Polarforschung 53 (2): 67—74, 1983

Grèzes Litées as a Special Type of Periglacial Slope Sediments in the German Highlands

By Johannes Karte*

Summary: Field and laboratory investigations into the sedimentology and geomorphology of thick stratified slope deposits (grèzes litées) in the Rothaargebirge, in the northeastern part of the Rhenish Slate Mountains, Federal Republic of Germany, show that these deposits were formed by a complex of geomorphic processes involving frost weathering, episodic or periodic aquatic transport and deposition in connection with surface runoff, slopewash and acitve layer interflow. The locally restricted occurrence of these deposits is related to favourable lithology and specific conditions of snow cover and ablation patterns in a periglacial environment close to the Pleistocene climatic snow line. Volcanic heavy mineral associations at the bottom of a cryoturbated horizon overlying the grèzes litées, which are typical for the Alleröd Laacher See eruption, suggest that the formation of these deposits ended by that time.

Zusammenfassung: In den höheren Lagen des Rothaargebirges im nordöstlichen Rheinischen Schiefergebirge treten lokal mächtige geschichtete Hangsedimente vom Typ der Grèzes litées auf, deren sedimentologische Eigenschaften und lithologische sowie geomorphologische Voraussetzungen näher untersucht wurden. Es kann gezeigt werden, daß diese Ablagerungen durch ein Prozeßgefüge nahe der pleistozänen klimatischen Schneegrenze entstanden sind, an dem Frostverwitterung, episodischer oder periodischer aquatischer Transport und Ablagerung in Verbindung mit Oberflächenabfluß, Abspülung und Mollisol-Interflow beteiligt sind. Das lokal begrenzte Vorkommen dieser Ablagerungen ist durch lithologische Gunstvoraussetzungen in Verbindung mit dem spezifischen reliefgesteuerten Ausaperungsverhalten der pleistozänen Schneedecke bedingt. Die mächtigen Grèzes litées-Folgen werden unterhalb der Landoberfläche von einem Horizont mit fossilen Frostbodenformen überlagert. Vulkanische Schwermineralassoziationen an der Basis dieses Frostbodenhorizontes, die dem allerödzeitlichen Laacher See-Ausbruch zugeordnet werden können, zeigen, daß die Bildung dieser Grèzes litées im Spätglazial der letzten Kaltzeit abgeschlossen wurde.

INTRODUCTION

As part of the Central European Highlands the northeastern Rhenish Slate Mountains constitute an uplifted shield area of moderate relief and altitude. They are underlain by Devonian and Carboniferous sandstones, quarzites, slates, shales and siltstones which are strongly folded. In the upper part, the so-called "Rothaargebirge" or "Hochsauerland", it is characterized by deeply dissected remnants of Tertiary planation surfaces, convexo-concave slopes with straight middle segments and structurally controlled landforms which rise to an elevation of 840 m.

Although this elevation may come close to the Pleistocene snowline, whose theoretical position is still open to speculation, there is no evidence that, unlike the Harz Mountains or the Black Forest, this part of the Central European Highlands developed its own local glaciation. Lying outside the area covered by the Scandinavian ice sheets it has, however, been exposed for several times to intense periglacial conditions.

On slopes these conditions are manifested by widespread sheets of solifluction debris which, particularly in connection with steeply dipping sandstones and slates, overlie a zone of downslope bended strata. The solifluction deposits are generally thin (0.3 to 1.5 m), and non-bedded but in many cases stratigraphically subdividable as to the processes of their formation (cf. SEMMEL, 1964; SCHRÖDER & FIEDLER, 1977a, b).

Apart from this there are a number of localised occurrences of distinctly stratified slope deposits of considerable thickness. In many respects they are similar to the ,,Grèzes litées" described as recent phenomena from the Arctic (MALAURIE & GUILLIEN, 1953; JAHN, 1960), as fossil sediments from Pleistocene periglacial Western (WATSON, 1965; GUILLIEN et al., 1974; MICHEL 1976; BOARDMAN, 1978) and Eastern Europe (CZUDEK et al., 1963) and New Zealand (HARRIS, 1975). They have also been re-

*Dr. Johannes Karte, Deutsche Forschungsgemeinschaft, Kennedyallee 40, D-5300 Bonn 2.

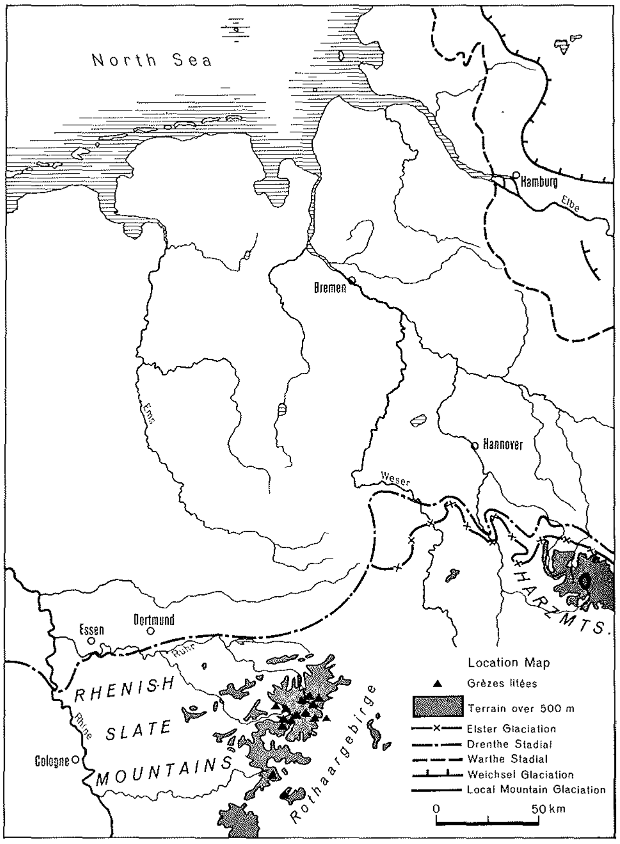

Fig. 1: Location map of the area of investigation and of grèzes litées occurrences in the Rhenish Slate Mountains, F.R.G.

Abb. 1: Lage des Arbeitgebietes und der Grèzes litées Vorkommen im Rheinischen Schiefergebirge.

ported from mediterranean environments (DRAMIS, COLTORTI & GENTILI, 1980) and the Hindu Kush (WASSON, 1979).

It is the occurrence of these deposits in different climatic zones and under different local site conditions which makes their genesis problematic. So far grèzes litées are not adequately defined as to their processes of formation. In a descriptive sense they constitute "bedded slope deposits of angular, usually pebble-size rock chips and interstitial finer material, in which the bedding is manifested by more or less regularly repeated alternation of grain size characteristics" (WASHBURN, 1979: 244).

This paper presents results of field and laboratory investigations into the geomorphology, lithology, sedimentology and stratigraphy of the grèzes litées type slope deposits in the "Rothaargebirge", northeastern Rhenish Slate Mountains. Here, the thickness of these deposits (cf. Fig. 2) which can be seen in exposures and which has partly been determined by seismic refraction soundings varies between 1.5 and more than 20 m (cf. LEUTERITZ, 1972; LUSZNAT, 1978; MÜLLER, 1982).

DISTRIBUTION AND GEOMORPHOLOGY

All hitherto known occurrences of grèzes litées in the Rothaargebirge (cf. Fig. 1) lie above 450 m a.s.l., predominantly between 500 and 700 m a.s.l. and on slopes exposed to N and NE. However, above 600 m a.s.l. this preference for a particular slope aspect becomes less significant.

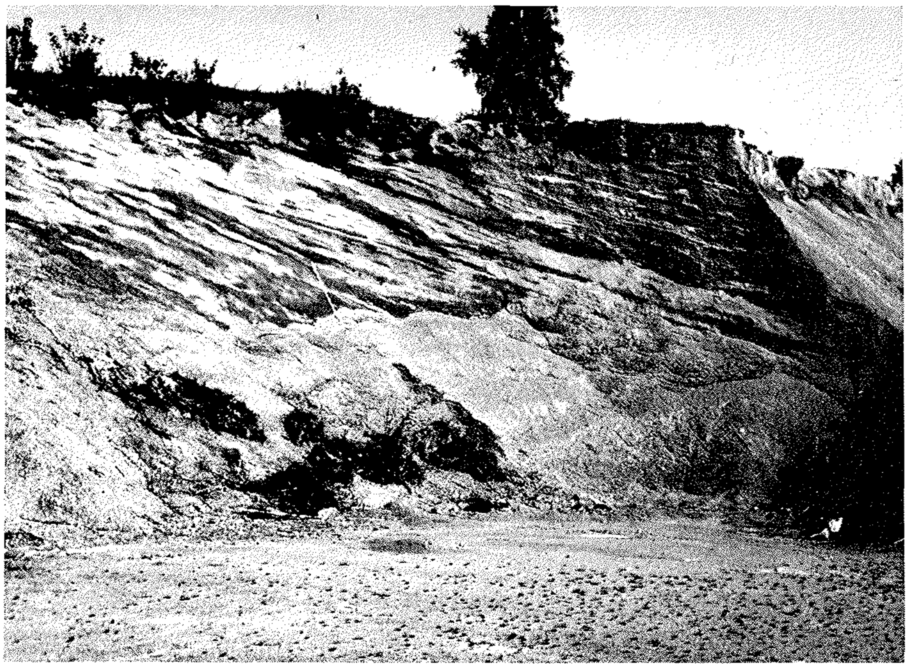

Fig. 2: Grèzes litées exposed 3 km W of Küstelberg, near Winterberg, Rothaargebirge.

Abb. 2: Grèzes litées -Aufschluß 3 km westlich von Küstelberg bei Winterberg im Rothaargebirge.

The topographic and geomorphological conditions where these deposits occur are also variable. Some form accumulations either at the bottom of slopes or as an infill of steeply inclined small valleys or ra-

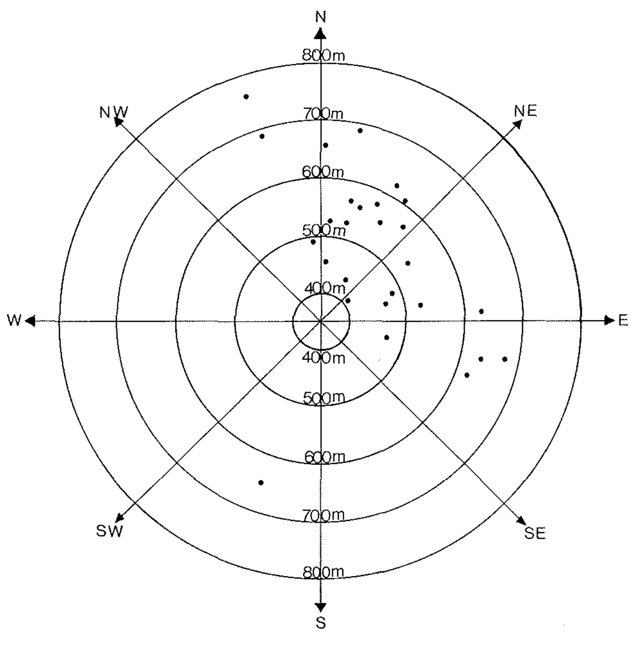

Fig. 3: Altitude and aspect of stratified slope deposits in the Rothaargebirge.

Abb. 3: Höhenlage und Exposition geschichteter Hangablagerungen im Rothaargebirge.

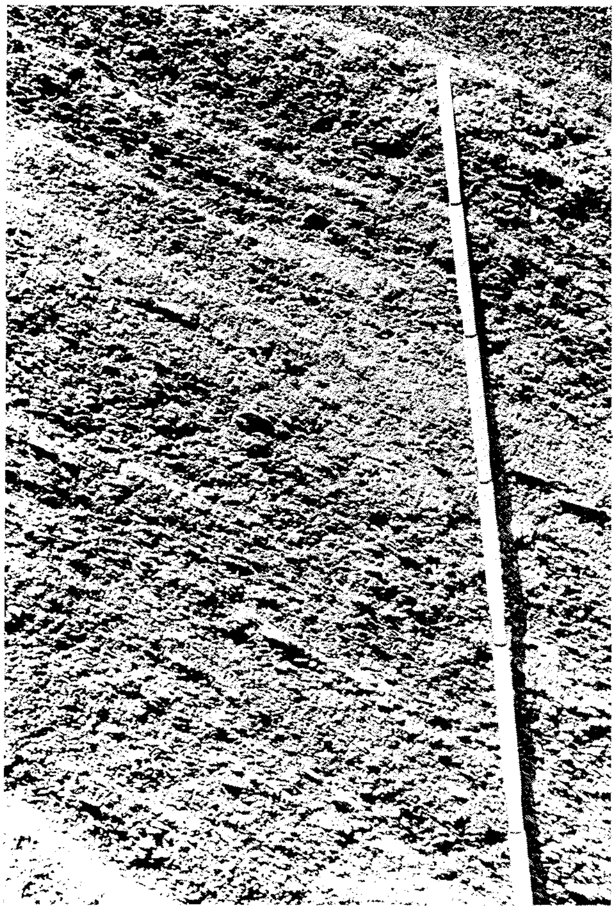

Fig. 4: Well bedded grèzes litées 3 km W of Küstelberg, near Winterberg, Rothaargebirge.

Abb. 4: Deutlich geschichtete Grèzes litées 3 km westlich von Küstelberg bei Winterberg, Rothaargebirge.

vines where they are actively eroded and redeposited. Others occur in watershed positions which explains their conservation as loose and easily erodible deposits. Others again can be found near the lower end of steeply inclined (up to 20 °) wide hollows and thus in the middle segments of slopes leading to sharply incised ravines with an active drainage system. Especially remarkable and problematic are a number of particularly thick deposits and their conservation in the middle segments of slopes with an inclination of 15 to 20 °, and in some cases even 35 °.

The deposits themselves show no distinct relief but their thickness presupposes deep hollows in the preexisting relief. Most of the topographic and geomorphological site conditions can be related to past or present hydrological conditions involving locally higher water supply. Another factor controlling the formation and distribution of these deposits is lithology. All occurrences are closely connected to outcrops of soft shales and siltstones which easily disintegrate into fine debris and silt under periglacial (cryogenic) weathering conditions.

SEDIMENTOLOGICAL CHARACTERISTICS

The conspicuous bedding of these slope deposits (cf. Fig. 4) is manifested by repeated alternation of grain

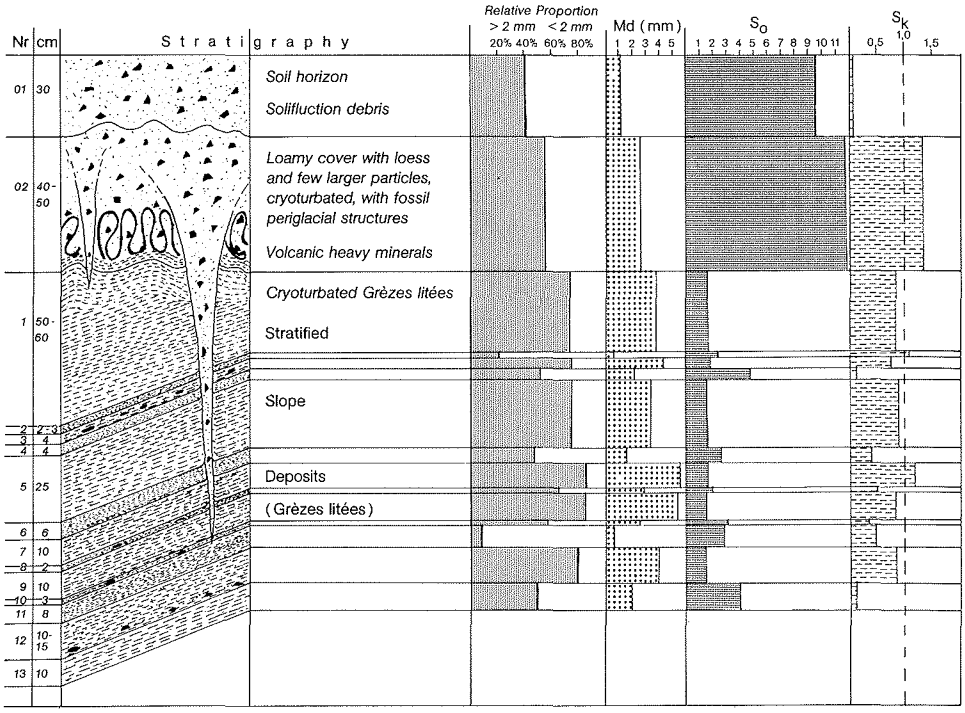

Fig. 5: Grèzes litées, Hesborn locality (490 m): Stratigraphy and sedimentary parameters.

Abb. 5: Grèzes litées bei Hesborn (490 m): Stratigraphie und sedimentologische Parameter.

size characteristics. The proportion of coarser to finer material can be shown by a section about 1 m thick consisting of 13 different layers (cf. Fig. 5).

Mean grain size characteristics of these layers show a prevalence of coarser fractions and also higher values of standard deviation for the coarser fractions but a secondary rise in the silt fraction (cf. Fig. 6). This rhythmical alternation of grain size is also expressed by parameters like the median or skewness. Typical are 2 to 15 cm thick layers of predominantly coarse angular to slightly rounded platy shale and siltstone debris alternating with thinner continuous to semi-continuous, edging bands of finer debris with a silty matrix and predominantly silty layers. Within the coarser fraction the size of the particles varies between 2 and 6 cm.

Together with imbrication and a dominant transverse orientation of the coarser particles, this distinct bedding is generally attributed to transport and deposition by surface water and/or slopewash. Although sorting within the individual layers of the grèzes litées is considerably better than in the overlying cryoturbated horizon, due to varying amounts of interstitial finer material, the degree of sorting is still generally moderate to poor.

X-ray diffraction analysis shows that both the finer fractions and the coarser debris are the mechanical weathering product of the shale and siltstone bedrock. The fine material was eluviated upslope by slopewash and subsurface wash and redeposited and illuviated further downslope as evidenced by silt coatings. The transport of both the coarser and finer fractions requires vegetation-free conditions. The eluviation of fines may have impeded gelifluction so that slopewash prevailed as transporting mechanism.

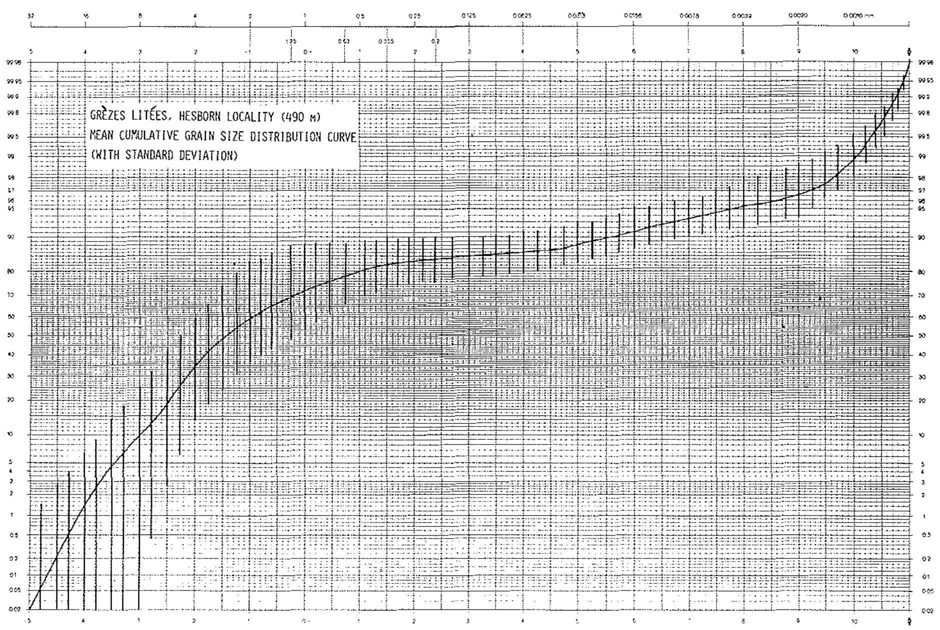

Fig. 6: Grèzes litées, Hesborn locality (490 m): Mean cumulative grain size distribution curve (with standard deviation).

Abb. 6: Grèzes litées bei Hesborn (490 m): Mittlere Korngrößenverteilung (mit Standarabweichung).

Transport of the coarser fractions requires minimum surface runoff velocities of between 1 and 3 m/sec. These can only be conceived during short term, accentuated intense surface runoff or slushflow. The required amounts of water are derived from the melting of long lasting snow patches in upper slope segments while middle segments of slopes where many grèzes litées occur had already become snowfree earlier. It is difficult to conceive that the large amounts of meltwater are derived mainly from the thawing of frozen ground as stated by some authors (e. g., JOURNEAUX, 1976). But, as shown by investigations in arctic environments, snow patches may locally, by lifting the active layer underneath them, add indirectly large quantities of active layer interflow to their own meltwater (cf. BALLANTYNE, 1978; LEWKOWICZ, DAY & FRENCH, 1978). Some localities are still today linked to springs which, under periglacial conditions, may have locally contributed water from permafrost seepages. The pre-existing hollows into which the grèzes litées were deposited may also have led to locally concentrated runoff.

The strata dip between 20 and 35° which is generally steeper than the present landsurface. This implies that the sediments were originally deposited on steeper slope segments, hollows, or into ravines. In some cases the direction of transport of the sediments deviates substantially from the orientation of the slope of the present landsurface. This can probably be explained by long lasting snow and firn patches at the bottom of slopes or in depressions which operated as an abutment for sediment transport (cf. GUILLIEN, 1964).

STRATIGRAPHY AND AGE

The thick stratified deposits cannot be further subdivided stratigraphically. On steeper slopes they are occasionally covered by a thin gelifluction horizon. Generally, the topmost 0.5 to 1.0 m of the originally stratified debris and fines are strongly cryoturbated and show epigenetic periglacial phenomena such as pseudomorphs of frost cracks, ice-wedges and soil wedges (cf. Fig. 7). It is overlain by a gelifluction sheet

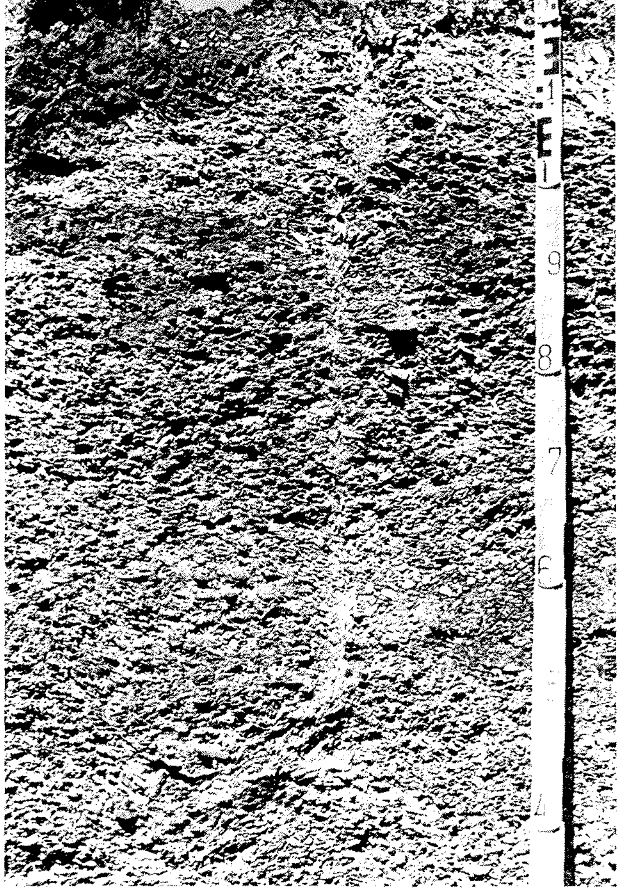

Fig. 7: Cryoturbated upper horizon of grèzes litées near Küstelberg with fossil frost crack.

Abb. 7: Kryoturbat überprägte Deckschicht der Grèzes litées bei Küstelberg mit fossiler Frostspalte.

conspicuous for its high content of loam and relatively few stones. Within the cryoturbated horizon and at the bottom of the overlying gelifluction sheet heavy mineral associations have been identified which are typical of volcanic ashes from the eruptions of the Laacher See volcano in the East Eifel during the Alleröd (about 11,000 B. P.) cf. FRECHEN, 1959; WINDHEUSER, 1977). Thus the topmost gelifluction sheet can be correlated to other gelifluction sheets of Younger Dryas age which are widespread in the Central European Highlands (SEMMEL, 1964). The morphodynamic change from prevailing slopewash and subsurface drainage to the formation of periglacial structures presupposes a stabilisation of the landsurface, presumably by invading vegetation during the late Glacial which would also promote gelifluction rather than slopewash. This change is supposed to have taken place in the area of investigation after the Older Dryas. There is no direct evidence for the age of the underlying stratified slope deposits. However, since they are stratigraphically not further subdividable and they are conserved as loose material on steep slopes, it can be assumed that they are of Main or even Late Weichselian age.

CONCLUSIONS

The grèzes litées type slope sediments in the higher parts of the northeastern Rhenish Slate Mountains are remarkable for their thickness and conspicuous bedding. They occur locally under specific geomorphological, lithological and hydrological conditions. From an analysis of the factors determining their spatial distribution and sedimentological characteristics it is concluded that these sediments were formed by a combination of frost weathering and episodic or periodic slopewash combined with subsurface drainage related to locally high meltwater supply. The latter was derived mainly from snow patches and only secondarily from the melting of frozen ground. Stratigraphical evidence shows that the formation of most of these deposits ended during the Older Dryas, or even earlier. The grèzes litées themselves cannot be further subdivided as to stratigraphy. This and the fact that they are conserved on steep slopes suggests that they are of Main Würmian/Weichselian age.

In more general terms, the significance of the grèzes litées indicates that, at least locally, periglacial morphodynamics in those parts of the Central European Highlands which were close to the former snow line, were dominated by a combination of slopewash processes related to nivation and specific patterns of snow ablation rather than by gelifluction.

References

Ballantyne, C. K. (1978): The hydrologic significance of nivation features in permafrost areas. — Biul. Peryglac. 27: 5—10.

Boardman, J. (1978): Grèzes litées near Keswick, Cumbria. — Biul. Peryglac. 27: 23—34.

Czudek, T., Demek, J., Panos, V. & H. Seichterova (1963): The Pleistocene rhythmically bedded slope sediments in the Hornomoravskj uvak (the Upper Moravian Graben). — Sbornik Geologichych Ved. A (1): 75—100.

Dramis, F., Coltorti, M. & B. Gentili (1980): Glacial and periglacial morphogenesis in the Umbria — Marche Apennines. — 24th Int. Georgr. Congress Tokyo 1980, Abstracts, 1: 114—115.

Frechen, J. (1959): Die Tuffe des Laacher Vulkangebietes als quartärgeologische Leitgesteine und Zeitmarken. — Fortschritte in der Geologie d. Rheinlande u. Westf. 4: 363—370.

Guillien, Y. (1964): Grèzes litées et bancs de neige. — Geologie en Mijnbouw, 3: 103—112.

Guillien, Y., Mainguet, M., Dewolf, Y., Joly, F., Raynal, R. & G. Soutade (1974): Grèzes, loess, groizes entre Manche et Méditerranée. — Notes et Compte Rendu, Groupe de Travail sur la régionalisation, 39—44, Paris.

Harris, S. A. (1975): Petrology and origin of stratified scree in New Zealand. — Quat. Res. 5: 199—214.

Jahn, A. (1960): Some remarks on evolution of slopes on Spitsbergen. — Z. Geomorph. N. F., Suppl. Bd. 1: 49—58.

Journeaux, A. (1976): Alternances du ruisselement et de la solifluction dans les milieux périglaciaires: exemples Canadien et expérimentations. — Biul. Peryglac. 26: 267—273.

Leuteritz, K. (1972): Geologische Karte von Nordrhein-Westfalen 1:25 000. Erläuterungen zu Blatt 4817 Hallenberg — Krefeld.

Lewkowicz, A. G., Day, T. J. & H. M. French (1978): Observations on slopewash in an arctic tundra environment, Banks Island, District of Franklin. — Geol. Survey Canada Paper 78-1A: 516—520.

Lusznat, M. (1978): Geologische Karte von Nordrhein-Westfalen 1:25 000. Erläuterungen zu Blatt 5015 Erndtebrück — Krefeld.

Michel, J. P. (1976): Un type particulier de depôt de pente quaternaire: les grèzes litées calcaires de Lorraine (Nordes de la France). — Rev. Géogr. Montréal 30: 379—386.

Müller, H. (1982): Geologische Karte von Nordrhein-Westfalen 1:25 000. Erläuterungen zu Blatt 4816 Girkhausen — Krefeld.

Schröder, H. & H. J. Fiedler (1977a): Beitrag zur Kenntnis der periglazialen Deckschichten des östlichen Harzes. Teil 1: Gliederung, Lithologie und Verbreitung der periglazialen Deckschichten. — Z. Geol. Wissensch. 5: 51—81.

Schröder, H. & H. J. Fiedler (1977b): Beitrag zur Kenntnis der periglazialen Deckschichten des östlichen Harzes. Teil 2: Genese, Stratigraphische Deutung und Parallelisierung der perigalzialen Deckschichten. — Z. Geol. Wissensch. 5: 1083—1104.

Semmel, A. (1964): Junge Schuttdecken in Hessischen Mittelgebirgen. Notizblatt hess. Landesamt f. Bodenforschung 92: 275—285.

Malaurie, J. & Y. Guillien (1953): Le modelé cryo-nival des versants meubles de Skansen (Disko, Greenland). Interprétation générale des grèzes litées. — Soc. Géol. France Bull. 6 (3): 703—721.

Washburn, A. L. (1979): Geocryology — A survey of periglacial processes and environments — London.

Wasson, R. J. (1979): Stratified debris slope deposits in the Hindu Kush, Pakistan. — Z. Geomorph. N. F. 23: 301—320.

Watson, E. (1965): Grèzes Litées ou éboulis ordonnés tardiglaciaire dans la région d'Aberystwyth. — Bull. Ass. Géogr. Franc. 338: 16—25.

Windheuser, H. (1977): Die Stellung des Laacher Vulkanismus (Ost-Eifel) im Quartär. — Sonderveröff. d. geol. Inst. d. Universität Köln 31, Köln.