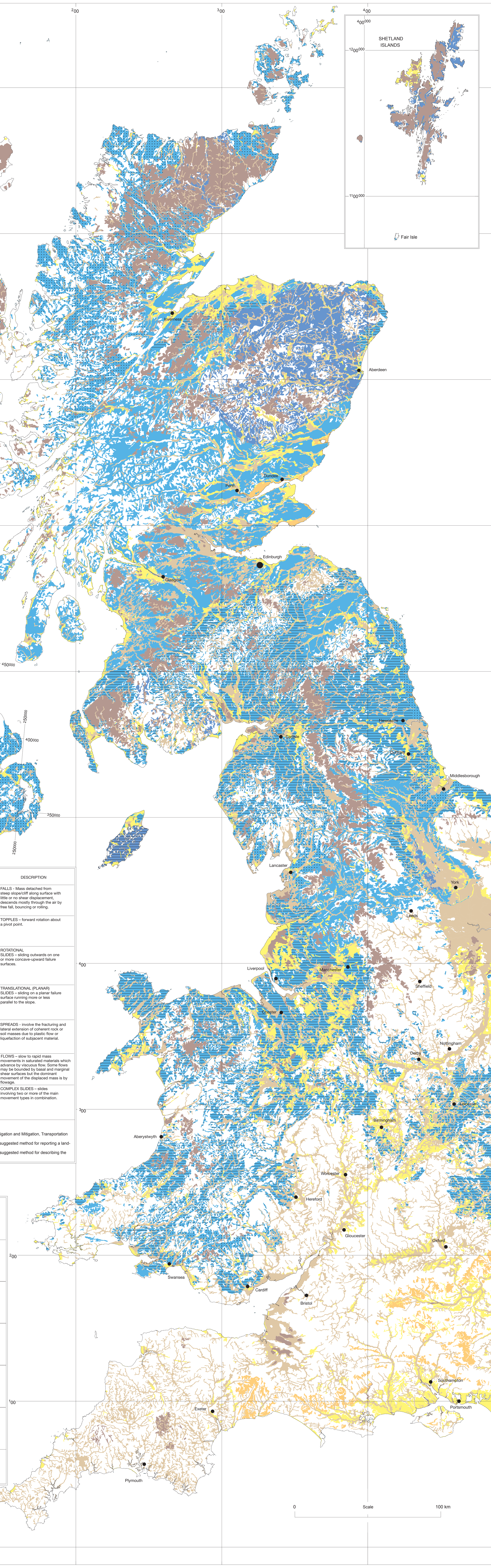
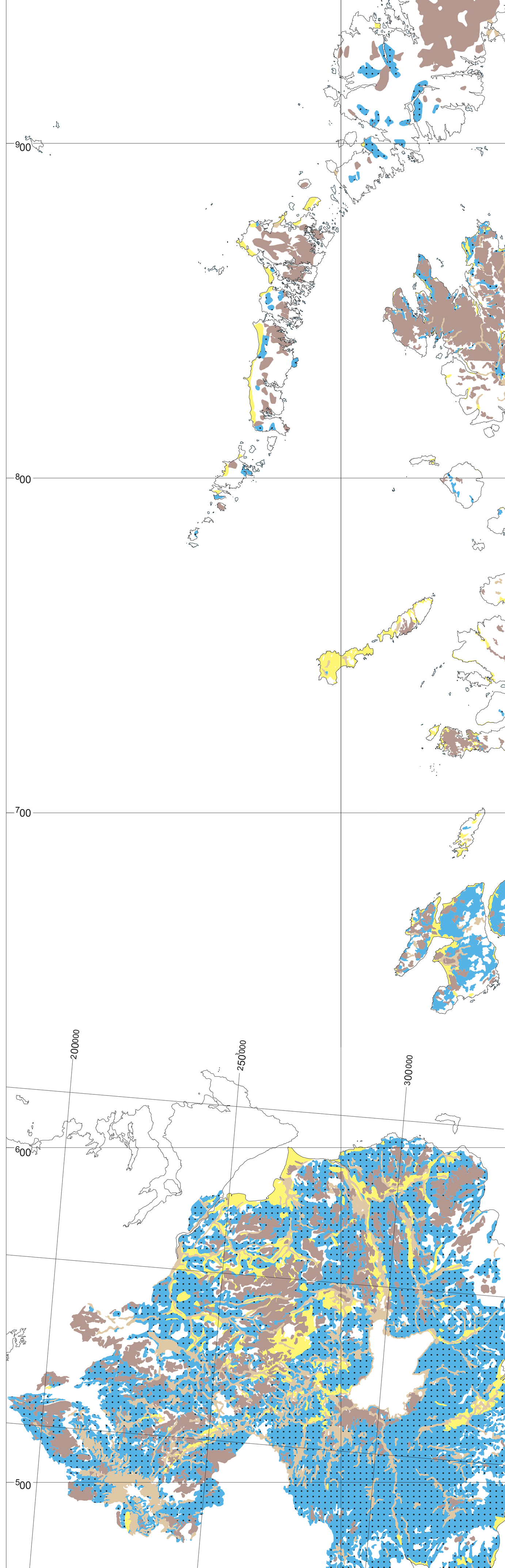
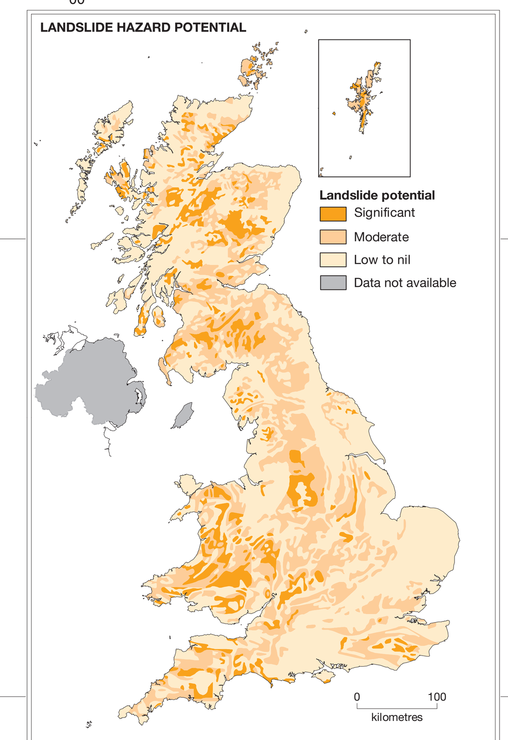
1:1 000 000 SERIES

ENGINEERING GEOLOGY (SUPERFICIAL) MAP OF THE UNITED KINGDOM



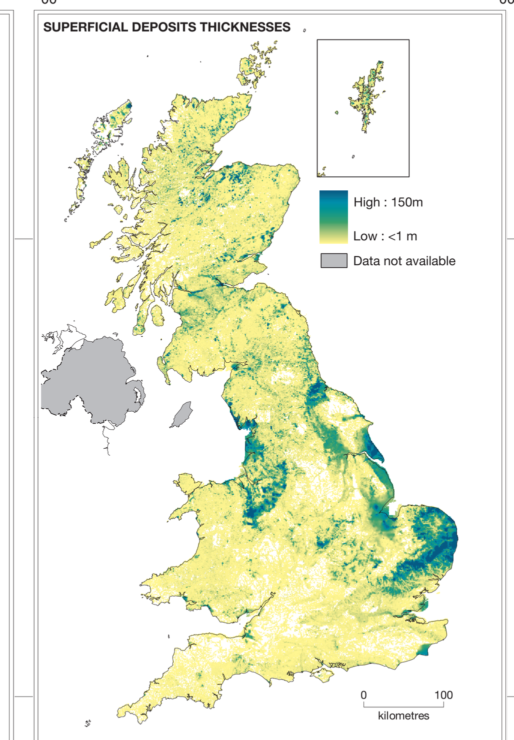


LANDSLIDE HAZARD POTENTIAL



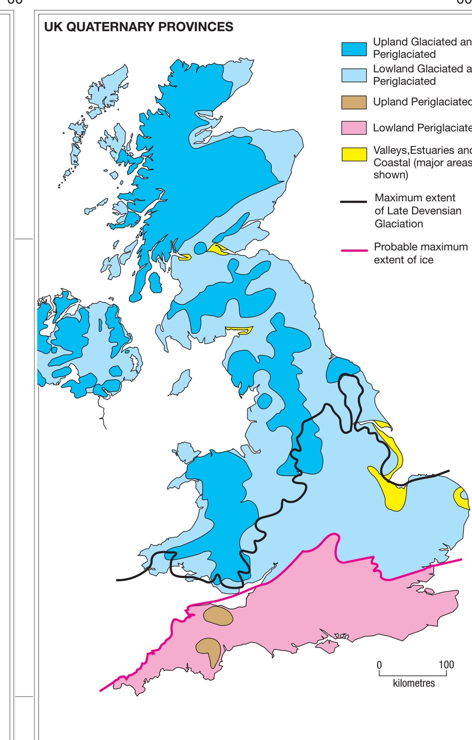
From Jackson, I. (editor). 2004. Britain beneath our feet. (Keyworth, Nottingham: British Geological Survey Occasional Publication No. 4.) Further information can be found on the GeoSure webpages: http://www.bgs.ac.uk/products/geosure/home.html

SUPERFICIAL DEPOSITS THICKNESSES



Based upon BGS Superficial Deposit Thickness Model (SDTM). Further information can be found on the STDM webpage: http://www.bgs.ac.uk/science/3Dmodelling/superficialthickness.html

UK QUATERNARY PROVINCES



Based upon Foster, S. S. D., Morigi, A. N., and Browne, M. A. E. 1999. Quaternary geology – towards meeting user requirements. (Keyworth, Nottingham: British Geological Survey.)

LITHOLOGY	DESCRIPTION (After BS5930:1999)
Organic Soil	Very soft to firm fibrous to amorphous PEAT. Deposits may be selectively worked to shallow depth in some areas. Very low to moderate permeability; flow dominantly through matrix.
Coarse Soil	Loose to dense fine to coarse-grained SAND or SAND and GRAVEL with some cobbles. Sandy clay and silt, sometimes laminated, occur locally, especially within terrace deposits which may also contain peat. High to very high permeability; flow is through matrix. Includes glaciofluvial sand and gravel, river terrace deposits, blown sand, coarse marine, coarse alluvium, head and talus deposits.
Fine Soil	Very soft to very stiff sometimes sandy CLAY or SILT. Desiccation of top few metres may result in firm to stiff material overlying soft to very soft deposits at depth. Generally very low to moderate permeability; flow dominantly through fissures. Includes lacustrine deposits, glaciolacustrine deposits, fine marine deposits, estuarine alluvium and lowland river alluvium (any of which may contain peat beds or lenses) and loess/loessic soils.
Fine and Coarse Soil	Soft to stiff sandy gravelly CLAY or clayey SAND and GRAVEL. Very low to high permeability; flow dominantly through fissures if low and matrix if high. Includes Clay-with-flints and some Head deposits.
Fine Till	Firm to very stiff or hard slightly gravelly sandy CLAY with few cobbles and boulders. Occasional medium to extremely widely spaced interbeds and lenses of sand and gravel may be present. Often fissured particularly in the upper few metres. Generally low permeability; flow through fissures and lenses/interbeds of sand and gravel where present.
Fine Till (Boulders)	Firm to very stiff or hard gravelly sandy CLAY with many cobbles and boulders, which may be strong. Often fissured particularly in the upper few metres. Occasional medium to extremely widely spaced interbeds and lenses of sand and gravel may be present. Generally low permeability; flow through fissures and lenses/interbeds of sand and gravel where present.
Fine Till (Layered)	Firm to very stiff or hard slightly gravelly sandy CLAY with interbeds of laminated clay/silt and beds/lenses of sand and gravel. Often fissured, particularly in the upper few metres. Low to high permeability; flow dominantly through lenses/interbeds of sand and gravel.
Coarse Till	Dense to very dense clayey SAND and GRAVEL with some cobbles and boulders. Low to moderate permeability; flow dominantly through matrix.
Coarse Till (Layered)	Dense to very dense COBBLES and BOULDERS with medium to very widely spaced thin to very thick interbeds of sand and gravel. Low to high permeability; flow dominantly through lenses/interbeds of sand and gravel.
	Note: Superficial deposits are shown only where mapping or boreholes prove deposits to be generally over 1 m thick. The deposits shown are those at surface, other superficial deposits may be present at depth.

Reference

British Standard BS5930:1999. Code of Practice for Site Investigations, incorporating Amendment 2 (2010). British Standards Institution: London.

SUPERFICIAL DEPOSITS

The last 2.4 million years has been dominated by alternating glacial (cold) and interglacial (warm) episodes. The rise and fall of sea level and advance and retreat of ice sheets and glaciers in response to these episodes has left a lasting impact on the geology and landscape of the UK. Deposits associated with two of the most recent glaciations, the Anglian and later Devensian, can be found across most of the UK. In many places they are in turn overlain by deposits from the current, Holocene, interglacial episode.

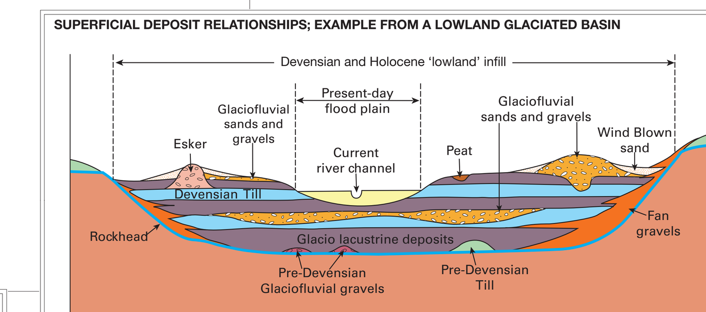
The significance of superficial deposits in engineering geology cannot be over-emphasised. Their extensive coverage of the UK landmass means that construction will frequently intersect them. In places, they have complex depositional relationships that can cause difficulty in developing accurate ground models. There is a high degree of variability in particle size and strength/density between superficial deposits, and often within a single deposit type; this may lead to severe differential settlements and complex groundwater regimes (which have implications for drainage, flooding and contamination). Deposits are also often soft or loose and susceptible to excessive settlement or running sand conditions. Loessic deposits, although of limited extent and thickness, may be susceptible to sudden collapse.

A summary of the characteristics of UK quaternary provinces, as shown on the accompanying inset map, is provided below:

PROVINCE	LANDFORMS	DEPOSITS
Upland Glaciated	Ice-scoured valleys and corries which contain depositional features such as kames, eskers and moraines.	Till, glaciofluvial deposits, alluvial fans, alluvium and peat. Landslip deposits.
Lowland Glaciated (within Devensian limit)	Drumlin fields, outwash terraces and kames and by erosional features such as crag and tail and glacial fluvial drainage channels.	Frequently thick and complex sequences of till and glaciofluvial deposits. Glaciolacustrine deposits, glaciomarine, raised marine deposits, raised beach deposits in coastal and estuarine settings. Alluvium and river terrace deposits.
Lowland Glaciated (beyond Devensian limit)	Featureless till plateaux sometimes with complex glaciofluvial deposits.	Thick complex sequences of interbedded till and glaciofluvial deposits. Alluvium and river terrace deposits.
Upland Periglaciated	Mountain-top residual deposit landforms.	Variably weathered bedrock. Head deposits, talus, peat and alluvium. Landslip deposits.
Lowland Periglaciated	Patterned ground (chalk polygons and stripes).	Head, clay-with-flints (residual deposit of chalk), loess, alluvium and river terrace deposits.
Valleys, Estuaries and Coastal	River and marine terraces, dunes forms, estuarine channels and mudflats.	Thick infills of late glacial and post glacial marine, estuarine and lacustrine deposits and peat. Alluvium, river terrace deposits, beach deposits and blown sand.

Based upon Foster, S. S. D., Morigi, A. N., and Browne, M. A. E. 1999. Quaternary geology – towards meeting user requirements. (Keyworth, Nottingham: British Geological Survey.)

SUPERFICIAL DEPOSIT RELATIONSHIPS; EXAMPLE FROM A LOWLAND GLACIATED BASIN



Superficial Deposits Diagram
From Booth, K. A., Booth S. J., and Slater, C. 2011. BGS Geological Cross sections & Quaternary Domains: User Guidance Notes. British Geological Survey Internal Report, IR/10/012. 36pp.

HEAD

Head is a type of mass movement deposit consisting of poorly sorted and poorly stratified angular rock debris and/or clayey hillwash and soil creep, mantling a hillslope and deposited by solifluction and gelifluction processes. Solifluction is the slow viscous downslope flow of waterlogged soil and other unsorted and unsaturated superficial deposits. The term gelifluction is restricted to the slow flow of fluidized superficial deposits during the thawing of seasonally frozen ground. Excess water supplied from the melting of segregated ground ice can generate high excess pore-water pressures, which greatly reduces the resistance of the mantle to downhill sliding and flow. As a result, gelifluction mantles can occur on very low angle slopes, down to 1 or 2°. Some clayey head deposits are prone to reactivation due to the presence of relict shear surfaces, produced during their formation under past conditions when the mantles had much higher water contents.

Due to their difficult recognition in the field and absence of subsurface information (boreholes), not all Head deposits have been mapped.

ARTIFICIAL GROUND

Human activity, both at the surface and below it, has resulted in widespread modification of the ground. The legacy of this activity includes both anthropogenic deposits (artificial ground) and voids. As the processes which form artificial ground vary, so too do the characteristics of individual deposits. As a consequence, artificial deposits may be highly heterogeneous, variably consolidated and be affected by soil and/or groundwater contamination (Rosenbaum et al. 2003). It is therefore imperative that comprehensive and systematic assessment of artificial ground be made where there is development and regeneration in an urban environment, both for individual construction projects and for regional planning purposes.

Artificial ground can be divided into several different types for mapping and classification purposes (after Rosenbaum et al. 2003). The following scheme has been adopted by the British Geological Survey for its 1:50 000 and 1:10 000 scale geological maps:

Worked Ground consists of areas where the ground is known to have been cut away (excavated) by people and includes quarries, pits, road and rail cuttings, dredged channels and cut-away landscaping.

Made Ground is an area where the material present is known to have been deposited by human activity on the former natural ground surface; it includes embankments, flood defences, spoil (waste) heaps, coastal reclamation fill, offshore dumping grounds and constructional fill.

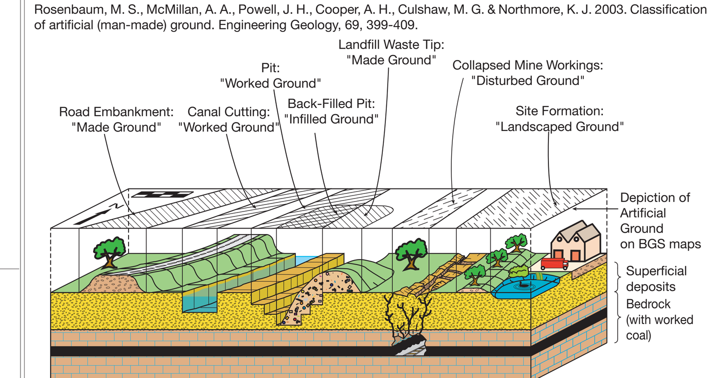
Infilled Ground is found where the ground has been excavated and then had fill materials deposited artificially. Examples include partly, or wholly, back-filled workings such as pits, quarries and opencast sites.

Landscaped Ground is found where the original surface has been extensively remodelled by both excavation and the placing of made ground but where it is impractical to delineate the areas separately.

Disturbed Ground consists of areas of surface or near-surface mineral workings where ill-defined excavations, areas of human-induced subsidence caused by the workings and spoil are complexly associated with each other (for example collapsed bell pits and shallow mineworkings and the spoil from these workings).

Reference

Rosenbaum, M.S., McMillan, A. A., Powell, J. H., Cooper, A. H., Culshaw, M. G. & Northmore, K. J. 2003. Classification of artificial (man-made) ground. Engineering Geology, 69, 399-409.



Artificial Deposits Diagram
From Price, S.J., Burke, H. F., Terrington, R. L., Reeves, H., Boon, D. & Scheib, A. J. 2010. The 3D characterisation of the zone of human interaction and sustainable use of underground space in urban and peri-urban environments: case studies from the UK. Zeitschrift der Deutschen Gesellschaft fur Geowissenschaften, 161 (2). 219-235.

INTRODUCTION TO THE MAP

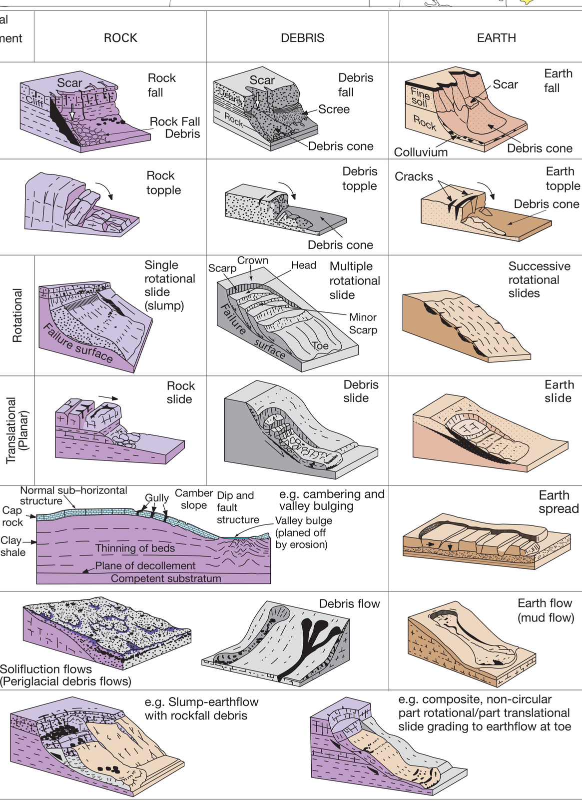
Engineering geology is a broad discipline within geology that is defined by the International Association for Engineering Geology and the Environment (IAEG) as: "... the science devoted to the investigation, study and solution of the engineering and environmental problems which may arise as the result of the interaction between geology and the works and activities of man as well as to the prediction of and the development of measures for prevention or remediation of geological hazards." Engineering geology is important, therefore, in the maintenance of public health, safety and welfare during development and redevelopment of the earth's surface and shallow subsurface, in safeguarding the geological aspects of the environment and in delivering economic benefit.

Two engineering geological maps of the UK have been produced at a scale of 1:1 million. One map shows the engineering geological characteristics of the bedrock, that is, those soils and rocks that were in place before the Quaternary Period. The second map shows the engineering geological characteristics of the superficial deposits emplaced during approximately the last 2 million years in the Quaternary Period. The reason for this separation is that Quaternary materials cover about 60% of the UK's surface and hence mask large parts of the earlier geology. However, they are often relatively thin (less than 10 m) so the bedrock is frequently intersected during building and construction.

These maps should not be used for site specific purposes, their intention is to provide an introduction to the engineering geology of the UK by presenting a broad overview of how engineering geological conditions change across the country. They provide the first stage to understanding the consequences of the interaction between human development, the ground and the natural processes acting upon it. For further information regarding engineering geological hazards, GeoSure products and other BGS datasets visit the BGS website http://www.bgs.ac.uk/ or contact BGS Enquiries enquiries@bgs.ac.uk.

Note: Superficial deposits are shown only where mapping or boreholes prove deposits to be generally over 1 m thick. The deposits shown are those at surface, other superficial deposits may be present at depth. Data for Northern Ireland, the Isle of Man and the Shetland Islands has been provided where available.

LANDSLIDE CLASSIFICATION

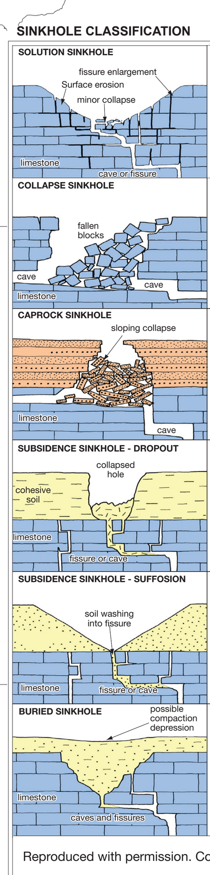


Movement Type	Material: ROCK	DEBRIS	EARTH	DESCRIPTION
FALLS	Rock fall	Debris fall	Earth fall	FALLS - Mass detached from steep slope/cliff along surface with little or no shear displacement, descends mostly through the air by free fall, bouncing or rolling.
TOPPLES	Rock topple	Debris topple	Earth topple	TOPPLES – forward rotation about a pivot point.
SLIDES – Rotational	Single rotational slide (slump)	Multiple rotational slide	Successive rotational slides	ROTATIONAL SLIDES – sliding outwards on one or more concave-upward failure surfaces.
SLIDES – Translational (Planar)	Rock slide	Debris slide	Earth slide	TRANSLATIONAL (PLANAR) SLIDES – sliding on a planar failure surface running more or less parallel to the slope.
SPREADS	e.g. cambering and valley bulging		Earth spread	SPREADS - involve the fracturing and lateral extension of coherent rock or soil masses due to plastic flow or liquefaction of subjacent material.
FLOWS	Solifluction flows (Periglacial debris flows)	Debris flow	Earth flow (mud flow)	FLOWS – slow to rapid mass movements in saturated materials which advance by viscuous flow. Some flows may be bounded by basal and marginal shear surfaces but the dominant movement of the displaced mass is by flowage.
COMPLEX	e.g. Slump-earthflow with rockfall debris		e.g. composite, non-circular part rotational/part translational slide grading to earthflow at toe	COMPLEX SLIDES – slides involving two or more of the main movement types in combination.

Based on:

Cruden, D. M. and Varnes, D. J. 1996. Landslide types and processes. In Special Report 247: Landslides: Investigation and Mitigation, Transportation Research Board, Washington, D.C.
The International Geotechnical Societies' UNESCO Working Party Report on World landslide Inventory. 1990. A suggested method for reporting a landslide. *Bulletin of Engineering Geology and the Environment,* Vol.41, No.1, 5-12.
The International Geotechnical Societies' UNESCO Working Party Report on World landslide Inventory. 1993. A suggested method for describing the activity of a landslide. *Bulletin of Engineering Geology and the Environment,* Vol.47, No.1, 53-57.

SINKHOLE CLASSIFICATION



Sinkhole	Formation process	Host rock types	Formation speed	Typical max size	Engineering hazard	Other names in use
SOLUTION SINKHOLE	dissolutional lowering of surface	limestone, dolomite, gypsum, salt	stable lanforms evolving over > 20,000 years	up to 1000 m across and 100 m deep	fissure and cave drains must exist beneath floor	dissolution sinkhole, cockpit, doline
COLLAPSE SINKHOLE	rock roof failure into underlying cave	limestone, dolomite, gypsum, salt	extremely rare, rapid failure events, into old cave	up to 300 m across and 100 m deep	unstable breakdown floor, failure of loaded cave roof	cave collapse sinkhole cenote
CAPROCK SINKHOLE	failure of insoluble rock into cave in soluble rock below	any rock overlying limestone, dolomite, gypsum	rare failure events, evolve over > 10,000 years	up to 300 m across and 100 m deep	unstable breakdown floor	subjacent collapse sinkhole, interstratal karst
SUBSIDENCE SINKHOLE - DROPOUT	soil collapse into soil void formed over bedrock fissure	cohesive soil overlying limestone, dolomite, gypsum	in minutes, into soil void evolved over months or years	up to 50 m across and 10 m deep	the main threat of instant failure in soil-covered karst	subsidence sinkhole, cover collapse sinkhole, alluvial sinkhole
SUBSIDENCE SINKHOLE - SUFFOSION	down washing of soil into fissures in bedrock	non-cohesive soil overlying limestone, dolomite,	gypsum subsiding over months or years	up to 50 m across and 10 m deep	slow destructive suidence over years	subsidence sinkhole, cover-subsidence sinkhole, alluvial sinkhole
BURIED SINKHOLE	sinkhole in rock, soil-filled after environmental change	rockhead depression in limestone, dolomite, gypsum	stable features of geology, evolved over > 10,000 years	up to 300 m across and 100 m deep	local subsidence on soft fill surrounded by stable rock	filled sinkhole, compaction sinkhole, paleosinkhole

Reference

Waltham, A.C., Bell, F.G., Culshaw, M.G. 2005. Sinkholes and subsidence: karst and cavernous rocks in engineering and construction. Springer. Berlin.

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

1:1 000 000 SERIES
ENGINEERING GEOLOGY (SUPERFICIAL) MAP OF THE UNITED KINGDOM

Compiled by William R Dearman, Marcus R Dobbs, Martin G Culshaw, Kevin J Northmore, David C Entwisle and Helen J Reeves.

Published 2011. John N Ludden, PhD, Director, British Geological Survey.

Engineering geological mapping units based on British Geological Survey 1:625 000 Geological Map of the United Kingdom (North and South sheets).

Bibliographic reference:
BRITISH GEOLOGICAL SURVEY 2011. Engineering Geology (Superficial) Map of the United Kingdom. WILLIAM R DEARMAN, MARCUS R DOBBS, MARTIN G CULSHAW, KEVIN J NORTHMORE, DAVID C ENTWISLE and HELEN J REEVES (compilers). British Geological Survey.

Published 2011. British Geological Survey, Natural Environment Research Council.

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Digital cartography by Caron Simpson, BGS, Keyworth.

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