Distribution of landslides and geotechnical properties within the Hampshire Basin

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ABSTRACT
This paper outlines the sedimentary sequences and geotechnical properties of the Hampshire Basin, a basin of filled with 700 m of Palaeogene clays, silts, sands and limestones in southern England. The paper presents results so far of a study to synthesize relevant geological and geotechnical data and relate these to the nature of the landslides in this basin. The study has found that stratigraphic sequences and geotechnical properties vary considerably across the basin owing to basin morphology and depositional environments which are correspond to complex paleogeography and tectonic movements during the Tertiary. Over-consolidated clays with low residual shear strengths are extensive on moderately steep slopes and prone to landsliding, especially on over-steepened coastal sections. Landslides vary from mudflows through mudslides, rotational landslides and minor falls. Landslide characteristics are strongly influenced by lithology but gradient appears to be the controlling factor in many cases. The presences of weak strata (clays, lignite, laminated layers), the pre-existing shear surface, the lithological interface (sand overlying clay) play important roles to locally control the position of the shear surface and the type of movements. At a basin scale, inland landslides are associated with the development of drainage system during and since the Tertiary.

1 INTRODUCTION

The Hampshire Basin underlies 3 400km^2 of the mainland of Southern England and the northern half of the nearby Isle of Wight (Figure 1). The Basin is bound to the north by an escarpment comprised of Cretaceous Chalk, and to the south by Chalk and a sequence of Jurassic strata. The low-lying central part of the basin is largely filled with Palaeogene sediments. This relatively weak infill gives rise to a subdued topography. Together with a lack of substantial development (except in a few urbanized areas and transport corridors), this low topography means that there are very few geological exposures and very little geotechnical data available. Although two sites; Barton on Sea and Bouldnor Cliffs are considered by Jones and Lee (1994) to be amongst the 'best-known' landslides in Britain, landslide activity is not widespread in the Palaeogene strata and rarely lead to large-scale failures. However, poor ground conditions and slope instability does pose a local hazard to infrastructure and property, especially on coastal sections prone to rapid erosion.

2 GEOLOGICAL SETTING AND STRATIGRAPHY

The Hampshire Basin (Figure 1) formed over a structurally complex basement, thought to consist of a series of blocks that underwent repeat movements during the Palaeozoic and Mesozoic. These blocks were covered by Cretaceous Chalk, syn- and post-depositional deformation of the Chalk resulted in the formation of an asymmetrical E-W trending basin bound to the north by a gently dipping Chalk limb (Weald Anticline) and to the south by a steeply dipping Chalk limb (Purbeck Monocline), (Jackson, 2008). The principal geological structures trend east-west or northeast-southwest (Melville and Freshney, 1982). Locally, the complex reactivation of basement faulting has produced many local structures forming gentle hills and valleys such as the anticline forming Portsdown Hill to the north of Portsmouth (Hopson, 2000). This complex evolving basin was largely filled by repeated transgressions and regressions during the Palaeogene (Gibbard and Lewin, 2003). Approximately 700 m of Palaeogene sediments from Upper Palaeocene (Upper Thanetian) to Lower Oligocene (Lower Rupelian) are preserved (Brenchley and Rawson, 2006).

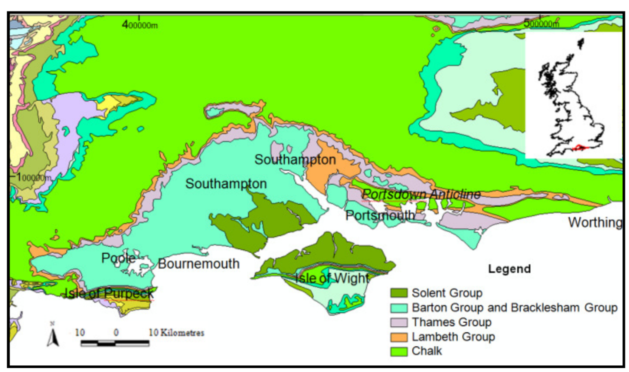

Figure 1. The Hampshire Basin (Digital geological data from EDINA Digimap Ordnance Survey Service)

The Palaeogene is divided into five groups shown in Table 1. The oldest sequences, the Lambeth Group and the Thames Group occur in narrow bands adjacent to the Chalk ridges. The Barton Group and Bracklesham Group underlie most of the basin but are exposed only at coastal sections or on steep (often engineered) slopes. The Solent Group is only present in the centre of the basin and on the northern coast of the Isle of Wight.

A result of the complex tectonic evolution and sea-level changes is that each division varies considerably across the Basin, with many recognized local stratigraphic terms and facies changes (Daley and Balson, 1999).

Table 1. Summary stratigraphy of the Palaeogene of the Hampshire Basin. Suffix indicate lithology is clay dominated (c), sand dominated (s) or limestone dominated (l).

Group	Local Formation Name
Solent	Bouldnor Formation (c)
	(*Bembridge Marls Member, Hamstead Member, Cranmore Member*)
	Bembridge Limestone Formation (l)
	Headon Hill Formation (c/s/l)
	(*Totland Member, Colwell Member, Linstone Chine Member, Hatherwood Limestone Member, Cliff End Member, Lacey's Farm Limestone Member, Fishbourne Member, Osbourne Marls Member, Seagrove Bay Member*)
Barton	Barton Sand Formation (s)
	Barton Clay Formation (c)
	Boscombe Sand Formation (s)
Bracklesham	Branksome Sand Formation (s)
	Pool Formation (c/s)
	Selsey Sand Formation (s)
	Marsh Farm Formation (c/s)
	Earney Sand Formation (s)
	Wittering Formation (c/s)
Thames	London Clay Formation (c/s)
	(*Bagshot Sand, Portsmouth Sand Member, Whitecliff Sand Member, Durley Sand, Nursing Sand, West Park Farm Member, Warmwell Farm Sand Member)*
Lambeth	Woolwich and Reading Formation (c/s)

3 GEOTECHNICAL CHARACTERISTICS

The complex stratigraphic relationships across the basin mean it is useful to consider the Palaeogene as three generalized lithological classes: stiff fissured clays, weakly cemented sands, and strong limestones with marls. The clay dominated strata (including Reading Formation, London Clay Formation and Barton Clay Formation) typically consist of thickly bedded stiff, fissured over-consolidated clays with beds and lenses of sand or silt. Sand dominated strata comprise fine to coarse-grained sand with laminations and beds of silty clays and fine sands. Partings of fine sands are common in some units (Wittering Formation, Branksome Sand Formation, Boscombe Sand Formation and Barton Sand Formation). Beds of limestone are present in the Headon Hill Formation and Bembridge Limestone Formation.

Three field exposures in Whitecliff Bay on the Isle of Wight [SZ637857- SZ645865] illustrate each group. Figure 2 shows typical exposures of the clay dominated Reading Formation, Figure 3 an exposure of the sand dominated Wittering Formation and Figure 4 the Bembridge Limestone Formation.

Figure 2. Exposure of the clay dominated Reading Formation [SZ637857]: firm to stiff, high plasticity, red-grey mottled CLAY

Figure 3. Exposure of the sand dominated strata of the Wittering Formation [SZ639861]: dense, yellow to orange, very fine- to fine grained SAND with high plastic, grey clay laminae

Figure 4. Exposure of the Bembridge Limestone Formation [SZ642863]: strong pale white LIMESTONE, underlying weak green mudstone of the Headon Hill Formation.

There is little published material on geotechnical properties within the Hampshire Basin. Cripps and Taylor (1986) include some information on Hampshire characteristics in their classic study of British over-consolidated clays and mudrocks. Burnett and Fookes (1974) established an eastward reduction in undrained shear strength and plasticity for the London Clay and attributed this to an eastward increase in clay fraction. This pattern, however, was determined mainly in the London Basin with limited data in the Hampshire Basin. Although both studies have been further developed and extended for the London Clay in the adjacent London Basin, little attention has been given to the Hampshire Basin. Several papers have been published by M.E. Barton and these provide an invaluable resource. However, these papers tend to be detailed studies of individual sites or lithological units.

Geotechnical properties taken from the literature, the British Geological Survey's National Geotechnical Database and from field investigations of this study are presented in Table 2. Even taking into account the effects of data aggregation, it can be seen that there is a wide variation. It has been suggested that such a range results from changes in mineral composition, consolidation, weathering and different geotechnical tests/ methods (Cripps and Taylor 1986). As expected, strength was strongly correlated with the depth from which geotechnical samples were taken.

Figure 5 demonstrates the wide range of natural water content; liquid limits and clay contents exhibited by strata. The Thames Group and Solent Group show the greatest plasticity, with clay contents that can exceed 80%. The Thames Group and Reading Formation can exhibit liquid limits greater than 100%. All clay dominated strata demonstrate normal plasticity. Plasticity does show some variation across the basin (Figure 6). For example, the Reading Formation exhibits low-intermediate plasticity in the west (Tolpuddle bypass) but high to extremely high plasticity in the east around Bognor Regis.

Table 2. Summary geotechnical characteristics of the Palaeogene sediments of the Hampshire Basin (after Barton, 1973, Barton, 1979, Barton and Roche, 1984, Barton et al., 1986, Cripps and Taylor, 1986). Additional geotechnical data obtained from British Geological Survey National Geotechnical Database and Hampshire County Council Engineering Geology Archive.

Basic Geotechnical Characteristics	Range of values
Water content (%)	4-55
Liquid limit (%)	19-121
Plastic limit (%)	10-41
Plastic index (%)	1-92
Clay fraction (<2µm) (%)	Up to 84
Dry Density, ρ_d (Mg/m$^{3)}$	1.22-2.04
Bulk Density, ρ_b (Mg/m$^{3)}$	1.64-2.44
Particle Density (Mg/m^3)	2.6-2.83
Undrained shear strength, S_u (kN/m^2)	5-930
Effective shear strength, c′ (kN/m^2)	0-112
Effective angle of friction, ϕ ′(°)	17-51.3
Residual shear strength, ϕ_r′ (°)	5.9-31.2

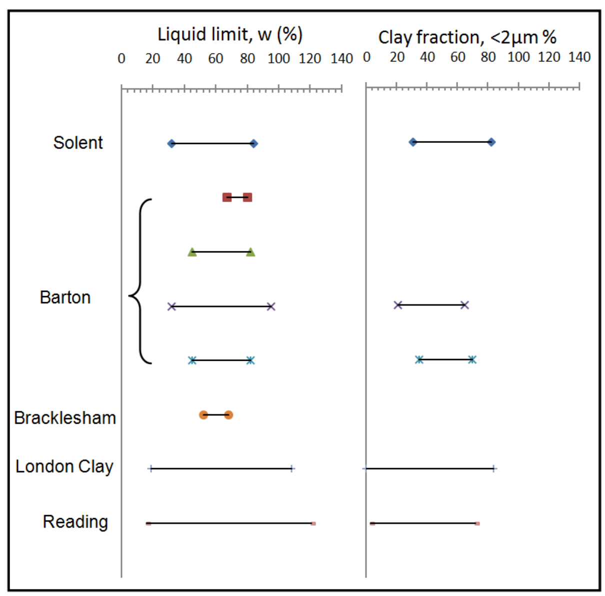

Figure 5. Liquid limits and clay fractions of the Paleogene sequences of the Hampshire Basin

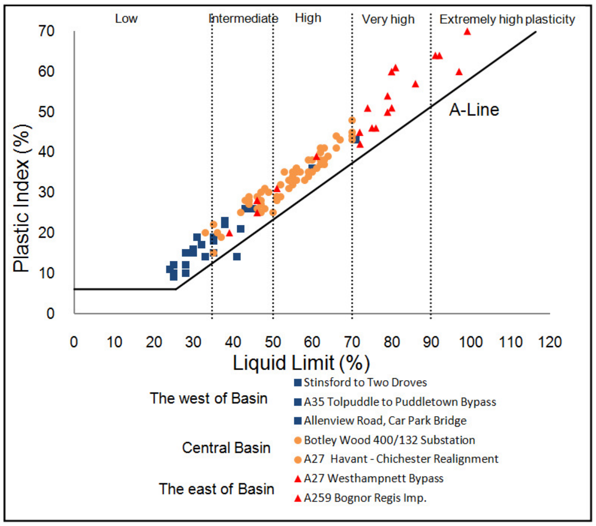

Figure 6. A variation in plasticity of the Reading Bed across the Hampshire Basin

A range of values of shear strength parameters (ϕ′) are summarized in Table 3. Undrained shear strength are shown in Figure 7. The sand dominated units exhibit a high effective angle of friction: Barton Sand Formation, (ϕ′=39-44°); Boscombe Sand Formation, (ϕ′=40°). The Bagshot Sand (London Clay Formation) presents the maximum value of ϕ′ at 51°. Barton, (1974) classified the Bagshot Sand, Boscombe Sand and Barton Sand shows as a 'soft sandstone' that in testing, exhibited brittle behaviour, low cohesion values. They also found these strata to be highly sensitive to submersion in water. Barton et al., (1986) described the Bagshot Sand Member in the East of the Basin and Barton Sand (Zone K) at Becton Bunny (centre of Basin) as well cemented and dense. They concluded that stability of slopes (which maintain slope angles greater than 50°) was enhanced by the presence of an iron oxide coating on vertical joints and between sand grains. They also demonstrated strength anisotropy, with strengths of the Bagshot Sand derived from direct shear test on perpendicularly orientated samples (ϕ′=50.3°) were higher than parallel orientated samples (ϕ′=44.2°).

Clay dominated units exhibit lower effective angle of friction: Barton Clay, (ϕ′=18-39°); London Clay, (ϕ′=18-35°); and Reading, (ϕ′=17-39°) (the British Geological Survey borehole data). The Solent Group exhibits a considerable reduction in ϕ_r' to a minimum value of 5.9° (ring shear test data). As over-consolidated clays, these lithologies may allow strain softening over time, leading to deformation and progressive failure (Gerrard, 1988). It has been reported that a gradient of 12° marks approximately the division between stable and unstable condition of natural slopes in London clay of the Hampshire Basin (Anderson and Richards, 1981). Pre-existing landslides in the basin may be reactivated at low residual shear strengths. For instance, reactivated landslides at Seagrove Bay (Winfield et al., 2007) occurred on Fishbourne Bed (very high plasticity clays with low measured residual shear strength of 6 to 7°).

Table 3. Shear strength parameters of the sediments of the Hampshire Basin from the literature and this study. (c′=Effective cohesion, ϕ′=Effective angle of friction, ϕ_r'= Residual friction angle)

Formation/Member	c′ (kN/m^2)	ϕ′(°)	ϕ_r' (°)
Solent Group (author data)			5.9-17.2
Hampstead Member (Hutchinson&Bhandari, 1971)			13.5
Fishbourne Member (Winfield et al., 2007)			6-7
Barton Sand (Barton, 1974,1986)	69	39-44	30.8
Barton Clay (weathered) (Cripps&Taylor, 1986)	7-11	18-24	15
Barton Clay (weathered) (Cripps&Taylor, 1986)	8-24	27-39	
Boscombe Sand (Barton, 1974)	83	40	
Bracklesham (Sand Facies) (Barton, 1979)	0	32.5	
Bracklesham (Clay Facies) (Barton, 1979)	0-55	18-32	
Bagshot Sand (Barton, 1986)	0-77	41-51	31
London Clay (author data)	0-112	18-35	
Reading (author data)	0-87	17-39	

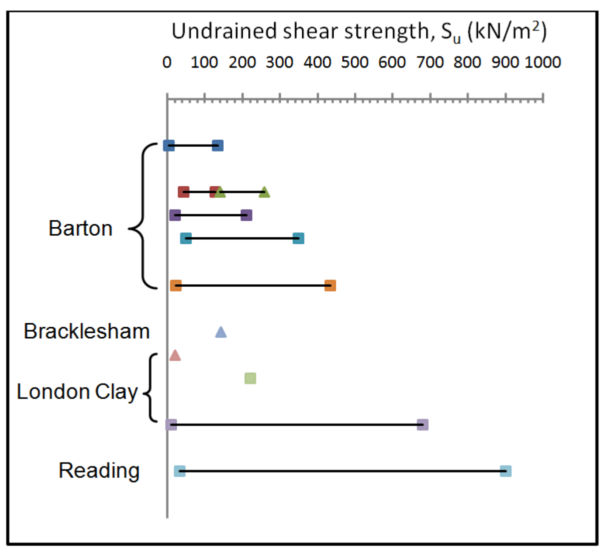

Figure 7. Undrained shear strength of the selected Formations sediments of the Hampshire Basin

4 LANDSLIDE FACTORS IN THE HAMPSHIRE BASIN

An important consideration for this study is the importance of local lithological variations that can exert significant influence over slope instability. Instability is common at the lithological interface where sands overlying clay such as the A3 shear surface of the Barton Clay cliffs (Barton, 1988). It is assumed that slippage near to or at this lithological junction is promoted by three possible causes: (i) more rapid re-distribution of seasonal pore pressure, (ii) faster equilibration of seasonal pressures depressed by unloading and (iii) seepage erosion in the sand. Slopes in the Hampstead Member [SZ389912] with a residual strength of 13.5°, are known to fail at gradients considerable lower than 6°, a phenomena thought to be related to undrained loading (Hutchinson and Bhandar, 1971).

The presence of laminae, thin beds or permeable channel-filled units can also affect local slope stability. It has been suggested that these units can influence the position of the shear surface by exerting a local control on pore water pressures and by giving rise to internal erosion (Hight et al., 2004). For example, the slip at Newhaven can presumably be attributed to elevated pore pressures in a thin laminated sand and clay unit of the Woolwich Formation at the base of the slip (Hight et al., 2004). Shear surfaces are also known to be controlled by weak layers such as a smectite rich bed within the Barton Clay Formation (Barton et al., 2006) or the weak lignitic clays within the Woolwich Formation (Hight et al., 2004) that readily form weak zones where shears can develop.

Geotechnical control over landslide type and morphology is also clearly demonstrated. Mudflows commonly develop on predominantly clay units (e.g. Reading Bed and London Clay), whilst minor rock falls are generally present on predominantly sandy units (e.g. Barton Sand Formation and Bracklesham Formation). In contrast, deep-seated rotational landslides generate when a caprock is present. For example, rotational landslides at Headon Cliff are controlled by the presence of limestone beds at many levels of the Headon Hill Formation and multiple rotational landslides at Seagrove Bay are controlled by the presence of Bembridge limestone. This follows Bromhead (1979) who postulated that if the crest is broadly similar in nature to the rest of the slope, then mudslides are the dominant form of mass movement, whereas if the crest is stronger or better drained, then deep-seated, rotational failures occur.

Another significant factor controlling the type of landslides of the Hampshire Basin is geological structure (position and dip of bedding) controls the type and process of landslides. This is well illustrated by the case study of the Bouldnor cliff (Hutchinson, 1983). The study found that minor mudslides and shallow landslides occurred where the more competent strata forms the cliff. In contrast, major landslides occur when the base of the clay stratum lies at or close to sea level and deep-seated rotational or multiple rotational slips have occurred where the more competent strata lies below the beach level. Moreover, in several areas on the northern Isle of Wight, the presence of the resistant Bembridge Limestone in the cliff foot and shore platform protect toe erosion and base failure thus preventing the potential for deep-seated landslides.

160 landslides are recorded in the British Geological Survey's National Landslide Database as existing on the Palaeogene deposits in the basin. This study reviewed existing records of these landslides and carried out further investigation by air-photo interpretation and field mapping to identify and characterize previously un-described sites. As might be expected, many of these occur on the northern coast of the Isle of Wight or southern coast of the mainland. Summary descriptions of key landslide sites are given in Tables 4 and 5. Coastal landslides on the mainland have occurred along the coastal cliffs in the central part of the basin. Steep cliffs of Branksome Sand [SZ065896] and Boscombe Sand [SZ115912] have partially been stabilized (Carter et al., 2004). In contrast, the Barton Clay slopes [SZ220931], affected by large-scale rotational landsliding and pervasive shear zones have been stabilised to only limited effect (Figure 8). Nearby slopes of the Headon Hill Formation [SZ270921] have naturally stabilised and are now well vegetated (Carter et al., 2004).

Figure 8. Large landslides on Barton Clay cliffs at Barton cliffs [SZ220931], Barton Clay: very stiff, fissured olive-grey, glauconitic CLAY. Despite the installation of toe protection and drainage schemes in some sections of the complex, the landslide remains highly active.

Landslides in the Palaeogene on the coast of the Isle of Wight can be characterized by complex sequences of rotational failures at the top of cliffs degrading into mudslides and flows towards the coast. Several have been examined in detail including the Fort Victoria Landslide, (Foster, 2010), Bouldnor Cliff (Hutchinson and Bromhead, 2002), and Seagrove Bay (Winfield et al., 2007). Each of these is currently active but thought to be associated with long-term changes in sea level and coastal erosion. Some landslide records in the northern Isle of Wight are summarized in Table 5. Figure 9 shows an example of a rotational landslide controlled by the presence of a strong caprock. Figure 10 shows an example from an eroding coast formed of the Bracklesham Group. Landslides in this sand-dominated unit are in the form either of gulley controlled mudslides or gulley controlled or small rotational landslides and topples from the steep sand cliffs.

Table 4. Published landslide data in the mainland of the Hampshire Basin

Location	Landslide records
Instability on natural slopes (Inland landslides)	
Lytchett Matravers [SY 945 977] (Bristow et al., 1991)	Several landslides on clays of West Park Farm Member and associated with springs issuing from the base of the overlying Warmwell Sand Member.
Arundel [TQ 028 056] (Aldiss, 2002)	Landslides in Reading Formation and London Clay Formation where steep slopes have been eroded at spring-heads or by rivers.
Halterworth [SU370 215] (Edwards and Freshney, 1987)	Landsides involve laminated clays of Wittering Formation just beneath the base of the Earnley Sand Formation.
Shoreham Harbour [TQ2245050] (Hight, 2004)	Failure in degraded cliff adjacent to roads. Investigation suggested slope failure controlled by weak lignitic clays within Woolwich Formation. Failure attributed to removal of the toe by dredging.
Instability on cut slopes	
Hedge End Southampton (Ekins, 1998) [SU482136]	A shallow rotational landslide occurred on the embankment on the B3036 road where London Clay Formation is used for slope materials.
Rushey Hill (Hight, 2004) [TQ2458013]	A259 coast road, along strike of Lambeth Group outlier below Rushey Hill, partly in cutting and partly in cut and fill. Road susceptible to instability, mainly associated with Woolwich Formation.
Instability on coastal slopes (Carter et al., 2004)	
Bournemouth Bay from [SZ055890] to[SZ170905]	Slope stabilization installed to some areas of cliffs along coastal section; re-graded, in places drained, vegetation encouraged. Locally, cliff instability remains a problem
Naish cliffs [SZ220931]	Large landslides along unprotected cliffs, loss of holiday camp lands at the cliff top f Barton Formation.
Central Barton-on-Sea [SZ238930]	Protection measures applied; however, initial stabilization only partially effective and in the winter of 1974/75 deep-seated failures led to loss of several properties.
Hill Head [SZ542021]	Inactive and vegetated cliffs were considered stable. However, landslides have recently been occurred at the cliff top in Hill Head Road (Broom, 2010).
Newhaven [TQ448001]	Landslides in Woolwich Formation threatened coastal defences (Hight, 2004).

Table 5. Published landslide data in the northern Isle of Wight

Location	Landslide records
Instability on natural slopes (Inland landslides)	
Durton Newport [SZ525884] (Hutchinson, 1965)	Unmapped slide in Hamstead Beds first seen in 1962, on 10° slope, 360 m wide, 45 m long.
Headon Point [SZ305862] (Hutchinson &Bromhead, 2002)	Continuation of coastal landslides of Headon Point in Osborne and Headon Beds.
Instability on coastal slopes	
Alum Bay [SZ305855]	Mudslides on Reading and London Clay form elongate basins, minor rock fall are common in sandy units of Bracklesham Formation.
Headon cliff [SZ310862] (Hutchinson, 1965)	Complex translation-rotational landslide of the Headon Hill Formation
Fort Victoria [SZ338895] (Foster, 2010)	Deep-seat rotational landslides on the Headon Hill Formation.
Bouldnor Cliff [SZ390910] (Hutchinson & Bhandari 1971, Hutchinson, 1983)	Landslides in Hamstead Member of Solent Group forming rotational landslides mudslide and mudflows.
Gurnard to West Cowes [SZ475955] (Halcrow, 2000)	Landslides are presented at many level within Bembridge Marls, Bembridge Limestone, and Osbourne Member.
Seagrove Bay [SZ632908] (Winfield et al., 2007)	A deep seated rotational landslide developed within Fishbourne Member.
Whitecliff Bay [SZ638857]	Mudslides developed in Reading Formation and London Clay Formation. Minor slope failures of sandy unit s of the Bracklesham Group.

Figure 9. Aerial photograph of complex multiple rotational landslides at Headon Cliff [SZ310862] in limestones and mudstones of the Headon Hill Formation. A moderately strong limestone bed forms a prominent scarp

Figure 10. Landslide in the sand dominated strata of the Bracklesham Group: green Sand, laminated clays with seams of lignite

30 inland landslides in the Palaeogene deposits are mapped in the mainland of the Hampshire basin and only two records in the Isle of Wight. These slides tend to be much more subdued and less active than their coastal counterparts. For the purposes of this study, identifying inland landslides through aerial photo interpretation was inconclusive for several locations and field-base survey was required to identify and describe landslides.

Early results from this survey indicate a distinctive variation in the morphology of landslides across the basin. For example, landslides in the London Clay in the eastern part of the basin in Arundel, [TQ 028 056], (Figure 11) have distinctive translation morphologies with visible scarps up to 3 m in height and active tension cracks. These degrade to elongate mudflows with lobes up to 4 m in height. These landslides occur on slopes with gradients of 7°. Towards the west of the basin landslides in the equivalent stratigraphy demonstrate much more subdued morphology. For example, around Lytchett Matravers, [SY 945 977], landslides in the London Clay had a very subdued morphology. On slopes with gradients of 10° or less, landslides tended not to show prominent rear scarps or translational elements. Lobes from these slides attained a maximum thickness of less than 1 m. Landslides in the west of the basin also appeared less active than their counterparts in the west. Detailed geomorphological mapping is underway to examine this further and determine what the controls on the pattern might be (age, geotechnical properties, gradient etc.).

Figure 11. The translational landslide developed in London Clay Formation [TQ 028 063] in Arundel. The presence of seepages in the area suggests that water could have softened the mobilized materials, reactivating this pre-existing landslide.

5 ANALYSIS OF LANDSLIDE DISTRIBUTION

A model has been constructed using ArcMap GIS to enable the comparison between the distribution of geotechnical properties, and their relationship with landsliding. Data layers of geology, drainage, and slope gradient derived from GIS-based surface analysis are overlaid with obtained National Landslide Database landslide records (Figures 12-13). Datasets used are OS Land-Form PANORAMA DTM, British Geological Survey 1:50000 digital geology map from EDINA Digimap Ordnance Survey Service. Figure 12 shows the locations of known landslides in the Hampshire Basin. It is demonstrated that landslides occur on all major Palaeogene lithologies and the majority of landslides occur on the north of the Isle of Wight within the Solent Group. Observing landslides in this manner is useful to obtain an overview but as described earlier, there are many local variations that are difficult to represent on a geological map of this scale.

Presenting the location of landslides overlain on a slope angle model proved useful in demonstrating the dominant influence of topography (Figure 13). The geomorphology of the Hampshire Basin clearly follows the nature of the underlying bedrock and geological structure. The basin forms an elongated concavity bound by the Chalk ridges that reach a maximum elevation of 250 m a.s.l. Palaeogene sediments form slopes and plains from sea level to elevations abutting the Chalk at 120m. In the east, they tend to form low relief coastal plains with elevations beneath 5 m.

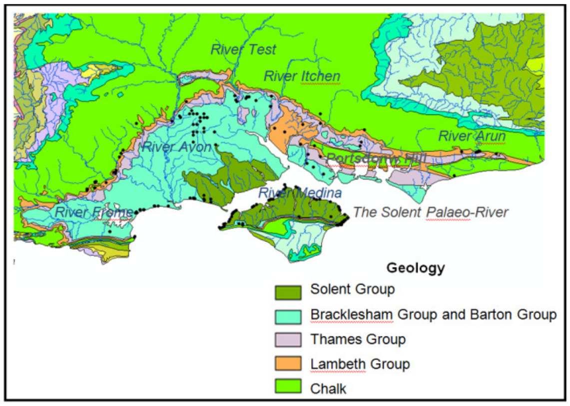

Figure 12. The location of landslides overlain on geology (Digital geological data from EDINA Digimap Ordnance Survey Service)

Towards the centre and west of the Basin sediments form gentle slopes at elevations between 35 m and 100 m. Coastal cliffs in the northern Isle of Wight range in elevation between 15 m to 90 m. It can be seen from Figure 13 that landslides are concentrated along steep coastal slopes in Poole and Christchurch Bay and the northern Isle of Wight. Inland landslides are not widespread being confined to relative steep slopes of the New forest and Corfe Mullen. Inland landslides have also occurred on steep slopes near the edges of the basin and on the dip slopes of the Portsdown Hill Anticline. Inland landslides concentrate on the steep river slopes to the east of the River Avon.

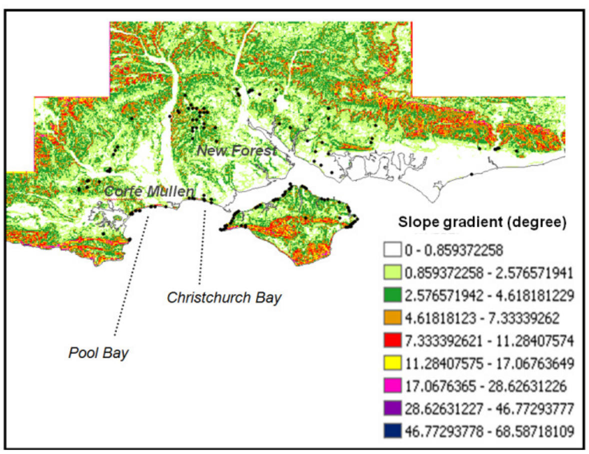

Figure 13. The location of landslides overlain on a slope angle model (Datasets used are OS Land-Form PANORAMA DTM, British Geological Survey 1:50000 digital geology map from EDINA Digimap Ordnance Survey Service)

6 CONCLUSIONS AND FUTURE WORK

The conclusions to date of this ongoing study are:

- The Palaeogene sediments of the Hampshire Basin demonstrate great heterogeneity resulting from complex basin morphology and complex depositional environment during the Tertiary. As a result, geotechnical properties vary across the basin. Variation within stratigraphic units is complex and a better understanding of this is beginning to emerge.
- Local lithological variations such as thin beds of lignite or smectite rich horizons can exert significant control of large landslide complexes.
- The principal controls of landslides are coastal exposure and gradient. These are related to the development of a drainage pattern during the Tertiary.

Work is underway to improve the geotechnical model of the Hampshire Basin, incorporating information regarding local units, layers and weathering zones. This model will assist in the understanding of the nature, distribution and evolution of landslides in the area.

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