BGS Geological Cross Sections & Quaternary Domains: User Guidance Notes

Information Products Programme

Internal Report is OR/10/030

BRITISH GEOLOGICAL SURVEY

INFORMATION PRODUCTS PROGRAMME

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BGS Geological Cross Sections & Quaternary Domains: User Guidance Notes

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Contents

Summary

This report provides guidance notes for all users of the Schematic Cross-Sections and Quaternary Domains GIS layers. It provides the background to the work, details of the data content and data format and notes on the recommended scale of use/search criteria.

1 The BGS Geological Schematic Cross Sections GIS

1.1 INTRODUCTION

The BGS geological schematic cross sections (GSCS) and Quaternary Domains GIS layers have been compiled from a range of BGS sources some unpublished and some drafted specifically for this work. The schematic cross sections presented are geographically-referenced for use in GIS and are drawn to illustrate the relationships of superficial deposits within parts of the UK in the context the Quaternary setting provided by a Quaternary Domains framework. The sections are mainly derived from the Industrial Minerals Assessment Unit (IMAU) reports of the late 1960s – late 1980s. This IMAU dataset comprising borehole records, grading information, geological maps at 1:25 000 scale and specific geological accounts is an invaluable but largely overlooked resource; this initiative repackages a key element of that dataset and seeks to bring the information to a new audience.

Within the GIS platform, hyperlinks attached to the lines of section open pdf illustrations of the sections; hyperlinks are also attached to the Quaternary Domains and thus to documents describing the recommended field practice for mapping these deposits. Coverage includes England, Wales and Scotland.

1.2 THE TARGET AUDIENCE

The GSCS dataset is primarily targeted at compilers of BGS GeoReports with a longer-term aspiration to making it available to a wide range of users including external enquirers. Its coverage and recommended scale of use make it an ideal dataset for national and regional scales of assessment and so its user-base is envisaged to include:

- Compilers of GeoReports
- 3D modellers (background information before detailed modelling begins)
- Field mappers (background information before fieldwork)

Specific uses in the future might include:

- VARs - Link with superficial thickness models and licence as a package
- Providing information for areas of sparse borehole coverage
- Enhancement of Lithoframe 3D modelling
- Linking with other cross sections generated as part of GSI3D
- Supplementary information for answering enquiries
- Educational/web delivery for schools/teachers

The BGS schematic cross sections and Quaternary Domains should be regarded as complementary to published BGS 2D geological maps and the ongoing programme of creating digital 3D models. The virtue of schematic diagrams is that in comparison to digital 3D models, they are relatively quick to draft; they enable the geologist to simply illustrate what can be complicated superficial relationships not evident in the BGS 2D map.

1.3 USING THE BGS SCHEMATIC CROSS SECTIONS GIS LAYER

1.3.1 Format and content

The GIS layers are available in ESRI's ArcGIS 9.2. The data includes:

Line data:

- Spatially-referenced lines of section; these lines are hyperlinked to the schematic cross sections held in PDF format (Figure 1). Each section has its relevant domain type attributed along the top of the section (Figure 2)
- Glaciation limits (Figure 1)
  - Red dash – limit of Devensian glaciation
  - Blue dash – limit of Anglian glaciation

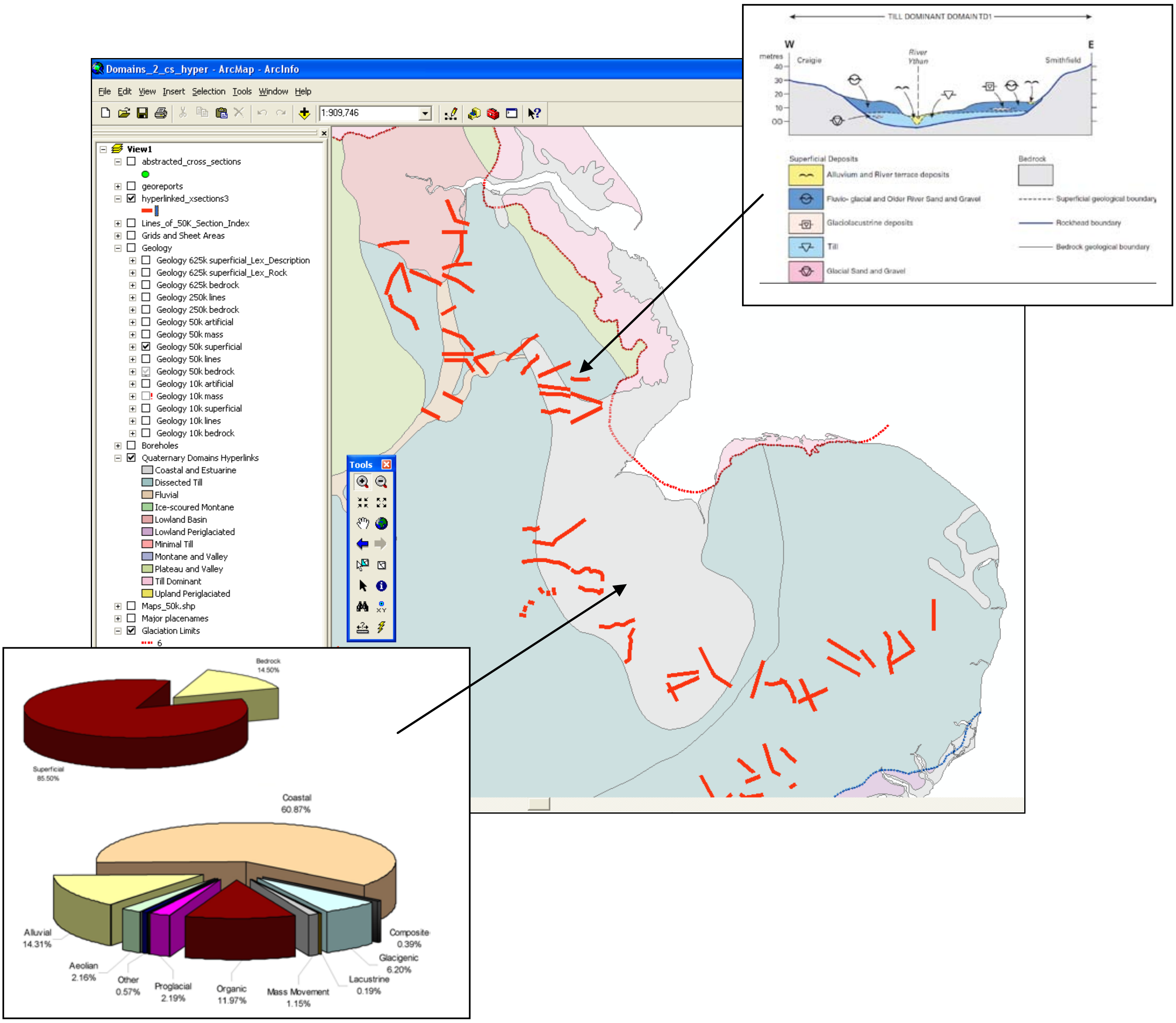

Figure 1: Showing the data available in the cross sections layer; red lines of sections are hyperlinked to pdf illustrations (example in insert), Quaternary Domains are also hyperlinked to pdf illustrations (example in insert). Red and blue broken lines depict known extent of the Devensian and Anglian glaciations, respectively. See also Figure 3.

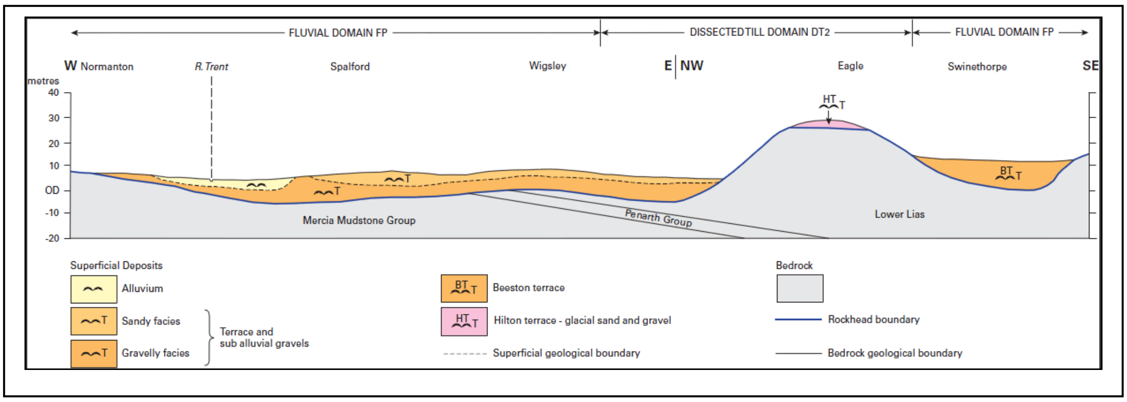

Figure 2: An example schematic cross section also showing the Quaternary Domains crossed.

Shape (polygon) data:-

- Quaternary Domains with hyperlinks (Figure 3)

  These domains are represented spatially as polygons and divided into the following categories:

  - Coastal, Estuarine and Alluvial
  - Dissected Till
  - Fluvial
  - Ice-scoured Montane
  - Lowland Basin
  - Lowland Periglaciated
  - Minimal Till
  - Montane and Valley
  - Plateau and Valley
  - Till Dominant
  - Upland Periglaciated

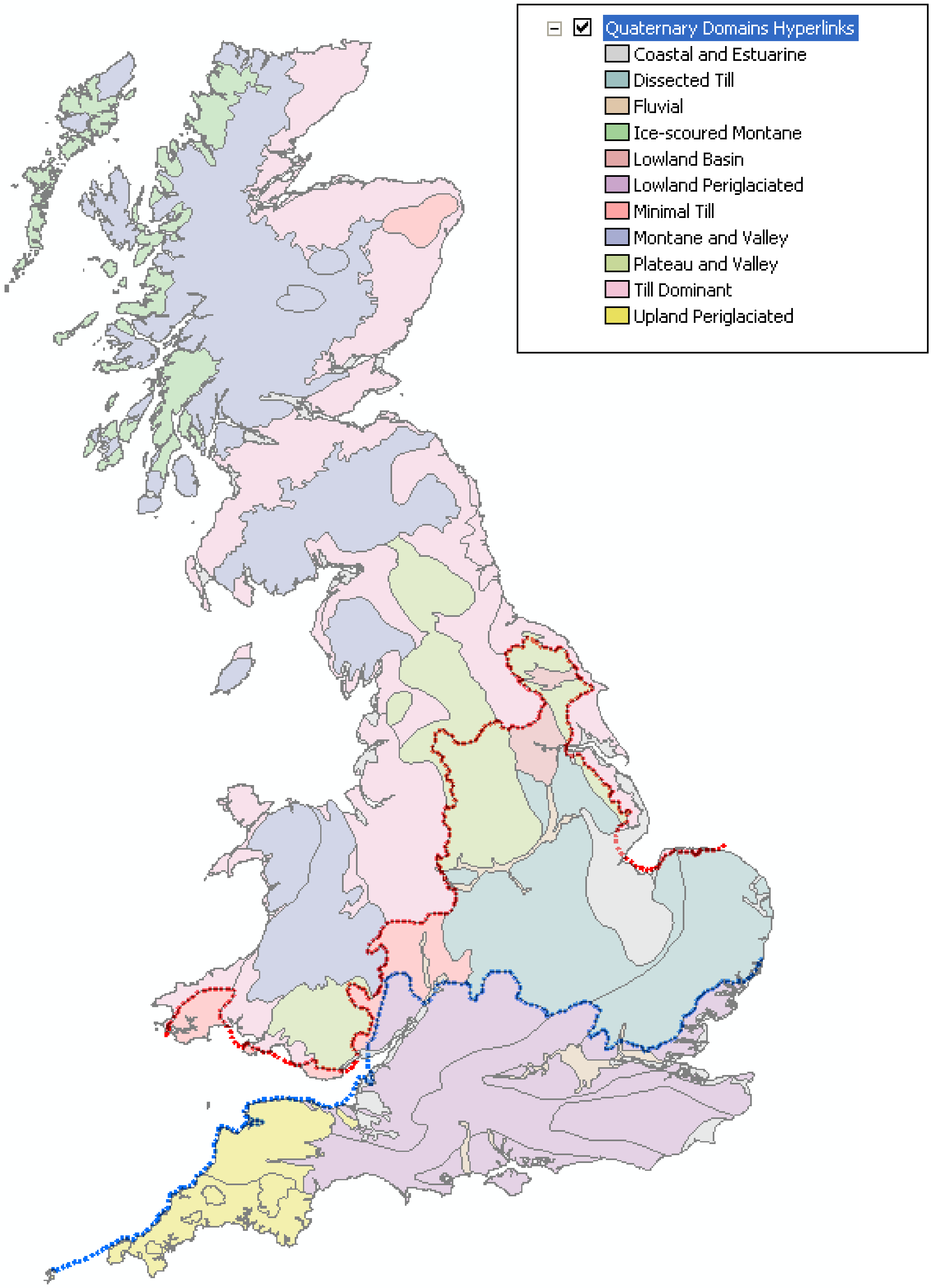

Figure 3: The Quaternary Domains of the UK and known ice limits; red dash = limit of the Devensian ice sheet; blue dash = limit of the Anglian ice sheet.

The shape data provides a hyperlink to further information specific to that Domain. It includes background information for project planning, a history of sedimentation and typical processes, recommended techniques for mapping, and specific problems that might be encountered.

For detailed information about Quaternary Domains please see Appendix 1 and 2.

1.3.2 Data history

The GSCS data is primarily derived from IMAU reports and some 1:10 000, 1:25 000 and 1:50 000 scale geological maps. Below is an outline of releases to date:

Version 1 Derived from:

- IMAU reports (published during 1975 to 1990; with associated map data at 1:25 000 scale)
- Quaternary Domains determined by the former Quaternary Mapping Methodologies project
- Known glaciation limits based on 1: 50 000 scale (Superficials) map data

1.3.3 Points to consider when using the dataset

The datasets are based on information held by the BGS at the time of compilation. Thus, the data are an amalgam of information compiled at different times, and at varying scales; there will inevitably be inconsistencies of interpretation, representation and usage of obsolete and reclassified lithostratigraphical terminology. Additionally, placement of the lines of section is estimated from the data available.

1.3.4 Using the GSCS dataset

In practical terms, it is recommended that when carrying out a spatial search against the GSCS data, the user should use a 50 m buffer for their site/area of interest to allow for the spatial accuracy of the underlying schematic data.

In summary

- The geological schematic cross sections layer has been developed variously from 1:50 000, 1:25 000 and 1:10 000 scale information; caution should be exercised if used at larger scales. Spatial searches against the data should be done with a minimum 50 m buffer.
- Data coverage includes England, Wales and Scotland.
- Lines of cross sections are created as vector lines and are available in a range of GIS formats, including ArcGIS (.shp), ArcInfo Coverages and MapInfo (.tab).
- Quaternary Domains are created as vector polygons and are available in a range of GIS formats, including ArcGIS (.shp), ArcInfo Coverages and MapInfo (.tab).
- The cross section images are provided as Adobe PDF files as a hyperlink from the GIS.
- The schematic cross sections layer is based on, and limited to, an interpretation of the records in the possession of The British Geological Survey at the time the dataset was created.

1.4 FURTHER INFORMATION AND CONTACTS

Further information on Geological Schematic Cross Sections, Quaternary Domains and other digital data provided by the BGS can be found on our website at www.bgs.ac.uk or by contacting:

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Appendix 1:

Quaternary Provinces and Domains

The landmass of Great Britain can be divided into two distinct provinces, based on the landscape evolution during the Quaternary, geomorphology, and the nature and distribution of superficial deposits across the landscape (Figure 2). The two provinces are the **Non-glaciated Province,** lying south of the known limit of the Anglian glaciation in England, and the **Glaciated Province** to the north of this line (Figure 2). Landscape development in the Non-glaciated Province was initiated during the Neogene (about 24 Ma ago), but was mostly influenced by the multiple climatic changes (ranging between periglacial, cool temperate and warm temperate) that occurred throughout the Quaternary. The processes of weathering, erosion and sedimentation were driven by this climate change; their record and inheritance has been little disturbed by external influences, and accumulated over a relatively long period of time.

By contrast, the landscape of the **Glaciated Province** (including both Upland and Lowland Britain) has few elements that have survived intact from the Neogene. Indeed, much of the Quaternary record has also been destroyed or fundamentally modified by subaerial erosion and successive Quaternary glaciations (at least 21 full glaciations – van Donk, 1976). The imprint of glaciation becomes greater northwards and westwards across the province, but its direct or indirect effects may be encountered anywhere. Glacial inheritance in its many forms is the dominant control on the subsequent landscape change, sediment flux, and landscape modification by paraglacial processes.

The Glaciated Province warrants a further subdivision at the Devensian glacial limit (Figure 2) into those areas (north and west of the limit) that were glaciated during the last, c. 100,000 year glacial-interglacial (Devensian-Holocene) cycle, and those (lying south of the limit) with deposits and landforms relating to earlier Quaternary glaciations. North of the Devensian limit, the deposits and landforms commonly display a distinctive ‘fresh’ morphology, an important physical characteristic that aids mapping by remote sensing methods. This sub-province includes relatively little-weathered deposits of the 'Newer Drift' of earlier workers, which equates with the **Caledonia Glacigenic Group** (of McMillan, 2005). Evidence of pre-Devensian glaciations is largely absent, former landforms and the sedimentary record having been eroded during the last glacial phase (Devensian).

In contrast, glacial deposits and landforms lying between the Devensian ice limit and the Anglian ice limit fall within the **Albion Glaciogenic Group** (of McMillan, 2005), which includes the 'Older Drift' of previous classifications. Ground in this sub-province has been subject to denudation and weathering over numerous Middle Pleistocene cold/temperate climatic cycles. The landscape is generally subdued, and the glaciogenic and related deposits tend to be well-dissected and, in places, concealed beneath periglacial deposits, including wind blown sand and silt.

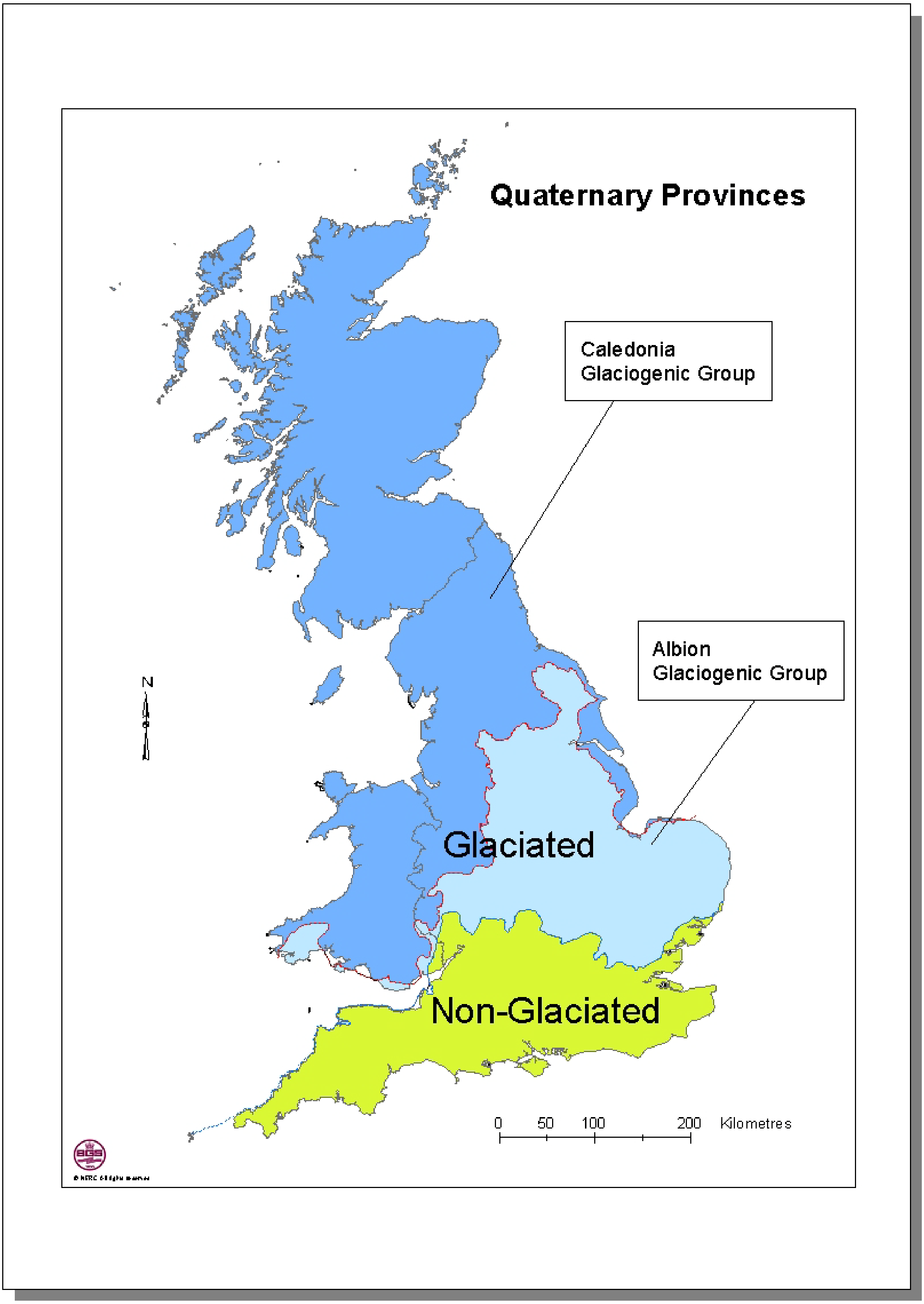


Figure 4: Quaternary provinces of the UK. The figure also indicates the limits of the glaciogenic groups of McMillan (2005)

Domains

Eleven domains may be differentiated within the two provinces, partly based on recurring geomorphological features and assemblages of superficial deposits, and partly on genetic linkages to the surface processes that formed them (Figure 3). The eleven domains are:

Glaciated province: Uplands

• Ice-scoured montane domain	**IM**
• Montane and valley domain	**MV**
• Plateau and valley domain	**PV**

Glaciated province: Lowlands

• Till dominant domain	**TD**
• Dissected till domain	**DT**
• Minimal Till domain	**MT**
• Lowland Basin domain	**LB**

Non-glaciated province

• Upland periglaciated domain	**UP**
• Lowland periglaciated domain	**LP**
• Coastal, estuarine and alluvial domain	**CE**
• Fluvial domain	**FP**

(See Appendix 2 for further details of each domain type)

As used here, domains are based very broadly on the ‘landsystems’ approach developed by Eyles (1983) and Benn and Evans (1998), in which each landsystem contains a hierarchical assemblage of landscape units that can be delineated at different scales. The basic mappable unit at the 1:10,000 scale is the ‘terrain element’, being regarded as a discrete unit defined by form and composition (e.g. an esker). These elements may be grouped for practical purposes at the 1:50,000 to 1:100,000 scales into ‘terrain facets’, which are parts of a landscape that are reasonably homogeneous and distinct (e.g. outwash plain). A landsystem is a recurrent pattern of genetically linked land facets, suitable for mapping at scales of 1:250,000 or 1:1 million.

Sub-domains are distinguished within some domains. These reflect regional changes in bedrock, which to some extent controlled the geomorphic processes. The combination of varied bedrock and processes influenced the resulting differences in landform.

- For project planning purposes, the domains approach should provide an insight into the landscape elements and the processes that created them, from regional to district and local level. Knowledge of domain characteristics will contribute to the pre-field assessment of the mapping task, indicating the likely complexity of the geology, the optimum field approach (strategy and methods), and other possibilities for enhancing or supplementing the mapping.

Mapping guidance for each domain includes:

- Primary mapping approach
- Supplementary mapping approach
- Specific mapping problems

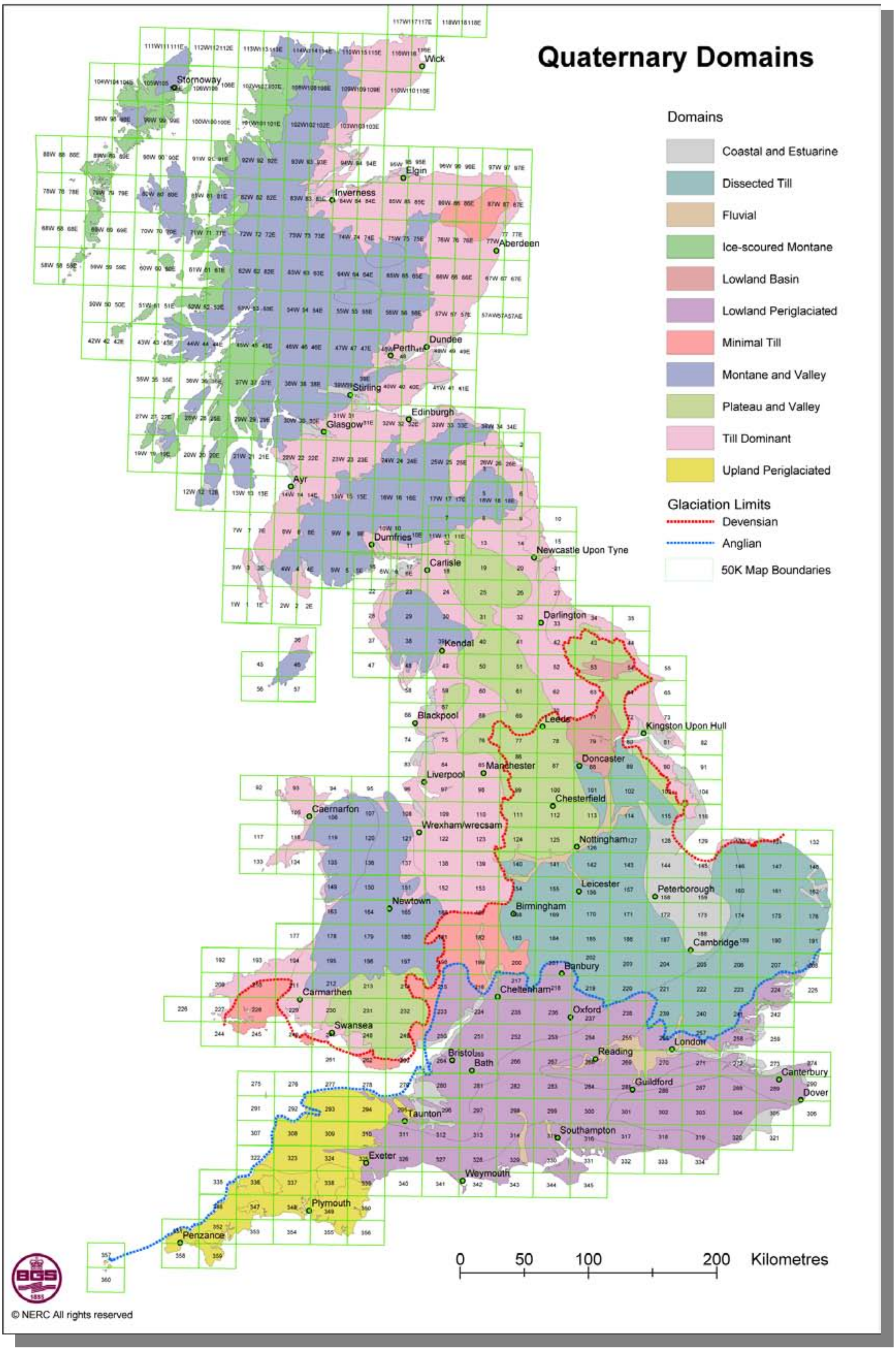


Figure 5: Quaternary Domains recognised in the UK (grid depicts the BGS 1:50K geological sheets)

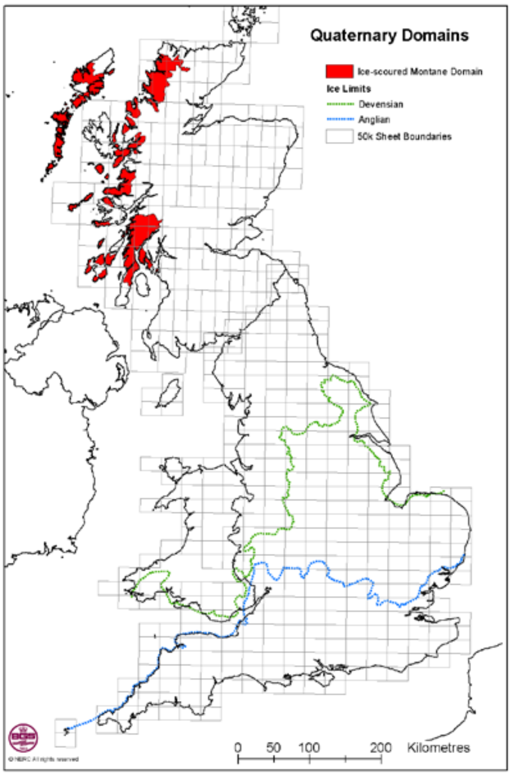
Appendix 2:

Description of each of the

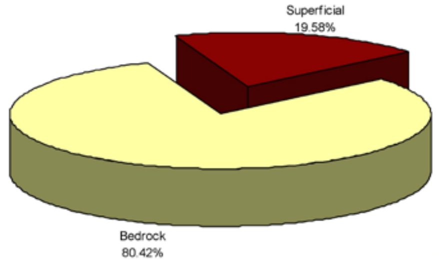
Quaternary Domains

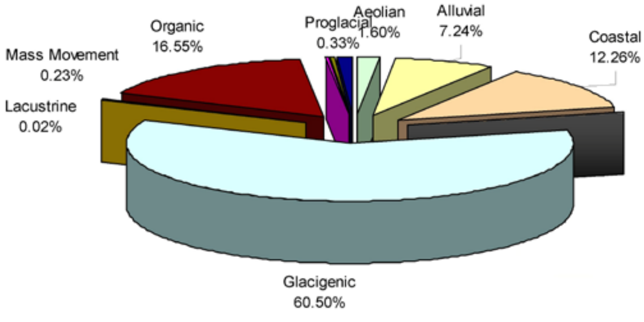
Glaciated province: Uplands

A) DOMAIN: IM ICE-SCOURED MONTANE



Bedrock/Superficial ratios

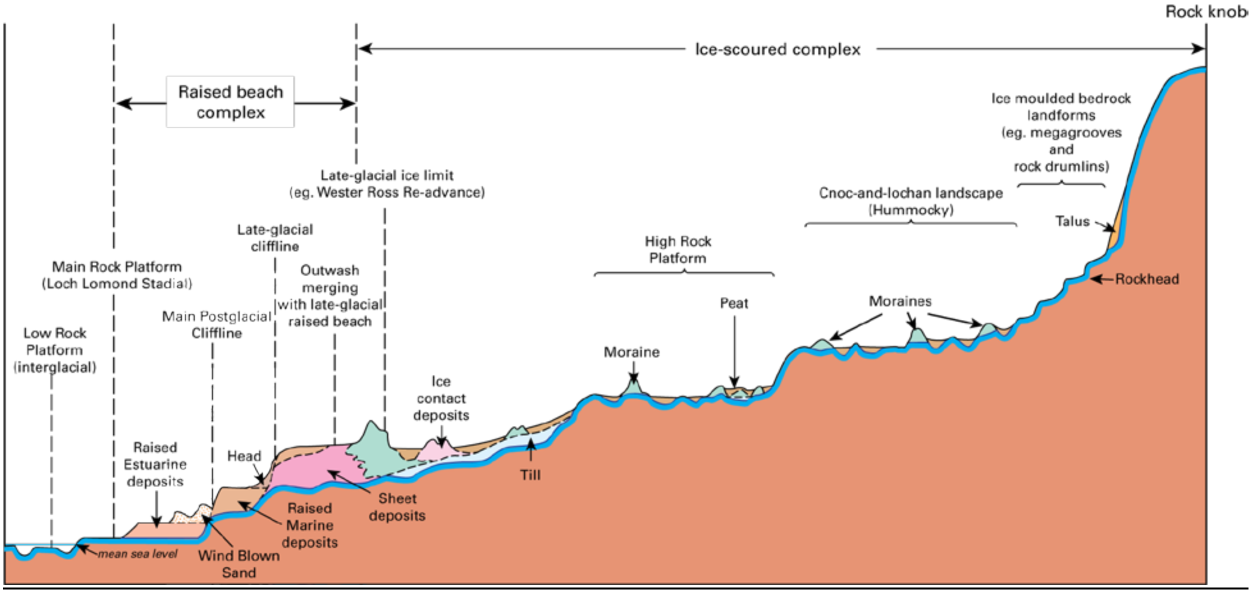




Superficial components

Pie chart proportions are based on an analysis of DigMapGB50 Version 2.

A generic schematic section showing elements of the ice-scoured montane domain



Background information for project planning:

Landforms, deposits and processes

This domain is largely devoid of superficial deposits (~20%) as it has experienced severe, widespread glacial erosion. Soil is thin or non-existent. The most characteristic landforms are ice-scoured and sculptured knock-and-lochan terrain, fjords and strandflats. Some mountains are included, with huge rugged corries and mountaintop blockfields.

Outcrops of till are sparse; the till is typically little weathered, extremely bouldery and contains much comminuted rock. Morainic deposits are commonly not distinguished from till on existing maps; they are also typically boulder-rich and form recessional ridges and hummocky ground within valleys. Glaciofluvial deposits are sparse, apart from where they merge with raised beaches.

Raised shorelines, beaches and wave-cut platforms are very common along the coasts. They occur as two distinct sets: Late Devensian and Holocene. The older set is locally associated with glaciofluvial deltaic deposits, which are important resources of sand and gravel.

Paraglacial and periglacial processes modified the landscape immediately following deglaciation, and marine processes affected the coasts during periods of high sea level. The occurrence of deeply weathered and decomposed bedrock is minimal. Active processes on higher ground include rock topples, debris flow, landslips and other gravitational mass movement processes. Large landslips are uncommon. Fluvial erosion and deposition is confined to narrow alluvial tracts in the valley bottoms. Ice-scoured hollows are ubiquitous on lower ground, and are generally filled with highly compressible deposits of peat, silt and clay. A wide range of coastal processes are in operation, and are reflected in the diverse nature of the coast, including rugged cliff lines with sea stacks, extensive sandy beaches, cobbly storm beaches and tombolos.

For mapping guidance:

Primary approach

Office-based information search and landform analysis followed by a preliminary field visit to confirm model and appropriate methodologies. The relative abundance of exposed rock, absence of woodland and minimal cultivation allows this domain to be mapped largely from aerial photographs, DEMs and other remote imagery. The ground coverage is highly dependent on the weather, the experience of the surveyor and the complexity of the ground; suggested daily average 5 km^2.

Supplementary approach

- Section logging
- Coring peat bogs
- Sampling and sample analysis
- Cosmogenic dating of large boulders and exposed rock surfaces.

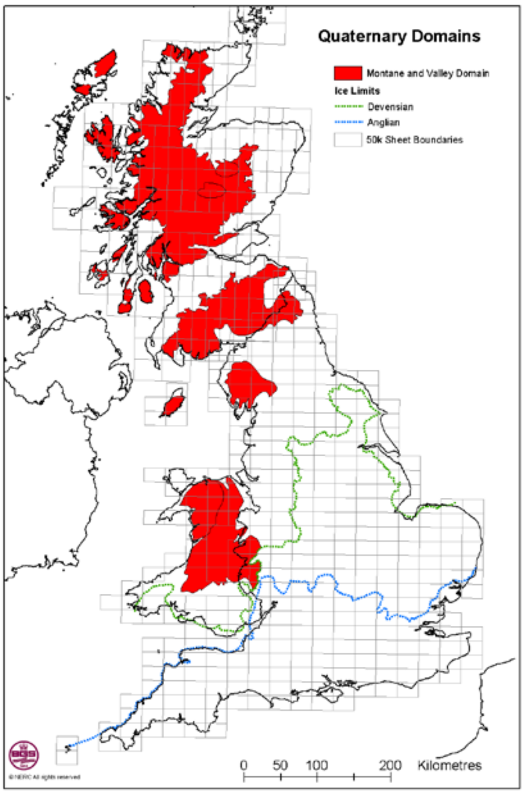
Specific problems

- Shooting season from early July to November on some estates
- Vast expanses of remote, relatively inaccessible, rugged ground with few footbridges.
- Some tracks accessible by four-wheel drive vehicles, but long days on foot cannot be avoided.
- In some sub-domains, distance from the main office and from field accommodation will constrain ‘time on the ground’.
- 10-day working week practice may be needed.
- Overnight stays in bothies unavoidable.
- Poor weather can seriously affect progress.

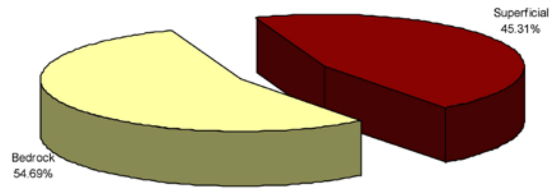
- Health and Safety issues are paramount for lone working in this terrain. Team working practices operating a ‘Buddy’ system recommended. Emergency beacons and satellite phones must be provided.
- Boats commonly required for access.
- In some sub-domains, the geological and geomorphological complexity of the glaciogenic features and deposits will require ground truthing to resolve.
- Assumptions about lithologies and likely processes have to be made where mapping is based largely on geomorphological interpretation. Thus, ground truthing by way of selected traverse is important, but the terrain limits access.

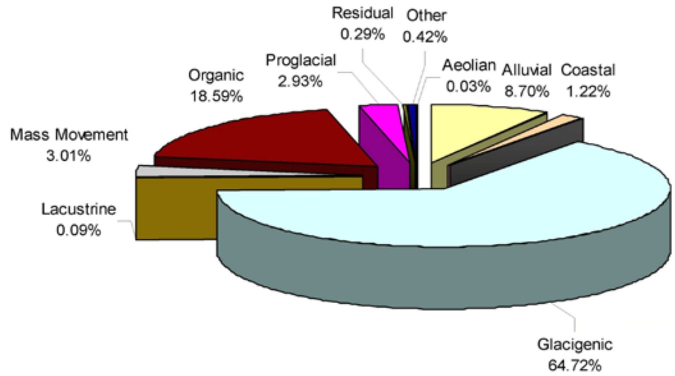
An experienced team is important, or sufficient time must be allowed for expertise to be gained.

B) DOMAIN: MV MONTANE AND VALLEY (seven sub-domains)



Bedrock/Superficial ratios

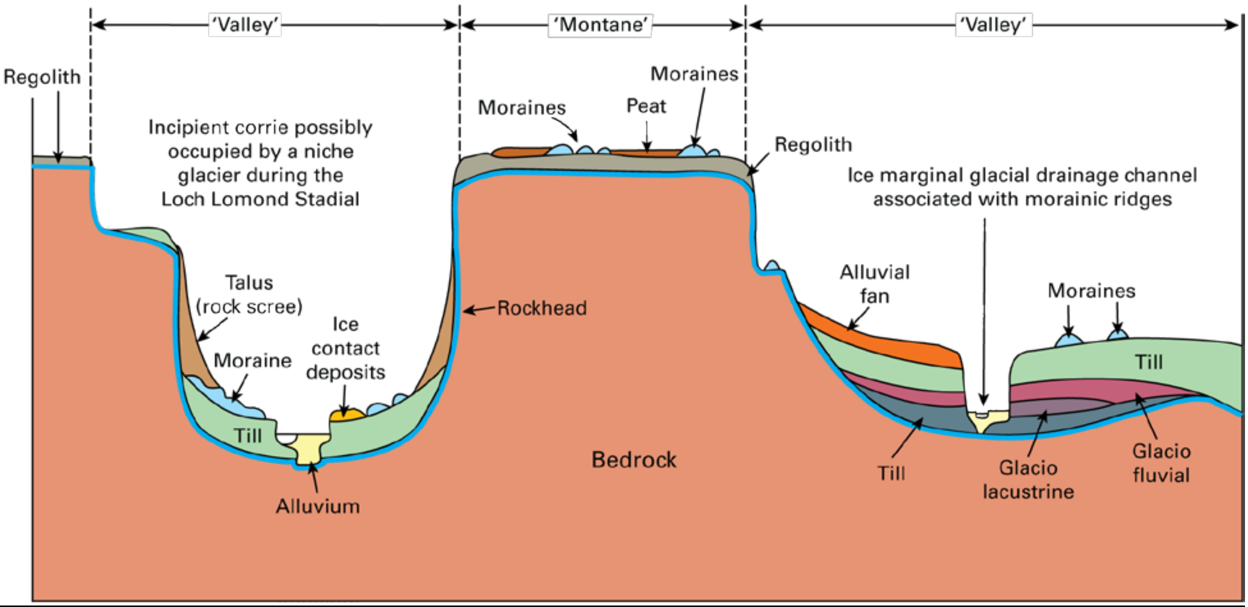




Superficial components

Pie chart proportions are based on an analysis of DigMapGB50 Version 2.

A generic schematic section showing elements of the montane and valley domain



Background information for project planning:

Landforms, deposits and processes

The landscape comprises mountainous terrain with precipitous slopes, craggy glaciated troughs, deep cirques, fjords and numerous lochs residing in ice scoured basins and hollows, or deeply dissected upland plateaux. Seven sub-domains distinguish locally variable terrain characteristics.

Till, morainic and glaciofluvial deposits are mainly restricted to valleys. Tills are generally of the lodgement type, being little weathered, extremely compact, commonly fissile, stony, massive, matrix-supported diamictons. Morainic deposits are typically gravelly and bouldery, forming valley floor mounds and ridges, and chains of mounds rising obliquely up valley sides in the direction of glacial retreat. Glaciofluvial deposits abound locally, being dominated by moundy ice-contact deposits such as kame terraces, plateaux (former fans and deltas) and eskers. Blanket peat is widespread on less rugged mountaintops and across plateaux.

Rubbly gelifractates mantle most summits. Many mountaintops are covered by up to about 3 m of gravelly material, formed mainly by the cryoturbation of disintegrated bedrock. Head deposits are ubiquitous on mountainsides and on lower ground. Large landslips are common on the steeper mountainsides. Patterned ground is common.

Active processes on higher ground include rock topples, severe debris flow activity during flash flood events, landslips and other gravitational mass movement processes. Active periglacial processes operate above about 800 m, where they produce a suite of phenomena, including small solifluction lobes, turf-backed terracettes and ploughing boulders. Slope modification continues, albeit restricted to colluvial and slow soil creep processes, with localised debris flows and landslips. Fluvial erosion and deposition is confined to narrow alluvial tracts in the valley bottoms.

For mapping guidance:

Primary approach

Office-based information search and landform analysis followed by a preliminary field visit to confirm model and appropriate methodologies. The relative abundance of exposed rock, scarcity of woodland and minimal cultivation away from valleys allows this domain to be mapped largely from aerial photographs, DEMs and other remote imagery. River cliff sections and landslide back-scars generally provide the best exposures for logging and determining superficial deposit thickness. Field traverses only possible in valleys. The ground coverage is highly dependent on the experience of the surveyor and the complexity of the ground; suggested daily average between 2 and 5km^2.

Supplementary approach

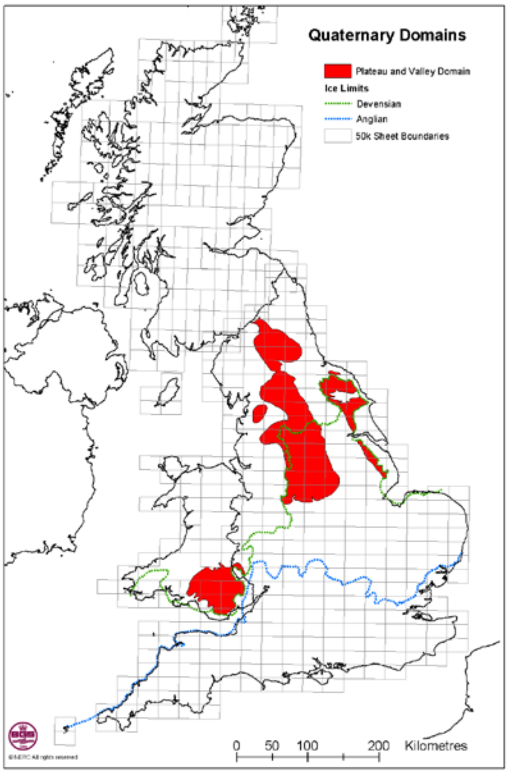
- Section logging
- Trenching
- Coring peat bogs
- sampling and sample analysis
- Cosmogenic dating of large boulders and exposed rock surfaces.

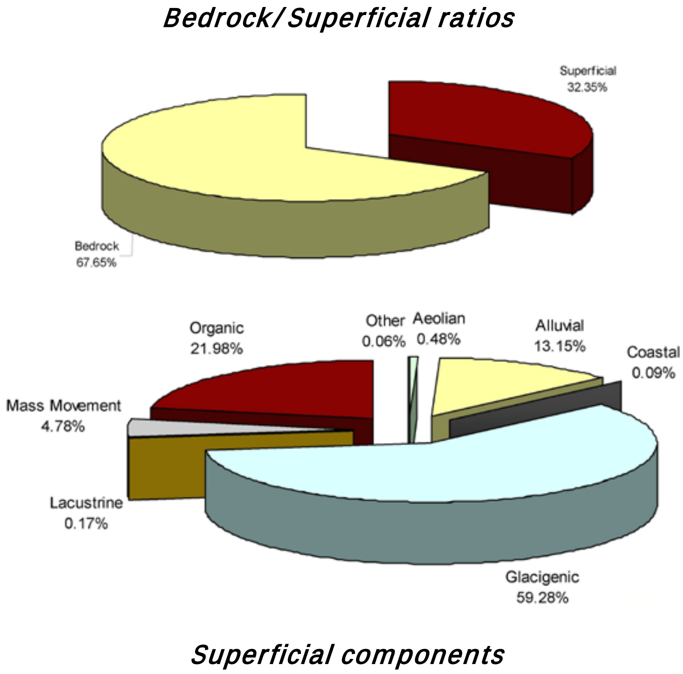
Specific problems

- Large areas are managed as shooting estates; the season extends from early July to November.
- Nature Reserves, SSSIs and other conservation areas are common; nesting and rearing season has to be avoided. Vehicular access is becoming severely restricted in National Parks, Nature Reserves and on National Trust property.

- Mapping difficult in some large areas of dense woodland, but the purchase of old aerial photographs (pre-conifer planting) may help.
- Includes large expanses of remote, relatively inaccessible, rugged ground with few footbridges.
- Four-wheel drive vehicle preferable.
- In some sub-domains, distance from the main office and from field accommodation will constrain 'time on the ground'.
- Long days on foot cannot be avoided.
- Some overnight stays in bothies may be required.
- 10-day working week practice may be needed.
- Poor weather can seriously affect progress, especially in the west.
- Health and Safety issues are paramount for lone working in this terrain. Team working practices operating a 'Buddy' system are recommended in remote areas, where emergency beacons and satellite phones must be provided.
- Boats occasionally required for access.
- In some sub-domains, the geological and geomorphological complexity of the glacigenic features and deposits will require ground truthing to resolve.
- Assumptions about lithologies and likely processes have to be made where mapping is based largely on geomorphological interpretation. Assumptions need to be tested by trenches, temporary exposure, etc., and have been proved wrong.
- GPS instruments may prove unreliable when working in the deeper valleys.
- An experienced team is important, or sufficient time must be allowed for expertise to be gained.

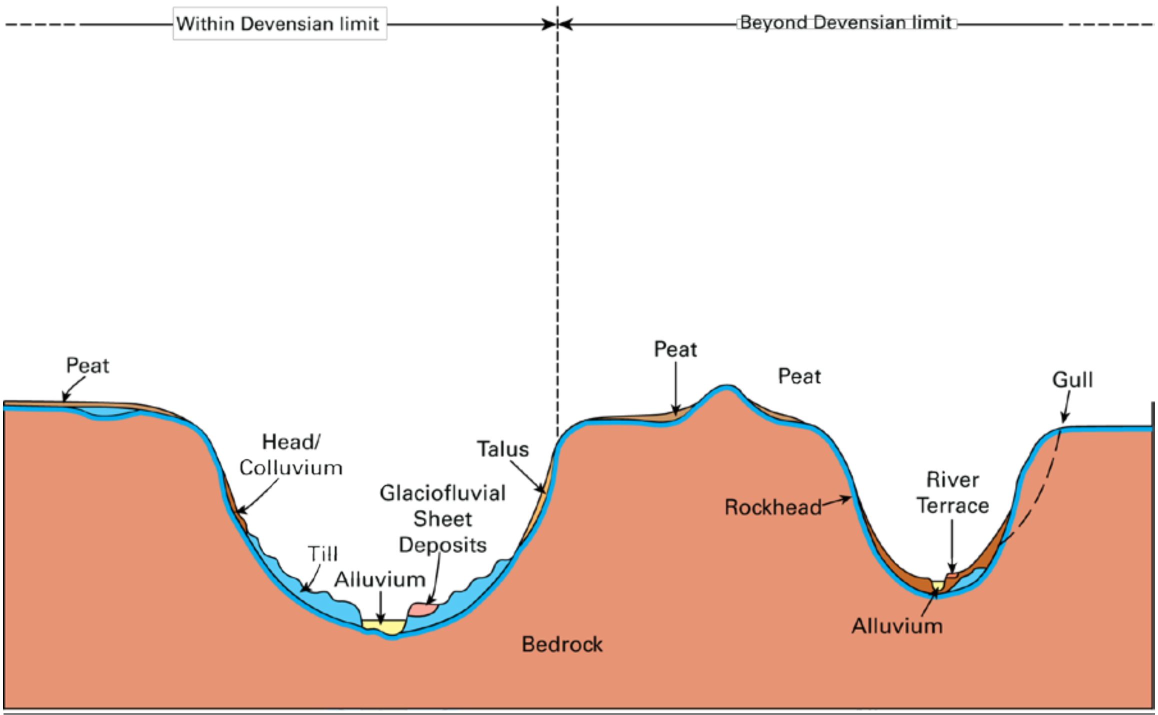
C) DOMAIN: PV PLATEAU AND VALLEY (with four sub-domains)





Pie chart proportions are based on an analysis of DigMapGB50 Version 2.

A generic schematic section showing elements of the plateau and valley domain



Background information for project planning:

Landforms, deposits and processes

This domain includes many of the uplands of England and south-east Wales. In the Pennines, bedrock comprises unmetamorphosed Carboniferous rocks of the Millstone Grit and Coal Measures (the Dark or High Peak landscape) or Carboniferous Limestone (the White Peak landscape). The bedrock underlying the North York Moors, although of Jurassic age, is similar in lithology and character to the Carboniferous strata of the Pennines, whereas the Devonian and Carboniferous bedrock in south-east Wales with the exception of areas such as the Brecon Beacons, tends to comprise softer shales and mudstones. The Yorkshire and Lincolnshire Wolds are dominated by dissected Chalk plateau. Over the Carboniferous and Jurassic strata, the landscape is primarily determined by differential erosion of the weaker shales and mudstones and the more resistant sandstones and limestones. The latter give rise to scarps and associated 'free faces or edges', which may be fashioned by weathering into tor-like features and surrounded by block debris. This topography was moulded by at least three glacial episodes; evidence for the earlier phases has been mostly obliterated by the Devensian glaciation, except perhaps in the southern Pennines.

Glacial erosion and the occurrence of till, morainic (drumlin fields and hummocky or moundy ground) and glaciofluvial deposits from late-glacial meltwater channels are mainly restricted to the valleys. Many of the major valleys were originally glacially scoured but are now flat-bottomed, with a partial fill of complex glacigenic deposits overlain by alluvium. Paraglacial and periglacial deposits are both common along valley sides. Blanket peat is widespread on plateau surfaces, where deeply weathered bedrock is common. Landslides and cambering are commonly developed along valley sides and escarpments, with strata in the central parts of valleys typically contorted as a result of complementary 'valley bulging' processes.

For mapping guidance:

Primary approach

Office-based information search and landform analysis followed by a preliminary field visit to confirm model and appropriate methodologies. Selected field traverses and spot inspections, taking particular note of soil and brash with exposure logging.

Supplementary approach

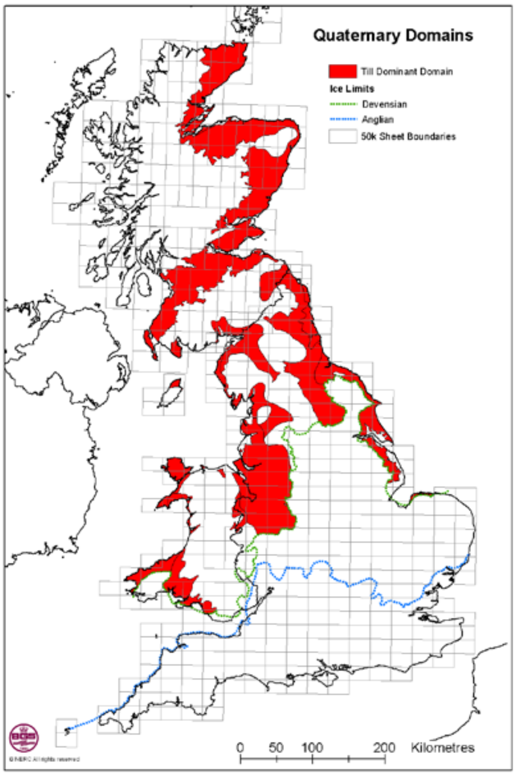
- Trenching and sampling supported by a wide-ranging sample analysis.

Specific problems

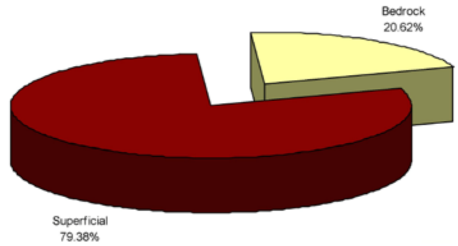
- In some sub-domains, distance from the main office and from the field accommodation will constrain the 'time on the ground'.
- Remote, rugged terrain not easily accessed; few roads; four-wheel drive vehicle preferable.
- 10-day working week practice may be needed.
- In some sub-domains, the geological and geomorphological complexity of the glacigenic features and deposits will require ground truthing to resolve.
- An experienced team is important, or time must be allowed for expertise to be gained
- GPS instruments may prove unreliable when working in the deeper valleys.
- Health and Safety issues are paramount for lone working in this terrain.

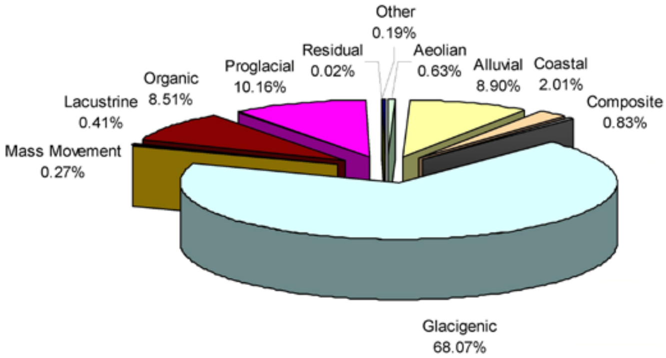
Glaciated province: Lowlands

A) Domain: TD Till dominant (with seven sub-domains)



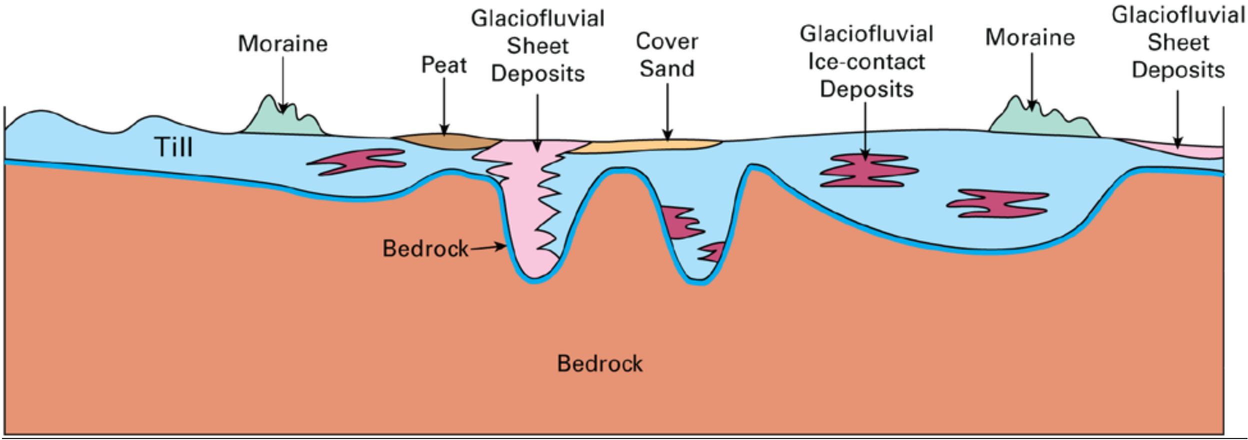
Bedrock/Superficial ratios





Superficial components

Pie chart proportions are based on an analysis of DigMapGB50 Version 2.



A generic schematic diagram showing elements of the till dominant domain

Background information for project planning:

Landforms, deposits and processes

This very extensive domain includes most of the lowlands of Britain lying to the north of the Devensian glacial limit. It is dominated by undulating, subglacially sculptured spreads of Devensian till that is plastered across hills and valley sides and, importantly, is also generally present beneath younger deposits occurring within valleys and on coastal plains. Till is locally concealed beneath extensive spreads of glaciofluvial sand and gravel and fine-grained glaciolacustrine deposits. The distribution of these deposits is patchy and closely linked to the pattern of deglaciation within an area. For example, many of the more extensive tracts of glaciofluvial ice-contact deposit (eskers, kames, terraces, fans and plateaux) occur where independently sourced lobes of ice abutted one another. A good example of such an'interlobate' spread is the Carstairs esker system in central Scotland, formed between Southern Uplands and Highland-sourced ice. The distribution of other spreads of glaciofluvial sand and gravel is related to former still-stands and local readvances of ice.

The composition and granulometry of till is generally closely related to the nature of the predominant underlying bedrock. For example, tills are typically clayey across Carboniferous strata and Palaeozoic mudstones, whereas they are sandier across Devonian and Permo-Triassic sandstones and granites. Very compact, stony, lodgement-type tills are most common close to mountainous ice sources, whereas less compact, deformation-type tills with well-dispersed stones within a clayey matrix are more common towards coasts.

For mapping guidance:

Primary approach

Office-based information search and DEM/NextMap landform analysis (but see caution below), followed by a preliminary field visit to confirm model and appropriate methodologies. Soil Survey information, boreholes and trench data invaluable aids. Ground truthing is essential, taking particular note of soils, soil brash and exposures, especially river and coastal cliff sections and drainage ditches. Farm buildings and churches commonly provide important information on lithology. Augering may be used to establish local stratigraphy or boundary placing, with an average daily ground coverage of 1 km^2. In some areas, augering will prove time consuming and unproductive. If augering is not employed extensively, the average daily ground coverage should be 2km^2 +.

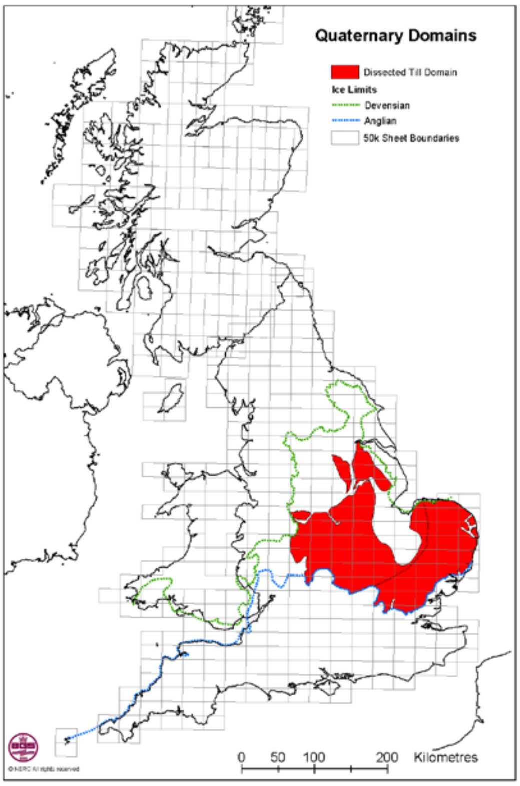
Supplementary approach

- Drilling, trenching and sampling supported by a wide-ranging sample analysis is highly desirable.

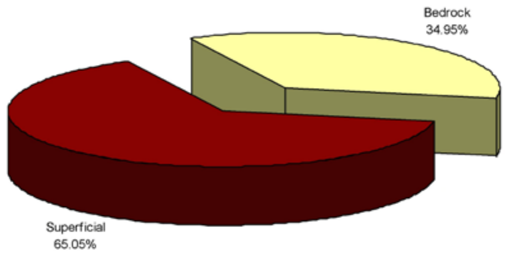
Specific problems

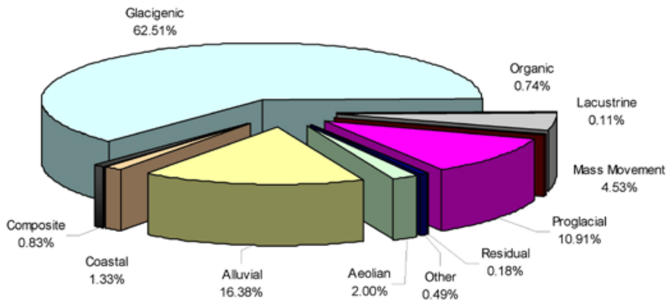
- In some sub-domains, the extreme distance from main office and from field accommodation will constrain ‘time on the ground’. 10-day working week practice may be needed.
- Late glacial outwash deposits often obscure tills and glaciolacustrine deposits, which hinders reliable stratigraphical interpretation.
- The landscape is commonly far more geologically and geomorphologically complex than it might appear from remote sensed interpretation.
- The locally unpredictable, heterogeneous geology is often difficult to depict on a 2D map; stratigraphical models and 3D modelling are problematic, especially in the absence of numbers of well-distributed boreholes.
- Some areas underlain by deposits that predate the last glacial advance often have little or no surface expression.
- An experienced team is important, or sufficient time must be allowed for expertise to be gained.
- GPS instruments are unreliable when working in some deep valleys and glacial drainage channels.
- Health and Safety issues are paramount for lone working in this terrain.

B) DOMAIN: DT DISSECTED TILL (with two sub-domains)



Bedrock/Superficial ratios

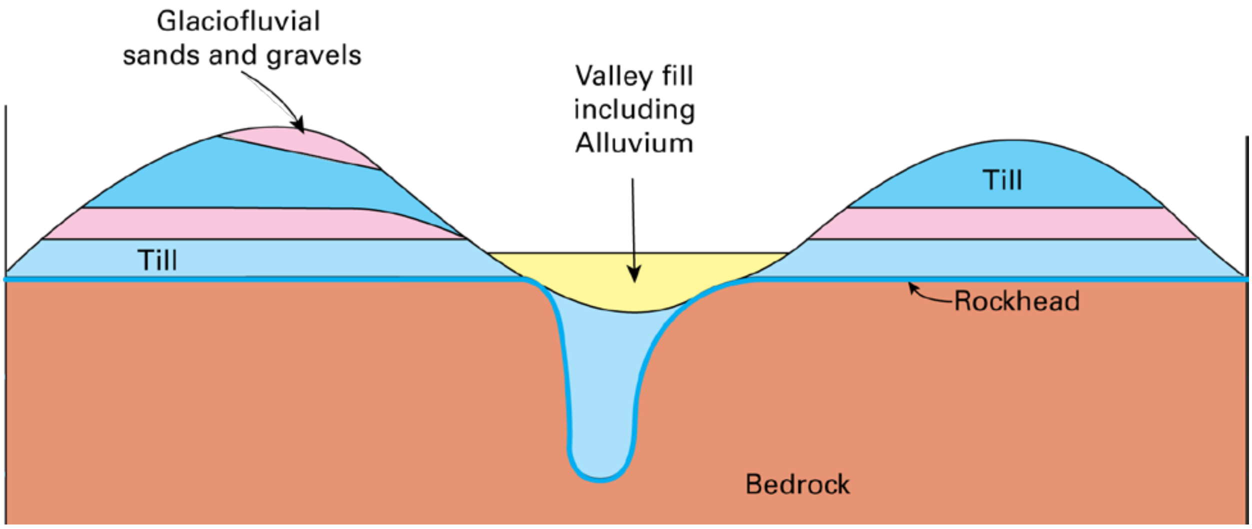




Superficial components

Pie chart proportions are based on an analysis of DigMapGB50 Version 2.

A generic schematic diagram showing elements of the dissected till domain



<u>Background information for project planning:</u>

Landforms, deposits and processes

This extensive domain comprises the lowlands of the Midlands and East Anglia lying between the Devensian and Anglian glacial limits. In East Anglia, the landscape is essentially a low-lying, relatively flat, dissected till plateau with a universal coverage of superficial deposits that include various glacial lithofacies (till, glaciofluvial and glaciolacustrine) laid-down by successive Middle Pleistocene advances of the British Ice Sheet. These largely exhibit a layer-cake stratigraphy, except in a zone encompassing Salthouse-Holt-the Cromer Ridge-Trimingham-Mundesley in north Norfolk where deposits have been highly tectonised and thrust-stacked locally. Extensive sands and gravels overlie the youngest till in north Norfolk and form positive topographical features such as the Cromer Ridge in northeast Norfolk. Pre-glacial sediments of the Crag and Dunwich groups can frequently be mapped in valley flanks that are cut through the till plateaux. Till only underlies river terraces and alluvial deposits locally in the valleys.

In the Midlands, the landscape was profoundly modified during the Anglian (Middle Pleistocene) glaciation, and subsequently by a regime of progressive uplift and incision under climates that oscillated between warm temperate and periglacial. Topography is characterised by subdued bedrock featuring, locally with ridges and scarps, but the dominant landforms are the extensive till-covered plateaux of the interfluves. Landslips associated with mudflow aprons are prominent features along the steeper slopes, particularly those developed on Jurassic mudrocks, but superficial deposits capping the slopes may also be involved. Head deposits form low-profile sheets on the lower parts of valley slopes and, together with colluvial deposits and alluvium, commonly underlie the flat floors of many small valleys. Palaeovalleys are characterised by layer-cake sequences, up to 80m thick, of glacial, glaciofluvial and glaciolacustrine deposits, which in part overlie Early Pleistocene (pre-Anglian) fluvial deposits. Slope instability features, associated with solifluction sheets and head aprons, are particularly extensive along scarp slopes or valley sides developed on mudstone-rich bedrock.

For mapping guidance:

Primary approach

Office-based information search essential, particularly for borehole data, followed by a preliminary field visit to confirm model and appropriate methodologies. Remote sensed imagery is often of little use because of ‘blanket’ cover of other sediments e.g. loess or coversand in northeast Norfolk. Ground truthing is essential, taking particular note of soil, soil brash and exposure logging where possible. Augering is essential to establish the stratigraphy and to position boundaries accurately. Generally, this domain is characterised by a labour-intensive, time-consuming effort, with usual daily average ground coverage of up to1 km^2. Because of the usual layer-cake stratigraphy, more rapid mapping could certainly be considered over the plateaux (2-5 km^2 per day). In the valleys, if poorer resolution boundary placement is acceptable, the daily average ground coverage could be increased up to 2 km^2.

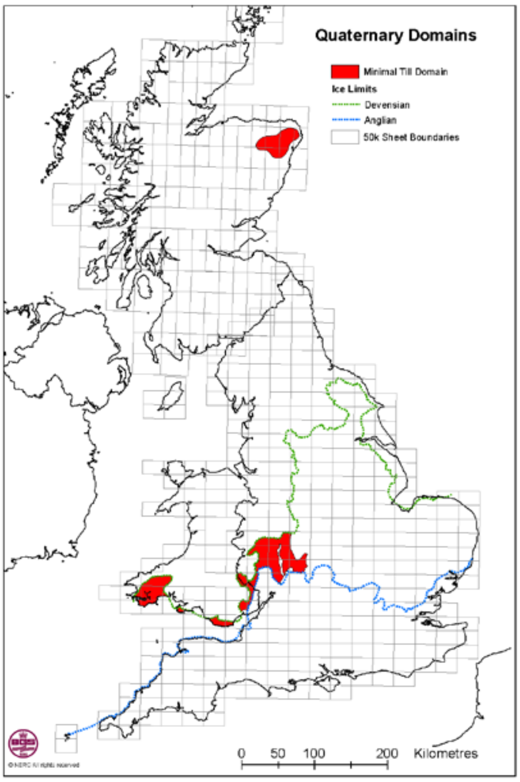
Supplementary approach

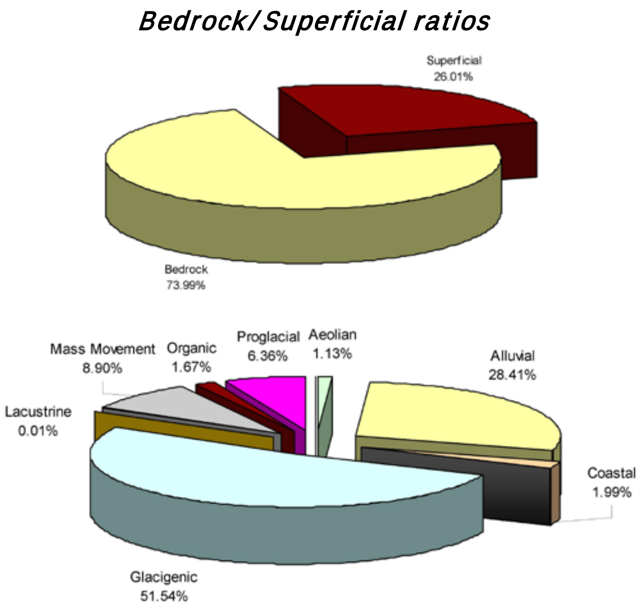
- Drilling, trenching and sampling programme supported by a wide-ranging sample analysis is highly desirable.
- Where the distribution of good to reasonable quality boreholes allows, e.g. in Essex, the use of appropriate modelling software (GOCAD or GSi3D) is highly recommended.

Specific problems

- As noted, generally a labour intensive, time-consuming domain.
- Remote sensed photographs are of limited use; however NextMap and locally LiDar data may prove invaluable. Ground truthing is essential.
- Distance from main office *and in some areas* from field accommodation may constrain ‘time on the ground’.
- GPS instruments may prove unreliable in the deeper valleys, wooded areas and adjacent to high cliffs.
- Health and Safety issues, e.g. lone working, coastal hazards and back-related injuries through augering.

C) DOMAIN: MT MINIMAL TILL (with three sub-domains)

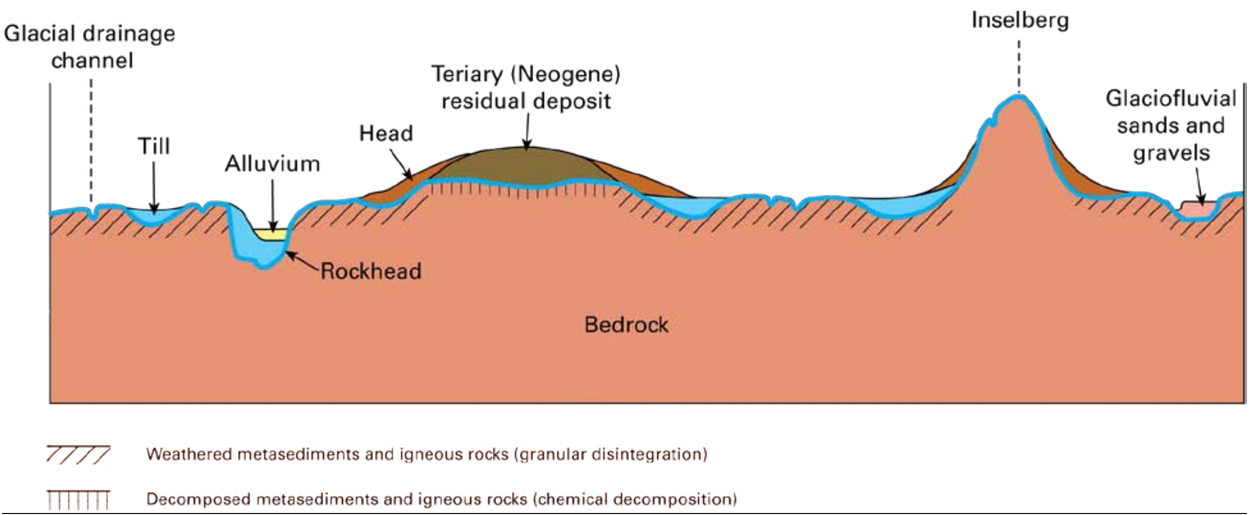




Superficial components

Pie chart proportions are based on an analysis of DigMapGB50 Version 2.

A generic schematic diagram showing elements of the minimal till domain



Background information for project planning:

Landforms, deposits and processes

This domain comprises two discrete areas.

1. Within the limits of the Devensian glaciation, in north-east Scotland, where little till or glaciofluvial material was laid down. Many older maps of the area show till as being widespread; in reality, it is commonly less than 1 m thick. There are occurrences of deep (<30 m), chemically weathered bedrock, mostly of granular type, and locally, complete decomposition to kaolinitic sandy clay. Associated with these regoliths are remnant deposits of Neogene flint and quartzite gravel. The predominant processes that have shaped this landscape are prolonged subaerial denudation during the Palaeogene and Neogene, and severe periglacial processes during the Pleistocene.

2. Beyond the limits of the Devensian glaciation, in the southern Welsh Borderland and Vale of the Severn, where there are no glaciogenic landforms and glaciogenic cover is generally patchy, consisting of weathered glacial deposits on valley sides and glaciofluvial deposits in the valley bottoms. Glacigenic deposits comprise glaciofluvial gravels, tills and glaciolacustrine silts, and are confined to 'buried' valleys, as in the Mathon Valley. Periglacial slope deposits are extensively distributed over valley sides. Fluvial deposits include possible pre-Anglian sands and gravels and post-Anglian glaciofluvial outwash terraces, river terraces and alluvium.

For mapping guidance:

Primary approach

Office-based information search and landform analysis followed by a preliminary field visit to confirm model and appropriate methodologies. Soil Survey data, borehole and trench information are invaluable aids. Ground truthing is essential, taking particular note of soils, soil brash and exposures, especially river and coastal cliff sections and drainage ditches. Farm buildings and churches commonly provide important information on lithology. Extensive augering may be unproductive. The daily average ground coverage is between 1 and 2 km^2.

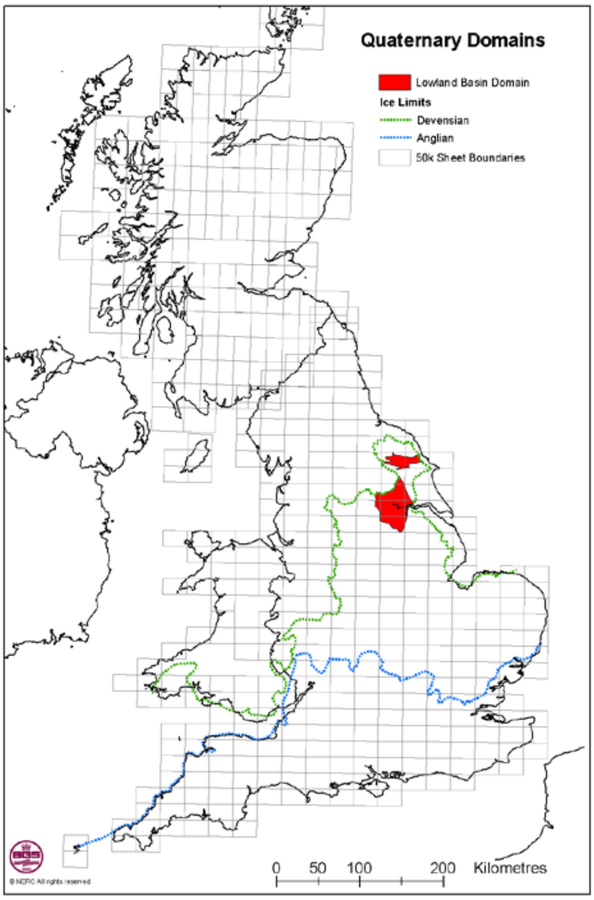
Supplementary approach

- Drilling and trenching essential, supported by a wide-ranging sample analysis.

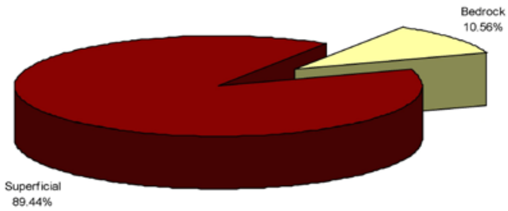
Specific problems

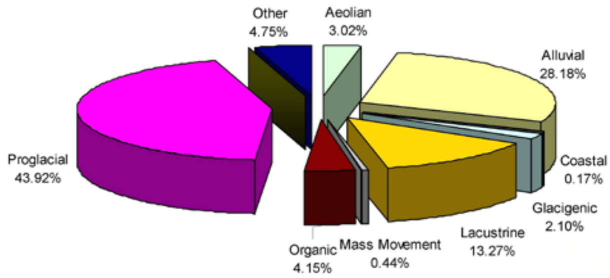
- Whether or not to map weathered/decomposed bedrock where present. In those instances where granite or micaceous psammite has decomposed to sand, it should be regarded as a superficial deposit and mapped. To complete this task adequately, much augering and trenching is required.

D) DOMAIN: LB LOWLAND BASIN (with two sub-domains)



Bedrock/Superficial ratios

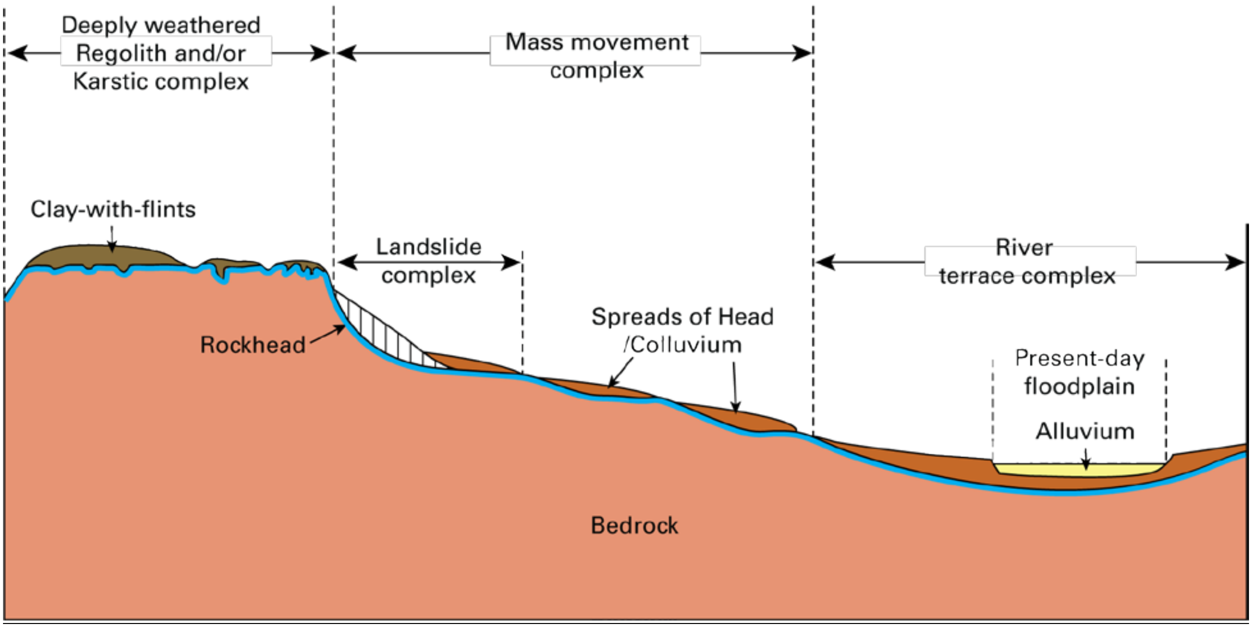




Superficial components

Pie chart proportions are based on an analysis of DigMapGB50 Version 2.

A generic schematic diagram showing elements of the lowland basin domain



Background information for project planning:

Landforms, deposits and processes

This domain includes several areas of low to very low relief, underlain by thick, stratified sequences of Devensian to Holocene age that are dominated by glaciofluvial sand and gravel and glaciolacustrine silt and clay.

Around the margins of parts of the domain, there are relict areas of till that may be Pre-Devensian. The deposits have yet to be formally defined on lithostratigraphical grounds, although they could equate with either the Lowestoft or Sheringham Cliffs formations of East Anglia.

For mapping guidance:

Primary approach

Office-based information search and landform analysis (LiDar or NextMap) are essential, followed by a preliminary field visit to confirm the model and appropriate methodologies. Ground truthing is very important. To understand the stratigraphical sequence, borehole, trenching, deep auger and shallow auger traverse information is essential. The daily average ground coverage is highly dependent on the mapping resolution and the methodologies chosen; will vary between ¼ and 5 km^2.

Supplementary approach

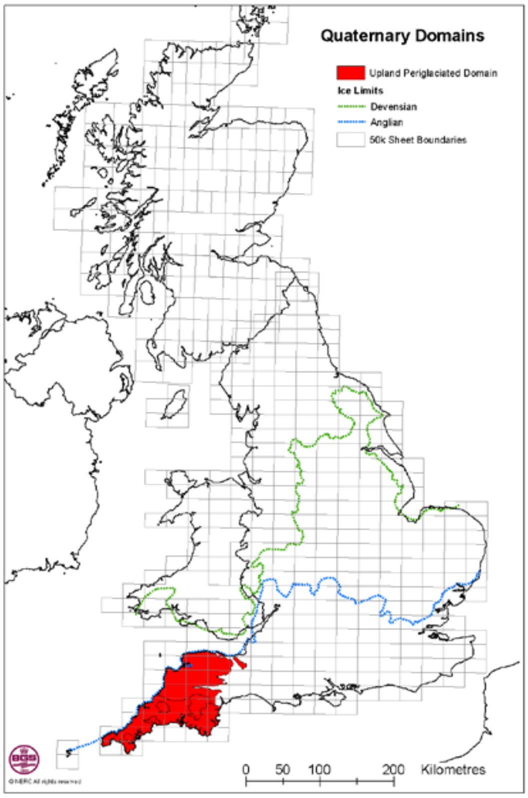
- Detailed lithological analysis of sediments from boreholes, sections and trenches are invaluable aids to the understanding of Devensian-Holocene landscape evolution.

Specific problems

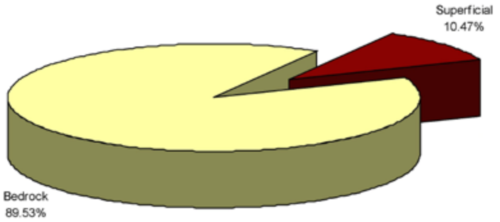
- NextMap data at c.1 m resolution is the ideal digital DTM; however, for some applications, the centimetre resolution provided by LiDar is required. This data is very expensive and not generally held by the BGS; projects should seek collaborative ventures where possible, e.g. with the EA as they hold much of the national floodplain, estuary and coastal coverage.
- Ground truthing is essential. Where deep augering is needed for stratigraphical purposes, it is labour intensive and time consuming.
- In some localities, distance from field accommodation may constrain the ‘time on the ground’.
- GPS instruments are essential for location.
- Health and Safety issues, e.g. lone working and back-related injuries through augering.

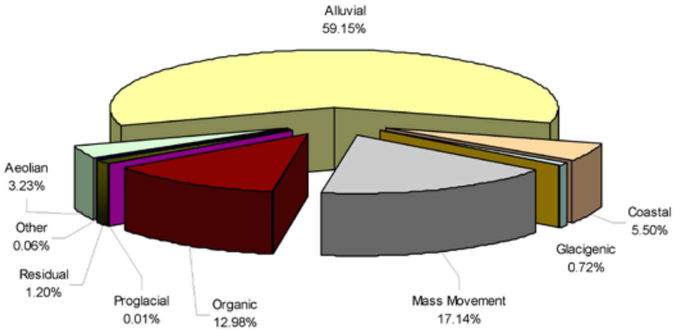
Non-glaciated province

A) Domain: UP Upland Periglaciated (with three sub-domains)



Bedrock/Superficial ratios

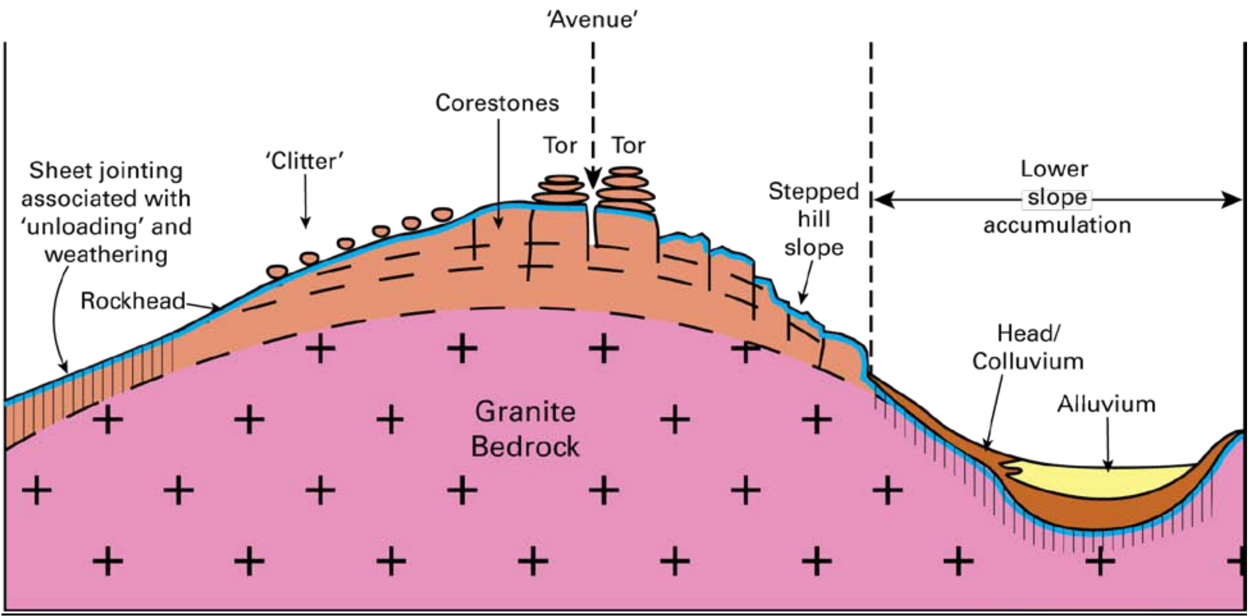




Superficial components

Pie chart proportions are based on an analysis of DigMapGB50 Version 2.

A generic schematic diagram showing elements of the upland periglaciated domain



Background information for project planning:

Landforms, deposits and processes

This domain lies entirely in south-western England. The landscape is a product of numerous geomorphic cycles, acting over a long period of time (since the Neogene) during which the climate has fluctuated from warm temperate to Arctic 'tundra'. Recent research suggests that perhaps much localised ice caps with associated valley glaciers developed in this area during the Middle and Late Quaternary. However, others consider the evidence to be ambiguous. The residual deposits overlying this relict landscape resulted from multi-phase reworking associated with periglacial processes, such as solifluction and frost shattering. They include deeply weathered regolith, landslip, solifluction drapes (head) and hillwash (colluvium).

The sub-domains partly reflect regional changes in bedrock and also significant landform differences.

For mapping guidance:

Primary approach

Office-based information search and landform analysis (LiDar or NextMap) are essential, followed by a preliminary field visit to confirm model. Depending on the purpose and scale of mapping, intensive ground truthing may be judged unimportant. Field observations and exposure logging, accompanied by augering where profitable, will provide some of the technical detail needed by some users. The daily average ground coverage will depend on the specific mapping requirements; this is reflected in the large range between ¼ and 25 km^2.

Supplementary approach

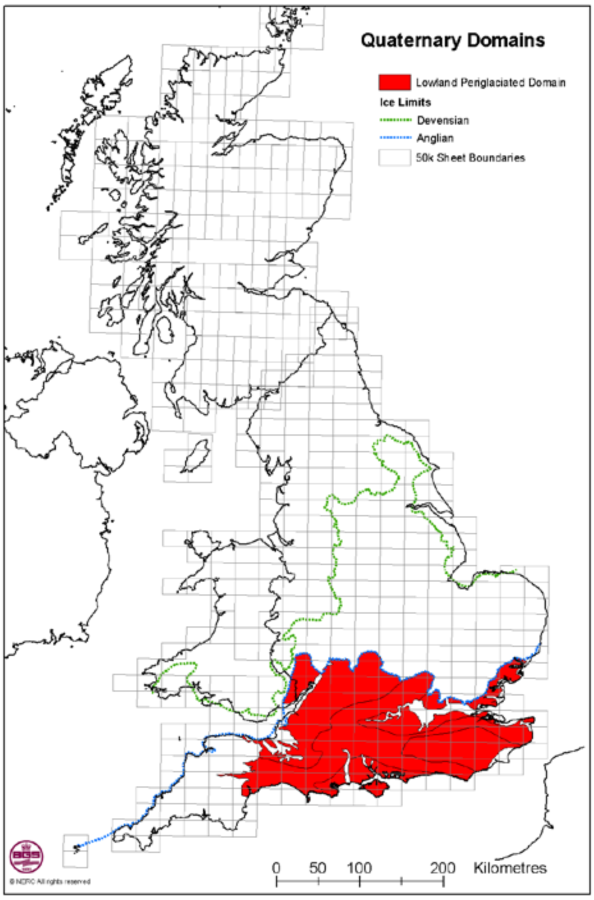
- Trenching with detailed logging, specifically looking for relict shear structures in periglacial deposits. Close-spaced sampling within the trenches and subsequent testing of these samples will provide geotechnical information regarding 'safety limits' of residual deposits. Drilling and probing provide less useful information, but should not be overlooked. Clay analysis and mineralogy of these samples may assist the understanding of likely potential for slope failure.
- Sampling for provenance and dating would prove useful.

Specific problems

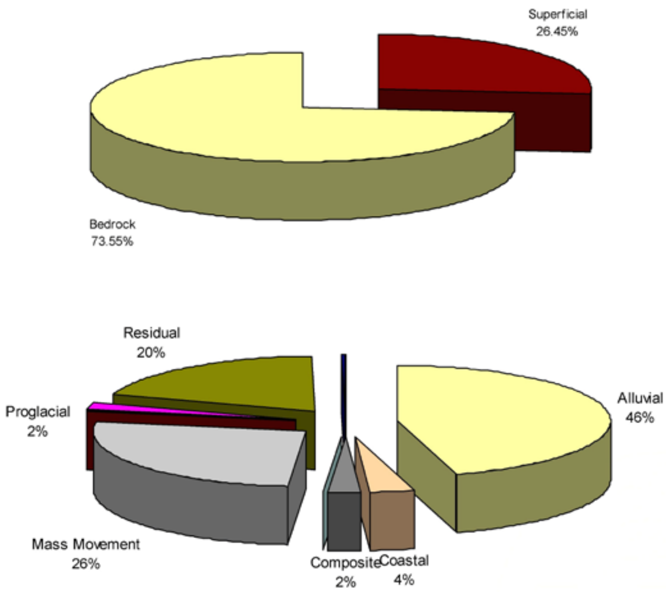
- The widespread extent of periglacial phenomena poses a significant problem in terms of deciding what detail (or resolution) meets the 'fit for purpose' criteria and thus the field time needed to map to this resolution. There are a number of possible solutions:
  - leave periglacial deposits/structures off published maps but inform the map user of their presence by including an awareness note on the published map. However, this awareness note must be supported with a schematic diagram showing likely occurrences and other summary data.
  - map the most significant periglacial deposits/structures as the project resources allow. Again, the map user must be informed as above.
  - undertake detailed mapping and trenching in key areas to characterise the periglacial deposits/structures. Use this information as a guide to the rest of the area.
  - undertake a DTM slope analysis in conjunction with aerial photography and targeted field observations in order to link critical slope breaks with the presence/absence of deposits/structures.

- Distance from the main office and in some areas from field accommodation may constrain 'time on the ground'.
- Health and Safety issues, e.g. lone working

B) DOMAIN: LP LOWLAND PERIGLACIATED (with five sub-domains)



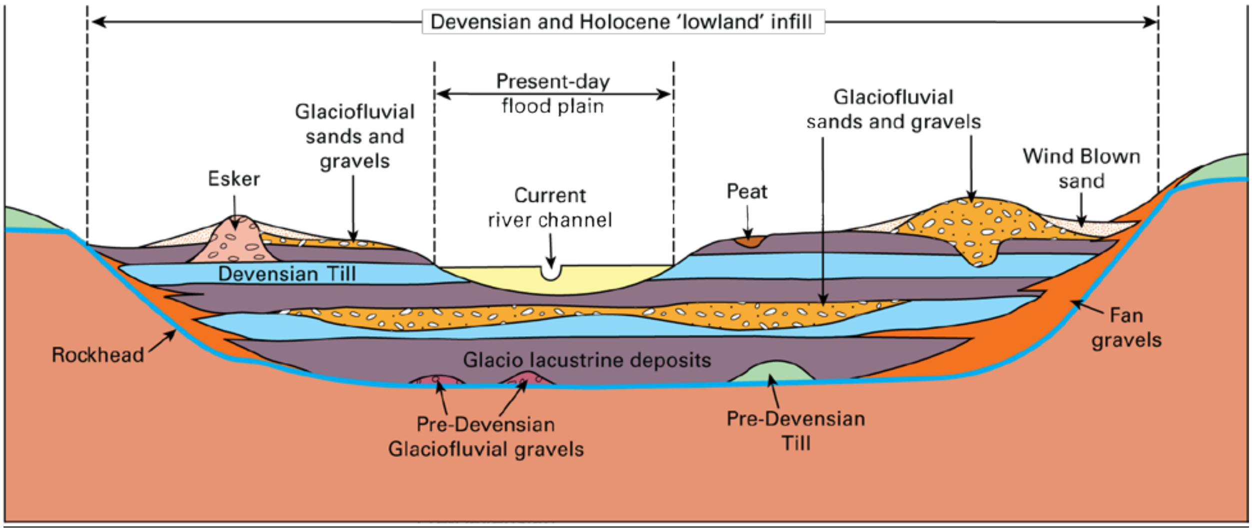
Bedrock/Superficial ratios



Superficial components

Pie chart proportions are based on an analysis of DigMapGB50 Version 2.

A generic schematic diagram showing elements of the lowland periglaciated domain



Background information for project planning:

Landforms, deposits and processes

This domain lies in southern and parts of southwest England, beyond the known southernmost limits of both the Anglian and Devensian ice sheets. The landscape is a product of numerous geomorphic cycles, acting over a long period of time (since the Neogene) during which the climate has fluctuated from warm temperate to Arctic 'tundra'. The residual and mass movement deposits overlying this relict landscape include deeply weathered regolith, landslip, solifluction drapes (head) and hillwash (colluvium). Failures (cambering) of relict structures (ice/sand wedges) are locally common. Early mapping either failed to recognise these deposits and structures or failed to understand their significance; certainly their widespread extent was omitted from published maps. The domain includes terrace deposits of former river systems, e.g. the Kesgrave Formation in Essex.

As variations in the bedrock geology have to some extent controlled the geomorphic processes, sub-domains are largely based on underlying rock-type.

For mapping guidance:

Primary approach

Office-based information search and landform analysis (LiDar or NextMap) are essential, particularly for borehole data, followed by a preliminary field visit to confirm model. Depending on the purpose and scale of mapping, intensive ground truthing may be judged unimportant. Field observations and exposure logging, accompanied by augering where profitable, will provide some of the technical detail needed by some users. The daily average ground coverage will depend on specific mapping requirements; this is reflected in the large range between ¼ and 25 km^2.

Supplementary approach

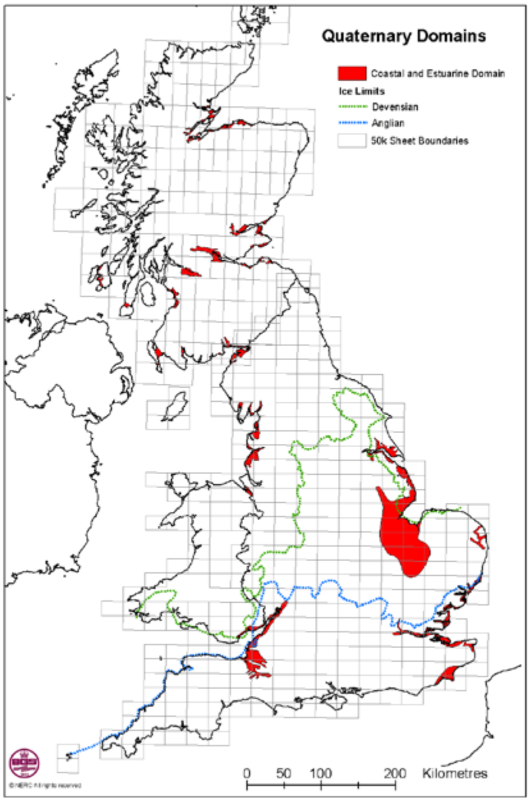
- Trenching with detailed logging specifically looking for relict shear structures in periglacial deposits. Close-spaced sampling within the trenches and subsequent testing of these samples will provide geotechnical information regarding 'safety limits' of residual deposits.
- Drilling and probing provide less useful information but should not be overlooked. Again, testing of samples may indicate potential for slope failure.
- Sampling for provenance and dating would prove useful.
- In some localities geophysics (ground conductivity) provides useful clues for boundary placement.

Specific problems

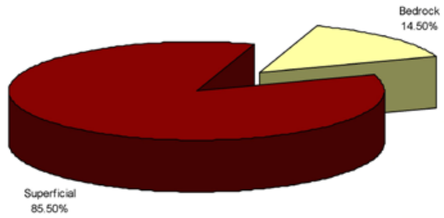
- The widespread extent of periglacial phenomena poses a significant mapping problem in terms of deciding what resolution detail meets the 'fit for purpose' criteria and the field time needed to fulfil these criteria. There are a number of possible solutions:
  - leave periglacial deposits/structures off published maps but inform the map user of their presence by including an awareness note on the published map. However, this awareness note should be supported with a schematic diagram showing likely occurrences and other summary data.
  - map the most significant periglacial deposits/structures as the project resources allow. Again, the map user should be informed as above.
  - undertake detailed mapping and trenching in key areas to characterise the periglacial deposits/structures. Use this information as a guide to the rest of the area.
  - undertake a DTM slope analysis in conjunction with aerial photography and targetted field observations in order to link critical slope breaks with the presence/absence of deposits/structures.

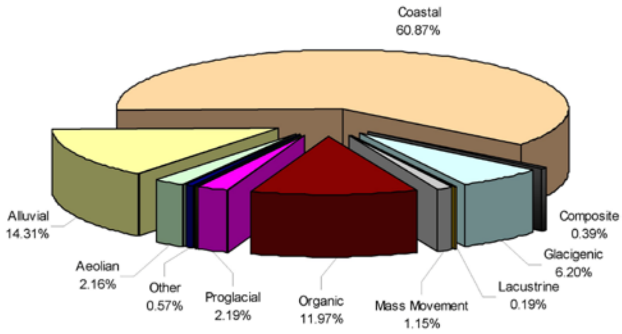
- Distance from main office and in some areas from field accommodation may constrain the 'time on the ground'.
- Health and Safety issues, e.g. lone working, potential unstable ground hazards

C) DOMAIN: CE COASTAL, ESTUARINE AND ALLUVIAL (with seven sub-domains)



Bedrock/Superficial ratios

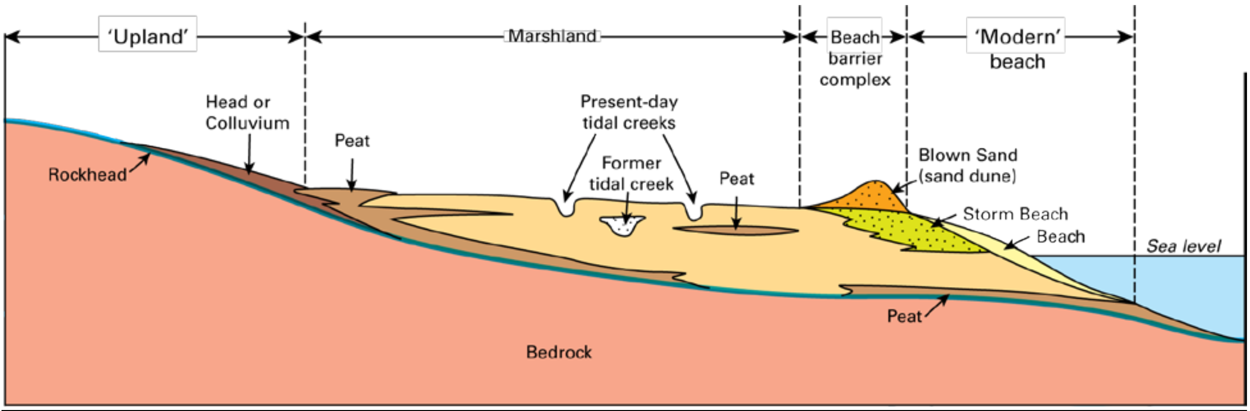




Superficial components

Pie chart proportions are based on an analysis of DigMapGB50 Version 2.

A generic schematic diagram showing elements of the coastal, estuarine and alluvial domain



<u>Background information for project planning:</u>

Landforms, deposits and processes

This domain includes the larger expanses of Holocene sediments and landforms throughout Britain, with the exception of blanket peat on the hills. It mainly includes areas of very low relief and low-lying coastal tracts underlain by thick sequences of alluvial, lacustrine, estuarine, beach, aeolian and marine deposits, locally concealed by and extensively interbedded with peat.

Holocene sedimentation across Britain has been influenced strongly by changes in sea level during the last c. 14,500 years. Large areas of raised beach and estuarine alluvium occur only to the north of a hinge line crossing northern England from about Barrow-in-Furness to Newcastle where they have been gently tilted away from a centre of uplift located in the western Highlands of Scotland. South of this line, sea level has generally risen continuously up to the present day. Generally, rising sea levels have caused 'ponding back' and increased sedimentation in the lower reaches of river valleys whereas dropping sea levels have brought about periods of floodplain incision. Estuaries and coastal inlets have experienced continuous changes leading to complicated interdigitation of deposits. Thus flood risk, compressible 'soils' and ground contamination are important issues in these areas, especially where they coincide with developed areas such as the Thames Gateway.

For mapping guidance:

Primary approach

Office-based information search and landform analysis are essential, followed by a preliminary field visit to confirm the model and appropriate methodologies. Ground truthing is very important. To gain a reliable understanding of the stratigraphical sequence, borehole, trenching and deep augering are essential. The daily average ground coverage is highly dependent on the mapping resolution and the methodologies chosen; between ¼ and 5 km^2.

Supplementary approach

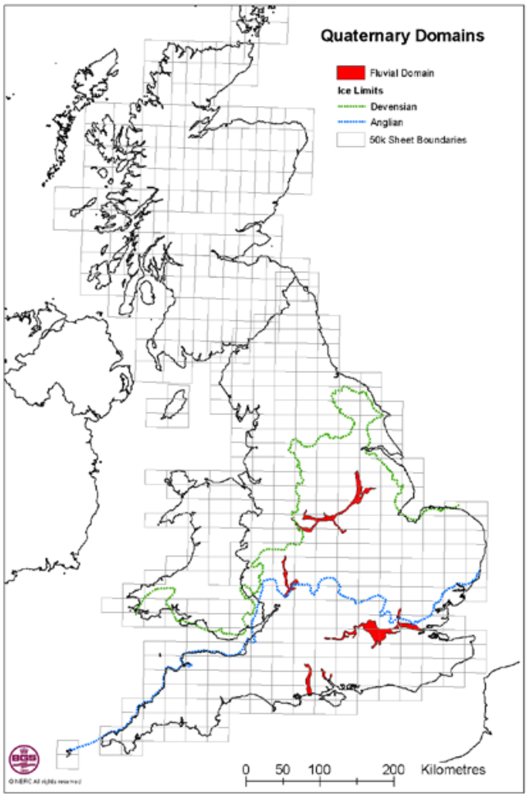
- Research into historical land use and geomorphological changes due to man's intervention, together with
- a detailed lithological analysis of sediments from boreholes.

Both approaches are invaluable aids to the understanding of Holocene evolution and aid predictive climatic impact modelling.

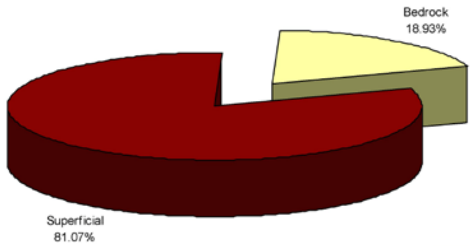
Specific problems

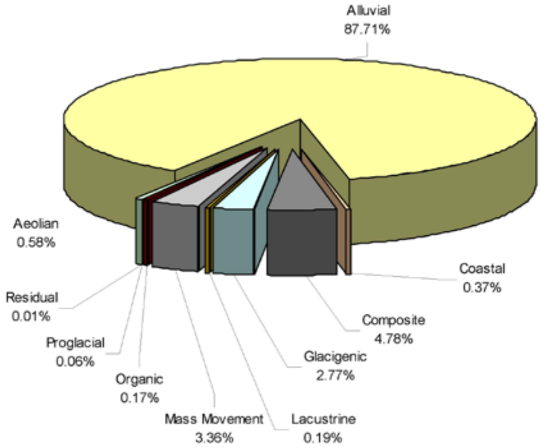
- NextMap data at c.1 m resolution is the ideal digital DTM; however, for some applications, the centimetre resolution provided by LiDar is required. This data is very expensive and not generally held by the BGS; projects should seek collaborative ventures with external agencies where possible e.g. the EA holds much of the national floodplain, estuary and coastal coverage LiDar data.
- If remote sensed data are used extensively, ground truthing is recommended.
- If deep augering is needed, it is labour intensive and time consuming.
- Distance from main office and in some areas from field accommodation may constrain the 'time on the ground'.
- GPS instruments are essential for location.
- Health and Safety issues, e.g. working in the coastal/intertidal zone, lone working and back-related injuries through augering.

D) DOMAIN: FP FLUVIAL



Bedrock/Superficial ratios

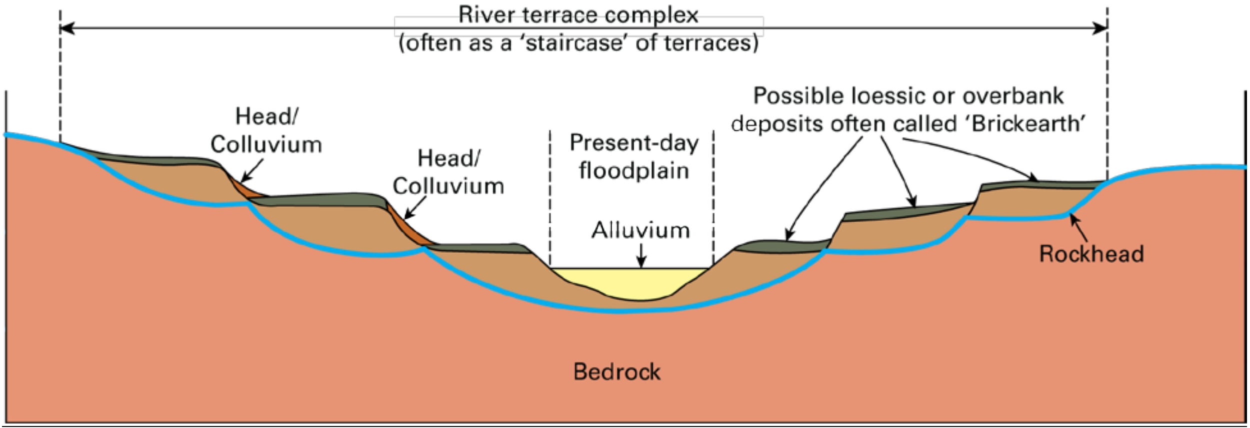




Superficial components

Pie chart proportions are based on an analysis of DigMapGB50 Version 2.

A generic schematic diagram showing elements of the fluvial domain



<u>Background information for project planning:</u>

Landforms, deposits and processes

This domain encompasses all the alluvial tracts that characterise the drainage systems of Britain; it therefore 'cuts across' most other domains and sub-domains. It is an important domain economically, because low-lying ground of this type has been favoured for siting major communications routes, industries and settlements.

The landforms are essentially the floodplain and associated river terraces. These are distinguished geomorphologically and lithologically. The typical floodplain consists of the alluvium of the active channel. This tract is bordered by a (generally) subtle concave slope break that marks the edge of the alluvium against the more steeply sloping ground of the valley side. Alluvial tracts are seldom completely 'flat' and in most cases the presence of fluvial features, such as gravel bars, levees and abandoned channels, imparts a topographic 'roughness' in which a vertical height range of up to 2 m is common. River terraces can be considered in two ways: the features formed by the terrace surface and edges, which are generally the most significant landforms for mapping purposes, and the aggradational terrace deposits, which underlie terrace surfaces and define the outcrops of terrace units on geological maps. In the larger and wider lowland floodplains, alluvial deposits commonly comprise a silt or clay/silt upper layer a few metres thick, underlain by sand and gravel of similar or greater thickness, some of which may represent the incised parts of earlier river terrace deposits. Both lithological associations can include lenses of lacustrine clay and peat-rich organic deposits; significant thicknesses peat may also be present at the surface in abandoned channels.

<u>For mapping guidance:</u>

<u>*Primary approach*</u>

Office-based information search and landform analysis (using NextMap or LiDar data) are essential, followed by a preliminary field visit to confirm model and appropriate methodologies. Ground truthing is very important. To understand the stratigraphical sequence, borehole, trenching and deep auger information are essential. The daily average ground coverage is highly dependent on the mapping resolution and the methodologies chosen, which accounts for a range of between ¼ and 5 km^2.

<u>*Supplementary approach*</u>

- Research into historical landuse and geomorphological changes due to man's intervention, together with
- a detailed lithological analysis of sediments from boreholes

are invaluable aids to understanding the evolution of the fluvial landscape, and in turn significantly aid predictive climatic impact modelling.

<u>*Specific problems*</u>

- At present, there is no convention for showing erosional terrace surfaces on BGS maps; this is a particular problem in upland drainage systems, e.g. the upper River Dyfi valley, Wales. In this fluvial tract, terraces are regarded as the products of post-glacial incision, and thus may or may not possess fluvial sediments deposited at the time of terrace formation.
- Currently there is a plethora of formal and informal lithostratigraphical schemes for fluvial terrace deposits. Schemes for formalising river terrace nomenclature, utilising lithostratigraphical units of member and/or formational status are published - such schemes are already in wide use on BGS maps e.g. the East Anglian region, but have yet to be adopted in other districts. River Catchment groups are proposed in MacMillan et al (2005).
- NextMap data at c.1 m resolution is the ideal digital DTM; however, for some applications the centimetre resolution provided by LiDar is required. This data is very expensive and not generally held by the BGS; projects should seek collaborative ventures with external agencies where possible e.g. the EA holds much of the national floodplain, estuary and coastal coverage LiDar data.
- GPS instruments are essential for location.
- Health and Safety issues e.g. lone working, possible flash floods.

REFERENCES

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