LANDSLIDE AND MASS MOVEMENT PROCESSES AND THEIR DISTRIBUTION IN THE WELLINGTON DISTRICT OF SOMERSET

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The British Geological Survey (BGS) has recently carried out a study of the slope processes that formed the landslide and mass movement deposits in the Wellington district of Somerset during the Quaternary. This landslide study, part of the continuing research into landslides and mass movement processes in Great Britain, recorded one hundred and eighteen landslides that were entered into the new National Landslide Database.

The landslides were studied using walkover field survey and office-based remote sensing techniques. Significant past and current landslide activity was found to be associated with three distinct slope behaviour units, which are defined by their bedrock geology and topology. The Upper Greensand Formation overlying the Mercia Mudstone Group defined slope behaviour unit A, the Upper Greensand Formation overlying the Lias Group identified slope behaviour unit B and the Penarth Group overlying the Mercia Mudstone Group, slope behaviour unit C. Geomorphological models for these units were created which described the landslide processes and the deposits that they engendered. The research in this area also enabled further refinement of the 'landslide domain' concept, which is being developed as a better way of describing and depicting the distribution of the wide range of landslides and mass movement deposits that are the result of the complex interaction of geological materials and climatic changes during the Quaternary.

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INTRODUCTION

This paper describes research to determine the landslide and mass movement mechanisms responsible for landside deposits in the Wellington district of Somerset (Figure 1) and determines the geographical extent of the resultant deposits. In 2002, detailed geological mapping in the district, by the BGS, was already at an advanced stage and had identified the lithologies most prone to landslide activity. However, mapping had also identified two main issues related to landslide activity. Firstly, evidence of the landslide processes and mechanisms active at the time of formation had been obscured by the degraded nature of the landslide deposit, making interpretation of the slope morphology difficult. Secondly, extensive areas of ground were thought to have been affected by landslide activity but had subsequently been reworked by natural and anthropogenic processes. At some locations, evidence was insufficient for the ground to be mapped as a landslide deposit according to the specifications required for depiction on a 1:10 000 geological map sheet, but it was thought likely that some form of landsliding had taken place in the past. To resolve these issues, a detailed landslide investigation was carried out. The investigation incorporated results from desk study, existing geological maps, new geological mapping, conventional interpretation of aerial photographs, digital photogrammetry and field surveying. The research was carried out in four phases, desk study, field investigation, remote sensing interpretation and analysis. Mapping of most of the 1:10 000 sheet areas had been completed prior to this survey and numerous landslides recognised. Completed field-slips and those in progress were made available to the landslide investigation team and were used in conjunction with an initial interpretation of orthometrically rectified digital aerial photographs. To obtain greater knowledge of the surface morphology of each landslide type in the district, walkover surveys were carried out in 2003. Individual slopes were selected for detailed case studies, and an interpretation of aerial photographs using ImageStation™ software to delineate landslide boundaries was carried out.

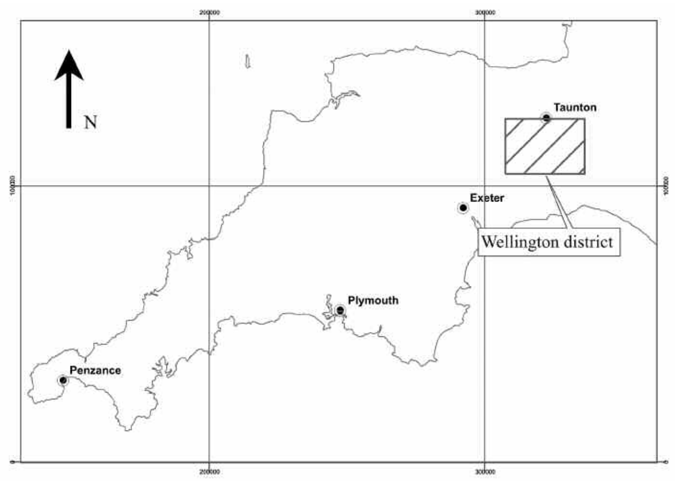


Figure 1. *Location of the Wellington district. The map uses the BGS 1:625 000 digital geological map as the background.*

One of the difficulties faced by this investigation was the identification of landslides within a degraded landscape. Although the Wellington District is south of the maximum ice limits of the Anglian and Devensian ice sheets, it has been subjected to repeated periods of periglacial conditions (Croot and Griffiths, 2001). Periglacial solifluction deposits in Britain have been recognised as having both morphological and compositional similarities to contemporary mudflows (Hutchinson, 1991; Wright and Harris, 1980).

Although no dating of landforms in the Wellington District has been carried out, Conway (1979) identified cold-climate pollen grains on landslide shear surfaces on the Dorset coast and found them to be 10,800-9,400 years in age. It is likely that at least some of the landslides in the Wellington District are contemporaneous with this end-Devensian age.

To add to the difficulties of dating landslides, little of the ground surface in the Wellington district can be considered to be completely 'natural'. Prehistoric clearance of woodland probably resulted in increased soil moisture, reduced root strengthening overland flow, run-off and localised erosion and deposition. These changes were likely to have increased landsliding on cleared slopes. The primary aquifer in the district is the Upper Greensand and this has been exploited as a water supply on a small scale by many houses, farms and villages situated at the foot of the Upper Greensand escarpment. The examination of historical maps indicated the presence of significant construction works for water supply. For example, in the area of the Gortnell Common landslide [NGR 316272, 117276, National Landslide Database Number (NLDN) 10816,] the 1905 Ordnance Survey (OS) 1:10 560 map shows an extensive network of drainage channels, tunnels and pipes that were used by the Taunton Corporation to provide water to Taunton. These workings are absent from current topographic maps but an aqueduct to the south that leads directly to the River Tone and Taunton is still marked.

The study area

The area covered by the Wellington District (British Geological Survey 1:50 000 scale geological map Sheet 311) is dominated by a plateau formed by the Upper Greensand Formation. The northern extent of this plateau is formed by the Black Down Hills, a north-facing ridge extending 18 km between Nicholashayne (NGR 310150,116000) and Buckland St Mary (NGR 327050, 113350). South of this ridge, the plateau is intersected by the valleys associated with the rivers Culm, Otter, Yarty and Axe. The River Culm separates the Blackdown Hills from a wider Upper Greensand plateau to the south also drained by the rivers noted above and their tributaries. The eastern part of the district is characterised by shallow slopes and gentle topography formed over Liassic mudrocks that extend beyond Ilminster (NGR 336000, 114650). A broad alluvium-filled northeast-southwest trending valley within the Penarth Group and Mercia Mudstone Group occupies the northeastern part of the district.

Lithostratigraphy and lithology

The bedrock of the Wellington District considered as part of this study consists of rocks ranging in age from the Triassic to the Lower Cretaceous. Hobbs *et al.* (2002) described the Triassic Mercia Mudstone Group as: 'a sequence of brown, red-brown, calcareous clays and mudstones, with occasional beds of impersistent green siltstone and fine-grained sandstone'. Weathering of these heavily overconsolidated mudrocks can result in reduced shear strength and can produce a marked increase in plasticity, especially at discontinuities or where there are variations in lithological composition or fabric (Bacciarelli, 1993). The depth of weathering can be considerable, exceeding 30 m in some areas, but more typically is 10 to 15 m.

The Penarth Group comprises the Westbury Formation and Cotham Member (undifferentiated) and the Langport Member of the Lilstock Formation. The Westbury Formation and Cotham Member (undivided in the Wellington district) consist of dark grey and green-grey, soft, laminated mudstones with thin beds of ooidal limestone in the upper part of the stratigraphy. The Langport Member (previously known as the 'White Lias') is a dominantly pale grey coloured, fine-grained, porcellanous limestone with subordinate beds of mudstone.

Lias Group strata within the district comprise the Blue Lias Formation, Charmouth Mudstone Formation and Dyrham Formation, all of Lower Jurassic age. The Blue Lias Formation consists of alternations of weak to strong mudstones interbedded with strong, well-jointed limestones which comprise 30-40% of the unit thickness (Denness, 1972). The Charmouth Mudstone Formation, in places, can be differentiated into a lower and upper part. The former tends to be dominated by units of friable mudstone, organic-rich mudstone and calcareous mudstone interbedded with limestone, and the latter is predominantly calcareous mudstone or marl. The Dyrham Formation comprises blue-grey, micaceous siltstone with impersistent beds of fine-grained, calcareous sandstone. Little geotechnical information about the Dyrham Formation in this area has been reported. The full thickness of the Lias Group is probably in the region of *c.* 135-150 m.

In southwest England, the Lower Cretaceous Upper Greensand Formation rests uncomformably on the underlying lithologies. Lithologically, the Upper Greensand Formation consists of a thin sequence of inorganic mudstones and siltstones, overlain by fine to coarse-grained, glauconitic, calcareous sandstones. Locally, at the top of the succession, are hard concretionary masses of chert, which often occur in discrete levels. When fresh the sandstone displays a distinctive green colouration, which rapidly weathers to sandy deposits of an orange-brown colour. Exposures of the Upper Greensand Formation are rare in the district as steep slopes or excavations are rapidly covered by landslide debris. The maximum thickness of the formation is in the order of 40-50 m, although fully developed thicknesses in the neighbourhood of Chard are noted as being *c.* 55m (Ussher *et al.*, 1906).

Quaternary deposits in the district comprise Head and Clay-with-flints. Head formed by solifluction under periglacial conditions and occurs in valley bottoms and low-lying areas, and as an apron around the foot of the Upper Greensand escarpment. Clay-with-flints is mostly found on the highest ground, as a blanket deposit overlying the Upper Greensand. The base of the Clay-with-flints deposit makes a sharp feature (break of slope) at the top of the Upper Greensand escarpment. The Clay-with-flints comprises mainly argillaceous materials with pebbles of flint and chert, derived from pre-existing strata. Where exposed the deposit mainly ranges from 3 m to 6 m thick, but the thickness shown on borehole records is very variable; from 2.4 m [ST 239 101] to 15.5 m [ST 218 076].

With regard to mass-movement potential of the lithologies, Hobbs *et al.* (2002) found the stability of slopes formed in the Mercia Mudstone Group to be strongly controlled by litho-stratigraphical variation, weathering and discontinuities. They found that these factors, and hence the natural angle of repose, varied widely and that it was hard to predict exactly how a particular slope would behave.

Hawkins and Privett (1981) also found the Cotham Member of the Penarth Group to be prone to landslide activity, with shear surfaces forming within it. Samples at the shear surface were described as highly plastic, with a residual angle of internal friction of 06° although this was thought unlikely to occur in the field. Both units are susceptible to weathering and degradation due to groundwater.

As with other rocks in the district, the Lias Group is usually weathered in the near-surface zone with strength and fabric often disturbed to depths greater than 2 m. Across the UK, the Lias is considered to be highly susceptible to slope failures (Jones and Lee, 1994), but these tend to be reactivations of relict landslides presumed to be of periglacial origin (Chandler, 1982). New slides only tend to occur where slopes have been oversteepened by excavation or erosion (Sellwood and Brunsden, 2000). The Dyrham Formation is generally considered to be a lithology that is prone to landsliding, and in other districts (for instance Yeovil and Moreton-in-Marsh) is associated with shallow multiple rotational slides (Baron *et al.*, 2002).

Of the lithologies considered above, the Upper Greensand Formation is the most highly susceptible to mass-movement. First time failures tend either to be small rockfalls or flows at weathered surfaces or large-scale non-circular rotational slides in bedrock. The tendency for the Upper Greensand Formation to fail in large-scale rotational movements has been observed throughout the southwest of England. Brunsden (1996) attributed this tendency towards large-scale failures to the difference between the value of its angle of friction (33-35°) and its angle of residual friction (12°).

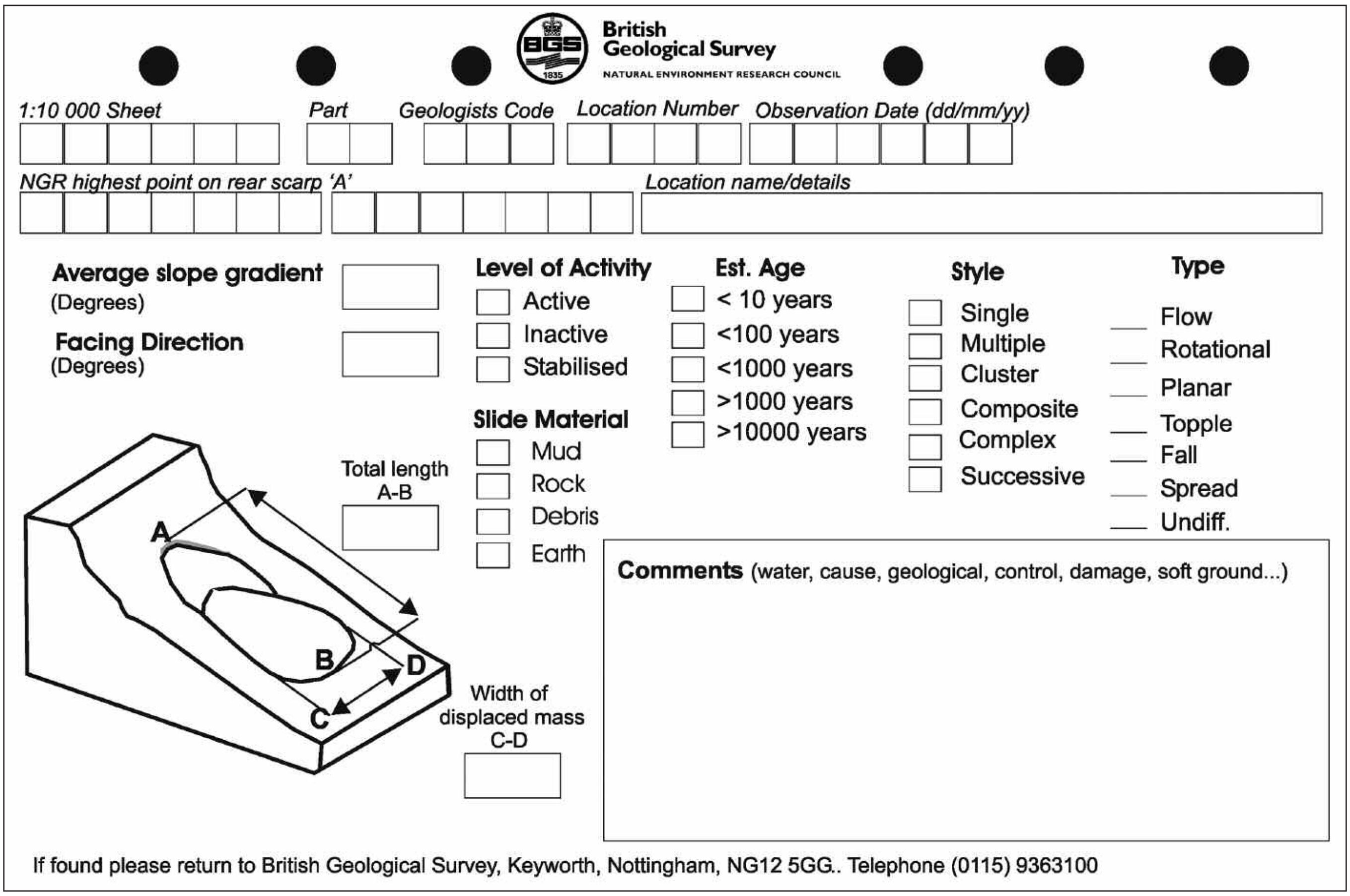
The Clay-with-flints is generally located on flat lying, or gently sloping, plateau areas and is not prone to slip unless over steepened. Superficial deposits in the area such as alluvium and peat deposits tend to occur at valley bottoms and are also stable unless over steepened. Head deposits are by definition mass-movement deposits and may be regarded as possessing only residual strength.

Mapping of the Wellington landslides

This study was the first of a new series of regional scale landslide investigations to be carried out by the BGS. The aim was to provide a large-scale view of the distribution of the landslides and the processes that created them. An initial visit confirmed significant variation in the surface expression of landslides within the district. Consequently the best approach was considered to be detailed field surveys, to enable an understanding of the slopes morphological range to be obtained, followed by analysis of aerial photographs.

The detailed field survey was carried out to determine the nature and form of landslides within the district. A number of sites, representative of possible different slope behaviour units, were chosen for more detailed investigation. Each site was examined using walkover survey techniques and geomorphological mapping. Their geographical location was established using handheld Global Positioning Systems (GPS) or by reference to 1: 10 000 scale maps, measuring tape and compass (tree cover often precluded the use of a GPS). Where appropriate, slope angles were measured using conventional Abney levels or sighting clinometers (Suunto type). Where access and vegetation allowed, landslides were both circumnavigated and traversed and important distinguishing features and forms noted. Each landslide was recorded using a field notebook format National Landslide Database Proforma (Figure 2), developed by the BGS for the rapid recording of basic landslide details. The pro-forma contains fields for location, dimensions, landslide type and causal factors. A more comprehensive pro-forma, used by the BGS for recording more detail of landslides and the adjacent slope was not considered appropriate for this scale of survey. The information collected on these proformas was transferred to the BGS National Landslide Database (NLD), thus creating a unique record for each landslide. Accordingly, each landslide recorded during this investigation has been attributed a BGS National Landslide Database Number (NLDN).

An important aspect of this study was the use of aerial photographs of the Wellington District. These were analysed using the ImageStation™ system. ImageStation™ is an interactive photogrammetric visualisation and interpretation system that allows the production of stereomodels, Digital Elevation Models and ortho-images from aerial photographs, and provides an environment for accurate 3D stereomodel interpretation. In all, ninety 1:25 000 scale colour aerial photos covering the entire BGS Wellington sheet area were processed. Landslide back scars, deposits and associated features were identified from the stereomodels using breaks in slope, changes in vegetation, tonal variations and shadows, and digitised in x, y and z coordinates. ImageStation™ proved to be a useful tool for identifying and interpreting landslides in this area, especially when the landslides were large and degraded. It was found that the ability to zoom to smaller scales for identifying regional patterns and then move to larger scales to identify small details was particularly useful. Dense vegetation cover limited the interpretation in some areas, but changes in tree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1:10 000 Sheet | Part | Geologists Code | Location Number | Observation Date (dd/mm/yy)

NGR highest point on rear scarp 'A' | Location name/details

Average slope gradient (Degrees)

Facing Direction (Degrees)

Total length A-B

Width of displaced mass C-D

Level of Activity: Active, Inactive, Stabilised

Slide Material: Mud, Rock, Debris, Earth

Est. Age: < 10 years, <100 years, <1000 years, >1000 years, >10000 years

Style: Single, Multiple, Cluster, Composite, Complex, Successive

Type: Flow, Rotational, Planar, Topple, Fall, Spread, Undiff.

Comments (water, cause, geological, control, damage, soft ground...)

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Figure 2. *Example of the field notebook format National Landslide Database Proforma developed by the BGS for recording basic landslide information.*

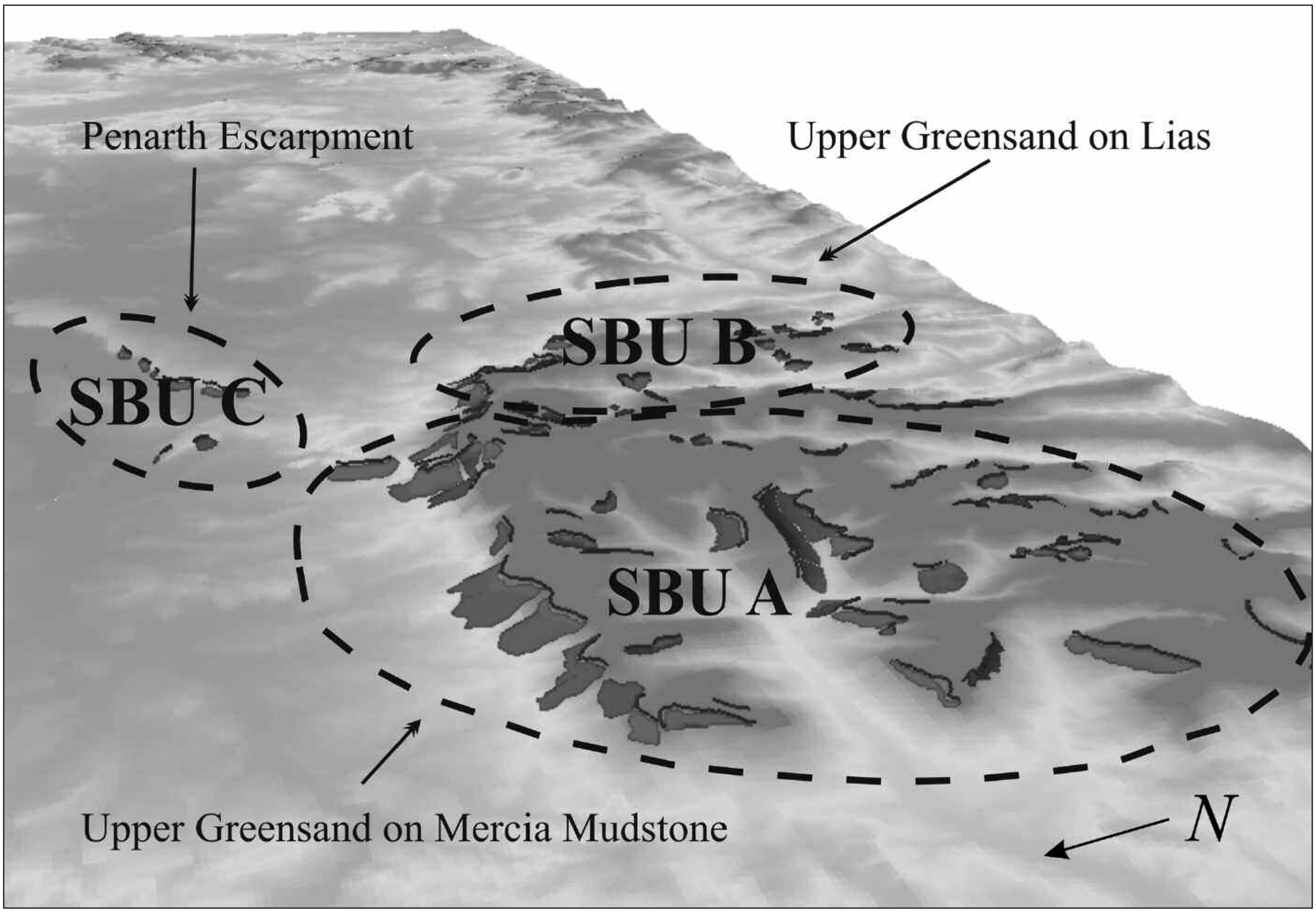


Figure 3. *A 3-D sketch view of landslides of the Wellington District looking towards the SE. Landslide deposits and back scars, digitised in 3D using the ImageStation™ system can be clearly seen. The spatial distributions of the three slope behaviour units identified are indicated by the dotted line.*

height, which often reflected changes in the elevation of the ground surface, were found to be useful on some densely forested slopes. This was especially true where distinctive breaks in slope, associated with slipped blocks, were present. It should be noted that the remote interpretation was carried out to provide a reasonably objective assessment of the distribution and style of landslides in the district not to identify areas of different slope behaviour units. Details of all additional landslides identified by the aerial photographic interpretation were added to the National Landslide Database.

One of the main advantages of using the ImageStation™ assessment and digitising the landslides interpreted boundaries is that the 3D stereomodel and 3-D digitised lines could be transferred directly into a Geographic Information System (GIS) for further analysis and modelling and cross sectional plots. Using the output from ImageStation™ the landslides can easily be plotted in 3D and their slope behaviour units groupings identified (Figure 3).

Slope behaviour units

Slope behaviour units are a convenient way to consider the processes that form and maintain a slope (Lee, 1997; Lee and Clark, 2002). This approach is based upon the premise that slopes with similar geomorphological components: geology, topography and hydrogeology, which have been subject to similar climatic conditions, can be expected to produce slopes of similar characteristics. Characterizing ground in this way is an efficient and effective method of classifying different slope types especially on the regional scale as used in this study. It also provides a useful method by which differences in landforms can be interpreted in terms of variations in the principal components, such as geological structure.

All the slopes in the Wellington District can be considered to be slope behaviour units. However, the research described in this paper was only concerned with identifying those slope behaviour units affected by landslide activity and incorporating these into a general model of landsliding in the district. Using a technique like this, if an identified landslide does not have well defined deposit extents but does exhibit specific features common to other recorded disturbed slopes in the area, the slide could still be recorded as evidence of activity within a slope behaviour unit without the usual definitive mapped landslide polygon. Experience gained from this district study is aiding the development of a "Mass-Movement Domain" mapping scheme for landslides.

After survey and analysis of this study area, three distinct slope behaviour units significantly affected by landslide activity were determined: (1) slope behaviour unit A comprising the Upper Greensand Formation overlying the Mercia Mudstone Group, (2) slope behaviour unit B comprising the Upper Greensand Formation overlying the Lias Group and (3) slope behaviour unit C comprising the Penarth Group overlying the Mercia Mudstone Group.

The descriptions of the nature and behaviour of these slope behaviour units, with a schematic cross section of one slide from each slope behaviour units, are shown in Table 1. The geological successions for slope behaviour units A and B provide a well-recognised situation for landsliding, where a more permeable lithology overlies a relatively impermeable one. Groundwater percolates through the relatively uncemented lithologies of the Upper Greensand Formation until it encounters the underlying impermeable Mercia Mudstone Group (slope behaviour unit A) or Lias Group (slope behaviour unit B). This intercepts the groundwater flow, changing the flow path from a mainly vertical to nearer horizontal (parallel

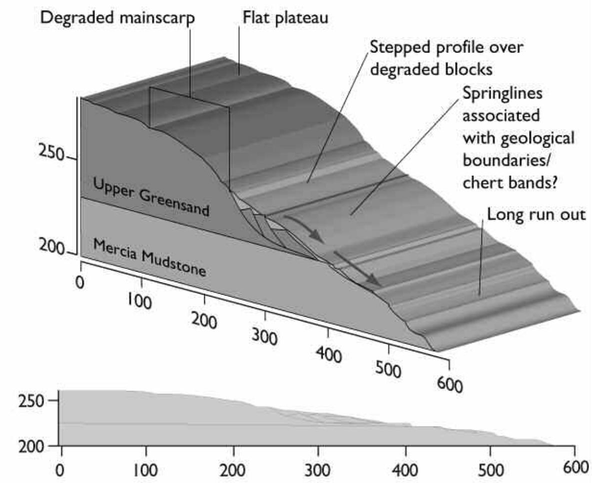
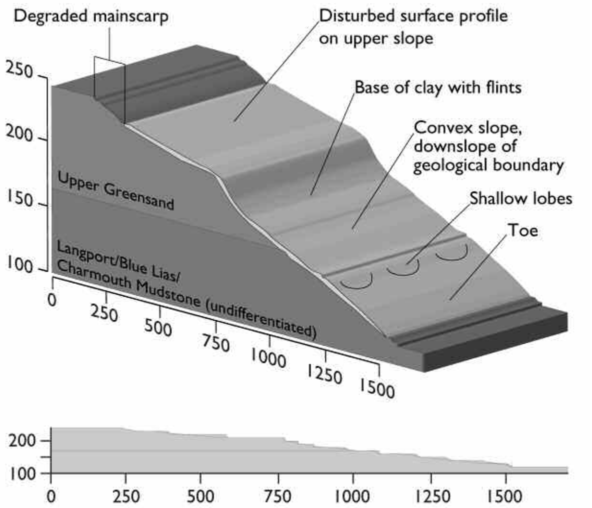
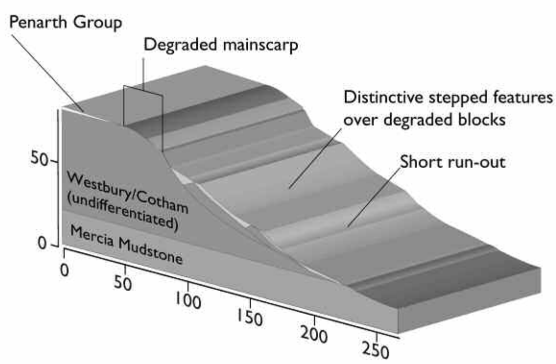
	Cross Section Example	Geology and Geomorphology
SBU A	*Blackdown Common* (NLDN 10812, NGR 311440, 116663)  	**Geology:** • Permeable Upper Greensand Formation overlying relatively impermeable Mercia Mudstone Group **Geomorphology:** • Markedly non-circular rotational failures • Very degraded translational blocks • Long run out of toe in degraded Upper Greensand up to 1400 m • Failure is most likely to occur at locations where water pressure is enhanced by impaired drainage (at chert or clay bands) or greater water flow (along fault zones).
SBU B	*Petronella Plantation* (NLDN 10784, NGR 327874, 116398)  	**Geology:** • Permeable Upper Greensand Formation overlying relatively impermeable Lias Group **Geomorphology:** • Markedly non-circular rotational failures • Lack of distinctive landforms but the topography has a generally disturbed, hummocky appearance. • Moderately long run out of Upper Greensand up to 800 m • Extensive shallow failures in lower slopes
SBU C	*Sedgemoor Grange* (NLDN 10851, NGR 333333, 123080)  All measurements are in metres	**Geology:** • Relatively permeable coarse-grained Penarth Group overlying relatively impermeable fine-grained Mercia Mudstone Group **Geomorphology:** • Non-circular rotational failures • Very distinctive blocks • Short run out

Table 1. *A summary of the slope behaviour units and their associated landslides in the Wellington district (cross section scale bars in metres).*

to the interface). An effective head is maintained over the underlying mudrocks, keeping them permanently saturated. This leads to the softening of the mudstone and reduces the effective stress in the saturated material that produces a weak zone within which failure surfaces are likely to propagate, thus leading to slope instability. It has been shown that failures within the Upper Greensand Formation in the southwest of England are more likely to occur in winter, especially if antecedent rainfall in the previous few years has been higher than average resulting in a relatively high water table (Brunsden, 1996; Forster, 1998). The most likely time of failure is during periods of particularly heavy through-flow following high effective rainfall. Failure is most likely to occur at locations where water pressure is enhanced by impaired drainage (at chert or clay bands) or greater water flow (along fault zones).

Slope behaviour unit C is characterized by a relatively impermeable, fine-grained lithology overlain by a relatively permeable, coarser grained lithology. The coarser grained lithology, the limestones of the Langport Member, forms a flat plateau above slopes formed within the Westbury Formation and Cotham Member (undifferentiated). The Langport Member (and possibly limestones of the Blue Lias/ Charmouth Mudstone Formation or the Clay-with-flints) acts as an aquifer, draining into and onto the slopes of the Penarth Group. Although degraded, it is usually possible to distinguish one or more ridges and back-tilted blocks within the Westbury Formation and Cotham Member slope segment. The base of a landslide is usually marked by a fairly sharp convex break in slope that generally occurs less than 200 m from the crest of the escarpment.

First time failures formed within slope behaviour unit C appeared to be shallower than those formed within slope behaviour unit's A and B. This is likely to be a function of topography as much as geology. The relatively low relief and limited run-out indicate that these failures are far more constrained geographically and have not involved large planar movement of the landslide block. The dominant landslide process of this slope behaviour unit is by shallow rotational failure within the Westbury Formation and Cotham Member facilitated by a supply of water from the Langport Member. It is difficult to determine, from the surface evidence alone, how deep these landslides are – it is possible that there is a mixture of shallow non-circular failures and deeper failures with more circular surfaces of failure.

Conclusions

Detailed re-mapping has greatly increased the number of recorded landslides in the Wellington District, Somerset, from 11 to 118. Each of the landslides considered in the work was classified within one of three slope behaviour units, defined by geology, topography and geomorphological form. The classification of landslides in this way has aided the process of landslide mapping and contributes to the understanding of different geomorphological processes over a large area.

Landslides in the district were predominantly rotational in nature, non -circular and ranging in size. The lithological sequences most susceptible to landslide activity are the Upper Greensand Formation over Mercia Mudstone Group, Upper Greensand Formation over Lias Group and Penarth Group over Mercia Mudstone Group.

An important aspect of this research was the integration of field and remote techniques. Field surveys were used to identify the components and overall form of slope behaviour units. These characteristics were then used by remote survey to identify the spatial extent of specific landslides and areas where landslides were thought likely to occur. Further fieldwork was then carried out to verify the aerial photograph interpretation. This process was important in the Wellington District where many landslides were very degraded, often covered with dense woodland and could cover large areas of ground, making field mapping difficult.

Acknowledgements

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References

BACCIARELLI, R. 1993. A revised weathering classification for Mercia Mudstone (Keuper Marl). In: CRIPPS, J.C., COULTHARD, J.M., CULSHAW, M.G., FORSTER, A., HENCHER, S.R. and MOON, C.F. (eds), *The Engineering Geology of Weak Rock. Engineering Geology Special Publication No. 8, Geological Society, London*, 169-174.

BARON, A. J.M., SUMBLER, M.G. and MORIGI, A.N. 2002. Geology of Morton-in-Marsh district. *Sheet description of the British Geological Survey 1:50 000 Sheet 217.*

BRUNSDEN, D. 1996. Landslides of the Dorset Coast: Some unresolved questions. *Proceedings of the Ussher Society*, **9**, 1-11.

CHANDLER, R.J. 1982. Lias Clay slope sections and their implications for the prediction of limiting or threshold slope angles. *Earth Surface Processes and Landforms*, 7, 427-438.

CONWAY, B.W. 1979. The contribution made to cliff instability by Head deposits in the west Dorset coastal area. *Quarterly Journal of Engineering Geology*, **12**, 267-275.

CROOT, D. and GRIFFITHS, J.S. 2001. Engineering geological significance of relict periglacial activity in South and East Devon. *Quarterly Journal of Engineering Geology and Hydrogeology*, **34**, 269-281.

DENNESS, B. 1972. The reservoir principle of mass movement. *Report Number 72/7, Institute of Geological Sciences.* 13 pp.

FORSTER, A. 1998. The Engineering Geology of the Sidmouth District, 1:50 000 Geological Sheet 326/340. *British Geological Survey Technical Report WN/91/1*, 51pp.

HAWKINS A.B. and PRIVETT, K.D. 1981. A building site on cambered ground at Radstock, Avon. *Quarterly Journal of Engineering Geology & Hydrogeology* **14**: 151-167.

HOBBS, P.R.N., HALLAM, J.R, FORSTER, A., ENTWISLE , D.C., JONES, L.D., CRIPPS, A.C., NORTHMORE, K.J., SELF, S.J. and MEAKIN, J.L. 2002. Engineering geology of British rocks and soils — Mudstones of the Mercia Mudstone Group. *British Geological Survey Research Report*, RR/01/02. 106 pp.

HUTCHINSON, J.N. 1991. Periglacial Slope Processes. In: FORSTER, A., CULSHAW, M.G., CRIPPS, J.C., LITTLE, J.A. and MOON, C.F. (eds.), Quaternary Engineering Geology. *Engineering Geology Special Publication No7, The Geological Society, London*, 283-331.

JONES, D.K.C. and LEE, E.M. 1994. *Landsliding in Great Britain*. Department of the Environment, London.

LEE, E.M. 1997. *The investigation and management of soft rock cliffs.* Proceedings of the MAFF Conference of River and Coastal Engineers. Department for the Environment, Food and Rural Affairs, London. B1.1- B1.2.

LEE, E.M. and CLARK, A. 2002 *Investigation and Management of Soft Rock Cliffs.* Department of the Environment, Fisheries and Rural Affairs, London.

SELLWOOD, D. and BRUNSDEN, D. 2000. Ground models for the coastal landslides at Lyme Regis, Dorset, UK. In: BROMHEAD, E., DIXON, N. and IBSEN, M.L. (eds), *Landslides in Research, Theory and Practice, Proceedings of the 8th International Symposium on Landslides.* Thomas Telford, London, 3, 1361-1366.

USSHER W.A.E, WOODWARD H.B. and JUKES-BROWNE A. J. 1906. The geology of the country between Wellington and Chard. Explanation of sheet 311. *Memoir of the British Geological Survey* (London).

WRIGHT, M.D. and HARRIS, C. 1980. Superficial deposits in the South Wales Coalfield. In: PERKINS, J. W. (Ed.), *Cliff and Slope Stability.* University College, Cardiff, 193-205.