RELICT LANDSLIPS IN THE NEW FOREST, HAMPSHIRE

By C. G. Tuckfield

Introduction

Although it is unwise to assume that man's activities have had no effect on the landscape or the vegetation of the New Forest (Tubbs and Dimbleby, 1965), the area does undoubtedly present opportunities for studying landforms which have been less affected by agriculture and other human activities than most of central southern England. It is partly for this reason and partly because of the advantages which the area offers for easy access and investigation that the New Forest was chosen in which to study erosion processes.

Three types of erosional process have so far been studied by the author in this area. The first of these, ephemeral gully development, is at present limited both in extent and intensity, although there are indications that it has been more important in the past (Tuckfield, 1964). The other two are types of mass movement which are of much greater extent, namely the removal of material by seepage concentrated along the lines of outcrops of particular geological horizons with the resultant formation of erosional scarps, termed seepage steps, and depositional debris slopes below, and landslipping. Since both the formation of seepage steps and landslips result in erosional scarps with depositional forms below them, they may sometimes appear superficially similar, but the cause of the mass movement and the processes involved in each case are entirely different. As a result, although both have a wide distribution over the northern part of the New Forest, the two are never found together.

Field Techniques

The distribution of the landslips was plotted on O.S. 1:25,000 maps, the position of the rear scarps being located as accurately as the scale allowed by reference to mapped features, and the area of slipped material being shown conventionally (figure 1).

The landforms within two type areas, each of about 20,000 square yards, were mapped at a scale of 1 inch to 50 feet, using prismatic compass and 100 feet tapes. First the slope facets and elements were mapped according to the system developed by Waters and Savigear (Waters, 1958 and Savigear, 1965); then the plans were hachured in the field, guided by the break of slope lines. In the finished plans (figures 2 and 3) the latter were omitted.

At each location where these large scale plans were drawn, and at two other sites where it was considered that the pattern of slipping was of particular interest, a profile was surveyed across the slipped area approximately perpendicular to the rear scarps using a staff and Cowley level. The profiles were drawn with a vertical exaggeration of X2 (figure 4).

All slope angles were measured with the clinometer incorporated in the army angle of sight instrument. The scale is graduated in divisions of ½°, which was considered accurate enough for the purpose. To begin with an Abney level was used but the army clinometer was found to be sufficiently accurate and much more convenient. A ranging rod was used to sight on when measuring the angles.

A very limited amount of augering was done with a screw type auger and a few small soil pits were dug.

Description of the Resultant Landforms

Most of the landslips occur on the steep slopes bounding the highest terraces in the north of the Forest (figure 1). Figure 5 shows a diagrammatic profile through a typical landslip drawn perpendicular to the terrace edge. Between the almost level terrace

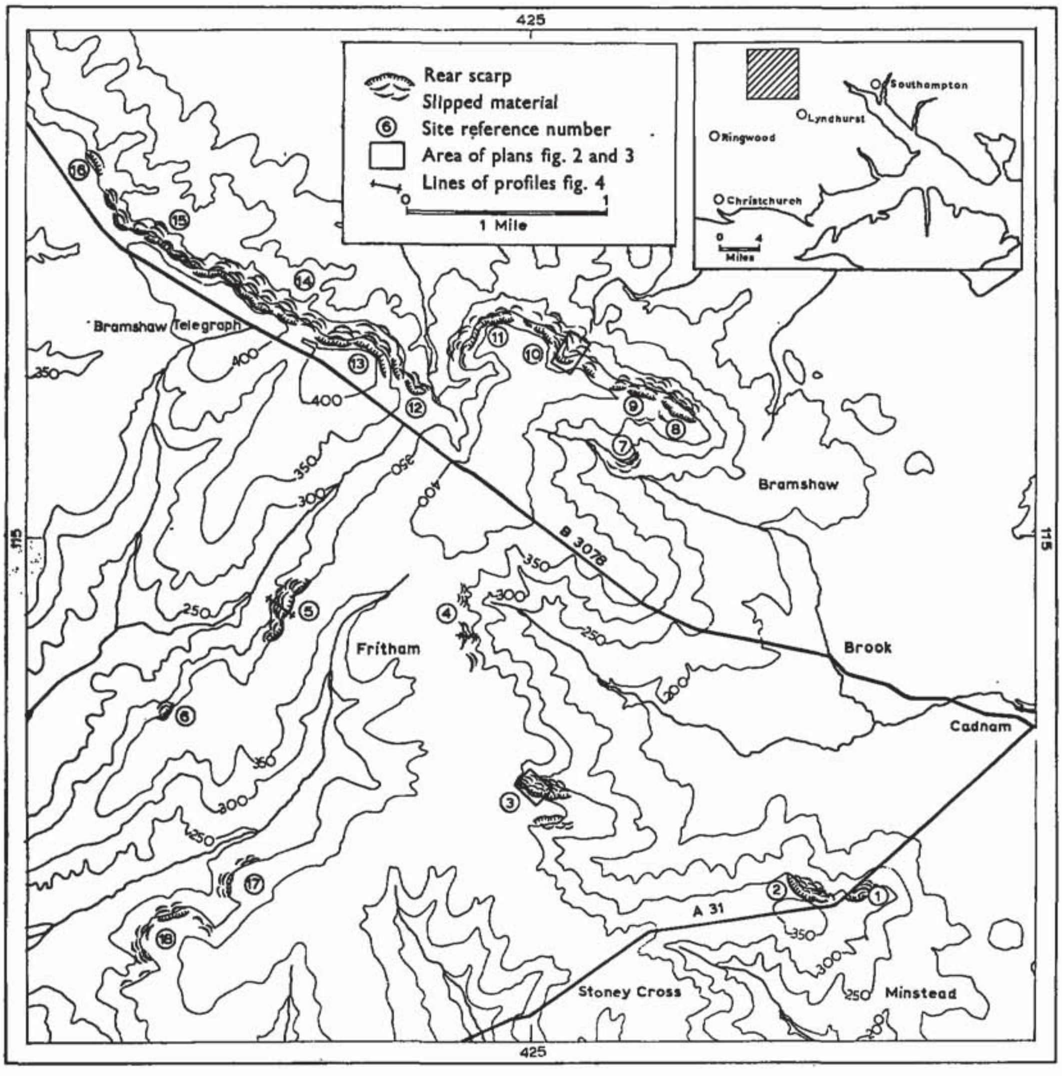

Fig. 1. Distribution of relict landslips in the northern New Forest.

surface and the lip of the rear scarp is an intermediate, gravel covered, gradually steepening slope of between 5° and 10°. The lip of the rear scarp appears usually as a recognisable break of slope but nevertheless merges smoothly into the steep convex-concave rear scarp which has a maximum gradient of over 20°. At the foot of the rear scarp, and separated from it by a trough some 100 feet to 200 feet wide, the slipped material forms a low ridge with a pronounced back slope of 2° or 3° and a much steeper forward slope. Beyond this ridge is a series of undulations or terracettes of generally decreasing amplitude and wave-length (*cf.* profiles in figure 4). The 'treads' of these may have a gentle back slope or may be almost level, but the forward slopes are much steeper, often about 10°.

In plan the rear scarp forms a scalloped pattern along the hillside, with the ridge formed by the slipped material running approximately parallel to it. Along the north-facing edge of the terrace at Bramshaw Wood (265157 to 250167, marked 8 to 11 in figure 1) and Franchises Wood (239164 to 215181, marked 13 to 16 in figure 1), the rear scarp and ridge can be traced almost continuously for distances of one and two miles respectively. The succeeding undulations or slips are also aligned approximately parallel to the main scarp but while in some places, notably in Franchises Wood, they can be traced individually for several hundred feet, in other places such as Dane's Hole (250130) (figure 3), they form a rather confused pattern of arcuate lobes with only a few more continuous ridges.

The intensity of mass movement varied from place to place with resulting differences in the landforms produced. An attempt is made in this paper to classify these, based upon the types recognised by Hutchinson in his description of landslips in London Clay (Hutchinson, 1957, figure 2). The classification adopted in the present paper is summarised in table 1. In table 2, which gives a list of all the sites in the northern New Forest at which relict landslips have been recognised, the dominant type of movement at each site is indicated by initial letters.

Letters used in Table 2	*Description of Landform*
R	Rotational landslip
S	Successive rotational slips
U	Undulations
R + U	Single rotational slip followed down-slope by undulations
L	Translational slab slides

TABLE 1. Landslip classification used in this paper based on Hutchinson, 1957

The most common combination in this area appears to be a single rotational slip followed down-slope by a series of undulations (R + U), as at Dane's Hole (250130) (figure 4, profile CD). In some places the rear scarp is formed of two or more rotational slips (S), as at Howen Bushes (231145) (figure 4, profile EF), while at other places rotational slips, usually smaller than the rear one, occur amongst the undulations (also

TABLE 2
SITES OF RELICT LANDSLIPS IN THE NEW FOREST

Location of Site	*O.S. Grid Ref.*	*Site No. in Fig. 1*	*Geological formations*	*Max. slope of rear scarp*	*Max. estd. original slope*	*Min. original slope*	*Dominant type of movement*
Castle Malwood:	SU						
S. side of A31	276121	1	Barton Clay	26°		9½°	R + U
N. side of A31	272122	2	Barton Clay	29°	11°	8½°, 9°	S
Dane's Hole	251130	3	Barton Clay	26°	13°	9°, 10°	R + U
Coppice of Linwood	245143	4	Barton Clay	—	10°	9°, 9°	U
Coppice of Linwood	245146	4	Barton Clay	—	9°	8½°, 9°	U
Howen Bushes	231143	5	Barton Clay over Bracklesham Beds	26°	13°	8½°, 8°	S
Hiscock's Hill	221137	6	Barton Clay over Bracklesham Beds	24°	13°	10°, 10°	R + U
Bramble Hill Walk	257156	7	Bracklesham Beds	—	9°	8°	U
Bramshaw Wood:							
S.E. end	262159	8	Barton Clay	24°	14°	10°	R + U
Centre	258162	9	over	21½°	13°	9½°	S
Two Beeches Btm.	253165	10	Bracklesham Beds	25°	12°	9°	R + U
Pipersweight Wood	247167	11	Barton Clay over Bracklesham Beds	26°	13°	8½°	S
Crow's Nest Btm.	241162	12	Bracklesham Beds	21°	14°	8½°, 9°	R + U
Franchises Wood:							
Ashens Hat	238164	13	Bracklesham Beds	29°	14°	9½°	S
Hope Cottage	229167	14	Bracklesham Beds	27½°	15°	—	S
Pound Bottom	219174	15	Bracklesham Beds	28°	16°	9½°	S
Golden Cross	215179	16	Bracklesham Beds	29°	13°	9°, 10°	R + U
Anses Wood	228124	17	Barton Clay	—	9°	8½°	U
Anses Wood	226123	17	Barton Clay	—	11°	8½°, 8°	R + U
Holly Hatch	221120	18	Barton Clay	19°	11½°	7½°, 8°	R + U
Inclosure	219116	18	Barton Clay	—	10°	8°	U
Ocknell	246114	19	Barton Clay	—	11°	8°, 9°	R + U
Inclosure	246117	19	Barton Clay	—	10°	9½°	U

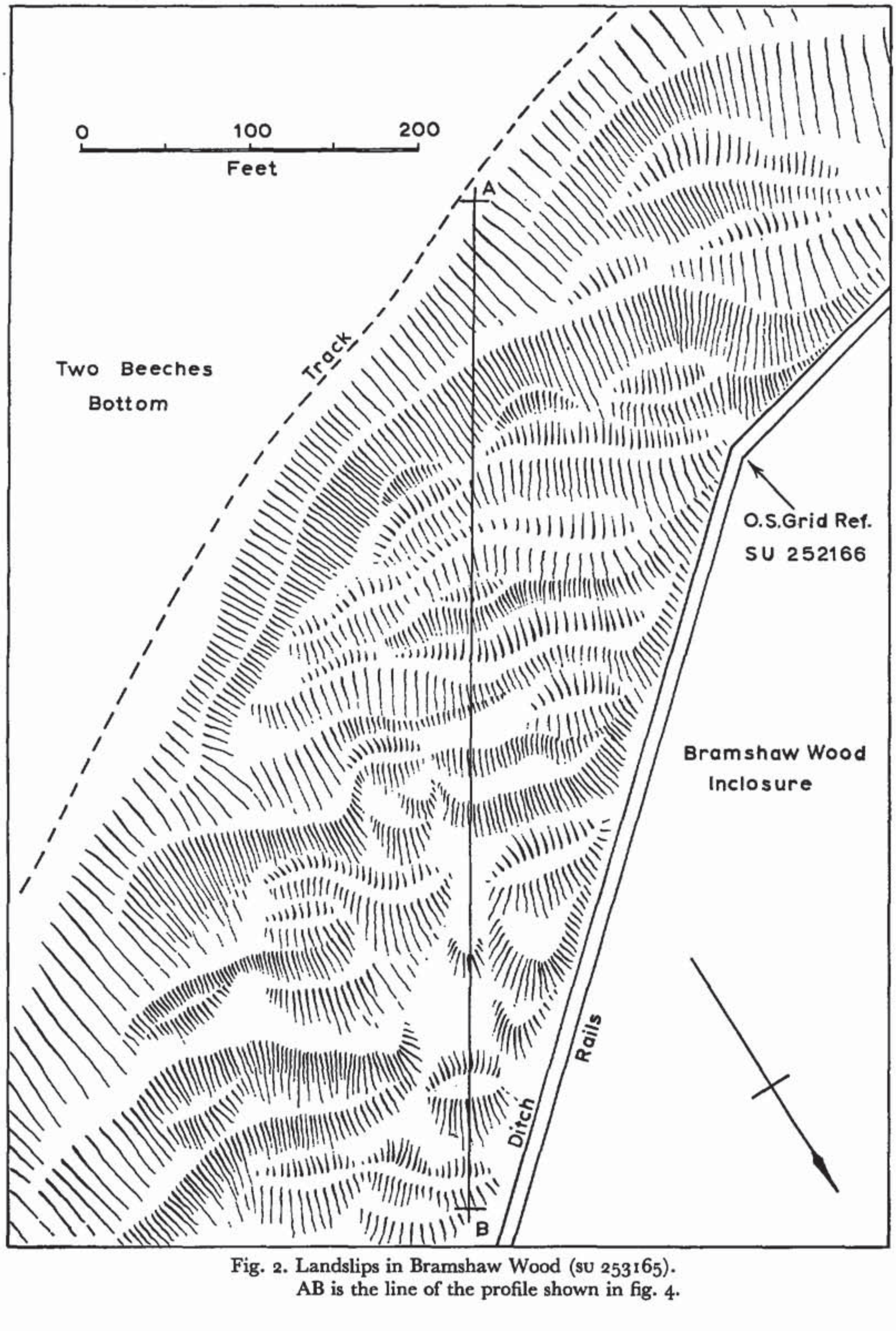

Fig. 2. Landslips in Bramshaw Wood (SU 253165).
AB is the line of the profile shown in fig. 4.

shown as S), as at Bramshaw Wood (253167) (figure 4, profile AB). This type of movement also occurred in Piper's Wait Wood (248167) and Franchise's Wood (237164).

There are other sites where there is no distinct rear scarp but only a series of undulations (U), as at Coppice of Lynwood (244144) (figure 4, profile GH). The size of such undulations varies from place to place, but an amplitude of between 3 and 6 feet and a wave-length of 150 feet or even less is common.

Lastly, on gentler slopes where landslips of the types described above have not occurred, slope failure resulting in small isolated slides, probably similar to the type described by Hutchinson as translational slab slides (L), has been found. Because of their scattered distribution and much smaller extent (often this type of movement has only involved a hundred or so square yards of ground), these are not shown on the distribution map (figure 1) or included in table 2 or figure 6, but examples of these occur at Slufter's Bottom (221094), Broomy Bottom (219110) and Deadman's Bottom (206171).

Although in table 2 only one type of slip has been indicated for each location, more than one type of movement can often be recognised at a site, and the one shown in the table is the most intensive form present. Thus if one starts at a point on the hillside where successive rotational slipping occurred and one travels along the escarpment, the successive slips may give way to one rotational slip with undulations, and then to undulations only which eventually die out as the slope becomes gentler. For this reason no attempt has been made to differentiate between the various forms of movement in the histogram (figure 6) as it was thought that this might be more misleading than helpful, but the possible correlation between original angle of slope and type of movement will be referred to later.

Measurement of Slope Angles

An attempt was made to measure three categories of slope angle at each site.

(i) The maximum slope of the rear scarp, marked rs on the diagrammatic profile (figure 5). As the scarp forms a smooth convex-concave curve, this will in theory be the slope at the point of inflection and there is therefore a certain degree of subjectivity in choosing the portion of the slope to be measured. In practice, to avoid too great an error, only those rear scarps on which the gradient remained approximately constant for a slope facet of at least 12 feet were measured.

(ii) The minimum slope on which slipping appeared to have occurred. This was obtained by tracing the landslip along the hillside in both directions until the points were reached at which the movement had ceased. At these points the maximum slope of the hillside was measured. In this way two slope measurements were obtained for each site. The slope angle obtained in this way can be considered to represent either the minimum slope on which slipping took place or the maximum slope that was stable at that time, since these two conditions meet at the point where the slope was measured.

(iii) Lastly an attempt was made to estimate the maximum slope angle which existed at each site at the time when the movement occurred. Clearly this was the most difficult measurement to obtain since at such a point the original slope has now been

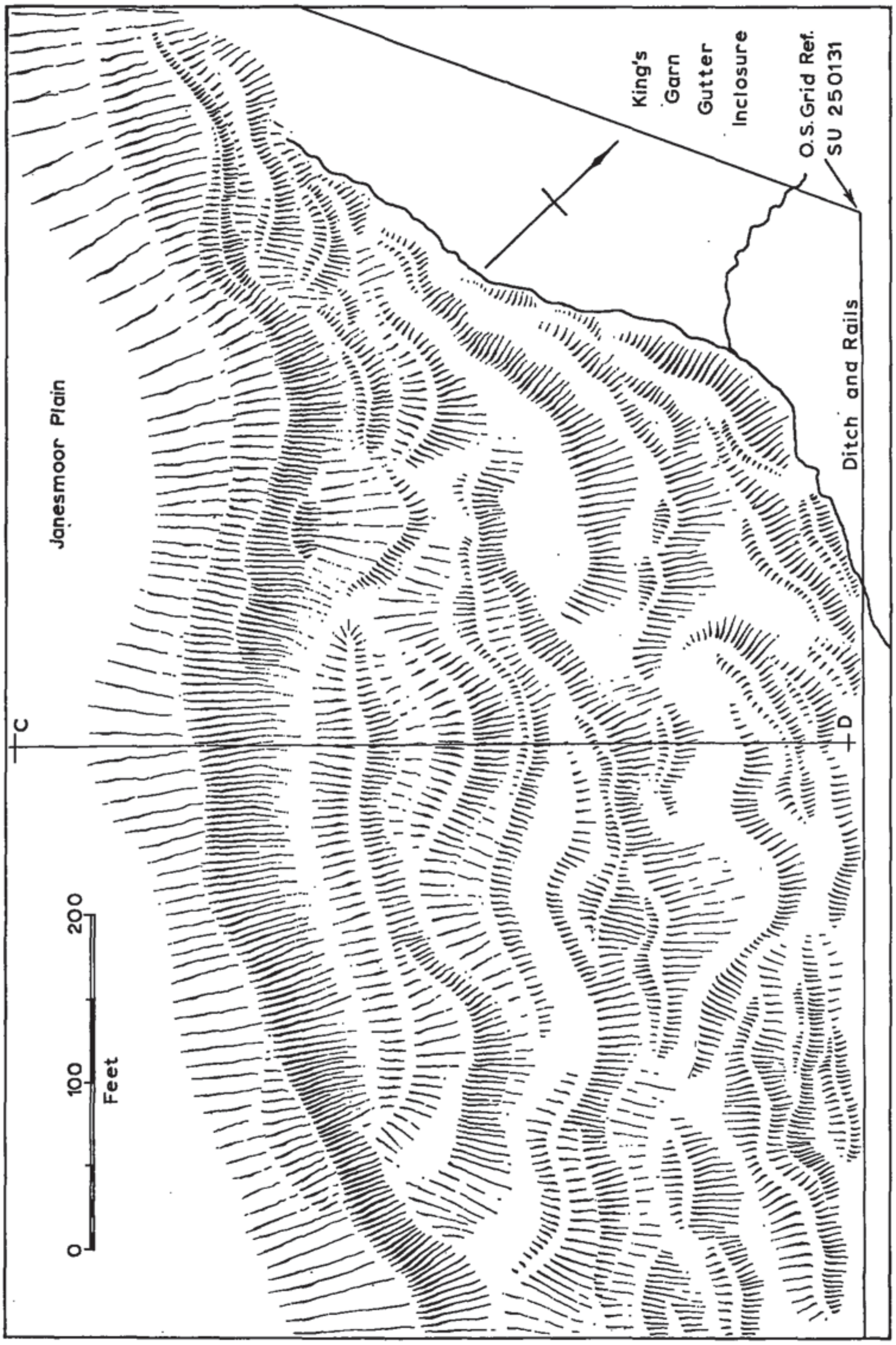

Fig. 3. Landslips in Dane's Hole (SU 251130). CD is the line of the profile shown in fig. 4.

destroyed. Two methods were employed, each involving a very high degree of subjectivity. The first was what has been described as a purely 'eye-ball' method: standing on the lip of the rear scarp, an attempt was made to reconstruct the landform before the movement took place and a ranging rod was placed accordingly at a point which appeared to coincide with a point at the foot of the original slope. The angle was then measured. The second method was to draw, on the surveyed profile of the present landform, the estimated profile of the original slope, as has been indicated on the diagrammatic profile (figure 5). The maximum gradient of this can then be measured with a protractor. The results obtained by the two methods were found to differ by only one or two degrees and so it is assumed that the maximum slope angles so obtained

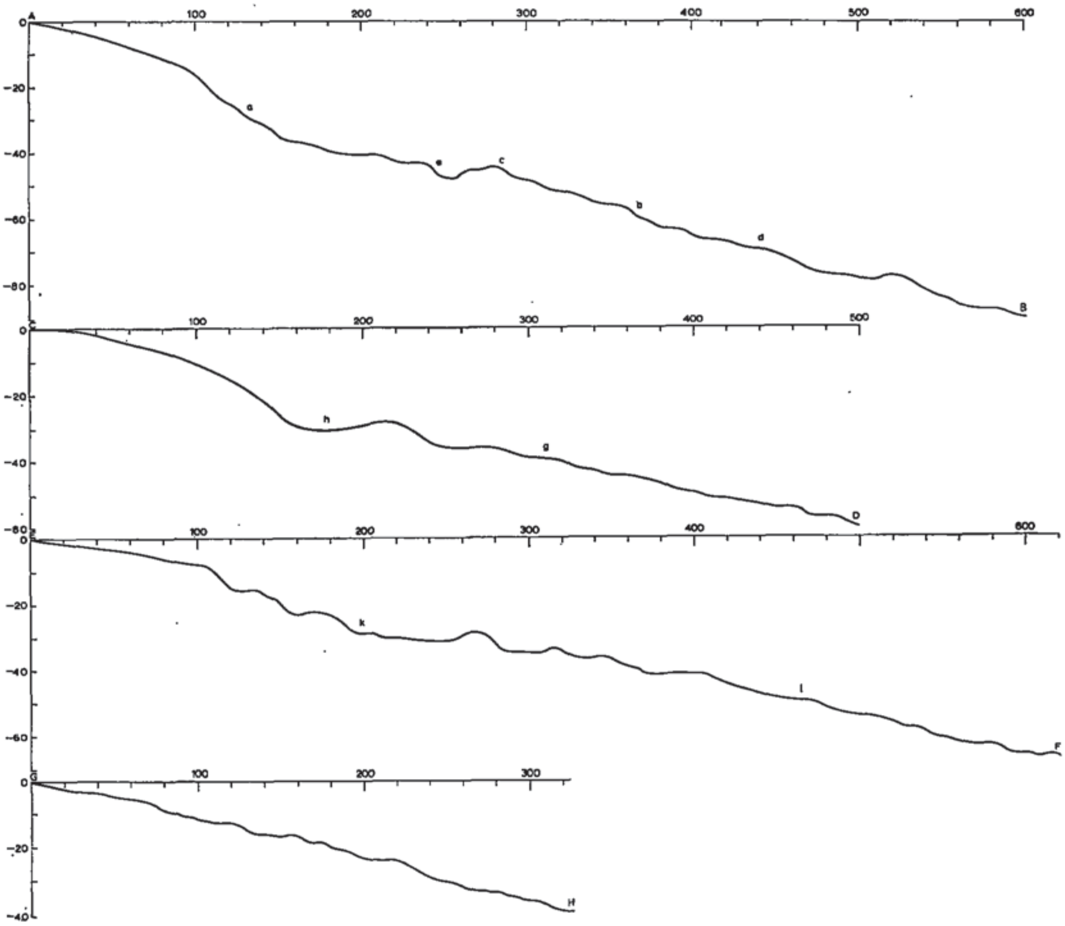

Fig. 4. Profiles of landslips. (Vertical and horizontal scales in feet.)
AB Bramshaw Wood (253165). See fig. 2.
CD Dane's Hole (251130). See fig. 3.
EF Howen Bushes (231143). See fig. 1, site 5.
GH Coppice of Linwood (245143). See fig. 1, site 4.

are perhaps near enough to the correct values to give at least some idea of the maximum slopes in this area before the slipping occurred.

These three categories of slope angle have been recorded for each site in table 2 and have been plotted in the form of a histogram in figure 6. It will be seen from the latter that the minimum slopes on which slipping occurred lie between 7½° and 10°, the median angle being 9°. The estimated maximum slopes before slipping occurred appear to have been between 9° and 16°, the median angle being 12°. In addition, reference to table 2 suggests that the magnitude of this angle determined to a large extent the type of movement which took place. Thus the steepest slopes (13° and over) appear to have suffered successive rotational slipping, while slopes between 10° and 13° produced a single rotational slip followed downslope by undulations. Slopes between 9° and 10° seem to have produced undulations only but slopes of as little as 7° suffered isolated patches of slope failure with small translational slab slides.

It is of interest here to compare these figures with the results obtained by Hutchinson for inland slopes on London Clay (Hutchinson, 1957). He found that rotational slipping had occurred mainly on slopes of 9½° and over (he found one example of this type of movement on a slope of only 8½°), that undulations were produced on slopes of 8½° and over, and that translational slab slides occurred on slopes of 8°. Slopes of less than 8° were apparently stable.

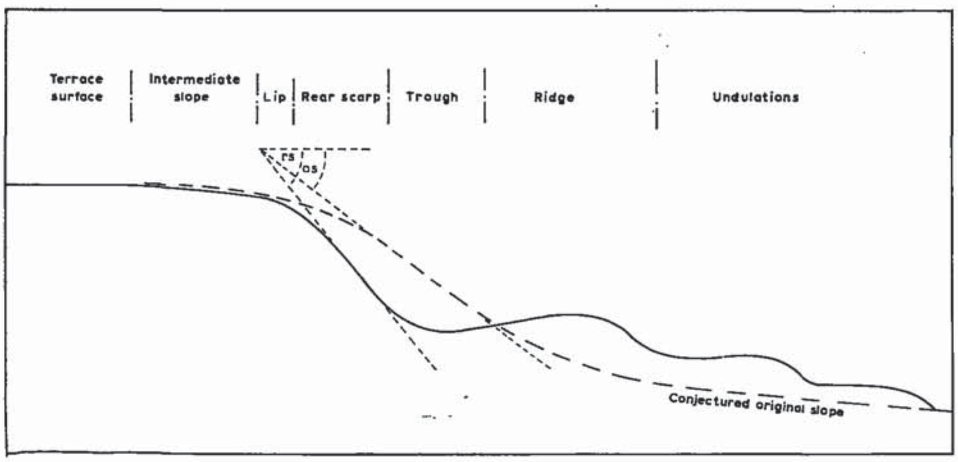

Fig. 5. Diagrammatic profile of a landslip (type R & U).
rs is the maximum slope angle of the rear scarp.
os is the maximum slope angle of the conjectured original slope.

Distribution

Figure 1 shows the distribution of these relict landslips in the northern New Forest. They occur chiefly on the steep scarps that form the edge of the higher gravel-covered terraces which give this part of the Forest its plateau-like character and, to a lesser extent, along the sides of the valleys which have been eroded into this plateau.

The greatest concentration lies along the N.N.E. – facing edge of the plateau which overlooks the Blackwater valley, where they are almost continuous from Bramble Hill (265157) to Golden Cross (215181), a distance of about 4 miles (sites 8 to 16 in figure 1). Elsewhere they occur in isolated locations, but at three of these, Castle Malwood (273121) (1 and 2 in figure 1), Dane's Hole (250130) (3 in figure 1) and Howen Bushes (231144) (5 in figure 1), the slips are very well developed. At other sites where they occur, the slips are either very limited in extent, as at Hiscock's Hill (221137) (6 in figure 1) or they consist largely of undulations only, as at Holly Hatch Inclosure (219116) and Anses Wood (226123) (17 and 18 in figure 1).

The map shows that the slips have occurred on most of the steepest slopes in the area; the few locations with steep slopes where they do not occur will be referred to later. The high correlation between mass movement and slope angle has already been referred to (page 8, table 2 and figure 6).

It is seen that the great majority of the landslips occur on N.E.-facing slopes, with a few (5, 6, 11, 17 and 18) facing west of north and only two (3 and 7) occurring in south-facing slopes. But as most of the steepest slopes face north-east, the correlation might be with slope angle rather than with aspect. However, there are at least three places with south-facing slopes of over 8° where slipping has not occurred, Fritham Plain (218128), Salisbury Trench (255144) and Ocknell Inclosure (246115).

A third apparent correlation is between mass movement and lithology. Comparison of the distribution map (figure 1) and the geology map (figure 7) shows that the land-

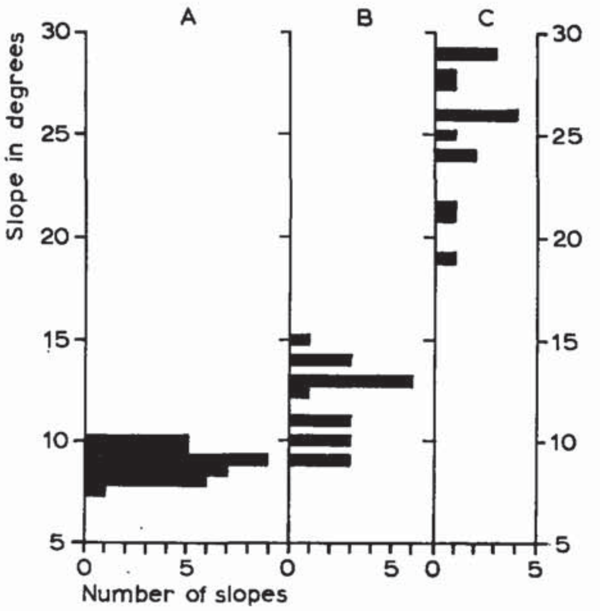

Fig. 6. Histogram of slope angles.
A Minimum slopes on which slipping occurred.
B Estimated maximum slopes before slipping occurred.
C Maximum slopes of present rear scarps.

slips are confined to the Bracklesham Beds and Barton Clay outcrops. The Barton Clay in this area is a consistently stiff clay (one sample contained 40% clay fraction, 33% silt and 19% sand), but the Bracklesham Beds are more variable, containing both clayey and sandy facies. The steep slopes bordering Fritham Plain referred to above and showing no signs of slipping were found to be in a sandy facies of the Brackleshams, but the steep slopes in Salisbury Trench and Ocknell Inclosure are both on Barton Clay, so here aspect might have been a factor. In the Barton Sand which outcrops just to the south of the area shown in figures 1 and 7, slopes of 18° and 21° at Withybed Bottom (257109) and Sandy Ridge (224083) were found which showed no sign of slope failure. But only very rarely were valley sides formed of Barton Clay and having slopes of 8° or over found to be without some form of slope failure.

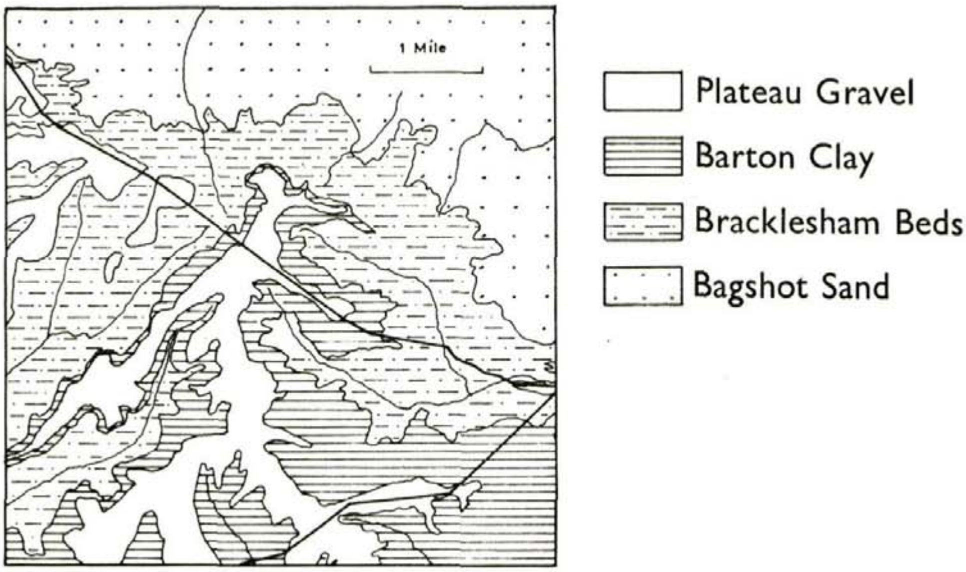

Fig. 7. Geology of the area shown in fig. 1.
(From the Geological Survey of England and Wales, sheets 314 and 315.)

Sub-Surface Structure

Undoubtedly sub-surface investigation would add greatly to an understanding of the processes involved in producing the landforms described in this paper and would help in reaching conclusions about the climatic conditions under which the movement took place. Unfortunately the writer has so far found sub-surface investigations a somewhat intractible problem. There are very few exposures within the slipped areas; even ditches are rare since these areas are in almost all cases covered with semi-natural woodland which receives the minimum of attention. Augering is difficult because of the amount of flint gravel in the superficial deposits. However, a few comments can be offered, based on the limited observations made so far at three type locations.

At Bramshaw Wood site (figure 2 and figure 4, profile AB) the solid clay of the Bracklesham Beds is exposed at several points on the main rear scarp (*a* on profile AB) and also on another rear scarp (*b* on profile AB). Very little superficial material is present anywhere on the main rear scarp. Elsewhere at this site most slopes appear to be underlain by at least 18 inches of superficial material and often by much more. At two points (*c* and *d* on profile AB) exposures show at least 6 feet of a superficial deposit of clay and gravel. This material shows little structure, the flints being disseminated fairly evenly throughout the clay, but with a few small lenses of gravel. In both cases these deep deposits lie on the treads of the terracettes, the forward slopes apparently bearing a thinner deposit, at one point (marked *e* on the profile) only 9 inches.

At Dane's Hole (figure 3 and figure 4, profile CD) the solid Barton Clay is exposed at a few points on the main rear scarp but at this site much more of the scarp bears a coating of gravel. A pit at one point however showed this to be less than 1 foot thick. Elsewhere, as at Bramshaw Wood, most of the slopes appeared to be underlain by a superficial deposit of clay and gravel but at this site the gravel fraction was much higher, especially near the surface, a pit on the tread of one terracette (*g* on profile CD) showing 9 inches of gravel overlying the usual gravel and clay mixture beneath. In the trough below the main rear scarp (*h* on profile CD), the gravel is covered by up to 8 inches of peaty silt. There seemed little difference at this site between the superficial deposits on the treads and the forward slopes of the terracettes.

At Howen Bushes (figure 4, profile EF) the solid Barton Clay was nowhere found exposed at the surface. Even the high rear scarps bore at least 2 feet of a mixture of clay and small flint gravel. A pit dug in one of the troughs (*k* on profile EF) showed 9 inches of peaty soil, followed by 6 inches of fairly large gravel, overlying a mixture of

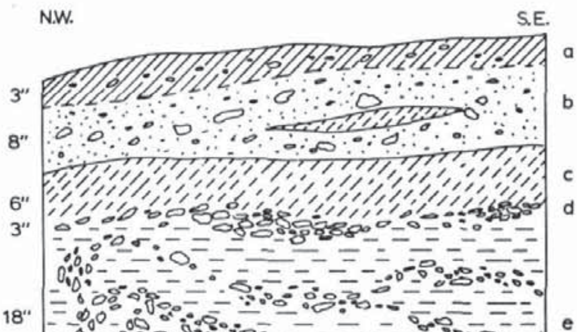

Fig. 8. Section of superficial material at Howen Bushes (231143).
(a) Thin peaty soil with flints.
(b) Washed sandy clay with flints and lenses of buried soil.
(c) Buried soil.
(d) Layer of flints at base of buried soil.
(e) Clay with lenses and layers of flints as shown.
(f) Bottom of ditch.

clay and gravel with the gravel content tending to decrease with depth. A ditch cut through the tread of one of the lower undulations (corresponding approximately with *l* on profile EF) produced the exposure shown in figure 8. The buried soil appearing in this exposure can be traced downslope for at least 50 feet and the underlying material shows structures similar to those produced by solifluction.

Conclusion

The landforms described in this paper appear to be relict features. No evidence was found in the northern part of the New Forest of recent landslips except very limited areas of slipping near the banks of rapidly eroding streams and a few very small slips on the main rear scarps. Almost all the landforms appear to be stable at present and most of the areas described are covered by mature woodland containing many oak and beech trees over 250 years old. It cannot however be concluded that slopes as steep as 25° are entirely stable under present conditions; a few small slips have taken place on these, some apparently in comparatively recent times.

But such evidence as I have been able to adduce suggests that the widespread mass movement described here took place in conditions quite different from the present. The structure of the superficial material in places (see figure 8) suggests that it moved as a very wet plastic sheet, perhaps under periglacial conditions. If this were so, the lack of deposits on the rear scarps would seem to indicate that the movement occurred quite late in the periglacial period. However as Dylik has emphasised (Dylik, 1967), there is difficulty in attributing solifluction to a particular climate and he points out that the only essential feature is the saturation of the upper layer with water, which can occur if rainfall is so heavy that saturation of the upper layer proceeds faster than percolation.

Several writers describing periglacial processes and landforms include landslips, terraces and undulations similar to those described here. Wooldridge in his account of the structure and geomorphology of the country around Fenhurst, Sussex (Wooldridge, 1950), and Ackermann and Cave describing the superficial deposits and structures in the Stroud district (Ackermann & Cave, 1967), both suggest periglacial conditions as the cause of rotational slipping, and Ackermann and Cave refer to terracettes and hummocky slopes with a series of backward dipping shelves sub-parallel with one another, which describes perfectly some of the slopes in the area of this study.

Jahn describes narrow solifluction terraces formed on 15° slopes in Spitzbergen with arcuate fronts (Jahn, 1967), the lower terraces including undulations formed by material being thrust over soil and turf. He mentions that the debris slopes often resemble landslides in moderate climates and concludes that slides occur in solifluction movement there. Williams, in a paper on solifluction features in Norway (Williams, 1957), also describes terraces formed on slopes between 5° and 20°, the terrace fronts occurring at varying intervals of some tens of metres. Often the terraces are little more than 'wrinkles'. He also shows a profile with a buried soil where the solifluncted material has overrun the original surface, producing small undulations or terracettes.

On the whole then, there would appear to be some justification for suggesting that the mass movement described here took place under periglacial conditions.

It would appear that, before slipping took place, slopes with a maximum angle of about 13° existed in this area but that, when the mass movement occurred, some type of slope failure seems to have occurred on practically all clay slopes of over 8°. There seems to have been a connection between the original slope angle and the type of movement which took place. Where the original slope was over 10° rotational slipping occurred, with successive rotational slips on many, but not all, slopes of over 13°. Small translational slips or soil undulations were produced on slopes between 8° and 10°. Slipping seems to have been more intensive on N.E. and N.-facing slopes, but this might have been because these slopes were already the steepest before the mass movement occurred.

Common has written, 'Periglacial activity, change in sea-level and post-glacial climatic change have all left their mark on slope deformation occurring in these islands, but on a scale that has still to be evaluated' (Common, 1966). It seems probable that the extensive mass movement described here took place under climatic conditions very different from the present. Whether these conditions were periglacial or post-glacial the author is not able to say but it is hoped that this short paper might be a contribution to such an eventual evaluation.

Acknowledgements

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References

Ackermann, K. J., and Cave, R. (1967), 'Superficial deposits and structures, including landslip, in the Stroud district, Gloucestershire', *Proc. Geol. Ass.*, 78, 567–85.

Common, R. (1966), 'Slope failure and morphogenetic regions' in Dury, G. H. (ed.), *Essays in Geomorphology* (Heinemann, London), 53–82.

Dylik, J. (1967), 'Solifluxion, congelifluxion and related slope processes', *Geogr. Annlr.*, 49A, 167–77.

Hutchinson, J. N. (1957), 'The free degradation of London Clay cliffs', *Proc. Geotech. Conf., Oslo*, vol. 1, 113–18.

Jahn, A. (1967), 'Some features of mass movement on Spitzbergen slopes', *Geogr. Annlr.*, 49A, 213–25.

Savigear, R. A. G. (1965), 'A technique of morphological mapping', *Ann. Ass. Am. Geogr.*, 55, 514–38.

Tubbs, C. R., and Dimbleby, G. W. (1965), 'Early agriculture in the New Forest', *Adv. Sci.*, June 1965, 88–97.

Tuckfield, C. G. (1964), 'Gully erosion in the New Forest, Hampshire', *Am. J. Sci.*, 262, 795–807.

Waters, R. S. (1958), 'Morphological mapping', *Geography*, 43, 10–17.

Williams, P. J. (1957), 'Some investigations into solifluction features in Norway', *Geogr. J.*, 123, 42–58.

Wooldridge, S. W. (1950), 'Some features in the structure and geomorphology of the country around Fenhurst, Sussex', *Proc. Geol. Ass.*, 61, 165–90.