INVESTIGATION OF SOME PERI-GLACIALLY MODIFIED SURFACE FEATURES WITHIN THE MOSS VALLEY NORTH-EAST DERBYSHIRE

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The Moss stream, an eastward-flowing tributary of the River Rother, rises to the south of Norton at a height of 630 feet O.D., and enters the Rother to the north of Eckington (Fig. 1). Its valley has an area of about 18 square miles, within wide flattish interfluves which still have gentle valley-ward gradients. The rocks within the Moss Valley are part of the Lower Coal Measure sequence, and are formed of alternating beds of relatively resistant sandstone (the Grenoside Sandstone and the Silkstone Rock) and less-resistant shales. They are influenced in the Moss Valley area by a series of folds, namely, the Norton-Whitwell and Troway Anticlines, and Povey Syncline (Fig. 2).

According to Raistrick (1933) and Edwards (1956) among others, the area under consideration was not covered by the ice sheet of the Last Glaciatin, but certain features, perhaps contemporaneous with this glacial episode, thought to result from periglaciation(1), can be recognised.

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(1) The term periglacial was introduced by Lozinski (1909), to refer to areas adjacent to the border of ice sheets. Periglacialists (e. g. Matthes 1900, Leffingwell 1915, Eakin 1961 and Fitzpatrick 1958) considered the periglacial zone as the zone in which, during any particular glacial phase, the climate favoured permanently frozen subsoil (tjaele) as is found at the present day in Greenland, Alska, northern Asia and Arctica. Three processes have been broadly accepted as the chief morphogenetic processes operating under such conditions; intense frost action, nivation and wind erosion.

They may be separately indentified as structural, erosional, and depositional features, and are the subject of the present discussion.

(A) Structural Features

1. *Cracks and Joints* :

Examination of rock exposures within the Moss Valley revealed that the rocks are heavily jointed and that other cracks are well developed. The master joints are approximately vertical and occur along the whole depth of the sections, (Plate 1) being on average about 4 feet apart.

Though these joints are initially the product of diastrophic processes, and probably related to the Permian earth movements, field investigation gave the impression that some of these joints (particularly those near to the surface) have been opend and widened by processes of freezing and thawing. These same processes might be responsible for the development of the majority of the smaller vertical and horizontal cracks within the upper part of the rocks.

2. *Superficial valley-folds* :

These comprise a variety of superficial displacements of the strata occupying the floors of lower slopes of the valleys. They may have a simple anticlinal form (Plate 2) or occur as a series of discontinous elongated domes (Plate 3). Within the Moss Valley, they were observed at ten or more place (Fig. 3), along or near to the Moss itself, particularly at the village of Ford. The general dip of the rocks to the south east of Ford is between 6° and 10° to the north east, while the axis of the small superficial valley fold, which disturbed these rocks has a general alignment perpendicular to the Moss. The beds are arched up with one limb dipping to the south east at 23° and the other to the north west at 20°. For about 100 yards to either side of this arch, no further signs of superficial disturbance could be found, the rocks resuming thior normal regional dip. Another minor fold was however recognised about 150 yards to the west of the previous example (Plate 3). Its width was of about 20 yards, and its height was about 25 feet, and the rocks consist of alternate massive and thick beds of sandstones and relatively thin beds of shales. The photograph indicates at right, the steep dip of the beds to the south west, at the left the obliquely standing beds in the bottom of the stream, and at the top, the apex of the fold.

In the Kettering District, Hollingworth and Taylor (1946, p. 25 — 26) described the superficial folds found there as a consequence of the differential unloading of the plastic Lias Clay due to normal subaerial denudation. They suggested that as the down-cutting of a stream proceeded, the excess load on either side of a valley would cause a flowage of clay towards the area of minimum load with consequent forcing up of the rocks in the valley bottom. Shotton, (1950, p. 111) has claimed that superficial valley folds were developed when the rocks were much softer than to-day, and he believes that the only time when a softening might have been possible was after a glaciation, when the deeply frozen ground had just thawed and melting of ice lenses along the bedding planes and joints of the shales would leave them in a very unstable state. He concluded that the movements of such folds might place at a time immediately following a glaciaton.

There are no glacial features within the Moss Valley, but the development of the folds described, might well have taken place during alternating phases of freezing and thawing, or in other words during a peri-glacial phase. Since all the superficial valley folds recognised, are located along the valley floors of the Moss and its tributaries, it is reasonable to consider their development as during the later periglacial phases of the Last Glaciation.

(B) Erosional Features

1. *Coombe-like features* :

Certain escarpments in the Moss Valley are characterized by shallow amphitheatre-like embayments which varied between 30 and 50 yards in width, and between 50 and 80 yards in length, having a back slope of 8° to 11° and a front slope of 3° to 5°. The best examples are those developed in the Ridgeway and Robin Brook escarpments to the south east of Gleadless (Plate 4). Large amphitheatre-like embayments in the escarpment of the South Downs were called by Bull (1936, 1940, p. 63), "Coombe-features" and he claimed that they may have developed from snow-filled gullies under periglacial conditions. Small (1961, p. 71) has, however, noted that features of similar form might be the result of spring sapping.

Field investigation has indicated that there were no definite water eroded channels leading from these coombes of the Moss Valley. Therefore, neither Bull's, nor Small's suggestions are wholly valid in this locality. However, the slopes at the foot of these coombes are covered by angular and sub-angular rock-fragments, which are probably the result of frost shattering and down slope movment. Presumably the fragments have been cut out of the hollow, and it may be suggested that the development of coombe-features within the Moss Valley was probably due to snow-patch action or nivation. The snow-patches may have accumulated on initially concave slopes, gradually giving rise to shallow circular and transverse hollows within the escarpment faces. Similar features have been recognised in Arctic regions by Matthes (1900), Lewis (1936 and 1939) and McCabe (1939).

2. *Dell-like valley heads* :

The streamless vales at the heads of some of the Moss tributaries are characterised by broad, shallow saucer-like forms termed "Dellen" by Penck (1953), a term which is rendered by "dell" in the English translation of Penck's "Morphological Analysis of Landform".

However, Dylik (1952, p. 15) suggested the term "corrasion trough or niche" while Cotton (1955, p. 1028 suggested the term "corrasion valley" for such features. Within the Moss Valley such dells are usually more than one third of a mile in length. Investigation of those to the north east of Bramley Hill Farm (Plate 5) and to the east of Marsh Lane (Plate 6), has revealed the following characteristics :—

i) a shallow and broad saucer-like form.

ii) an average width of more than one third of a mile.

iii) a back slope which varies between 3° and 6°.

iv) a gentler frontal slope that varies between 1°and 3° in gradient.

v) a location on relatively less-resistant rocks.

vi) evidence of sheet-wash and soil creep, with debris containing angular rock-fragments occuring particularly on the frontal slopes.

These characteristics give the impression that the dells in the Moss Valley like coombe-features may have been extended by snow melt. During freezing phases the dells would be occupied by snow-patches. During the thawing phases, melt water would descend very slowly underneath them and as a result, the dells would be gradually deepened, attaining a relatively steep back slope and tending to form small saucer-like hollows. With later down-slope movement of congeliturabte from the higher scarp face, the dells may have been smoothed and blanketted with solifluction deposits.

3. *Rounded knob-features* :

The term smooth rounded knob was used by Cotton (1955, p. 1016), to refer to smooth rounded topped hills, modified by peri-glacial conditions. Within the Moss Valley more than a dozen examples of smooth rounded knobs have been recognised, and some of them are indicated on Figure 3. The best examples are those to the west of Highlane (Plate 7). They occupy an area of about half a square mile on the interfluvial crest of the Shire and the Moss Brooks, and vary in altitude between 600 and 650 feet O.D.

Matthes (1900, pè 176) claimed that the rounded summits, crests and spurs of the Big Horn Mountains are product of periglacial modification. Similar features have been described from New Zealand, and Central Poland by Cotton (1955, p. 101 and Dylik (1952, p. 22), respectively. The latter considered them to be denuded vestiges of diverse, mostly irrecognizable glacigenetic forms, and to be of utmost interest, being illustrative of the destruction achieved almost entirely by congelifraction. In the area under consideration, the knobs appear to be cuestas in a late stage, their subdued form being due to their long exposure to recent peri-glacial conditions, the slopes bieng down graded by congelifraction and congeliturbation.

(C) Depositional Features

The examination of weathered material is often of importance since it may throw light on particular processes and on the approximate time taken for its production. Within the Moss Valley a thickness of regolith(1) was observed to overlie most of the rock exposures. It is usually between 5 and 8 feet in thickness, and is composed of small angular to subangular fragments of sandstone in a sandy or clayey-sand matrix. The fragments vary in diameter from 2 to 6 inches, but often have sharp edges as if they had been shattered.

It is probable that most of these rock-fragments are the product of intense forst action under peri-glacial conditions. Their main source would be the higher sandstone escarpments which bound the Moss and most of its tributaries. Most of the fragments would be broken down to small pieces with the repeated freezing and thawing and attrition during transport. However, the most significant depositional features within the Moss Valley are "head and colluvium", landslips", and "hummocky grounds".

1. *Head and colluvium* :

The term "head" is broadly used by British writers to refer to soliflual deposits. In America the term

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(1) The writer uses the term "regolith" to refer to the superfical blanket of debris, including therefore materials weathered in situ, head, and the soil or solum.

"solifluction" which interoduced by Anderson (1909), is extensively used to refer to the downslope movement of lubricated debris and fragments under periglacial condition. An excellent historical account of the mapping and description of head has been given by Dines et al (1940. p. 198 — 226). He defined "head" as superficial deposits of a structureless and rubbly character that can be classed either with true glacial deposits or with river deposits. They are specially noticeable beyond the southern limit of glaciation, but they also sometimes occur within the glacial regions. Consequently, the writer uses the term "head" for anamolous deposits of heterogeneous unsorted, nonstratified materials of local derivation, mainly found in nonglaciated areas. Such deposits were recognised in several places within the Moss Valley (Fig. 3).

Plate 8, shows an exposure of head to the west of Dolves Wood on a very steep slope (about 30°) at the edge of a sandstone quarry,. The head is mainly composed of large angular blocks, flakes and chips of both hard and soft sandstones. The angular blocks vary between 4 and 16 inches and in thickness between 1/2 and 1 inch. Cracks within the fragments and their sharp edges suggest their producion by frost-shattering. This rubble is unsorted and is set in a matrix of soft yellowish and light-brown silty sand.

The most interesting exposure of head within the Moss Valley was examined in 1962, in a trench to the south of Plumbley village. The deposit was of unsorted, non-stratified, angular rock fragments, mainly of sandstone in a matrix of weathered silty sand, and included two thin black zones of organic material (about 1 inch in thickness). It could be suggested that the black layers represent warmer phases alternating with periods of periglaciation, that the Moss Valley was affected by at least two periglacial phases during the Last Glaciaion.

Since congelifraction and solifluction are very active underperiglacial conditions (Bryan 1934 and 1946), the Moss Valley surface was presumably somewhat reduced in height, though the amount of lowering is difficult to assess. A minimum estimate may be obtained from a modern example. At the foot of the escarpment to the east of Carterhall Farm (Plate 9) debris has accumulated behind stone walls, which are more than 500 yard long and about 10 feet high and were constructed about 200 years ago. The debris has been derived from a field of about half a square mile in an area on the escarpment. Present day plughing of the field leads to a fairly high rate of soil creep, and it would not seem unreasonable to assume that far more debris and regolith were removed from the slopes under periglacial conditions.

2. *Landslips and Hummocky Grounds* :

Within the Moss Valley landslips were observed on the western side of Hemsworth Brook, and on the southern side of the Moss (Fig. 3). In both of these localities the downslope movement of the landslips is with the dip. Three successive slip mounds and scars were recognised at the first locality, while in the second they seem to have been smoothed a little by later soil creep and sheet wash and to have been partially destroyed, or reduced in area, as a result of lateral erosion of the Moss stream.

Similar features have been described by Smith (1936 and 1949, p. 851) and Bass (1954, p. 15), both of whom considered them to be the product of periglacial condition. Nivation and solifluction might have been important agents in the production of the small Moss Valley landslips. As a result of nivation the slopes were probably steepened in places with melting of snow and ice, when the rocks may have become saturated with water and the slopes rendered unstable, downslope movement may have resulted forming small landslips.

Areas of hummocky ground have been observed within the Moss Valley on slopes between 3° and 10°, where the surface is composed of small mounds of mainly fine sand and silt covered by grass. Some of these mounds are ellipsoidal, while others are more linear in form. Similar features have been described by sharp (1942, p. 298) in the Wolf Greek Valley, who considered them to be the product of differential freezing and thawing. In the Moss Valley several possible origins may be suggested :—

i) former coal mining;
ii) soil creep on steep incised valley sides;
iii) freezing and thawing processes under periglacial conditions.

Since the hummocks occur over relatively wide areas, usually more than five acres, it is difficult to consider their origin as being due to the effect of former mining. There seems no reason either why recent soil creep should give such locallized features. Thus, due to their location near to, and their association with the landslips (Fig. 3), it may be that the third suggestion is the most likely.

Modification of the surface configuration under periglacial conditions

Though geomorphology deals with the study of the surface of the earth, the study of the surface as a whole is often neglected, attention being paid mainly to specific features. An attempt is made here, however,to show how far the surface as a whole has been modified under periglacial conditions. Three generalized units of the land surface of the Moss Valley may be recognized.

1. The highest unit, comprising the interfluvial slopes of the Moss Valley, is gently undulating. The average valley-ward slope is no more than 2°, and the accumulations of regolith in some localities, particularly down the dip slopes and at the foot of some of the cuestas, give the impression that the surface has been smoothed over by processes of solifluction and soil-creep. These carry several surface forms of late mature stage such as the smoothed rounded knobs and subdued cuestas.

2. The intermediate unit consists of the rather steeper slopes descending towards the bottom of the valleys. The slopes vary between 3° and 6°, and they have been less modified under periglacial conditions, being less smooth and consisting of alternating convex and concave breaks of slope. The coombe features, head, and dellen tend to be concentrated in this unit.

3. The lowest unit of the surface comprises steeper slopes adjacent to the valley bottom. They vary between 4° and 12°, and are the least modified by periglacial condi tions. In some areas the sandstone escarpments form sharp convex-concave breaks -of-slope, but, certain periglacial features are restricted to this unit, namely landslips, hummocky grounds and superficial valley folds.

The surface of the Moss Valley therefore, has to some extent been reduced and smoothed by periglacial processes. Snow patches probably occupied surface concavities during the freezing phases, and most slopes were affected by solifluction, during the thawing phases. In other words, periglacial processes have contributed to the detailed form of the Moss Valley, the major elements of which were already in existence, and periglaciation has meant a modification to existing forms rather than the production of wholly new features.

Summary

Periglacial conditions prevail under a very cold climate and involve alternating freezing and thawing phases. These particular conditions are believed to have occurred in the Moss Valley at times of maximum or near maximum glaciation. Three processes might be considered to be the chief geomorphogenetic processes operating under these conditions, namely, intense forst action, nivation and wind action.

Within the Moss Valley, three groups of features are thought to have been modified by or to have resulted from periglaciation. They are referred to as structural, erosional and depositional features, and all must be considered as fossil-forms since they are not the product of the present day climate.

Recognition of these specific surface forms has contributed to an assessment of the modification of the surface configuration of the Moss Valley under periglacial conditions. The surface, as a whole, may be thought to comprise three units having regard to the variation in surface form. The highest unit is extensively smoothed and flattish having average slope of about 2° and incorporates surface-forms of late mature stage. The intermediate unit is composed of a seris of slopes of between 3° and 6°. It also includes some periglacially modified features such as head, coombe-features and dellen. The lowest unit, of steeper slopes between 4° and 12°, near the valley bottom includes landslips, hummocky grounds and superficial-valley folds.

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Plate (1) : An exposure of Silkstone Rock on the eastern side of Sheffield Road to the south of Mosbrough.

Plate (2) : A superficial valley fold to the south east of Ford.

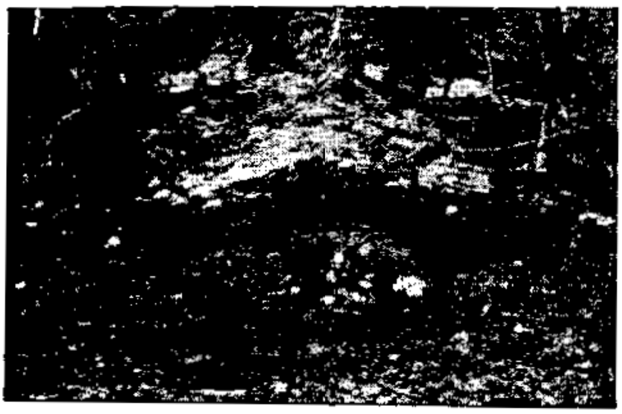

Plate (3) : A superficial valley fold to the south east of Ford.

Plate (4) : Coombe-features on the eastern valley side of Robin Brock — south east of Gleadless.

Plate (5) : Dell like valley head at Bramley Hill Farm.

Plate (6) : Dell like valley head to the east of Marsh Lane.

Plate (7) : Rounded knobs to the south west of Highland.

Plate (8) : Head deposits to the east of Doves Wood.

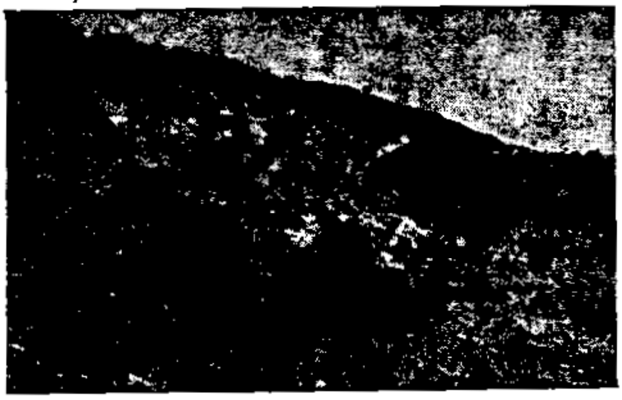

Plate (9) : Colluvial deposits to the east of Carter Hall Farm.