOCENE SLOPE DEVELOPMENT ON GLACIAL AND PERIGLACIAL EOLIAN SEDIMENTS IN NORTHWESTERN SAXONY

INTRODUCTION

On the northern edge of the West and Central European old mountains there is a relatively compact loess zone. The loesses of this region, part of which are fairly thick, often show an abrupt decrease in thickness at their northern border. Over a short distance, which is often as small as a few hundred meters, the northern edge of the thick loess is reached.

North of this sharp border are eolian sediments with coarser grain-size and considerably lesser thickness (< 1 m). These are sand-loesses, wind-deposited silty sands and sands, separated by a stone line from the underlying older sediments. The area under investigation forms part of this transitional region from loess to sand-loess and eolian sand with a negligible thickness.

THE AREA UNDER INVESTIGATION

The area studied lies in the region of transition from the Hill-country of Saxony and Thuringia to the lowland adjoining to the north. It comprises the environs of Leipzig. From the north, a spur of the North German Lowland, the Leipzig Bay, projects into the Hill-country.

Mesozoic, Paleozoic or even older rocks are only rarely outcropping. The Tertiary deposits play a more important part. The part of the present plain was at that time covered with thick terrestial and marine sediments so that all the relief features were largely levelled.

The crucial time of formation was the Middle and Young Pleistocene. Thick fluvial sediments of the Early and Middle Pleistocene rivers cover the Tertiary basement.

Saale ground- and end moraines are, apart from these, widespread. All these sediments form the substratum of the Vistula-stage sediments.

After the retreat of the Drenthe ice, during the Drenthe and during the Warta and Vistula stages, the most important features of the present relief developed in the Leipzig area under periglacial climatic conditions.

In the lowland region, the slope gradients vary 0° to 2° whereas in the hill-country they reach values of 3—7°. Precipitation increases from less than 500 mm in the north-west up to 660 mm in the south-east.

AIM AND METHODS OF INVESTIGATION

In the area studied, the covering sediments, which are mostly of eolian origin, are predominantly Vistulian deposits. The object of investigations was to identify the processes of degradation and accumulation operating under periglacial conditions in the various parts of the area under consideration during the Vistula stage and thus to contribute to knowledge of the Young Quaternary phase of formation.

The method adopted was to analyze the sediments — which are mostly of eolian origin and vary in facies and time of formation — with regard to their sedimentary properties and in order to use as time marks, the soil formations of the Interglacials and Interstadials which are of importance as standard strata. Since the sandy loesses, sand-loesses and eolian sands of generally insignificant thickness were completely obliterated by soil formations, approximative methods had to be used in order to get an idea of the original sedimentary properties [1].

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[1] This is a brief survey of such methods: The grain-size mixtures are determined "with and without clay (<2 microns)", (Method after Kundler, 1959). By this method it was tried to estimatie the extent of the change of the sediments due to soil formation. The sorting values after Trask, the average grain diameter, the degree of fineness after Schönhals (1955), the middle sand fraction (500—200 microns) and a series of grain-ratio numbers were designed to provide a better insight into the na-

The covering sediments were classified by using the sand-silt ratio $\left(\frac{2000\text{—}50 \text{ microns}}{50\text{—}2 \text{ microns}}\right)$ after Neumeister (1966).

Sediment	Sand-silt ratio $\frac{2000\text{—}50 \text{ microns}}{50\text{—}2 \text{ microns}}$
Loess	0—0.11
Sandy loess	0.12—0.35
Sand-loess	0.36—1.50
Silty eolian sand	1.51—3.00
Eolian sand	3.01

It should be noted that sand-loess, silty eolian sand and eolian sand were secondarily more or less mixed with alien material, chiefly gravels, by cryoturbation, solifluxion and slopewash.

RESULTS

The occurrence of the loesses depends on the "pre-loess" relief conditions and on the position relative to the river valleys. East of the rivers, the loess border shrinks back southward as the flat relief projects to the south. In the southern part of the area under investigation, loesses and loess derivatives of sometimes more than 10 m thickness were deposited in the region of hilly relief. Today the loess region is a hill-country with slope gradients 0° to 7°.

The Elster and Pleisse rivers flowing from south to north mark the border of these areas of facies of eolian sediments. West of the Elster there are calcareous loesses (7—10% $CaCO_3$ in Young Vistulian loess). Between the Elster and the Pleisse rivers the $CaCO_3$ content is lesser, while east of the Pleisse lies the area of non-calcareous loesses. This distribution of the loesses and their material properties depend on their position relative to the deflation areas and the periglacial conditions of degradation and climate.

Investigations started from well-dated loess profiles; thus results concerning relief development and degradation conditions in

ture of the sediments. Mineralogical procedures were also used. Pedological methods included: determination of humus, that of the $CaCO_3$ content, of the volume ratios and pH values as well as the use of transparent sections.

the region of coarse-grained Vistulian covering sediments of negligible thickness could be obtained.

The Eemian interglacial soil, occurring in the western part of the area in question as Pseudogley-Parabraunerde, is the most important standard stratum. This soil was largely removed. It is absent especially from the convex slopes under the thick Vistulian loess and is preserved on plain surfaces only. Allochtonous sediments of this soil are deposited in the basins.

According the Lieberoth (1963), this degradation took place in an early phase of the Vistula stage (Wα after Lieberoth).

Characteristic of the loess sedimented after this degradation phase is that it was secondarily re-deposited and occurs as solifluxion or deluvial loess. Several weak soil formations, the uppermost of which is attributed to the Paudorf Interstadial, are intercalated into this sequence of Old and Middle Vistulian loesses.

The Paudorf soil was removed in certain relief situations; that took place at the beginning of the Vistulian Pleniglacial degradation. In that period, Old and Middle Vistula loesses are assumed to have been extensively removed especially in the border zone of the loess region. The loess deposited in the Pleniglacial, extends farther beyond the region of the Old and Middle Vistula loesses, where outside the range of the Old and Middle Vistula loesses, it lies directly on Pre-Vistulian sediments (ground moraines, fluvial and glacifluvial formations), a stone-line occurs at its base, which results from the aforesaid degradation phases. This Pleniglacial Vistula loess steadily decreases in thickness and increases in grain size towards the north. There is a continuous transition from sandy loess to sand-loess and finally to eolian sand.

The Pleniglacial sediments are less than 1 m thick, with a stone line separating them from the underlying Pre-Vistulian ground moraines as well as from fluvial and glacifluvial sediments.

Nowhere in this region was Eemian soil found under Pleniglacial sand-loesses and eolian sands of lesser thickness.

Large portions of the deposition surface of the eolian covering sediments mentioned above have a slope gradient 0° so that it is possible to estimate the rate of degradation since the Eemian on such completely plain surfaces. This is done by means of a comparison with the loess region in the south, where Pseudogley-Parabraunerde is found locally under loess of some 10 m in thickness on a ground moraine decalcified to a depth of 2 m. On a similar ground moraine located about 5 to 10 km from this outcrop the decalcification under sand-loess of negligible thickness reaches only ca. 0.5 m below the upper edge of the ground moraine, and no evidence of Eemian soil was found between the overlying sand-loess and the ground moraine.

If it be assumed that the two decalcification limits were formed simultaneously and should therefore be regarded as Eemian areal degradation of at least 150 cm after the post-Eemian must be assumed for the almost plain areas. Possibly the amount of degradation is even larger because under the sand-loesses of small thickness the $CaCO_3$ level must be assumed to have sunk during the Vistulian and Holocene, while the $CaCO_3$ level on the ground moraine under the calcareous loess of 10 m thickness is unlikely to have sunk since that time. On surfaces grading more than 0°, that is on the hill- and river valley sides, degradation since the Eemian has been even greater. Thus, the 150 cm given above are only a minimum value of the plain surfaces (Fig. 1).

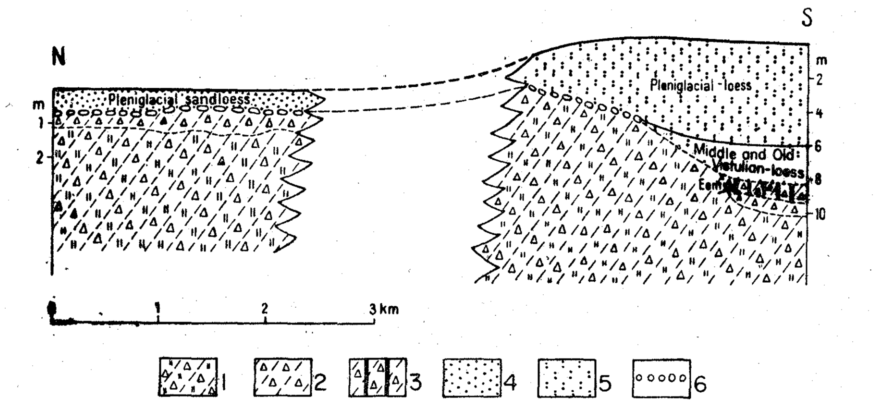

Fig. 1. Decalcification limit in ground moraines and the rate of post-Eemian degradation upon the flat surfaces

1. calcareous ground moraine; 2. decalcified ground moraine; 3. Eemian soil; 4. sand-loess; 5. loess; 6. stone-line

It may be concluded: firstly, that the region of the sand-loesses and eolian sands of small thickness was a region of degradation till far into the Pleniglacial and secondly, that probably all the phases of degradation observed in the loess region developed here most intensively.

The region described was a very important one for the supply of material for loess sedimentation, the more so as westerly and north-westerly winds contributed largely to this sedimentation. This cannot, however, be dealt with here.

In addition to the most widespread Pleniglacial deposits there occur more recent eolian sediments. East of the river valleys Pleniglacial sandy loesses and sand-loesses are overlain by younger, coarser-grained eolian sediments some 40 cm in thickness. A weakly developed gravel line at the interface and the partial degradation of well-developed soil horizons suggest degradation of the upper parts of the Pleniglacial sandy loess. Evidence of cryogenic processes resulting in the formation of ice wedges and frost-boils is here also noticeable. Parts of the overlying sediment were kneaded into the underlying soil, a Pseudogley-Parabraunerde. Also, parts of the A_3-horizon of this soil were kneaded into the B_t-horizon of the same soil. On the evidence of its strong development this soil must be dated as belonging to a late glacial Interstadial. It is probably Alleröd in age. The overlying sand-loess is also of late glacial origin, as indicated by the above mentioned characteristics and is dated as Younger Tundra (Fig. 2).

The late glacial sedimentation of sand-loess and eolian sand overlaps with the loess border region. In Leipzig area, however, it is restricted to places in river valleys and sandy areas where there was material available for deflation. The examples mentioned show that within Vistulian there was a frequent alternation of degradation and eolian accumulation.

In the loess region, however, no more eolian sediments were deposited after the Pleniglacial, though Late Glacial and Holocene slope processes largely changed the relief of the loess region. The processes of periglacial degradation in this area are best elucidated on the ground of the stone lines and stone accumulation horizons underlying the eolian sediments. East of the rivers and in the sand regions, numerous ventifacts were found in the stone lines. Here, deflation must have played a major role, the more so as the sand required as abrasive material for the formation of ventifacts was available. On the other hand, on a completely plain surface with no sand available, a stone line can likewise be due to deflation alone. In such stone lines, however, there are no ventifacts because there was not enough sand available for abrasion.

In a faintly grading relief, slopewash is regarded as a potent agent of degradation. Stone accumulation horizons up to 10 cm in thickness with an unsorted mixture of ventifacts and rounded sto-

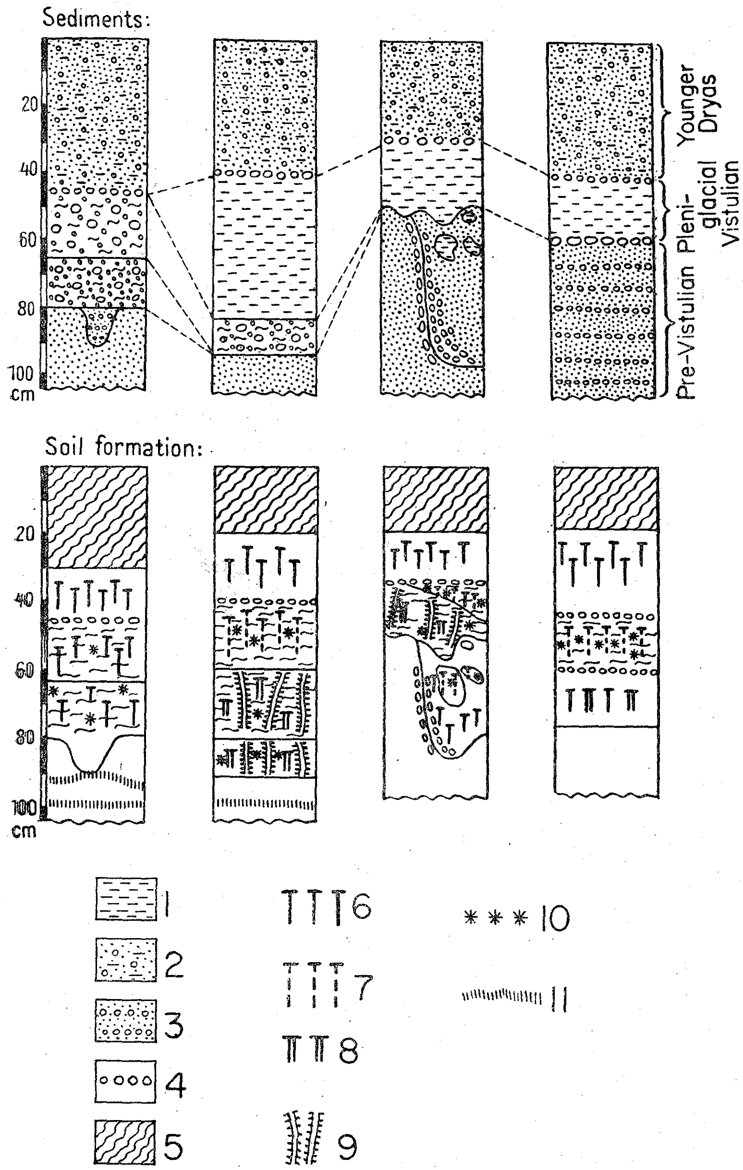

Fig. 2. Sand-loess (Younger Dryas) above older sediments as the material for soil formation. Profiles at Borna

1. sandy loess; 2. sand-loess with gravels; 3. sand with gravels; 4. stone-line; 5. plough-horizon; 6. brown horizon; 7. eluvial horizon; 8. illuvial horizon; 9. pseudogley horizon; 10. iron- and manganese concretions; 11. clay bands

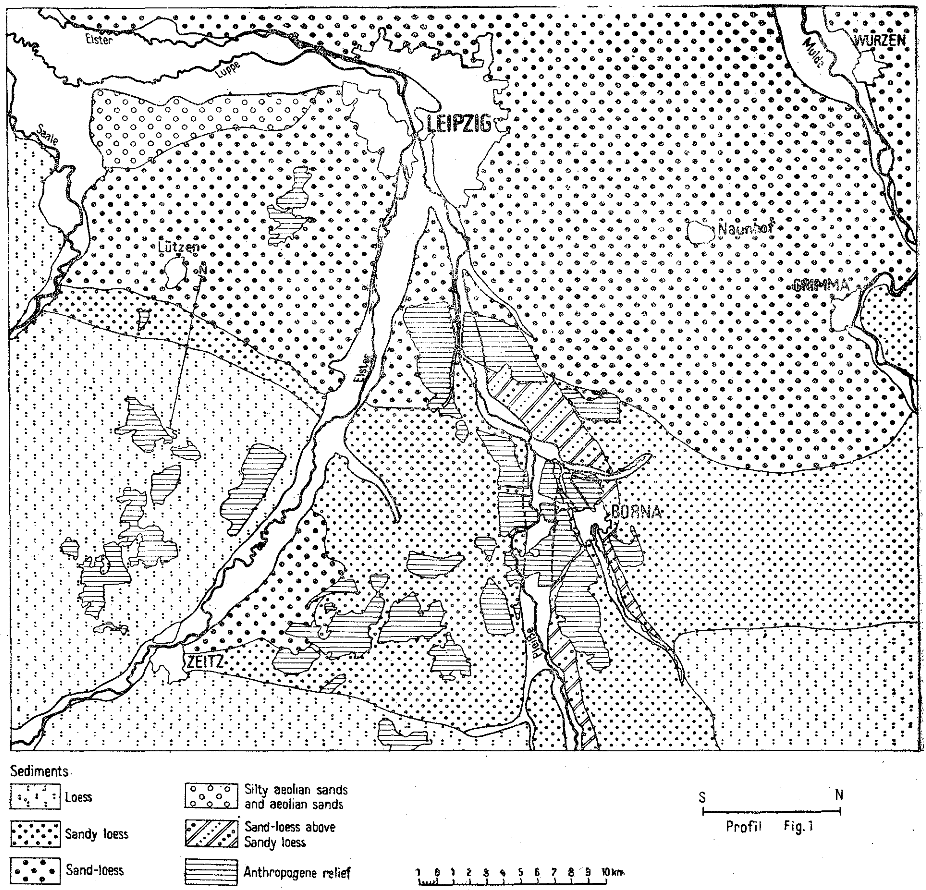

Fig. 3. Young-Pleistocene covering sediments

nes devoid of fine-grained cement suggest vigorous slopewash. Still, stone horizons accumulated by solifluxion and including a clayey-silty cement were found beneath the eolian sediments. Moreover, cryogenic processes such as upheaving of stones by frost action and pipkrake formation contributed to degradation.

SUMMARY

Using geomorphologic, sedimentologic and pedologic methods attempts were made to obtain information on the type and intensity of the Vistulian slope development and on the deposition of

the eolian covering sediments of the North-west Saxon region of old moraines. The occurrence of loess depends on the relief and the position relative to the river valleys in a flat relief area. The lithologically different facies of the sand-loesses and the eolian sands of lesser thickness are due to their position relative to the sand supplying river valleys, and also to some extent dependant on the grain-size composition of the underlying sediments providing the material.

The region of thick loess offered conditions for relief development which were quite different from those in the area of sand-loesses and eolian sands of lesser thickness. On almost plain surfaces, with a minimum degradation of 1.5 m since the Eemian is assumed in the latter area, but in the hilly area the magnitude of degradation is even higher.

The highest amounts of degradation are attributed to the early phases of the Stadials, whereas in the subsequent phases of a Stadial eolian sediments were deposited, which were more or less re-deposited depending on the climatic conditions of the Stadial, the slope form and the facies area.

Localized sedimentation, of which there is no evidence as yet in the region of thick loess, took place east of the river valleys in the Younger Tundra time.

The Holocene slope formation is considerably more marked in the loess region than in the sand-loess or eolian sand areas.

References

Kundler, P., 1959 — Zur Kenntnis der Rasenpodsole und Grauen Waldböden Mittelrusslands im Vergleich mit den Sols lessivés des westlichen Europas. *Ztschft. f. Pflanzener., Düngung, Bodenkunde,* Bd. 86.

Lieberoth, I., 1963 — Lößedimentation und Bodenbildung während des Pleistozäns in Sachsen. *Geologie,* Bd. 12.

Neumeister, H., 1965 — Probleme der nördlichen Lößgrenze. *Leipziger Geog. Beiträge, Prof. Lehmann z. 60 Geb.*

Neumeister, H., 1966 — Die Bedeutung der äolischen Sedimente und anderer Periglazialerscheinungen für die Bodenentwicklung in der Umgebung von Leipzig. Diss. Leipzig.

Richter, H., 1964 — Der Boden des Leipziger Landes. *Wiss. Veröff. Dtch. Inst. f. Länderkunde,* N. F., 21/22.

Schönhals, E., 1955 — Kennzahlen für den Feinheitsgrad des Lösses. *Eiszeitalter u. Gegenwart,* Bd 4/5.