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GRÈZES LITÉES NEAR KESWICK, CUMBRIA

Abstract

Stratified slope deposits or grèzes litées are described from northern Cumbria, England. The stratigraphy, morphology and lithology of the deposits is examined and results of fabric and particle size and shape analyses are discussed. It is suggested that the grèzes litées originated as periglacial slope deposits probably during Younger Dryas (pollen Zone III) time.

INTRODUCTION

DEFINITION OF GRÈZES LITÉES

WASHBURN (1973) describes grèzes litées as "bedded slope deposits of angular, usually pebble-size rock chips and interstitial finer material". Their precise origin is open to dispute, but there seems little doubt that the angular gravel results from frost shattering, and the bedded nature of the deposits suggests water as the transporting agent. Creep and gelifluction have also been put forward as playing some part in their formation. The seasonal melting of permanent or semi-permanent snowdrifts seems the most likely source of the water responsible for the bedding (GUILLIEN, 1951), though in central Wales (WATSON, 1965) and Tasmania (DERBYSHIRE, 1973) it has been pointed out that stratified slope deposits are not associated with north-facing slopes where permanent snow patches might have been expected to lie.

The rhythmic character of some deposits suggest that "an alternation of processes may be involved" (WASHBURN, *op. cit.*), and DYLIK (1960) has shown this to be the case with the stratified slope deposits of southern Poland. In Tasmania it has been suggested (DERBYSHIRE, 1973) that the periodicity of the bedding may indicate an annual depositional rhythm related to winter rockfall activity and summer solifluction.

This paper describes deposits of a grèze litée character near Keswick, Cumbria (Fig. 1). Stratigraphical and morphological evidence is presented as well as the results of particle size and shape analyses. It is argued that these deposits accumulated under periglacial conditions during Late Glacial, Younger Dryas time (pollen Zone III).

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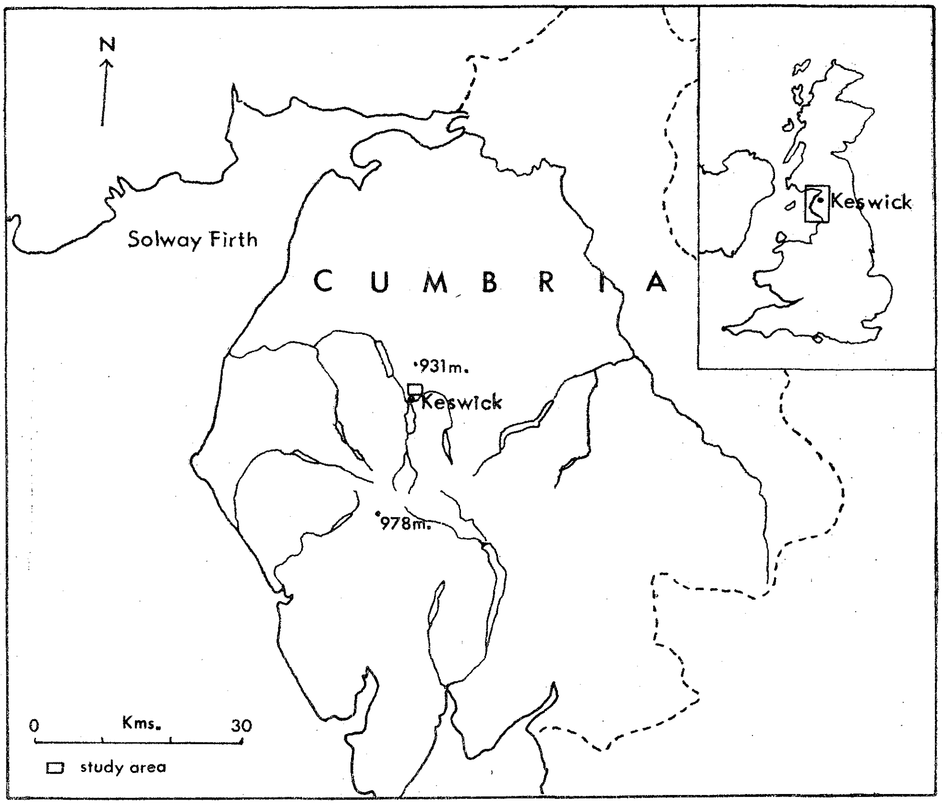

Fig. 1. Location of study area north of Keswick, Cumbria

THE STUDY AREA

During the construction of the Keswick Northern Bypass three temporary exposures of grèzes litées were examined. In addition, trial pit and borehole data obtained during surveys for the road have been studied.

The deposits occur 1 km north-east of the centre of Keswick near Greta Bank Farm (NY 272241) in an area where the Keswick Bypass is being constructed across the lower slopes of Latrigg (279246). The road slopes from 130 m altitude in the east to 90 m in the west. Outcrops of well-cleaved Skiddaw Slate occur on the south-facing slope of Latrigg (Fig. 2). The position and general form of Latrigg suggest that its slopes are the product of glacial erosion.

To the south and west of Greta Bank Farm are well-defined till drumlins with crest-line orientation in sympathy with the regional trend around Keswick (315°–135°).

The present day vegetation of the area is indicated on Fig. 4. Above the 244 m contour (800 ft.) the upper slopes of Latrigg are smooth, grass-covered moorland interupted by occasional slate outcrops. Its present

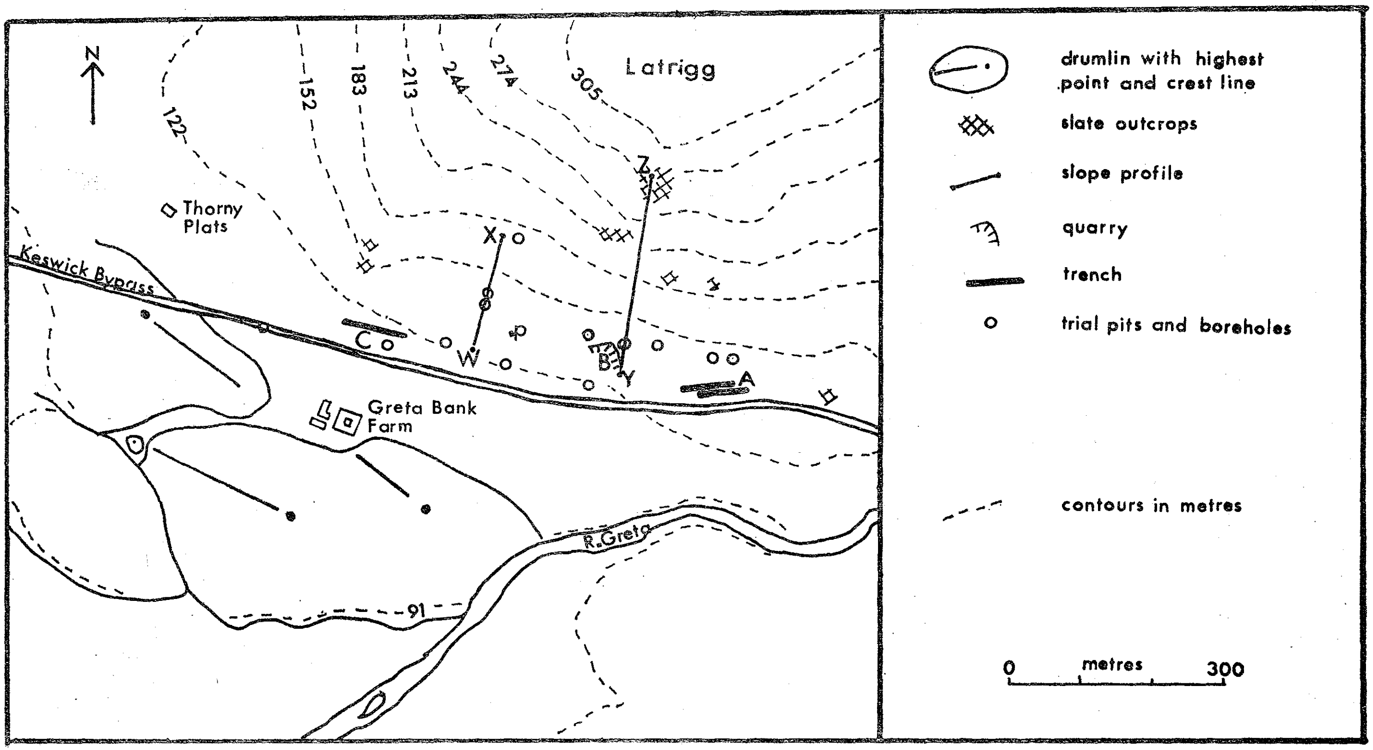

Fig. 2. Relief and landforms of the study area

appearance is due to three factors: mantling by slate scree deposits which are to be seen where footpaths and tracks give rise to small areas of erosion; deforestation during and after the last war; and sheep grazing preventing regeneration of the Woodland.

DESCRIPTION OF THE DEPOSITS

TEMPORARY EXPOSURES

Details of three temporary exposures are given below; their locations are shown on Fig. 2.

Site A

1 m of slate gravel rests on till in a 30 m long trench. The deposit is well stratified with gravel layers rich in interstitial material interbedded with predominantly gravel-size, loose, slate layers. Parallel to this exposure and 2 m upslope a similar trench reveals 1 m of slate gravels.

Site B

At this site the slate gravels have been quarried at some time in the past but during construction of the bypass an unsuccessful attempt was made to locate the water-table by digging a vertical pit into and below the north face of the quarry. This resulted in an excellent exposure of 4.4 m depth of gravels. The uppermost 1 m was a slate gravel with a fine matrix which is much less apparent in the underlying 3.4 m of loose slate fragments.

A sample was taken from the uppermost 1 m of gravels and another from 3 m below ground surface. Table I gives details of particle size analysis carried out on these samples and the moment statistics for these analyses are also presented.

Table I

	Sediment Analysis				Moment Statistics (phi units)			
	sample wt. Kg.	% gravel	% sand	% silt+ clay	M.	s. d.	sk.	K
Upper bed	4.2	52.5	42.84	4.66	−1.14	1.4	+0.3	3.3
Lower bed	3.6	86.84	10.79	2.37	−2.2	1.2	+1.6	6.8

M. = mean, s.d. = standard deviation, sk. = skewness, K. = kurtosis

A feature of the upper bed was the high percentage of interstitial material: 38 % of the sample being coarse and very coarse sand. The corresponding percentage in the lower bed was 8.6%. This sample was dominated by a large gravel component.

Random samples of 100 stones of greater than 1 cm in length were selected from both beds for analysis of shape. The results are shown in Table II and can be compared with the same ratios obtained by POTTS

Table II

Measurement of Shape

	Keswick Lower bed	Keswick Upper bed	Central Wales stratified scree	Laboratory freeze — thaw cycles
	n = 100	n = 100	n = 80	n = 28
Thickness / Major axis	0.259	0.221	0.144	0.138
Thickness / Minor axis	0.441	0.352	0.231	0.240

Data from Central Wales and laboratory experiments from POTTS (1970).

(1970) for a sample from stratified screes in central Wales and a sample produced by freeze—thaw cycles in a laboratory. In both cases the samples are lithologically similar to those from the Keswick area.

It can be seen that the values obtained for the Keswick samples are in all cases higher than those obtained by POTTS. This may be a result of minor lithological differences or it may indicate a lesser intensity or number of freeze—thaw cycles in the Keswick area.

Measurements of the orientation and dip of the long axis of 50 elongate particles from site B indicate that 70% of the readings fall within the 90° sector, 155°—210°, with the median between 180° and 190°, in close argeement with the direction of the surface slope (198°) (Fig. 5). The mean dip of the particles is 16° and the angle of the surface slope at this site is 23° but the upper profile in Fig. 4 suggests that in parts of the area under discussion the original plane of deposition was at a lower angle than the present ground surface. This pattern therefore represents an imbricate structure with respect to the plane of deposition. MCCANN (1961) has suggested that such an arrangement is to be expected in water-laid gravels deposited by streams flowing over high gradients.

Site C

In a trench at this site grèzes litées overlie till and incorporate within their lower layers glaciated cobbles of Threlkeld Microgranite and Borrowdale Volcanic Series lavas. There are many more non-slate stones within the grèzes litées than are seen at any other exposure, presumably due to

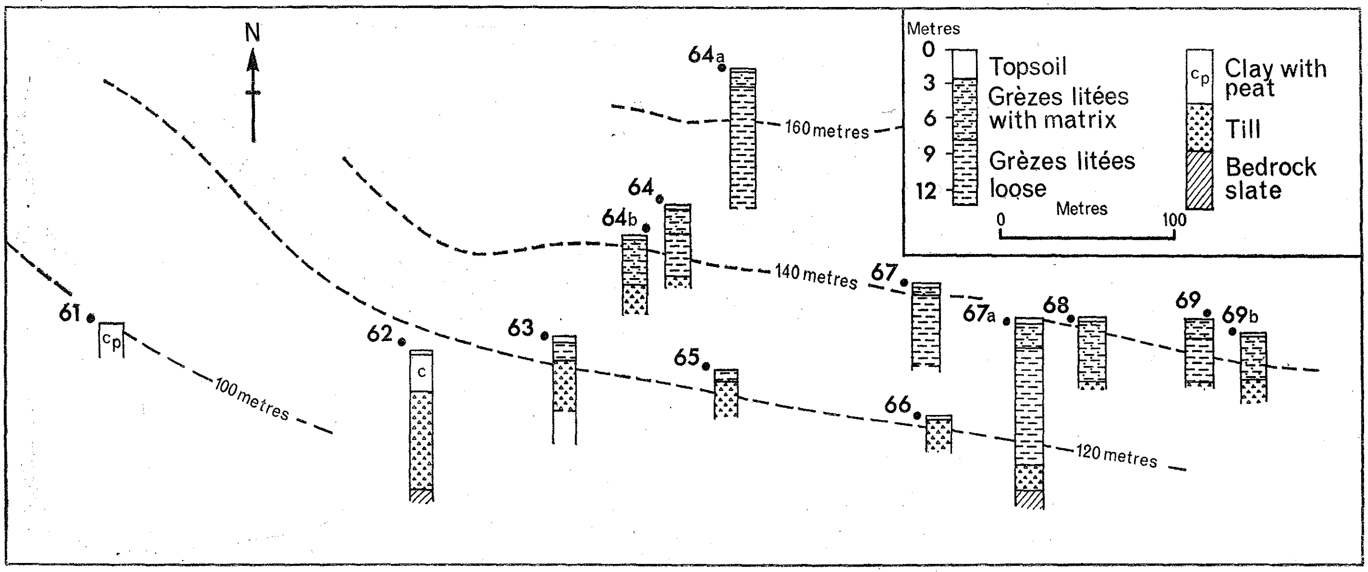

Fig. 3. Position, altitude and stratigraphy of trial pits and boreholes on the lower slopes of Latrigg

the proximity of the till junction and the relatively low altitude of the site. As the trench slopes to the west it becomes deeper (2 m) and the grèzes litées regain their typical slate-dominant character. No till is to be seen in this section. This change is probably related to movement away from the till-covered lower slopes of Latrigg into a shallow depression where greater thicknesses of slope deposits have accumulated. At site C the grèzes litées contain lenses of slate gravel bound by a firm matrix and the bedding appears to be involuted near to the surface and is cut by small faults. Such structures were not observed elsewhere.

Fig. 3 suggests that the grèzes litées at this site are of limited areal extent. A few metres to the south of site C, borehole 62, contained a firm clay with angular gravel, overlying till. It seems probable that the clay is a hillwash deposit incorporating the fine fraction of the local till and the slates weathered from the slopes above. The local till contains little angular slate. One hundred metres west of site C, in borehole 61, clay with traces of peat was recorded which again is interpreted as being a Post Glacial hillwash deposit.

BOREHOLES

Borehole and trial pit records provide further information on the extent and nature of the grèzes litées in the area of the temporary exposures (Fig. 3).

(a) It can be seen that considerable depths of slope deposits occur at sites 64a (12 m) and 67a (12.5 m).

(b) South of sites 63, 65 and 66 where a thin layer of grèzes litées overlies till, the slope deposits have not been observed. Altitudinally, they do not seem to occur in this area below 118 m.

(c) The borehole and pit data confirm the observations at site B, as to the change in character of the grèzes litées from an upper gravel, bound by a fine matrix, to a coarser, openwork or loose gravel below.

SLOPE MORPHOLOGY

Two slope profiles were surveyed with a tape and clinometer and their location is shown on Fig. 2. The underlying stratigraphy is obtained from boreholes and pits that lie on, or close to, the lines of profile (Fig. 4).

From profile W–X it can be seen that the till surface on which the grèzes litées rest is at a lower angle than the present ground surface. The till beneath the grèzes litées outcrops 30 m to the east of the profile at P on Fig. 2, and its presence would seem to be responsible for the high slope angles on the lower part of the profile. In view of the nature of the topography to the south it is probable that the grèzes litées on the lower part of the profile are partly burying a drumlin.

On profile Y — Z the steady increase in slope angle was noticeable, from 17° at the base to 46° on the slate outcrop. Along most of its length this profile is crossing a poorly-vegetated talus slope composed of slate debris that is coarser than that which makes up the grèzes litées at the exposures. Neither the exposures nor the boreholes indicate the relationship of the surface talus deposit to the grèzes litées but it seems likely that the latter

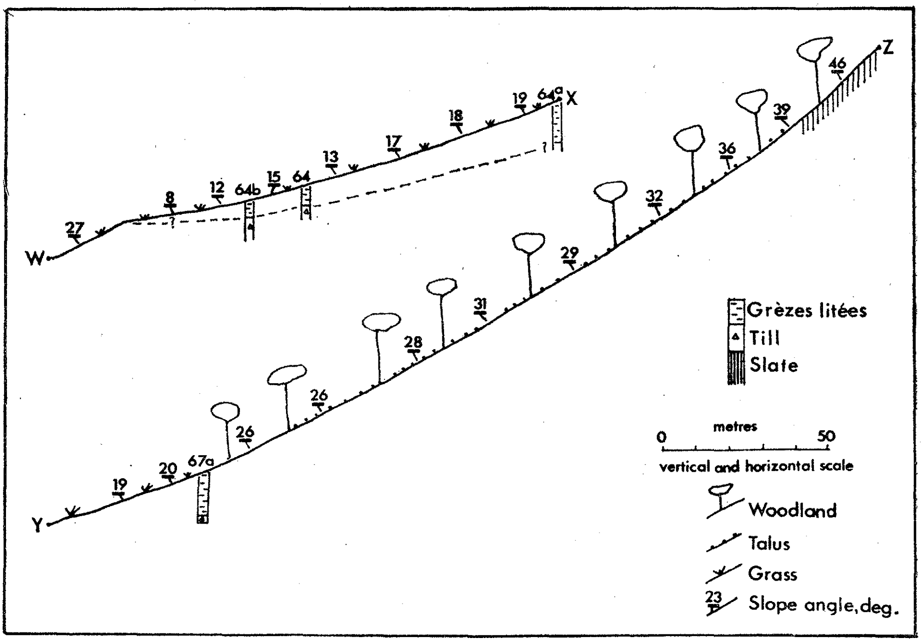

Fig. 4. Slope profiles of Latrigg
For location see Fig. 2

are the fines removed under certain climatic conditions from an unsorted rockfall deposit, by water, and deposited down slope at a decreasing angle of rest.

On both profiles the greatest thicknesses of grèzes litées occur where angles of about 20° are recorded. Values of between 8° and 23° for the surface slope are similar to those reported by WATSON (1965) in central Wales where the range was from 8° to 27°. Due to the orientation of the exposures in the Keswick area it was not possible to measure the angle of the bedding but this will be less than the mean dip of the particles which is 16° at site B. GUILLIEN suggested that 25° is the upper limit of bedding angles in grèze litée deposits.

The upslope extent of the grèzes litées in this area is not known; thicknesses of 12 m and 12.5 m recorded at boreholes 64a and 67a respectively do not suggest that thinning is imminent, though the character of the deposit may change as the slope angle increases. On the slope profile the lack of a break of slope suggests a gradual downslope change in debris composition.

It can be seen that both profiles are concave. WATSON (1965) notes that at 13 out of 14 sites in the Aberystwyth area slopes developed on grèze litée deposits were concave. In a High Arctic environment, HOWARTH

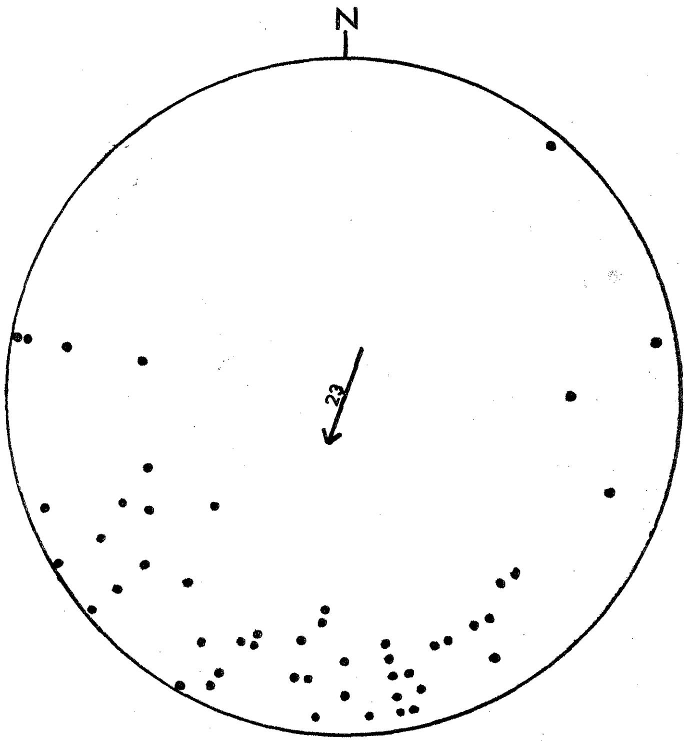

Fig. 5. Orientation and dip values of 50 elongate particles at site B

Orientation values are related to true north. The angle of dip is indicated by the position between the outer margin of the circle which represents a horizonatal plane (0°)) and the centre point which represents a vertical plane (90°). The arrow indicates the direction of hillside slope and the figure on the arrow indicates slope angle at the site

and BONES (1972) found that 86 % of the slopes due to rockfall which they surveyed exhibited concavity in their profiles; whereas 95 % of the slopes influenced by meltwater flow were concave. Significant differences were recorded in the angle of the slopes: those due to rockfall tended to be steeper than the slopes affected by water. In that environment meltwater was a particularly effective agent of debris transport on the talus slopes during the short summer period of melt, especially where the permafrost table was at or near the surface, thus preventing percolation into the scree. WILKINSON (1972) points out that on steep Arctic slopes composed of coarse openwork material (which would seem to be similar to the thick lower bed on the slopes of Latrigg), meltwater tends to be beneath the surface within the active layer.

DISCUSSION

ORIGIN OF THE DEPOSITS

At each of the temporary exposures the deposits are seen to be bedded: lenses of matrix-rich slate being a feature of the upper gravels. In the lower gravels the imbricate structure strongly suggests that these are slope deposits laid down by running water. Interstitial material occurs in both the upper and lower gravels but is more in evidence in the former. The division into upper and lower gravels is based on visual evidence at site B which is supported by borehole data and the particle size analysis of the samples.

The term *grèzes litées* was originally used to describe deposits in France but has been uncritically applied to similar deposits elsewhere. DYLIK (1960) has objected to its use with regard to the Polish deposits which he claims represent a particular variety of a more general category of rhythmically stratified slope deposits. The deposits described here, in the Keswick area, could be included in the category *grèzes litées* as defined by WASHBURN (quoted above), but could not be described as *rhythmically* stratified slope deposits. Instead, it has been shown that a two-fold succession is typical and it is probable that a change in the intensity of frost shattering, and/or a diminution of meltwater energy was responsible for this pattern. As with the rhythmically bedded deposits it is suggested that their accumulation has been mainly the result of sheetwash (DYLIK, 1969), the most probable source of water being from seasonal snow melt.

THE AGE OF THE GRÈZES LITÉES

At this locality the grèzes litées overlie till (Fig. 3). In Cumbria this extensive till sheet on which drumlins are the characteristic landforms is generally thought to be Late Devensian (Vistulian) in age (EVANS and ARTHURTON, 1973). A Late or Post Glacial age is therefore indicated for the grèzes litées.

The mountains of Cumbria were ice-free by 14,300 B.P. or soon after (PENNINGTON and BONNEY, 1970). There is some evidence to suggest that the period immediately following this, though extremely cold, was probably relatively dry (COOPE and BROPHY, 1972). It may be that such a climate would not be conductive to frost shattering. POTTS (1970) has shown that rates of rock shattering increase in environments where water is available to migrate towards centres of freezing such as cleavage planes in slates and shales.

Around 13,000 B.P. western Britain was affected by a rapid climatic amelioration and by 12,500 B.P. summer temperatures were at least as warm as those of the present day (Coope and Brophy, 1972). This period of warmth probably lasted for 1000 years (13,000–12,000 B.P.) and was replaced by a gradual deterioration which culminated in Younger Dryas time (10,800–10,000 B.P.). The relationship of this pattern of climatic change reported from western and lowland Britain to the classical continental pattern based on plant pollen has recently been discussed by Pennington and Suckin (1975).

In Cumbria, Younger Dryas time was characterised by a well-documented re-advance of corrie glaciers. Johnson (1975) has described involutions in head deposits in southern Cumbria thought to be formed during this period and indicating "strong cryergic activity". Ample moisture from seasonal snow melt was available during Younger Dryas time as evidenced by the severe erosional effects reported from many parts of the British Isles e.g. Sissons (1969), Kerney, Brown and Chandler (1964), Rowlands and Shotton (1971). In central Wales Late Glacial stratified screes have been described by Watson (1965).

It seems likely that grèzes litées such as those described here are the result of severe frost action and meltwater flow across talus slopes. During Late and Post Glacial time it is thought that such conditions would largely be confined to Younger Dryas time. Thus it is suggested that the accumulation of, in places, at least 12.5 m of frost-shattered debris was most probably achieved in the periglacial climate of that period.

In other parts of the country considerable landscape change took place during a relatively short period of geological time. On the lower slopes of Latrigg a landscape which was largely product of glacial processes was significantly modified by weathering and deposition of great thickness of periglacial slope deposits. Since Younger Dryas time landscape evolution would seem to have been minimal.

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