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Classification of artificial (man-made) ground
and natural superficial deposits
applications to geological maps and datasets in the UK

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This volume was prepared for BGS use, and is released for information; comments on its applicability for wider use would be welcome and should be sent to the Rock Classification Scheme Coordinator, Dr M T Styles, British Geological Survey, Keyworth, Nottingham NG 12 5GG.

1 INTRODUCTION

The Digital Map Production Implementation project initiated a review of the BGS Rock Classification Scheme in order to set up hierarchical schemes and master dictionaries of terms for the geological map digital database. This report describes the proposed classification schemes for drift (see Section 4 for definitions) of Pleistocene and Recent age comprising artificial (man-made) ground and natural superficial deposits. Traditionally the mapping of drift has used methods and classification criteria that differ from those employed for sedimentary rocks. For this reason the latter are treated separately in a companion volume (Hallsworth and Knox, 1999). The schemes have been revised from earlier versions following the advice of a BGS Review Panel, other BGS staff and external reviewers.

The proposed classification schemes are designed specifically for applications to geological maps and datasets in the UK and the surrounding continental shelf and as such consider only deposits which are commonly mapped at 1:10 000 scale (onshore) or are shown on the offshore 1:250 000 scale maps. The schemes are based with modification upon the specifications for 1:10 000 and 1:50 000 onshore maps, field mapping procedures (BGS, 1995) and mapping procedures for marine deposits of the subtidal zone and adjoining continental shelf. They are designed to be used and interpreted by both geologists and non-geologists to allow thematic material comprising identified classes of superficial deposits to be extracted from geological maps and other datasets. The schemes can be developed further to cover other classes of materials, particularly from overseas tropical and subtropical land, shelf and deep-sea areas, which have not been assessed for this report.

2 BASIS OF THE CLASSIFICATION SCHEMES

2.1 BGS mapping specification

In Britain most traditional onshore investigations of the drift have employed a morphogenetic and lithogenetic terminology. As a result the database including past and present 1:10 000 and 1:50 000 scale Geological Survey maps uses an amalgam of terms which have a dominantly genetic basis. This report similarly adopts a genetic approach to conform with current mapping practice and to be of prime use for dictionary construction and maintenance of datasets. It is, however, recognised that an objective description involving nongenetic classifications based on sedimentological, structural, physical, and chemical criteria to construct lithofacies associations is desirable (Eyles et al., 1983; Hambrey, 1994; Reading, 1986). Lithofacies and lithostratigraphical classifications are clearly valuable and have in recent years been applied by BGS (see for example 1:50 000 Series Sheet 162 Great Yarmouth, BGS, 1990). For lithified sedimentary rocks where morphogenetic criteria are less important, it is possible to employ directly measurable physical and compositional criteria to construct compositionally based classification schemes (for example Tucker, 1992; Hallsworth and Knox, 1999; Gillespie and Styles, 1999) and reference in this report is made to such schemes where appropriate.

2.2 Mapping of drift: practical considerations

In the field, geologists and geomorphologists map the landform (morphology) and, where possible, record the physical, sedimentological and lithological (compositional) characteristics of the surface materials. During the process of map compilation these characteristics are interpreted to deduce the origin (genesis) of the deposits. Usually the map shows the origin, qualified by the lithology of the top metre of deposit. Quaternary sequences may be deduced from temporary cuttings, natural sections and subsurface datasets including boreholes and trial pits. Where good subsurface datasets exist, maps of resources, geotechnical and lithological profiles may be constructed (for example Browne and McMillan, 1989, 1991; Cratchley and Lake, 1975-77; Merritt, 1992).

A single criterion may be sufficient to determine the origin of a deposit, but this is rare. In general a combination of characteristics is required, but these may not always be available. For example, a landform may be mapped both on the ground and from remote datasets including air photographs and satellite imagery, but only limited information may be available on the nature of surface sediments in terms of their composition, lithology and texture. Conversely, subsurface information from boreholes and trial pits will consist of lithological (or compositional) and other physical characteristics, but surface morphological information may be absent or insufficient to interpret the genesis of some sediments. Thus, in theory it is possible to systematically subdivide any one deposit into its textural, morphological and genetic components, but in practice it is seldom possible to do this. Consequently, as recognised in Britain and elsewhere (see Fulton, 1993 for discussion of surficial geology mapping in Canada) the composition and nature of map unit materials over wide areas are generally inferred from the landform.

2.3 Genetic classification approach

The genetic approach adopted in this report applies both to artificial (man-made) ground and natural superficial deposits. For artificial deposits (Section 3), the man-made origin constitutes the primary criterion for classification, and if known, the nature of the ground and the composition of the man-made material can also be included. For natural superficial deposits (Section 4), lithological and geomorphogical qualifiers are given where known. The classification scheme acknowledges that sediment origin may or may not be known. A hierarchical scheme is developed linking the principal genetic class (Level 1) with basic (Level 2) and more detailed mapping categories (Levels 3 and 4). The scheme incorporates the necessary cross-references, synonyms and obsolete terms for digital retrieval purposes. The definition of each genetic category and its subdivisions may include textural and other physical information, which may be common to more than one genetic class.

3 ARTIFICIAL (MAN-MADE) GROUND

Outlined in this section is an hierarchy for artificial (man-made) ground, comprising the major categories mapped by BGS: worked ground, made ground, infilled ground, landscaped ground and disturbed ground. A glossary of commonly used terms associated with these categories is provided (Appendix 1).

These categories include both man-made deposits and voids, that is, areas that have been worked or excavated such as pits, quarries and cuttings. The categories have been used widely in recent BGS mapping projects, particularly in urban, applied (thematic) geological mapping studies supported by the former Department of the Environment (DoE), and are now routinely delineated on current BGS 1:10 000 geological maps (BGS, 1995). They will appear to an increasing extent on newly published BGS 1:50 000 series maps, a number of which incorporate urban areas surveyed during recent applied geological mapping projects.

3.1 BGS classification of artificial (man-made) ground

The classification of artificial ground (modified from BGS, 1995) is shown in Table 1 and illustrated in Figure 1. The basic mapping categories (Level 2 of Table 1) are defined below.

CATEGORY	DEFINITION
Made ground	Areas where the ground is known to have been deposited by man on the former, natural ground surface: road, rail, reservoir and screening embankments; flood defences; spoil (waste) heaps; coastal reclamation fill; offshore dumping grounds; constructional fill (landraise).
Worked ground	Areas where the ground is known to have been cut away (excavated) by man: quarries, pits, rail and road cuttings, cut away landscaping, dredged channels
Infilled ground (formerly termed 'Worked Ground and Made Ground')	Areas where the ground has been cut away (excavated) and then had artificial ground (fill) deposited: partly or wholly back-filled workings such as pits, quarries, opencast sites; landfill sites (except sites where material is dumped or spread over the natural ground surface; see landraise).

The categories listed above are the most commonly used; in addition, the following categories have been used, predominantly in areas mapped during applied geological mapping projects.

Landscaped ground	Areas where the original surface has been extensively remodelled, but where it is impractical or impossible to separately delineate areas of worked (excavated) ground and made ground
Disturbed ground	Areas of surface and near-surface mineral workings where ill-defined excavations, areas of man-induced subsidence caused by the workings and spoil are complexly associated with each other, for example collapsed bell pits and shallow mine workings

3.2 Classification of fill, made ground and waste

Attempts have been made to classify types of fill and waste material (DoE, 1993; European Waste Catalogue, 1993; DETR/EA, 1998). However, fill materials at any one site are commonly an admixture of organic, chemical and inert materials. The nature of the fill can vary, both vertically and horizontally, over a short distance, and at sites where there is no record of the fill, or at poorly monitored landfill sites, the nature of the fill can only be determined by a densely spaced, borehole site investigation.

The UK Waste Classification Scheme (Draft for discussion, 1998), jointly produced by the Department of the Environment, Transport and the Regions (DETR) and the Environment Agency (EA) considered the classification of waste, and recommended that waste material should be classified in a consistent manner nationally. The index to the first level categories of waste composition the DETR/EA Scheme is listed in Table 2a. This Scheme (DETR/EA, 1998) should be consulted for more detailed listings and classification of waste materials.

Due to the possible contentious problems in classifying fill types, it is considered best practice to record only the proven types of fill at a site, or where there is uncertainty concerning the nature of the fill it should be recorded as 'undifferentiated'. Since there is much disagreement and uncertainty concerning the classification of waste material, we recommend that for mapping purposes, the material type (deposit), where known, is classified using the list of common terms used in the UK for waste/fill - shown at Level 4 of Table 1, and defined in Appendix 1. The categories are cross-referenced, by number, to the probable first level categories of the UK Waste Classification Scheme shown on Table 2a.

3.2.1 Landfill sites

In some urban areas with extensive man-made deposits it is not always possible to determine whether a 'landfill' site registered by a local authority represents *made ground* (for example, spreads on the pre-existing ground surface, also known as 'Landraise') or *infilled ground* (for example quarries). It may be necessary to show such sites on thematic maps as 'Landfill site, undifferentiated', denoted by a unique line-type.

A European Community (EC) directive (OJ No. C 212/33, 1993) classifies landfill sites according to their origin.

- municipal waste
- industrial waste

and also according to their characteristics

- hazardous waste
- non-hazardous waste
- inert waste

However, since 'non-hazardous' may include some organic materials that could, under certain conditions, give rise to hazardous methane or carbon dioxide, this classification is considered as too ambiguous to be of use in classifying the material type. The EC classification of Landfill Sites is shown as an example of landfill subdivision (Table 2b), but it is not recommended for wider use.

3.3 Appearance on BGS maps

The mapping categories (Section 3.1) are shown on BGS 1:10 000 and 1:50 000 series geological maps by various styles of hatching over the underlying drift deposit or bedrock; colour fill (Figure 1) or colour hatching may be used on digitally generated maps. The boundaries are shown by a fine, dashed line on geologists' 1:10 000 scale standards, although digital versatec prints have in the past shown the boundary as a continuous fine line.

3.4 BGS categories and widely used terms, and their suggested hierarchical rankings

The hierarchical scheme (Table 1) for the artificial (man-made) ground classification scheme is discussed below.

Level 1 This shows artificial (man-made) ground undivided.

Level 2 Users wishing to retrieve information on the map-face will generally select the major (Level 2) categories defined in Section 3.1 (such as made ground, worked ground subdivisions shown on the 1:10 000 map), or perhaps a combination of one or more of these with a particular type of underlying natural superficial deposit or bedrock. For example, an enquirer studying aquifer pollution from landfill sites may wish to show the incidence of *infilled ground* overlying sand and gravel deposits and/or sandstone bedrock.
The mapping categories (Level 2) are rarely subdivided on BGS 1:10 000 scale maps. Where good records exist, types of *made ground* and *fill* have been categorised. For instance the BGS Stoke-on -Trent Project for the DoE (Wilson et al., 1992) showed subdivisions of the made ground on a thematic map, including: colliery waste, ironworks slag and ceramic waste. Borehole logs received from outside sources, particularly site investigation records, commonly describe the nature of the made ground (fill) deposit, and this information may be required from the database.

Level 3 Below this major category comes the geographical/topographical category. This is not systematically recorded or presented on standard 1:10 000 maps, although individual sites such as sand and gravel quarry (worked ground), infilled opencast coal site (infilled ground), railway embankment (made ground), bell pits (disturbed ground) may be denoted on the map face. The majority of borehole logs received by BGS do not record the topographical category, and the record will 'step' from the major category (Level 2) (for example made ground, infilled ground) to details of the deposit or material type (Level 4) (for example ash, colliery waste, blast furnace slag).

Level 4 Level 4 in the hierarchy is the material type (deposit). Common terms used for waste/fill material in the UK are shown in Table 1, and are defined in Appendix 1. The material may be denoted on the map face either on its own (for example colliery spoil), or together with the topographical category (for example disused pit infilled with blast furnace slag). The deposit is not systematically recorded by BGS during mapping surveys, chiefly because it is commonly not visible, and because of the variable nature of the material, both horizontally and vertically, at many sites. As noted in the Stoke-on-Trent example (Wilson et al., 1992), above, some thematic maps may show subdivisions of infilled ground (worked and made ground) based on material type or a combination of material type and topographical category (Level 3)(opencast coal site, colliery waste). Borehole logs may record the nature of the made ground or fill material; in BGS logs this is usually recorded as a comment or qualifier.

The UK Waste Classification Scheme (DETR/EA; Draft 16 for Consultation, 1998) classifies waste materials according to composition; it also provides an index and code for common types of waste and mixed waste. Table 2a shows the first category of waste in this scheme which should be consulted for more detailed classification of waste. The EC Landfill Site Classification (1993), shown in Table 2b, is not recommended for use in mapping schemes (see discussion in Section 3.2).

4 NATURAL SUPERFICIAL DEPOSITS

This classification scheme describes natural superficial deposits of Quaternary age occurring in the UK and its Continental Shelf. Natural superficial deposits including both glacial and alluvial deposits have been traditionally referred to as 'drift', a term first introduced in the early 19th century. BGS now uses this term to represent all superficial deposits including man-made (artificial) deposits (Section 3) (BGS, 1995). Deposits found overseas including subtropical and tropical (residual) weathering products and sediments formed in volcanic, karstic, desert and ocean environments are not considered in this volume although the lithified equivalents are described in Hallsworth and Knox (1999). Reference is, however, made to far-travelled, wind-borne volcaniclastic materials (for example tephra; see Section 4.10). The boundary between sediment and sedimentary rock is transitional and reference should be made to Hallsworth and Knox (1999) for details of textural and compositional characteristics.

4.1 Genetic classification scheme

The classification scheme for natural superficial deposits is based with modification on the genetic classifications outlined in the specifications for the preparation of 1:10 000 scale maps (BGS,1995). The classification of marine sediments of the subtidal zone and adjoining continental shelf follows currently recommended mapping practice for compilation of the offshore 1:250 000 series maps. The depiction of natural superficial deposits on the onshore BGS 1:10 000 series is achieved by means of a symbolic notation (Table 3) in which the basic genetic symbol may be embellished with lithological, mode of origin/morphogenetic, lithostratigraphical and chronostratigraphical qualifiers (BGS, 1995). Landform is depicted by symbols and form lines. For natural superficial deposits the 1:10 000 scale map specification identifies a total of ten genetic categories and one of miscellaneous deposits (uncertain origin). The classification scheme reported here differs in some respects (Tables 4, 5). The undivided mapping category of 'mass movement, gravitational accumulates and residual deposits' is separated into two genetic classes, mass movement and residual deposits. 'Organic deposits' are divided into two classes, organic deposits and biological deposits. 'Raised Marine Deposits' and 'Interglacial Deposits' are recognised within the relevant coastal zone, lacustrine and alluvial deposits genetic classes. The new genetic class marine deposits is introduced to cover deposits of the continental shelf below Mean Low Water Mark (MLWM) which are not visible and are morphologically determined by acoustic means. 'Glacial deposits' are divided into two classes, proglacial and glacigenic deposits.

The primary classification or Level 1 identifies twelve principal genetic classes and one of unknown/unclassified origin (Tables 4,5). Throughout this section the genetic class is shown in bold type. Tables 10 to 23 show how each genetic class may be subdivided into a hierarchy of component mapping categories (Level 2). Levels 3 and 4 are detailed mapping categories as applied for example on geotechnical maps. In this section, terms employed at levels 2 to 4 are shown in italic type. (Bold and italic type is used here for the convenience of the reader, and is not intended as a general practice.) The hierarchy employs a terminology which is currently used and generally accepted by BGS. Broad definitions of each genetic class and its lithogenetic or morphogenetic subdivisions are presented in Appendix 2, to enable the terms to be incorporated in the standard BGS nomenclature and to create master dictionaries for BGS datasets. Figures 2 to 16 illustrate the depositional setting of a variety of natural superficial deposits.

Table 4 shows the links between the genetic classes and field characteristics including composition, sedimentary structures and landform which in turn can be used to define lithofacies and domains (Section 4.5) and lithostratigraphy (Section 4.6). The definitions of each genetic class and its component categories may include information on grain size, grain shape, lithology and colour (see Section 4.2 below) but the provision of detailed descriptions is beyond the scope of this report. Consequently, Appendix 2 should be used only as a general guide to enable the consistent identification of superficial deposits and associated landforms. Positive criteria for identifying and differentiating deposits (usually to levels of detail not applicable on BGS maps) is well covered in readily available specialist texts. Recommended reading includes Ballantyne and Harris (1994) for a modern appraisal of periglacial deposits; Catt (1986) for soils (this text includes a deposit identification flowchart); Hambrey (1994) for glacial deposits; Bennett and Glasser (1996) for summary tables and diagrams illustrating glacial depositional landforms and processes; Reading (1986) and Reineck and Singh (1973) for marine, lacustrine and deltaic deposits.

4.2 Composition (lithology and texture) and sedimentary structures

Whether or not origin is known, superficial deposits may be defined compositionally (Table 4) by lithology and texture (grain size and shape) of constituent particles and by sedimentary structures. These parameters are of key importance for determining the provenance and depositional environment of the sediment. Records of temporary and natural sections, boreholes and trial pits provide compositional and structural information of varying quality and detail. Many records of boreholes, for example, fail to record even basic lithological information, referring to the superficial deposits simply as ‘drift’. Where textural data are available, grain size may be defined in terms of the BGS grain-size scheme (Table 6 adapted from Wentworth, 1922) and grain shape determined according to the parameters of roundness and sphericity (Table 7).

For superficial deposits commonly used grain-size terms include gravel, sand, silt and clay. These terms and combinations of them, used adjectivally (for example silty sand) to denote varying proportions of defined grain sizes (as shown in Tables 4 to 6), are recorded in BGS databases and shown on BGS 1:10 000 series maps by prefixing the basic mapping symbols (BGS, 1995) (Table 3). Although gravel may be defined as granule and pebble grade material, in practice sand and gravel shown on many geological maps consists of a much wider range of grain sizes and may include cobbles and boulders. Furthermore, the use of the terms in borehole, field description and map databases is frequently based upon observation unverified by particle size analysis. Broad indications of proportions of different size fractions where possible have been coded in the BGS Borehole Database (Giles, 1991). For sand and gravel resource assessments which employed a systematic programme of particle size analysis the BGS adopted different grain-size criteria based upon industrial requirements (Thurrell, 1981; Merritt, 1992). Table 8a,b illustrate the resource assessment criteria.

Offshore, BGS 1:250 000 series sea-bed sediment maps adopt a classification (Table 8c) modified after Folk (1954) for mobile marine deposits in the subtidal zone and on the adjoining continental shelf (Section 4.16; Table 21). In this classification the term mud is used for silt and clay undivided.

In addition to the grain-size terminology shown Table 6, a textural (nongenetic) classification (Table 24) has been applied to poorly sorted sediments (Moncrieff, 1989; Hambrey, 1994) in which the term diamict (embracing the unlithified diamicton - used in BGS superficial deposits classifications - and lithified equivalent diamictite) was classified. This term is being used increasingly as a non-genetic textural term. Diamicton is defined as an unlithified, extremely poorly or poorly sorted, terrigenous sediment that contains a wide range of particle sizes (modified definition after Flint et al., 1960). The term diamicton is commonly employed in the description of glaciolacustrine and glaciomarine clays with dropstones (proglacial deposits, Section 4.17; Table 22) and for tills classified under glacigenic deposits (Section 4.18; Table 23).

Sedimentary structures form an important dataset used in determining the depositional environment and contribute along with textural information to the interpretation of suites of sediments in terms of lithofacies associations (Section 4.5; Table 9). Acoustically mapped bedforms are used to classify sea-bed lithologies identified under the marine deposits genetic class (Section 4.16; Table 21).

4.3 Landform

Where bedrock is concealed by superficial deposits the surface landform may reflect the structure of the underlying rocks, the geometry of rockhead and the depositional or erosional environment of the cover. Feature mapping, whether to determine structure of the subcrop or to establish the environment of deposition of the superficial deposits, forms an important aspect of onshore survey. Landform, therefore, forms an integral part of any classification scheme for superficial deposits, and when applied to a knowledge of structural and compositional characteristics (see Section 4.2 above) of a deposit enables the origin of the deposit to be determined. A variety of depositional and erosional landforms associated with glacial, fluvial and coastal processes are shown on BGS maps (BGS, 1995). Even when other characteristics are unknown a classification by landform provides an important basis for further investigation. Basic landform definitions include:

fan	a gently sloping mass of detritus in plan view typically taking the form of a cone or sector of a circle, i.e. fan-like (for example Figures 2, 4, debris cone)

plain	a flat or gently undulating area, usually at a low elevation with reference to sur rounding areas
hummocky/ moundy terrain	low, rounded, hills or knolls (for example Figure 14, kames)
ridge	general term for an elongate long, narrow, elevated mound (for example Figure 14, eskers)
terrace	a long, narrow, relatively level or gently inclined surface, bounded along one edge or both edges by steeper slopes (backfeat-ures), usually descending on one side and ascending on the other (Figure 6a).
cover or veneer	a thin, laterally extensive accumulation of superficial sediment of relatively uniform thickness, which may drape a pre-existing landform.
complex	an assemblage of associated landforms (for example Figure 9b)

4.4 Other physical qualifiers

Modern descriptions of sediments employ standard colour charts such as the Munsell Soil Color Charts (1994) and geotechnical classifications including BS5930 (British Standard Code of Practice for Site Investigations 5930. 1981). Geotechnical classifications of natural superficial deposits, particularly mass movement (Section 4.7; Table 10) and residual deposits (Section 4.8; Table 11), have been used in many BGS applied and thematic geological mapping projects. Reference is made to currently used terms in the relevant sections of this report.

4.5 Lithofacies and sediment-landform associations (domains)

Bodies of unconsolidated sediments with specified physical and sedimentary characteristics are commonly referred to either a single lithofacies or a lithofacies association. BGS geologists have in recent years employed lithofacies codes (Table 9) to enable a first stage, nongenetic description of field and borehole sequences. The principal schemes adopted include those of Miall (1977) who established a formal facies code to enable rapid description of braided stream deposits applicable particularly to alluvial, proglacial and some glacigenic environments (Sections 4.13, 4.17 and 4.18) and of Eyles et al. (1983) for diamicton (Section 4.18; Table 24).

Landform–sediment associations (domains) may also be usefully employed to depict available information about superficial deposits. Broad classifications of characteristic surface morphologies when linked to sequences of sediments with characteristic sedimentary and structural data, provide not only an understanding of origin but may also lead to useful applications, such as the determination of near-surface groundwater movement. Domains may also depict glacitec-tonically affected terrains where postdepositional deforma-tion has resulted in folded and thrust-repeated sequences (for example NIREX, 1997).

4.6 Lithostratigraphical classification

A stratigraphical approach with lithostratigraphical formations systematically defined in terms of lithology, distribution and geometry of deposits together with an assessment of depositional environment is also a valuable and recommended procedure (BGS, 1995). Provisional Quaternary formational nomenclature has been adopted for parts of the continental shelf (for example the North Sea, Gatliff et al., 1994; and Irish Sea, Jackson et al., 1995). Lithostratigraphical mapping has been applied onshore in coastal and estuarine areas for example in the Clyde valley (Browne and McMillan, 1989, 1991), the Moray Firth (Merritt et al., 1995) and in East Anglia (BGS, 1990, Arthurton et al., 1994).

Fluvial deposits of former river systems may also be mapped lithostratigraphically. For example in central and southern Essex according to Whiteman (1992) ‘at least eight gravel units attributable to the pre-Anglian-Glaciation River Thames are present.’ In order of descending altitude and decreasing age they are the Bushett Farm, Stebbing, Bures, Moreton, Waldringfield, Ardleigh, Wivenhoe and Lower St. Osyth Gravels. On lithological evidence these units can be divided into two groups: the Sudbury Formation consisting of the four higher older members, and the Colchester Formation consisting of the four lower younger members. Encompassing the whole of the Kesgrave Sands and Gravels, these two formations constitute the proposed Kesgrave Group. BGS has, thus far, mapped the Kesgrave Group (undivided) elsewhere (and prior to 1992) in East Anglia (Arthurton et al., 1994).

During the mapping of the 1:50 000 series Sheet 162 Great Yarmouth (BGS, 1990; Arthurton et al., 1994), the following nomenclature was applied to superficial deposits of glacigenic, fluvial and coastal origin:

Corton Formation of Anglian (Elsterian) age. It comprises a sequence of glacigenic deposits including up to three units of Cromer Till, inter-vening sands, and gravels.

Lowestoft Till Formation overlies, and has a ‘discordant’ relationship with, the *Corton Formation;* it is also of Anglian age. It comprises the Lowestoft Till, the Oulton Beds and the Pleasure Gardens Till.

Breydon Formation is of Holocene age and occupies a buried valley cut through older Quaternary deposits. It comprises a sequence of peat and clay units: Basal Peat, Lower Clay, Middle Peat, Upper Clay, and Upper Peat.

North Denes Formation is also of Holocene age, and rests unconformably on the Breydon Formation (and older Quaternary formations). It comprises the deposits of a coastal barrier that extends in a tract up to 1 km wide between Caister-on-Sea and Gorleston-on-Sea, a distance of some 8 km.

The value of applying a lithostratigraphical framework for suites of lithologically and genetically variable Quaternary sediments is that it enables a relatively clear presentation of the geological history of a region.

4.7 Mass movement deposits (Table 10; Figures 2 to 4)

Level 1 Mass movement is a general term for the gravita-tional transfer of material downslope. It excludes subsidence-related movement. Movement may be slow as in solifluction (creep), or rapid as in most landslips. Mapped categories of ***mass movement deposits*** (Level 1) frequently but not always comprise compositionally and textually het-erolithic deposits. Some deposits may have a rock type qualifier, for example limestone talus (scree). Landslip is shown on 1:10 000 and 1:50 000 series BGS geological maps by vertical hatching over the underlying drift deposit or bedrock. The rest of the mapped categories are shown by a conventional drift symbol, combined with colour fill or colour edging. The boundaries are shown by a finely dashed line on geologists' 1:10 000 manuscript maps, although digital versatec plots show the boundary as a continuous fine line.

Although shown on 1:10 000 series geological maps 'Foundered Strata' and 'Rock Creep' are not included in the proposed classification scheme on the grounds that they are not superficial deposits.

The hierarchical scheme (Table 10) is described below:

Level 2 **Mass movement deposits** may be subdivided into four mapping categories (Table 10 and Appendix 2). These are *landslip, talus (scree), head and dry valley deposits*. Figure 2 illustrates types of *landslip* and associated deposits. Drift or solid material within the landslip (i.e. the slipped material) is not distinguished on the map. However, the bedrock unit(s) in the undisturbed back face, underlying the slipped material, may be shown. Figures 3 to 4 illustrate the environment of deposition of a range of both **mass movement** and **residual deposits** (see Section 4.8 below) formed under past and present periglacial conditions in mountain areas and illustrate how the classification given in the 1:10 000 scale mapping specification (BGS, 1995) may be applied.

Level 3 *Landslip, talus and head* may be further subdivided into potentially mappable categories at Level 3 (Table 10, Figure 3 and Appendix 2.1). However of these categories *landslip* is rarely subdivided on BGS maps. Borehole logs received by BGS may describe the nature of the rock type (rock type qualifier) in the mass-movement deposits, and this information may be required from the database. This information may be flagged on the face of the map.

Landslips are identified and named principally on the type of movement involved (topple, fall, slide, flow, spread or complex) and on the type of material involved (rock, debris, earth) (Figure 2). Where the original bedrock is intact, but has moved downslope, (for example some rotational slides), boreholes may record the bedrock type (see Hallsworth and Knox, 1999). Individual landslips can be defined in more specific terms where appropriate, for example where material characteristics and water content conditions (at the time of movement) are known in more detail, such as in 'earth flow' (dry loess flow) or 'earth (loess) flow'. Complex slides involving more than one type of movement can be described in terms of the sequence of the movement types, for example rock fall-debris flow, rotational slide-earthflow, or translational debris slide-debris flow. Engineering geological terms such as debris, earth and rock have precise definitions (see Appendix 2.1) which may differ from, or overlap with, current sedimentary rock classification (for example grain-size scale, Table 6; Hallsworth and Knox, 1999).

Talus may be mapped as *sheet* and *cone* deposits (Figures 2 to 4). *Head* may be divided into *hillwash deposits (colluvium),* the slope foot deposits that result from the combined action of runoff and creep, and *coombe deposits* (frost shattered chalk and flint on chalk outcrop). Although including a fluvially derived component *dry valley deposits*, shown in the 1:10 000 scale mapping specification under 'Fluvial Deposits' (BGS, 1995), are dominantly the product of solifluction processes, and are classified in the proposed scheme under the **mass movement** genetic class.

Level 4 Some of the landslip movement types (topples, falls, slides and flows) can be further subdivided. These subdivisions may be flagged on the map face, or recorded in borehole logs. However, logs derived from boreholes penetrating landslip may record the nature of the bedrock strata or superficial deposit encountered (Hallsworth and Knox, 1999).

4.8 Residual deposits (Table 11; Figures 3,4)

Level 1 For BGS mapping classification purposes, **residual deposits** include weathering products remaining in situ following alteration of the parent material by the action of chemical and/or physical weathering processes. Deposits which have been moved (usually on slopes) are classified under **mass movement deposits** (Section 4.7). Particularly but not exclusively in upland Britain **residual deposits** occur either as *block-field* or *regolith* and are the products of freeze-thaw, rock weathering in periglacial conditions. A systematic description of frost weathered deposits is given in Ballantyne and Harris (1994, Chapter 9) who describe the wide range of both **mass movement** and **residual deposits** associated with the Late Devensian periglacial and active periglacial mountain environments. Figure 3a, b illustrates the application of the basic BGS mapping classifications to mountain top and slope deposits. Figure 4 shows the application of mapping categories to a catena of slope deposits which is typical of many British mountains (a catena is a topographically controlled cover sequence of superficial deposits of approximately the same age and parent material).

Also included in the residual deposits genetic class are ore deposits in clay, formed by near surface oxidation, which in the UK include materials such as gossan, and cemented or indurated soil horizons (K horizon) formed from the precipitation of calcium and magnesium carbonates (calcrete) and other minerals carried in solution.

The hierarchical scheme (Table 11) is outlined below:

Level 2 Residual deposits are subdivided into *duricrust, blockfield, clay-with-flints* and *regolith*.

Duricrusts are not commonly found in temperate climatic zones such as in Britain today, as they are mainly formed in weathering zones in arid, semiarid and semitropical environments. Some categories (for example calcrete) are also present as sedimentary 'bedrock' (fossil calcrete).

Blockfields (felsenmeer is an obsolete term) are distinguished as an accumulation of blocks of rock, formed in upland areas by frost weathering, the mechanical disintegration of well-lithified rock as the result of repeated freezing and thawing (Ballantyne and Harris, 1994) under periglacial (glacier ice-free), cold climatic conditions (Figure 3a, b). They comprise openwork accumulations, on level or gently sloping ground, of angular to subangular blocks of rock over solid or weathered bedrock such as quartzite and microgranite. Fine-grained detritus and soil are absent from these accumulations. The susceptibility of different lithologies to frost weathering results in a wide range of particle sizes; rocks with foliation (for example schists) are more likely to weather to fine-grained components which may generally be described under the term *regolith*. Subdivisions of *regolith* are described below (Level 3).

The deposit *clay-with-flints* is defined as a reddish brown, stiff, clay containing abundant clasts of orange-brown stained nodular and broken flints, commonly associated with deposits of sand, sandy clay, silt, 'loam and pebbles' that have been mixed with the clay by solution, cryoturbation and solifluction. 'Clay-with-flints' as applied by BGS is a product of the solution of the Chalk and the incorporation of residual material from Palaeogene deposits, mainly the Reading Beds. It occurs mainly in southern England resting on, and in places filling solution pipes in, the Chalk. (Hull and Whitaker, 1861; Whitaker, 1864; Jukes-Browne, 1906; Catt, 1984; Hopson, 1996).

It is recognised that other workers may give a different definition of *clay-with-flints*. For example, Loveday (1962) defines clay-with-flints *sensu stricto* which excludes 'Plateau Drift'. That shown on BGS maps may include 'Plateau Drift' and its use is therefore in *sensu lato* (Catt,1984; Hopson, 1996).

Level 3 *Regolith* can be usefully subdivided into *weathered rock* and *saprolite* in terms of the rock weathering profile classification used by engineering geologists (Geological Society Engineering Group Working Party Reports, 1977, 1990, 1995). For relatively uniform rock materials which are moderately strong, or stronger, in their fresh state and which show a clear gradation in engineering properties during weathering, a six-fold classification of rock material weathering grades may be defined (shown diagrammatically in Table 12).

These grades are referred to, as appropriate, in the definitions of **residual deposits** (Appendix 2.2). It should be noted that weathering profiles developed in some rock sequences (for example layered strong and weak rock) may contain heterogeneous assemblages of materials at different stages of material weathering (i.e. zones containing a combination of the material weathering grades noted above). Recommended methods for describing and classifying more complex weathering profiles are given in the Geological Society Engineering Group Working Party Report, 1995. In some instances, a formal classification may not be appropriate and only a description of the weathering features may be warranted.

Duricrusts are subdivided into a number of the categories reflecting the major mineral species present. These subdivisions may be mapped separately or flagged as lithological qualifiers on the face of the map (BGS, 1995); they may also be recorded in borehole logs.

4.9 Aeolian deposits (Table 13; Figures 3b, 8, 9)

Level 1 **Aeolian deposits** include wind-blown deposits formed in a variety of depositional environments and climates. The terms used are defined in Appendix 2.3.

Level 2 The classification scheme subdivides **aeolian deposits** into the 1:10 000 scale map categories of *blown sand*, *older blown sand*, *loess* and *fluvio-aeolian silt* at Level 2. Cemented examples of blown sand are termed aeolianite.

Loess deposits are wind-blown dust accumulations which comprise homogeneous, structureless, highly porous, buff-coloured silt (Pye, 1995). They were formed in a periglacial environment and occur extensively in southern Britain (Catt, 1977). Some but not all 'brickearths' (including the terms 'head brickearth', 'river brickearth' and 'loam') shown on BGS maps may have a loessic origin (Dines et al., 1954). Brickearth and its associated terms are now regarded as obsolete, and for the purposes of the BGS map classification the term *fluvio-aeolian silt* is introduced as a separate category of either uncertain or aeolian/fluvial origin.

Level 3 *Blown sand* usually occurs in the form of *beach dune sand*. The deposits form ridges which normally lie landward of the backshore (supratidal) coastal zone (Figures 7 to 8). *Blown sand* forms a component of **coastal zone deposits** (Section 4.15; Table 20, Figures 8 to 9) which include *coastal barrier deposits* (composed of *older sand dunes*, *beach and washover deposits*). The sediments are characterised by large-scale sets of cross-bedding, and are composed of very well-sorted, fine- to medium-grained sand. The deposits retain physical and compositional characteristics of beach sands from which they are derived.

Although not used for BGS mapping purposes, *beach dune sand* may be further subdivided into a series of morphological classes (Cooper, 1967). Beach dunes may also be classified in terms of maturity and relative stability. *Embryonic dunes* or *foredunes*, formed in close proximity to the beach, are essentially incipient dunes in which coarse, sand-binding grasses such as couch and lyme initiate dune development. The next stage in dune formation is represented by *mobile* or *yellow dunes* on which marram (or marrum) grass grows. The grass partially stabilises the dunes. These dunes attain heights of tens of metres and form prominent dune ridge profiles. The ultimate dune form is that of the older *stable* or *grey dune* on which an extensive vegetation is developed. These forms have a more subdued profile compared with the mobile dune forms.

Older blown sand may be subdivided (Level 3) into Pleistocene *beach dune sand, coversands and niveo-aeolian sands*. *Coversands*, although less extensive than *loess*, are found in parts of northern and eastern England. They comprise dune bodies of well-sorted sands, are generally derived from glaciolacustrine and glaciofluvial deposits (see Section 4.16) and formed a periglacial environment (Ballantyne and Harris, 1994). *Niveo-aeolian sands* (Figure 3b) form in snowstorms under periglacial processes active today on high mountains.

4.10 Organic deposits (Tables 14, 15; Figures 5, 8b)

Level 1 In Britain there are a wide range of organic deposits of which usually only a small number of sedimentary deposits together with sedentary deposits (*peat*) are shown on BGS maps. West (1979) referred to organic deposits under the classification of 'non-glacial biogenic deposits' which he subdivided on the basis of the following characteristics.

- i the position of the deposit in relation to the free water surface or groundwater
- ii the manner of deposition: autochthonous (in situ), sedentary deposits (peats) or allochthonous (sedimentary) gyttja muds
- iii the supply of mineral nutrients to plant communities producing the deposits
- iv the topography and drainage conditions (with particular reference to peats)

Table 15 sets out some examples of organic deposits classified according to West (1979) with modifications after Lindsay (1995). Only *peat* is considered under the **organic deposits** genetic class of the superficial deposits classification scheme. Diatomite and shell marl are classified as **biological deposits** (Section 4.11). Other organic deposits, because they are not usually mapped, are omitted from the classification scheme. These include sapropelic deposits such as gyttja of the coal series (Tucker, 1991; Hallsworth and Knox, 1999) comprising jelly-like ooze or sludge composed of plant remains, (including algae), formed in anaerobic conditions in stagnant or standing bodies of water. 'Submerged Forest', also omitted from the scheme, is defined as the remains of stumps and trunks of trees visible between tide marks or detected below low water mark, still in place of growth usually in peaty soil or peat.

Level 2 In Britain extensive areas of *peat* formed during the last 10 000 years (during the Flandrian or Holocene Stage). *Peat* is also present as interbeds within earlier lacustrine and terrestrial interglacial sequences. Comprised of masses of semi-carbonized vegetation which has grown under water-logged, anaerobic conditions, in bogs or swamps, they yield important dateable indicators of former climatic conditions (for example pollen). Microscopic layers of *tephra* (volcaniclastic wind-borne deposits) may also be present within peat and lacustrine sequences (Knox, 1993).

Two principal types of mire (peat-forming ecosystems) are present in Britain. The fens of eastern England (minerotrophic mires) are supplied with water and mineral nutrients from groundwater. Bogs (ombotrophic mires) are entirely dependent upon precipitation (Lindsay, 1995; Steel, 1996).

Level 3 The classification scheme (Table 14) adopts the terminology specified by BGS (1995) which emphasises the geographical setting, topography and drainage conditions as well as the origin of the peat-forming vegetation (Table 15). Peat may accumulate in fens and in three main types of bog namely blanket bog covering large tracts of upland where the climate is wet enough, raised bog generally found in lowland areas (Figure 5a, b), and intermediate bog found in wet lowland areas which are marginal for blanket bog development (Steel, 1996). Reflecting these environments, five mapping categories shown on 1:10 000 scale maps (BGS, 1995) form the Level 3 subdivisions. These are *basin peat, hill peat, blanket bog peat, fen peat* and *peat flow* (Table 14). A sixth category *raised bog peat* is also included in the proposed Classification Scheme.

Generally dark brown or black peats formed in ombotrophic bogs (for example *blanket bog* and *hill peat*) contain recognisable vegetable fragments, but very little mineral material. These peats commonly form on flat or moderately sloping ground which is subject to high rainfall enabling plant communities to grow beyond the influence of the groundwater level. Figure 5b illustrates the development of a raised bog. High input of mineral nutrients into lowland depressions commences with the formation of *basin* and *fen peat* composed of sedge and other fen plants. When the depression is completely infilled ombrotrophic *raised bog peat* typically composed of *sphagnum* mosses begins to develop. *Bog* and *fen peats* can form in areas where the level of groundwater is high due to impeded drainage, and may also develop landward of salt marsh in coastal settings such as in East Anglia or in the Forth valley (Section 4.15; Figures 5a, 8b, c). *Peat flow* is produced in a peat bog by a bog burst. The burst is due to the release of pressure as the bog swells when water is retained in the marginal dam of growing vegetation. Bog bursts can also be initiated by landfill loading.

4.11 Biological deposits (Tables 15, 16)

Level 1 **Biological Deposits** (including some non-marine biogenic sedimentary deposits, as defined by West, 1979) are defined as being of organic origin and directly formed and characterised by living organisms which secrete either silica or carbonate to form a skeleton or shell. These sediments are shown in the 'organic deposits' genetic category of the 1:10 000 scale mapping specification (BGS, 1995).

Level 2 **Biological deposits** may be subdivided into *diatomite, shell marl, shell bank deposits* and *bio-*

clastic sand. *Diatomite* (diatom-rich sediment) and *shell marl* (freshwater shell-rich) are examples of limnic, minerotrophic, lake sediments (West, 1979; Table 15) Freshwater lake shell marls may also be referred to as shell-rich gyttja. *Shell bank deposits* and *bioclastic sand* are marine deposits composed of broken and fragmental remains of organisms including shells, coral and *lithothamnium* algae. Subdivisions of unlithified shallow marine shelf carbonate sediments including shell bank deposits are referred to by means of ornament on BGS 1:10 000 series maps.

4.12 Chemical deposits (Table 17)

Level 1 **Chemical deposits** are defined as sediments formed primarily of precipitation from solution or colloidal suspension or by the deposition of insoluble precipitates. This genetic class overlaps with the **residual deposits** (*duricrusts*; Table 11) and **lacustrine deposits** (Table 19) classes. The latter includes non-carbonate salts which are described in Hallsworth and Knox (1999).

Level 2 For the purposes of the superficial deposits classification scheme only nonglacial, inorganic sediments (as defined by West, 1979) including tufa (sinter, travertine) and *manganiferous/ferruginous deposits* are considered as Level 2 subdivisions.

Level 3 **Tufa**, including deposits of springs, may be further subdivided on the basis of chemical composition into *calcareous* and *siliceous types*. *Tufa* together with *bog iron ore,* a porous earthy form of limonite (impure hydrous ferric oxide), are currently depicted by symbol on 1:10 000 series maps (BGS, 1995). Many other mineral species form in superficial deposits accumulating in bogs, swamps, lakes and marine environments. Examples include vivianite (hydrated ferric phosphate) and the manganiferous/ferruginous oxide minerals such as wad (manganese oxides) and umber (brown earth). These minerals, although recognised in the field and by analytical means, are not mappable deposits and are therefore not included in the classification scheme.

4.13 Alluvial deposits (alluvium) (Table 18, Figure 6a, b)

Level 1 **Alluvial deposits** (*synonymous with alluvium*) embraces the 'fluvial deposits' genetic category of the 1:10 000 scale map specification (BGS, 1995). Included within this genetic class are all water-borne deposits of rivers and streams not specifically associated with glacial processes operating in the **proglacial** and **glacigenic** environment (see Sections 4.16 and 4.17).

Level 2 **Alluvial deposits** (alluvium) are divided into *fluvial deposits* and *alluvial fan deposits* at Level 2. In Britain, alluvial deposits are the erosion products of streams and rivers derived from bedrock and other superficial deposits. Deposits of this genetic class may also be present within sequences of interglacial deposits, and facility for differentiating these is provided in the 1:10 000 series map specification (BGS, 1995) which specifies a superscript symbol to the basic genetic symbol. Warp is a category of artificially induced alluvium not differentiated in the classification scheme. *Alluvial fan* (or cone) *deposits* are laid down as fans of predominantly coarse sediment by ephemeral streams which feed to larger streams and rivers.

Level 3 **Fluvial deposits** may be further subdivided into *terrace deposits* which may be symbolised as undifferentiated or as successively older terraces on 1:10 000 series geological maps (BGS, 1995; Figure 6a). Other subdivisions, such as overbank/floodplain, levee, bar and channel deposits (Figure 6b), are not normally shown on BGS 1:10 000 series maps. Grain size and grain morphology of deposits are related to provenance, depositional environment (current velocity and water depth are important factors) and sediment input to river and stream systems.

4.14 Lacustrine deposits (Table 19; Figure 12 - glacilacustrine setting)

Level 1 **Lacustrine deposits** are defined as the equivalent of the 1:10 000 scale map specification 'lacustrine deposits' genetic category (BGS, 1995). Lakes are standing-water bodies, filled with freshwater or water of varying degrees of salinity. Thus in the lacustrine environment there is a transition from lakes with a wholly clastic input to those with significant salt precipitation. The latter process is of limited importance in Britain during temperate and glacial climatic regimes. Non-carbonate salts are considered in detail in Hallsworth and Knox (1999).

Level 2 The classification scheme divides **lacustrine deposits** by depositional environment including *deltaic, beach* and *shoreface deposits*. The last two named categories are combined in a single class distinguished by suffix letter in the 1:10 000 scale map specification (BGS, 1995). Deltaic deposits are shown with a delta suffix. Deltaic deposits can be subdivided into fluvial-, wave- and tidal-dominated types, but this classification is not used on BGS maps. *Glaciolacustrine* deposits are considered under **proglacial deposits** (Table 22; Figure 12). Facility for differentiating interglacial lacustrine deposits is provided in the 1:10 000 scale map specification (BGS, 1995) which specifies a superscript symbol to the basic genetic symbol.

4.15 Coastal zone deposits (Table 20; Figures 7 to 9)

The present system for depicting coastal zone deposits on the 1:10 000 series geological maps uses a series of symbols (BGS, 1995), common to land survey usage, with a suffix to depict specific depositional environments. In the subtidal zone, the units may be further defined by their geometry (for example sheet or bank).

This scheme is workable above the low water mark for the terrain is observable and can be classified using air photographs and field observations. A specific problem of this part of the zone is its variability on a seasonal and historic basis, thus lines accurately drawn may soon become less accurate.

A more severe problem arises in the subtidal zone (below the low water mark) which is normally not visible, and where acoustic techniques provide a guide to the form and lithology of the sea bed. In UK settings and with currently available BGS published maps, data are rarely sufficiently closely spaced to allow a detailed geological interpretation at 1:10 000 scale. The exceptions are those areas covered by Hydrographic Office side-scan sonar surveys, but access to these data may be restricted for security reasons. In general, there is rarely time available to examine these data in the detail required to portray it on a 1:10 000 scale map. Commonly, the data do not extend landward to the low water mark.

For these reasons the scheme outlined below considers the intertidal and supratidal parts of the **coastal zone deposits**. A pragmatic scheme for the subtidal part of the zone and adjoining continental shelf is presented within a **marine deposits** genetic class (Section 4.16). A clear morphological or sedimentological distinction cannot always be drawn between the lower part of the subtidal zone and the rest of the continental shelf, and the two are considered as one for mapping purposes.

Level 1 The classification scheme employs the term **coastal zone deposits** which may be equated with the mapping terminology, and is taken to include all intertidal and supratidal deposits. Subtidal deposits are not classified in this scheme. **Coastal zone deposits** includes all deposits of the nearshore environment including foreshore, backshore, estuary (*intertidal deposits*) and saltmarsh/lowland hinterland (*supratidal deposits*) (Table 20; Figures 7 to 9). Wind-blown deposits within this zone are classified under the **aeolian deposits** genetic class except where they cannot be differentiated (for example *coastal barrier deposits* category, see below).

Facility for separating interglacial marine deposits is provided in the 1:10 000 scale map specification (BGS, 1995) which specifies a superscript symbol to the basic genetic symbol. The specification also defines *raised marine deposits* with a unique basic symbol appropriately qualified by suffix and subscript. A difficulty here is deciding whether these deposits are purely marine, that is subtidal, or intertidal. In the latter case they would represent a sub-set of the **coastal zone deposits** but in the former they would represent a sub-set of the **marine deposits** (described in Section 4.16 below).

Level 2 **Coastal zone deposits** can be subdivided in a number of ways and the scheme below (modified from Reineck and Singh, 1973) employs only basic mapping categories which can be defined in relation to the influence of tidal conditions appropriate to British coasts. Two categories are used at Level 2 of the heirachy.

- *supratidal deposits* laid down on the backshore between the highest point of active coastal processes (for example the inland limit of an active shingle ridge or saltings) and the spring tide Mean High Water Mark(MHWM) as defined by the Ordnance Survey).
- *intertidal deposits* laid down on the foreshore between the MHWM and the spring tide Mean Low Water Mark (MLWM).

The topographically lower limit of the intertidal deposits is taken here at Mean Low Water Mark (MLWM), the low water limit shown on Ordnance Survey 1:10 000 and 1:25 000 series maps. However, the low water mark may extend lower than this during Spring Tides, and on Hydrographic Office charts the zero datum is set even lower at the level of the Lowest Astronomical Tides (LAT). The relationship between these datums should be shown in the marginalia of any map containing details of the intertidal zone.

Level 3 Most of the Level 2 categories can be subdivided into categories of mappable deposits (Level 3) which are defined on morphological and compositional characteristics (Figures 7 to 9). It is recognised that some categories of deposits will overlap to landward of the Mean High Water Mark (MHWM), for example shingle ridges or salt marsh.

Supratidal deposits of the backshore comprise storm *beach deposits, washover fans, coastal barrier deposits, chenier deposits* and *salt marsh*. *Washover fan deposits* consist of mainly sand deposited by the action of overwash produced by storm waves on the landward side of a bar or barrier beach (Figure 9b, c). *Coastal barrier deposits* comprise a complex of Holocene (but older than present day) accumulations of blown sand, beach and washover sediments where these deposits cannot be differentiated (Figure 9b, c). *Beach dune sand* (see **Aeolian deposits**) ('blown sand' of the 1:10 000 scale map specification) normally forms as dune ridges in the backshore zone or on barrier islands (Figures 7 to 9).

In the intertidal (foreshore, Figure 7a, b) zone *salt marsh* and *tidal flat* deposits develop in estuaries, lagoons and bays (Figure 8a, b) or behind barrier islands (Figure 9) along gently dipping sea coasts with marked tidal rhythms where enough sediment is present and strong wave action is not present (Reineck and Singh, 1973). The interdigitation of sediments that formed in intertidal flat, salt marsh and fen areas in response to fluctuating Flandrian sea-level changes is well documented, for example in coastal fenland areas of the Wash, East Anglia (Gallois, 1994; Figure 8b) and in the Carse of Stirling (Sissons and Smith, 1965). *Tidal river, channel or creek deposits* formed within channels in coastal mudflats and lagoons can be filled with sediments of a wide range of grain sizes from muddy sand to mud. *Beach deposits* show regular variations or zones of energy conditions across the foreshore down to the shoreface, as reflected in sand grain-size curve patterns. *Shell bank deposits* are considered elsewhere (Table 16).

'Deltaic deposits' are recognised in the 1:10 000 scale map specification (BGS, 1995) and can be depicted with the use of a delta symbol suffix to the basic symbol. Currently, except for lacustrine (Section 4.14), glaciolacustrine and glaciomarine (Section 4.17) deposits, the deltaic classification is not used on BGS 1:10 000 series maps.

4.16 Marine deposits (Table 21)

Marine deposits are generally not visible, and acoustic means are generally employed to determine their morphology. Sampling aids the acoustic approach in determining the lithology of the material at sea bed (Fannin, 1989). The main problem in this environment is that the lines of traverse are rarely close enough to map accurately the various morphologies. The exception to this occurs in areas covered by Hydrographic Office side-scan sonar surveys, where traverse lines are usually sufficiently close to cover all the ground. However, such is the density of data that the geologist rarely is afforded time to map the ground at the 1:10 000 scale. The scheme outlined below is for areas where Hydrographic Office side-scan surveys are not used, and data are scarce in relation to that obtainable by observation onshore. The scheme is applicable for all the continental shelf below Mean Low Water Mark (MLWM).

Level 1 **Marine Deposits** are the unconsolidated sediments that cover the sea bed beneath the fully marine areas of any water depth. No distinction is made here for the purpose of the 1:10 000 scheme for sediments between supratidal or oceanic depth sediments, although no 1:10 000 series maps currently extend coverage to oceanic depths.

A problem commonly faced is deciding the limits of an unit which has a feather edge. On side-scan sonar records sediment bodies a few centimetres thick may show as broad sheets, whereas on seismic profiles units less than about 0.5 to 1 m thick cannot be mapped extensively. The procedure adopted here follows the land mapping precedent of only mapping units that are 1m or more in thickness. Thus, for marine deposits the limits of bodies deduced from seismic profiles are afforded greater value for determining the limits of bodies than those deduced from side-scan sonar records

Level 2 The simplest division of **marine deposits** is based on lithology. The general subdivision adopted by BGS is the Folk (1954) triangular diagram (Table 8c) dividing the sediments on the basis of their mud, sand and gravel proportions. Decisions may be according to sample density as to whether to simplify the categories on the diagram. Where the sediments are predominantly muddy the Folk classification is based on clay, silt and sand ratios, but it is rare that sufficient analyses are available of the clay/silt ratio to use this scheme.

Level 3 Further subdivision of the units depends on available data, and full subdivision at this level is not recommended lest geological linework becomes contrived and of limited importance. The scheme recommends that Level 3 divisions listed below should be added where possible, but areas should be left blank where data or ease of classification limit the geologist's ability to draw the line with confidence.

The primary division is based on bedforms with categories including *sand wave field, mega-ripple field, sand ribbons, sand patches, sand banks*. Additional information such as the orientation of the sand wave or mega-ripple crest lines, the asymmetry of the bedforms and their wavelength and amplitude, could also be added to the map face. Gravel-rich sediments may be formed into waves. Muddy sediments commonly show no bedforms but may display signs of mass movement, the limits of which might be mappable. A wide range of other features may be observable at sea bed and these include pock marks, comet marks extending from upstanding features, cold-water coral reefs, bioherms, and made ground disturbed by trawling or dredging. The list here is not comprehensive and the geologist should be allowed to develop the opportunity to map new features as they arise using a BGS-approved convention.

4.16.1 Mapping areas with Hydrographic Office side-scan sonar coverage

A significant part of the UK inner continental shelf has a complete side-scan sonar coverage collected by the Hydrographic Office. Such is the density of this data, with individual lines spaced at 150 m or less, that there is rarely time to interpret all the data available for inclusion in the 1:10 000 series maps. However, mapping at 1:25 000 scale has been carried out in some areas. The Hydrographic Office interpretations carried out since the mid-1980s are of high quality and in most cases can be used with no requirement to resort to the original data. The data, and especially the side-scan sonar interpretations, are confidential and permission from the Hydrographic Office is required before the data can be used on a map.

Where the unconsolidated sediment cover is thin or absent the records may show an abundance of bedrock features at the sea bed, and some mapping of lithology and structure may be possible. The quality of the interpretation is significantly greater where seismic lines and bedrock samples are also available.

4.16.2 Mapping areas of older Quaternary deposits

In many areas of the continental shelf, the sediments at the sea bed are underlain by older Quaternary deposits. These are most commonly recognised using seismic-reflection techniques that allow sediments of different physical types to be identified, and mapped, from their distinguishable acoustic characteristics. Using this technique, a seismic stratigraphy can be established and, based on experience, possible or probable lithologies can be assigned to the units. Ideally, there is core or borehole information which allows a more-precise lithological description to be applied to the seismic unit, although this may involve relatively long-range extrapolation. Seismic profiles can also provide evidence of sedimentary processes such as delta formation or mass-flow, and glaciomarine sedimentation can be proposed for typically well-layered units.

4.17 Proglacial deposits (Table 22; Figures 10 to 15)

Level 1 Included within this genetic class are all sediments deposited by meltwaters in the proglacial environment (that is deposits formed directly within or under glacier ice are excluded). In general, **proglacial deposits** can be described as water-borne, sorted sediments which range in grain size from clay to cobble grade depending upon the energy of the depositional environment and sediment input. The 1:10 000 scale map specification (BGS, 1995) places these deposits together with those of **glacigenic** origin (Section 4.18 below) within a single category 'Glacial deposits'.

Level 2 **Proglacial deposits** are divided into three categories defined by the dominant depositional processes. These are *glaciofluvial sheet and channel deposits* (fluvial environments), *glaciolacustrine deposits* (glacial lake environments) and *glaciomarine deposits* (coastal and near-shore environments).

Level 3 Sediments characteristic of specific depositional environments are shown at Level 3. These include outwash deposits (sandur) of river plains (Figures 10, 11, 15) (equivalent to 'glaciofluvial sheet deposits' of BGS, 1995) together with *beach deposits, subaqueous fan deposits* and *deltaic deposits* of glacial lakes and marine waters (Figures 12 to 13). These categories can be recognised by associated morphogenetic landforms (such as terraces, sandur and valley trains) which are commonly depicted either by suffix to the basic mapping symbol or by form lines on 1:10 000 Series geological maps (BGS, 1995).

Some sedimentological characteristics typify the unique conditions under which the sediments can be laid down. For example *glaciolacustrine deltaic lake bottom* sediments may exhibit varved lamination, reflecting seasonal input of sediments of different grain size and composition (De Geer, 1912; Eyles and Eyles, 1992; Figure 12). There is however considerable overlap in the sedimentology exhibited by the Level 3 categories, for example glaciofluvial outwash and fluvial terraces, and fluvial deposits defined under other genetic classes including **alluvial deposits** (Table 18) **lacustrine deposits** (Table 19) and **glacigenic deposits** (Table 23). *Subaqueous fan deposits* could be regarded either as of **proglacial** or as of **glacigenic** origin; typically they are laid down as laterally overlapping esker fans in a body of standing marine or fresh water from subglacial tunnels at the margin of a glacier (Rust and Romanelli, 1975; Figure 13b).

4.18 Glacigenic deposits (Tables 23 to 26; Figures 10, 11, 13 to 16)

Level 1 In the BGS 1:10 000 scale map specification (BGS, 1995) **glacigenic deposits** are considered within the broader category of 'glacial deposits'. The classification scheme described here defines **glacigenic deposits** as sediments laid down within or under glacier ice or deposited by an ice sheet.

Level 2 **Glacigenic deposits** are subdivided into three categories (Level 2): *ice-contact glaciofluvial deposits* which for the most part are water-borne, sorted sediments; glacially deposited *till (undifferentiated)/glacial diamicton:* and *morainic deposits* which may include both water-laid and glacially dumped materials.

Level 3 *Ice-contact glaciofluvial deposits* and *morainic deposits* may be subdivided into a series of morphogenetic classes (Level 3) (Figures 13 to 16). *Ice-contact glaciofluvial deposits* are divided on morphological grounds into *kame and kettle deposits* and *esker deposits* (Figure 14). The former comprise kames (mounds or hummocks) of mainly water sorted sand and gravel formed at the margin of melting glaciers and kettles (hollows) caused by the melting of blocks of stagnant ice. Eskers comprise a series of sinuous ridges of sand and gravel that formed in streams flowing between ice walls in subglacial and englacial tunnels. Eskers can also form in supraglacial streams let down into the glacier (Saunderson, 1975). The scale of landforms is variable. Thus, in Britain esker ridges are typically up to 10 km long and 5 to 20 m high (see Auton, 1992). In continental areas of Scandinavia and Canada, esker 'trains' can be up to 500 km long.

Till is deposited directly by and deformed underneath a glacier. It consists predominantly of diamicton, a mixed, unsorted sediment of sand and coarser grains set in a clay/silt matrix (see Section 4.2; Table 24). Till may be subdivided into a series of purely genetic categories (Level 3), recognisable on the basis of physical parameters. These include *lodgement, deformation, flow* and *melt-out tills*. The BGS 1:10 000 scale map specification (BGS, 1995) recognises *deformation till* as broadly defined by Elson (1961) but more recently, a detailed classification scheme for subglacially deformed materials was devised by Banham (1977) (Figure 16). The characteristics of till and morainic deposits are described in detail by Bennett and Glasser (1996) (Tables 25, 26). Of the many categories of moraine only *hummocky moraine* is currently shown on BGS maps. This category together with *push moraine* are presented in the superficial deposits classification scheme. BGS maps also show drumlins (Table 26) and other features such as glacial striae and roche moutonnée that are indicative of ice flow direction. A full treatment of **glacigenic deposits**, including till classifications, is given in Goldthwaite and Matsch (1989).

4.19 Lithological and morphological description of natural superficial deposits of unclassified origin

Landform, compositional and textural descriptions (Table 4b) form an integral part of the description of all the genetic classes defined above (Sections 4.7 to 4.18). Such descriptions may also be applied where the origin of a deposit is uncertain and no genetic classification can been applied.

Level 1 *For deposits of unclassified origin* (Table 4b), a classification may be given in terms of *composition* (lithology and texture) (Section 4.2) and/or *landform* (Section 4.3).

Level 2 Level 2 categories provide a basis for a nongenetic description of the sediment. The many categories of onshore landforms and features may be depicted on 1:10 000 Series geological maps (BGS, 1995) by means of form lines. Where an origin of a deposit is defined, option is provided for suffix letters to be attached to the basic lithogenetic mapping symbol. Acoustically identified bedforms of **marine deposits** in the subtidal zone and continental slope are discussed in Section 4.16. For composition, a textural definition is possible where observational or particle size analysis data allow an assessment of grain size ranges to be made (Section 4.2; Tables 4b, 7, 8).

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APPENDIX 1 GLOSSARY OF COMMONLY USED TERMS FOR ARTIFICIAL (MAN-MADE) GROUND

Most of the categories at Level 4 of the artificial (man-made) ground classification scheme are self explanatory, others less so. The listings comprise the categories most commonly encountered, at this 'material' level, in site investigation records and during field survey; it is not exhaustive, and it is assumed that further categories will be added. Categories of waste are listed in the UK Waste Classification Scheme (DETR/EA, Draft for Consultation, 1998). The first level categories in this scheme are shown in Table 2a. Natural materials are commonly a component of artificial deposits. For definitions see Section 4 and Appendix 2 of this report or the appropriate section of the BGS Rock Classification Scheme (Gillespie and Styles, 1999; Hallsworth and Knox, 1999).

Definitions are based on:

The Concise Oxford dictionary of earth sciences. 1990. Allaby, A, and Allaby, M (editors). (Oxford: Oxford University Press.)

Penguin dictionary of geology. 1972. Whitten, D G A, and Brooks, J R V. (Harmondsworth: Penguin Books.)

The concise Oxford dictionary. (6th edition. 1976). Sykes, J B (editor). (Oxford: Oxford University Press.)

aggregate in the building industry: a range of mineral substances, for example sand, gravel, crushed rock, stone, slag and other minerals which, when cemented, forms concrete, mortar, mastic, plaster. Uncemented, it can be used to as a bulk material in road-making and ballast

asbestos waste waste material derived from of asbestos products or their manufacture

ash general term for powdery residue left after combustion of any substance (also used geologically for volcanic particles less than 2mm in size; (see Gillespie and Styles, 1999)

ballast coarse stone mixed with sand etc. Used to form bed of railway or substratum of road

bell pit in mining, a bell-shaped excavation in which the extracted material was dragged to a central shaft; an obsolete method for extracting mineral deposits from shallow depths. Disused bell pits are usually collapsed and/or partly backfilled with rock waste

building rubble waste material derived from construction, usually consisting of brick, concrete, stone and plasterboard with minor amounts of wood and metal. May be partly organic in content

blast-furnace slag semi-fused or fused waste material produced in the metal industry

brick clay kneaded, moulded and baked (fired) or sun-dried; usually a small, rectangular block

cardboard thick paper or paste board

ceramic waste (undifferentiated) waste material from the pottery and ceramic industries, commonly comprising partly fired and fired clay products

chemical waste (undifferentiated) waste material, and by-products derived from the chemical industry and chemical processes

china clay waste kaolin and waste materials derived from the extraction of kaolin from granitic rocks

clay waste generally clayey material usually containing at least 20% by weight of clay particles (less than $^{1}/_{16}$ mm in size according to the scale of Wentworth, 1922)

clinker semi-fused or fused, hard foundry slag; stony residue from burnt coal

coal shale colliery waste, generally of a fissile shaly nature.
colliery waste also known as *spoil; tip and bing* (Scotland) heterolithic waste material produced from the mining of coal or associated ironstone and fireclay; commonly a mixture of mudstone, siltstone, sandstone, carbonaceous 'shale' and coal, with minor amounts of ironstone. May contain secondary minerals such as pyrite and sulphur

domestic/garden refuse undifferentiated organic and inorganic waste

effluent waste liquid flowing from a sewage tank or industrial process etc

fill general term for material used to infill a void or cavity in the earth's surface or sub-surface; constructional fill (made ground) is material placed above the natural earth surface

foundry sand or sand waste, may be impregnated with organic materials produced in the metal and glass industries

foundry slag semi-fused or fused waste material produced in the metal and glass industries

furnace ash residue left after the combustion of any substance, but commonly coal in metallic blast furnaces

garden waste predominantly organic waste including woody materials, grass and soil

herbicide substance toxic to plants and used to kill unwanted vegetation

industrial waste (undifferentiated) waste products from industrial processes

landfill site waste disposal site used for the controlled deposit of the waste onto or into land

landraise site a specific type of landfill site (see above) where the waste is deposited on the pre-existing natural ground surface; the deposit is classified as made ground in the BGS Rock Classification Scheme

mine dumps (tailings) inferior part of ore or mineral or surrounding rock, usually deposited close to the mine (see mineral waste)

mineral waste (undifferentiated) general term for the waste products of mining and surface mineral workings

mine stone (synonym: **spoil;** see also **colliery waste**) generally the inorganic material commonly used for ballast or aggregate. May be partly organic in content

oil shale waste waste products from the mining of dark grey or black shale containing organic substances that yield liquid hydrocarbons on distillation

organic waste (undifferentiated) waste materials containing carbon compounds, such as wood, plant materials, coal

paper substance made from compacted interlaced fibres of rags, wood, straw

pesticide substance used for killing pests, especially insects

plasterboard board with a core of plaster for walls

pulverised fuel ash (pfa) pulverised (fine grade) ash waste from the burning of coal, usually in coal-fired power stations; commonly used as an inert fill material, or for the production of breeze blocks

quarry waste general term for waste materials consisting mostly of rock with overburden drift deposits, derived from quarrying (see rock waste, slate waste, shale waste)

radioactive waste general term for waste materials derived from nuclear processes that are contaminated with radionuclides; may be classified as low-level, intermediate or high-level waste

rock waste general term for waste materials consisting mostly of rock, derived from quarrying or excavation

sewage sludge solid waste material from sewage treatment works**shale waste** waste material derived from quarrying or mining of fissile mudstone (for example alum shale, bituminous shale)

slate waste waste material derived from quarrying or mining of slate (cleaved, fissile, low-grade metamorphosed mudstone)

spoil earth material (rock or unconsolidated sediment) thrown up or brought up in mining, excavating or dredging (synonym **mine stone**, which consists predominantly of **colliery waste**)

toxic waste poisonous waste

waste general term for superfluous material (refuse) and by-products of manufacturing, mineral extraction, or physiological process, no longer serving a purpose, and which the holder discards or intends or is required to discard. Some categories of waste, however, may constitute a re-useable resource, for example **colliery waste (spoil)** which is re-used (and re-classified as **mine stone**) as a fill material, or **pfa** (mixed with cement) re-used as a grouting material

APPENDIX 2. GLOSSARY OF COMMONLY USED TERMS FOR NATURAL SUPERFICIAL DEPOSITS

Definitions of terms used in the Natural Superficial Deposits Classification Scheme Levels 1-3 are based on specialist texts (see References and text) and the following dictionaries and handbooks:

The concise Oxford dictionary (6th Edition). 1976. Sykes, J.B. (editor). (Oxford: Oxford University Press).

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Appendix 2.1 Mass movement deposits (Table 10; Figures 2 to 4)

colluvium (see **hillwash**)

complex landslip landslips which exhibit at least two types of movement (falling, toppling, sliding, flowing, spreading) in sequence. Many landslips are complex, although one type of movement may dominate over the others at certain areas within a slide or at a particular time (for example: rockfall-debris flow).

coombe deposits solifluction and gelifluction deposits (head) found in some valleys on chalk and other limestone bedrock (coombe rock, where cemented)

debris in engineering geology terminology, predominantly coarse, usually superficial, material in which more than 50% of the fragments are greater than 2 mm (i.e. predominance of gravel to boulder-sized material)

debris cone (see **talus cone**)

dry valley deposits (obsolete: Nailborne Deposits) superficial deposits derived dominantly by solifluction processes in valleys cut into porous rocks, particularly limestones. Deposits may have a fluvially derived component

earth in engineering geology terminology, fine-grained material in which more than 50% of the fragments are less than 2 mm (i.e. sand, silt and clay-sized particles); includes a wide range of materials from non-plastic sand to highly plastic clay

falls landslip involving the detachment of a mass of rock or soil from a steep slope along a surface on which little or no shear displacement takes place. The material then descends largely through the air by falling, saltation or rolling (see also **rock fall**, **debris fall**, **earth fall**)

flows landslip comprising a spatially continuous movement in which surfaces of shear are short-lived, closely spaced and not usually preserved. The distribution of velocities in the displacing mass resembles that in a viscous fluid whereby intergranular movements predominate over shear surface movements. Two broad categories of flows, 'debris flow' and 'earth flow', may be distinguished based on the predominance of coarse or fine material. A mudflow is a type of earth flow that is wet enough to flow rapidly and that contains at least 50% of sand-, silt- and clay-sized particles. Flows may be wet or dry and exhibit a wide range of movement rates from very slow (about less than 1.5 m/yr) to extremely rapid (more than 3 m/sec)

gelifluction deposits (see **head**)

head (solifluction and **gelifluction deposits**) 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. The flow is initiated by meltwater from thawing ice lenses

hillwash (colluvium) slope-foot deposits formed as the result of runoff and creep

landslip (synonym: **landslide**) the relatively rapid movement of a mass of rock, earth or debris down a slope

mass movement (on slopes) the outward and downward gravitational movement of earth material on slopes without the aid of running water as a transportational agent.

(This definition does not deny the importance of water or ice, as destabilising factors. It excludes subsidence and other mass movement on flat ground.)

rotational slide type of slide characterised by movement along a curved, concave-upwards failure surface; this imparts a back-tilt or into-slope dip to the slipped mass which thus sinks at the rear and heaves at the toe

rock as used in landslip terminology: hard or firm rock that was intact and in its natural place before the initiation of movement

slides landslip involving the downslope movement of a rock or soil mass occurring dominantly on surfaces of rupture or relatively thin zones of intense shear strain (slip, shear or failure surfaces) which may be curved or planar. (See also **rotational slide, translational slide**.)

soil in engineering geology terminology, includes any loose or poorly cemented aggregate of solid particles, either transported or residual in origin. May be divided into **debris** and **earth** depending on dominance of coarse or fine material, respectively

solifluction deposits (see **head**)

spreads a classification of landslip in which movement involves the fracturing and lateral extension of coherent material, either bedrock or soil, owing to liquefaction or plastic flow of subjacent material. The zone of failure is not a well-defined shear surface. The coherent upper units may subside into softer underlying material and in doing so may rotate, tilt and eventually disintegrate. The term 'spreads' may also be used generally to qualify the description of a wide range of areally extensive superficial deposits

talus (synonym: **scree**) the accumulation of angular rock fragments derived from steep rock slopes or cliffs by the mechanical weathering of the rock mass. The mass of talus is formed as a result of transport by gravity over short distances. Usually forms heaps or irregular **talus sheets** of coarse debris at the foot of steep slopes/cliffs (see also **talus cone**). Talus deposits include fallen rock debris, but here they are distinguished from landslip ('rockfall') deposits in that they are accumulations resulting largely from the spalling of rock fragments of all sizes due to natural weathering processes. They are not primarily due to rock falls which are usually joint-bounded masses or blocks breaking away from unstable slopes and triggered by non-weathering events such as seismic shocks and oversteepened scarps

talus cone (synonym: **debris cone**) matrix-supported or matrix-rich, cone-like accumulation of rock fragments of any size or shape at the foot of a gully or chute in a cliff or steep slope. Formed by mass-movement–rainwash, sheetwash, debris flow, mudslide or avalanche

talus sheet (see **talus**)

topples landslip involving the forward rotation, out of the slope, of a mass (or block) of rock or soil about a pivot point or axis at the base of the affected mass

translational slide type of slide involving movement along a more-or-less planar failure surface. Movement is commonly controlled by a shallow plane of weakness (for example a bedding plane or the contact between bedrock and overlying detritus) running roughly parallel to the slope of the ground. The moving mass has little or none of the backward-tilting characteristics of a rotational slide and the moving mass may commonly slide out on the original ground surface

Appendix 2.2 Residual deposits (Tables 11 and 12, Figures 3, 4)

blanket head (see **regolith**)

blockfield (obsolete: felsenmeer) in situ, or nearly in situ, accumulation of frost-shattered openwork rock blocks of different sizes and shapes on level or gently sloping mountain surfaces, derived from subjacent bedrock. The formation of blockfield is dependant on rock lithology and structure. Frost-susceptable, foliated rocks (for example schists) will break down to finer grained detritus (regolith). Blockfields *sensu stricto* are openwork and are characterised by the absence of soil accumulations

calcrete (synonym: **caliche**) an indurated deposit (**duricrust**) mainly consisting of Ca and Mg carbonates. The term includes non-pedogenetic forms produced by fluvial or groundwater action; they may be pedogenetic by lateral or vertical transfer. Subdivisions are usually made on the basis of degree and type of cementation (for example powder, nodular, concretionary)

clay-with-flints a reddish brown, stiff, clay containing abundant clasts of orange-brown stained nodular and broken flints, commonly associated with deposits of sand, sandy clay, silt, loam and pebbles that have been mixed with the clay by solution, cryoturbation and solifluction. 'Clay-with-flints' as applied by BGS is a product of the solution of the chalk and the incorporation of residual material from Palaeogene deposits, mainly the Reading Beds. It occurs mainly in southern England resting on, and in places filling solution pipes in the chalk (Hull and Whitaker, 1861; Whitaker, 1864; Jukes-Browne, 1906; Catt, 1984; Hopson, 1996). It is recognised that other workers may give a different definition of clay-with-flints. For example, Loveday (1962), defines clay-with-flints *sensu stricto* which excludes 'Plateau Drift'. That shown on BGS maps may include 'Plateau Drift' and its use is therefore is *sensu lato* (Catt,1984; Hopson, 1996)

duricrust an indurated product of surface and near-surface processes formed by cementation or replacement of bedrock, weathering deposits, unconsolidated sediments, soil or other materials produced by low-temperature physiochemical processes

ferricrete (synonym: **iron laterite, iron pan**) a form of indurated deposit (duricrust) consisting predominantly of accumulations of iron sesquioxides. It may form by deposition from solution, moving laterally or vertically, or as a residue after removal of silica and alkalis. The terms 'carapace' for moderate induration and 'cuirrasse' for high induration may be used. The deposit may be pedogenetic by retention or accumulation of minerals and by segregation within vadose profiles. Groundwater forms are pisolitic. Subdivisions are based on degree and type of induration (for example pisolitic, scoriaceous and vesicular, petroplinthite)

gossan near-surface, iron oxide-rich zone overlying a sulphide-bearing ore deposit, caused by the oxidation and leaching of sulphides

iron laterite (see **ferricrete**)

iron pan (see **ferricrete**)

mature soil weathered material in which all semblance of original texture and structure has been lost: those soils falling into weathering Grade VI (residual soil) and including pedological soil horizons A and B

regolith (synonym: **blanket head**) general term used to describe the in situ or nearly in situ weathered products (including disintegrated rock, rock fragments and mineral grains) overlying fresh or relatively fresh rock (the weathered mantle). Can be subdivided into **weathered rock** and **saprolite**, and classified according to engineering geological weathered rock grades (see **weathered rock, saprolite** and **residual soil**)

residual deposit weathering product remaining in situ following alteration of the parent material by the action of chemical and/or physical weathering processes

residual soil material derived from in situ rock weathering in which all trace of the original rock texture, fabric and structure has been destroyed; this represents a more advanced stage of weathering than saprolite; those deposits falling into engineering geological weathered rock material Grade VI and comprising pedological soil horizons A and B

saprolite highly to completely weathered materials derived from the in situ alteration and decomposition of parent rock mainly by chemical weathering processes, but which retain evidence of the original rock texture, fabric and structure: classified as engineering soils falling into rock weathering Grades IV (highly weathered) and V (completely weathered), that is, those weathering grades where more than 50% of the parent rock material is decomposed or disintegrated to soil

weathered rock weathered material which, depending on degree of disintegration, may be described in terms of rock material weathering grades Grade II (slightly weathered), Grade III (moderately weathered), Grade IV (highly weathered), Grade V (completely weathered), Grade VI (residual soil). In engineering geological terms slightly to moderately weathered material falling into weathering Grades II and II are considered as weathered 'rock' for engineering purposes, and Grade IV to VI material as 'soil'. **Saprolite** refers to soil-like Grade IV and V material which has been altered and decomposed by chemical weathering processes

Appendix 2.3 Aeolian deposits (Table 13, Figures 7 to 9)

aeolian deposits (synonym: **wind-blown deposits**; obsolete: eolian) sediments which have been deposited by wind. Aeolianite is the cemented form

beach dune sand backshore deposits of well-sorted, wind blown sand, which can be subdivided on the basis of morphology into transverse, oblique, parabolic forms

blown sand sand that has been transported by wind; sand consisting predominantly of wind-borne particles

coversands periglacial aeolian blanket deposits of lowland areas comprising fine- to very fine-grained sand, usually horizontally bedded but may form subaerial dunes with large-scale cross-bedding. Size sorting is not as marked as in coastal beach dune sands

dune mobile accumulation in the form of a ridge, bank or hill generally of sand

fluvio-aeolian silt (obsolete: brickearth, head brickearth, river brickearth, loam) loess-like, usually structureless, deposit of primarily aeolian silt/very fine-grained sand which has been moved, redeposited and/or modified in situ by various secondary processes (for example fluvial, colluvial, pedogenic processes). Deposits may be variably sandy or clayey, but retain a dominant particle size within the coarse silt to very fine-grained sand range (see also **loess)**

loess a widespread, homogeneous,commonly unstratified, porous, friable,unconsolidated but slightly coherent, usually highly calcareous fine -grained, blanket deposit (generally less than 30 m thick) of marl or loam, consisting predominantly of silt with subordinate grain sizes ranging from clay to fine sand

niveoaeolian sand massive (unbedded) sands deposited by wind in heavy snow storms

older blown sand comprises Pleistocene **beach dune sands** and **coversands**

Appendix 2.4 Organic deposits (Tables 14; 15; Figures 3b, 5, 8b)

bog waterlogged, spongy ground containing acidic decaying vegetation consisting primarily of sphagnum mosses and sedges that may develop into peat

basin peat peat formed of decomposed plants growing in a minerotrophic mire or swamp occupying hollows, valley bottoms or lake basins fed by inorganic mineral nutrients from groundwater (see also **fen peat**)

blanket peat bog peat of an ombotrophic mire, with little or no input of inorganic mineral nutrients, covering stable features of original surfaces on long slopes and gentle ridges subjected to high rainfall (see also **hill peat**)

fen peat peat formed of decomposed fen plants including sedges growing in a minerotrophic mire or swamp which is fed by inorganic mineral nutrients from groundwater. The peat contains little or no sphagnum

hill peat upland blanket peat, as occurs particularly on plateau mountain tops

peat partially decomposed mass of semi-carbonized vegetation which has grown under waterlogged, anaerobic conditions, usually in bogs or swamps

peat flow a flow of peat produced in a peat bog by a bog burst. The burst is a response to the release of pressure as the bog swells due to the retention of water by a marginal dam of growing vegetation or for anthropogenic reasons (for example by landfill loading)

raised bog peat a bog with thickest accumulation of peat in the centre. The surface is largely covered by sphagnum mosses which because of their high degree of water retention make the bog more dependent on the rainfall than on the water table. A raised bog peat may develop over a basin infilled with fen peat

swamp low waterlogged ground with shrubs and trees. Partial decomposition of swamp vegetation to form peat will occur under oxygen-deficient (anaerobic) conditions

Appendix 2.5 Biological deposits (Tables 15, 16)

bioclastic sand sand composed of broken and fragmental remains of organisms including shells, coral and *lithothamnium* algae

biological deposits directly formed and characterised by living organisms which secrete either silica or carbonate to form skeleton or shell (included with sedimentary biogenic deposits as classified by West, 1979)

diatomite dense chert-like deposits formed of single-celled siliceous plants which lived in either marine or freshwater (consolidated equivalent of diatomaceous earth and indurated diatom ooze)

shell bank deposits mound-like or ridge-like deposit consisting of largely unbroken shells, mainly in situ

shell marl (synonym: **shell-rich gyttja**) a light coloured calcareous deposit formed in fresh-water lakes and composed largely of uncemented mollusc shells and precipitated calcium carbonate, along with the hard parts of minute organisms

Appendix 2.6 Chemical deposits (Table 17)

chemical deposits sediments formed primarily by precipitation from solution or colloidal suspension or by the deposition of insoluble precipitates

duricrusts see Table 11 and Appendix 2.2

ferruginous/manganiferous deposits deposits formed in a variety of environments comprising mixtures of hydrated ferric and managnese oxides and other oxides

tufa (synonym: **sinter, travertine**) sedimentary rock composed of calcium carbonate or silica, formed by evaporation as a thin, surficial, soft, spongy, cellular or porous, semifriable encrustation around the mouth of a hot or cold spring or seep, or along a stream carrying calcium carbonate in solution, or exceptionally as a thick, bulbous concretionary or compact deposit in a lake or along its shore. It may also be precipitated by algae or bacteria

Appendix 2.7 Alluvial deposits (alluvium) (Table 18; Figure 6)

alluvial deposits (synonym: **alluvium**) (obsolete: warp, artificially induced alluvium) general term for clay, silt, sand, gravel. Unconsolidated detrital material deposited by a river, stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta, or as a cone or a fan at the base of a mountain slope

alluvial fan deposits (synonym: **alluvial cone**) low, outspread, relatively flat to gently sloping mass of loose rock material, shaped like a fan or segment of a cone. Deposited by streams at the mouths of tributary valleys onto a plain or broad valley

fluvial deposits sedimentary deposits consisting of material transported by, suspended in, and laid down by a river or stream

interglacial fluvial deposit fluvial deposits of pre-Late Devensian age. May be differentiated on 1:10 000 Series geological maps (see BGS, 1995)

terrace deposits alluvium forming one of a series of level surfaces in a stream or river valley, produced as the dissected remnants of earlier abandoned floodplains

Appendix 2.8 Lacustrine deposits (Table 19; Figure 12 - glaciolacustrine setting)

lacustrine beach deposits intertidal zone deposits comprising mainly sand with subsidiary gravel

interglacial lacustrine deposit pre-Late Devensian lacustrine deposits (may be differentiated on 1:10 000 Series geological maps)

lacustrine deltaic deposits a coarsening upward sequence of sediments laid down in a prograding delta at the fluvial-lacustrine boundary as fluvial current velocity is dissipated. The deposits comprise sand, silt, clay, and the remains of brackish water organisms and organic matter. Deltaic deposits can be subdivided in a variety of ways, for example by fluvial, wave and tidal influence

lacustrine deposits laid down as deltaic, lake bottom and shore sediments in lakes. Includes clastic deposits, composed of coarse-grained bedload and suspended fine-grained material brought by streams flowing into lakes. Under arid and semiarid conditions evaporites form an important component of lake sediments

lacustrine shoreface deposits sands and gravels distributed within a narrow steeply sloping zone by oscillating waves and changing currents. The zone spans the area from the low-water shoreline to fair-weather wave base

Appendix 2.9 Coastal zone deposits (Table 20; Figures 7 to 9)

beach deposits intertidal zone deposits consisting mainly of sands with subsidiary gravels; shell fragments may be present

beach dune sand see Table 13 and Appendix 2.3

chenier deposits sand occupying a long, low, narrow, wooded, beach ridge or hummock which forms roughly parallel to a prograding shoreline, resting on peat or clay. Width varies from 40 to 400 m and length can be several tens of kilometres

coastal barrier deposits comprise a complex of pre-present day Holocene accumulations of blown sand, beach and washover sediments where these deposits cannot be differentiated

deltaic deposits a coarsening upward sequence of sediments laid down in a prograding delta at the fluvial-marine boundary as the fluvial current velocity is dissipated. The deposits comprise sand, silt and clay. Deltas can be subdivided into fluvial-, wave- and tidal-dominated depositional environments each of which has a characteristic morphology. Progradation gives rise to topset, foreset and bottomset beds

interglacial marine deposits marine (including coastal) deposits of pre-Late Devensian age

intertidal deposits sediments laid down on beaches and tidal flats or in estuaries, lagoons, bays and behind barrier islands along gently dipping sea coasts

raised marine deposits isostatically uplifted marine (including coastal) deposits which crop out in part above high water mark

salt marsh deposits (synonym: **merse deposits**, Scotland) dominantly very fine-grained sand and mud, interbedded shell layers, plant roots and irregular wavy bedding deposited on flat, poorly drained land that is subject to period or occasional flooding by saline or brackish water. The saltmarsh is usually covered by a thick mat of grassy, halophitic plants

sandbar low ridge of sand, formed by longshore currents in the subtidal zone that borders and parallels the shore and is built up to the water surface by wave action

storm beach deposits low rounded ridge of coarse materials (gravels, cobbles and boulders) piled up by very powerful storm waves at the inland margin of a beach, above the level reached by normal spring tides

supratidal deposits lowland hinterland deposits lying at or above normal high water level including **storm beach ridges, coastal barrier deposits, washover fans** and **salt marsh deposits**

tidal flat (including **mud flats** and **sand flats**) an extensive nearly horizontal marshy land in the intertidal zone that is alternately covered and uncovered by the rise and fall of the tide, consisting of unconsolidated sediment (mainly mud and/or sand). May form the top surface of a deltaic deposit

tidal river or **creek deposits** (synonym: **tidal channel deposits**) sediments comprising a range of grain sizes from mud to sand, deposited within channels in tidal flats and lagoons

washover fan a fan-like or lobate body of sediment, usually of sand, deposited on the landward side of a bar or a barrier separating a lagoon from the open sea, produced by storm waves. Spreads of sand deposits can build up from overlapping fans

Appendix 2.10 Marine deposits (Table 21)

marine deposits taken to include subtidal (shoreface) deposits and deposits of the adjoining continental shelf; muds, silts sands and gravels deposited below Mean Low Water Mark (MLWM) including acoustically determined bedforms

Appendix 2.11 Proglacial deposits (Table 22; Figures 10 to 15)

beach deposits (see **glaciomarine deposits**; Appendix 2.8 **lacustrine deposits** and 2.9 **coastal zone deposits**)

deltaic deposits (see Appendix 2.8 **lacustrine deposits** and 2.9 **coastal zone deposits**)

glaciofluvial sheet and channel deposits mainly sand and gravel deposited by meltwater streams flowing from wasting glacier ice; typical landforms include terraces and outwash (sandar) plains (see **outwash deposits**)

glaciolacustrine deposits (synonym: **glacilacustrine deposits, glacial lake deposits**) laid down in glacial lakes. Composed of coarse-grained bedload and suspended fine-grained material transported by meltwater flowing into lakes bordering the glacier. Deposits include sands, silts and clays of deltaic origin, shoreface sand and gravel and lake bottom varved, fine-grained (fine sand, silt and clay) sediments. Dropstones from floating ice are a common feature

glaciomarine deposits (synonym: **glacimarine deposits**) sediments, glacial in origin, deposited in marine waters. Fine-grained (silt and clay) deposits of subtidal sea-bed environments may or may not contain marine macro/micro fauna and may have been deposited from suspension in cold freshwater plumes (fed by meltwaters) within saline waters. Such deposits have a high clastic content derived from glaciers. Dropstones from floating ice are common (Figure 13). Coarse-grained deposits (sand and gravel) are present as intertidal beach and subtidal (shoreface) deposits

outwash deposits (synonym: **sandur** - singular, **sandar** - plural) stratified detritus of coalescing outwash fans, mainly sand and gravel removed or washed out from a glacier by meltwater streams and deposited in front of or beyond the margin of an active glacier on the outwash plain

subaqueous fan deposits stratified sand and gravel deposited by glacial meltwater issuing from the glacier margin in a body of standing marine or fresh water (Figure 13)

subtidal/ sea-bed deposits (see **glaciomarine deposits**)

terrace deposits (see Appendix 2.7 **alluvial deposits**)

Appendix 2.12 Glacigenic deposits (Tables 23 to 26 Figures 10, 11, 13 to 16)

deformation till (synonym: **shear till, squeeze flow till**) *sensu lato* (Elson,1961) weak rock or unconsolidated sediment detached and deformed by subglacial shearing under the sole of a glacier involving the plastic deformation, squeezing or pressing of glacial debris (diamicton). Deformation till may also be associated with endiamict glacitectonite (Banham 1977) which consists of materials so highly attenuated by subglacial shear that all primary structures have been destroyed and the material homogenised (see Figure 16)

esker deposits long, low, narrow, sinuous, steep-sided ridges or mounds composed of irregularly stratified sand and gravel deposited by a subglacial or englacial streams flowing between ice walls of a glacier (Figure 14). In Britain, esker ridges range in length from less than a kilometre tens of kilometres, and in height from about 5 to 20 m

flow till glacial debris moved mainly by gravity flow upon its release from glacier ice

glaciofluvial ice contact deposits stratified sand and gravel and interbedded diamicton deposited by meltwater and ice under (subglacial), within (englacial) and at the margins of glaciers (see **kame and kettle deposits, esker deposits**)

glacitectonite (see **deformation till**)

hummocky moraine an area of mound-and-hollow topography that may have been formed either along an active ice front or by masses of stagnant ice (see **morainic deposits**; Table 26)

ice-contact glaciofluvial deposits stratified drift deposited in contact with melting glacier ice, such as an esker, kame, kame terrace or delta usually marked by numerous kettles

kame and kettle deposits irregular mound (kame) and hollow (kettle) terrain is the characteristic morphology of ice-contact deposition of sand and gravel (Figure 14). The deposits were laid down over and adjacent to bodies of ice

lodgement till usually overconsolidated, geotechnically stiff to hard till. It has been formed beneath a glacier as successive layers of glacial debris (ill-sorted rock flour and gravel to boulder grade, generally referred to as diamicton) plastered upon bedrock or other glacial deposits, by pressure melting and/or other mechanical processes

melt-out till deposits produced by the slow release of subglacial or englacial debris from ice that is no longer sliding or deforming internally

morainic deposits (moraines) rock material which has been carried and deposited and/or pushed/thrust by glacier ice. The deposits are recognised by various characteristic landforms (Table 26), and are variably composed, depending on the material which has been picked up by the ice. Some moraines are dominated by water-sorted stratified, sand and gravel, some by till (diamicton)

push moraine a broad,smooth, arc-shaped morainal ridge consisting of material mechanically pushed or by an advancing glacier (see **morainic deposits**; Table 26)

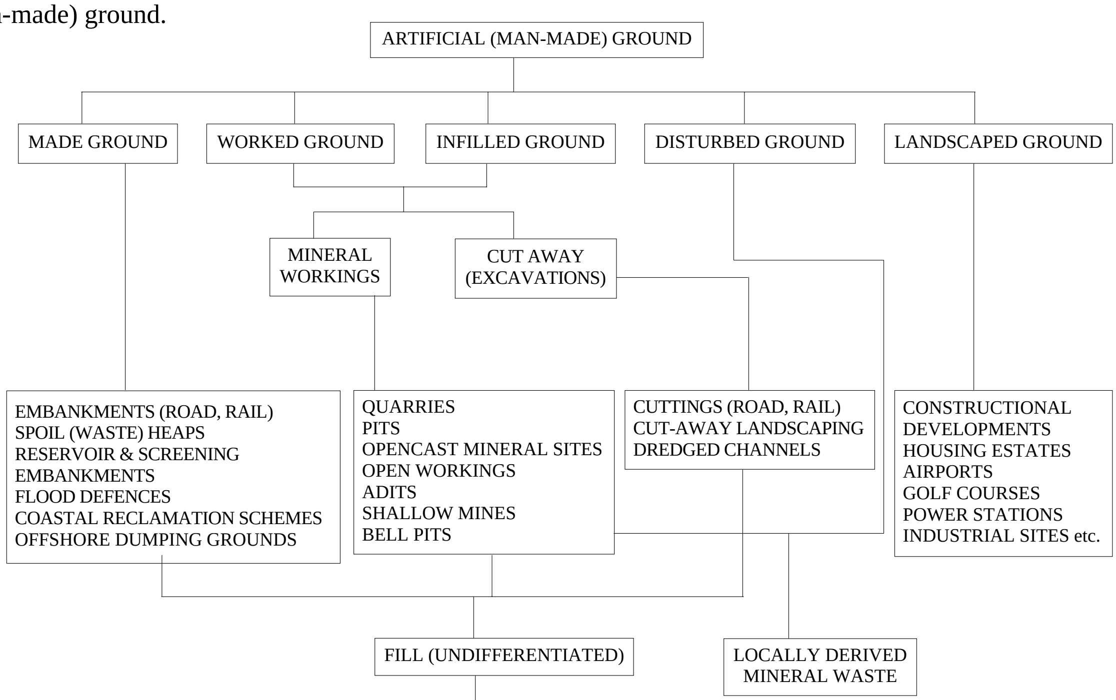
till (synonym: **boulder clay**) (obsolete: pinnel). unsorted and unstratified drift, generally overconsolidated, deposited directly by and underneath a glacier without subsequent reworking by water from the glacier. It consists of a heterogenous mixture (diamicton) of clay, sand, gravel, and boulders varying widely in size and shape (see Section 4.2)

Table 1 Artificial (man-made) ground.

LEVEL 1

LEVEL 2
BGS MAPPING
SUBDIVISION (shown
on 1:10 000 MAPS)

LEVEL 3
TOPOGRAPHICAL/GEOGRAPH-
ICAL
CATEGORY (may be flagged
on fieldslip or on 1:10 000 map,
or recorded on borehole log)



LEVEL 4
MATERIAL TYPE (DEPOSIT)
(may be flagged on fieldslip or 1:10 000 map or
recorded on borehole log)
Categories of waste composition have been defined in the
DETR/EA draft UK Waste Classification Scheme (1998);
see Table 2a for the main (first level) categories of waste

LIST OF COMMONLY USED TERMS FOR WASTE/FILL IN THE UK (See Appendix 1)

AGGREGATE	21
ASBESTOS WASTE	26
ASH	27
BALLAST	24
BLAST-FURNACE SLAG	27
BRICK	21
BUILDING RUBBLE	22
CARDBOARD	22
CERAMIC WASTE	21
CHEMICAL WASTE (undifferentiated)	28,29, 30
CHINA CLAY WASTE	21
CLAY (BRICK/TILE) WASTE	21
CLINKER	27
COAL SHALE	27
COLLIERY WASTE (SPOIL)/MINE STONE	27
DOMESTIC/GARDEN REFUSE	22
EFFLUENT	22
FOUNDRY SAND	24
FOUNDRY SLAG	27
FURNACE ASH	27
GARDEN WASTE	22
HERBICIDE	29
INDUSTRIAL WASTE (undifferentiated)	many categories
MINE DUMPS (tailings)	27
MINERAL WASTE (undifferentiated)	27
OIL SHALE WASTE	27
ORGANIC WASTE (undifferentiated)	29
PAPER	22
PEAT	22
PESTICIDE	29
PLASTERBOARD	22
PULVERISED FUEL ASH	27
QUARRY WASTE	27
RADIOACTIVE WASTE	31
ROCK WASTE	21
SEWAGE SLUDGE	22
SHALE WASTE	27
SLATE WASTE	27
SOIL	22
SPOIL	27
TOXIC WASTE (undifferentiated)	many categories
WOOD	20

(numbers refer to categories of the first category UK Waste Classification Scheme; Table 2a)

Table 2 UK Waste and European Community Landfill Site Classification Schemes.

a. The UK Waste Classification Scheme.
(Draft for consultation)
Index to the first category of waste[1]

Cat No	Category of Waste (first level)
21	Inert
22	General and biodegradable
23	Metals and discarded (scrap) composite equipment
24	Contaminated general
25	Healthcare risk wastes
26	Asbestos
27	Mineral wastes and residues from thermal processes not listed elsewhere
28	Inorganic chemical
29	Organic chemical
30	Mixed chemical "small"
31	Radioactive
32	Explosives

[1] For further subdivisions and categories see: The UK Waste Classification Scheme DETR/Environment Agency; Draft for Consultation (version consulted is Draft 16, July 1998)

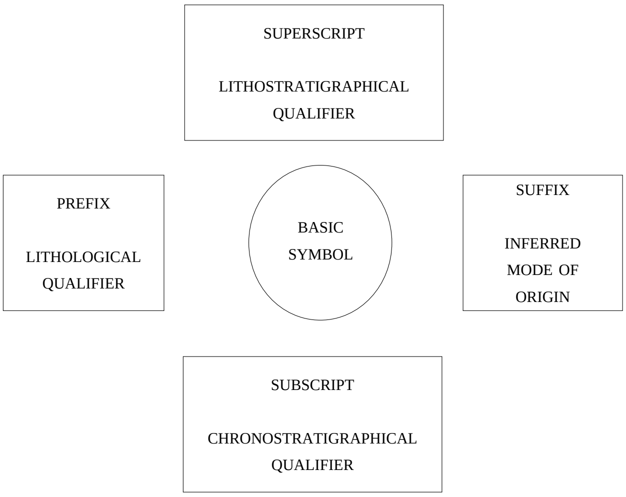
b. Landfill Site Classification (European Community).**

i	Hazardous waste
ii	Municipal and non-hazardous waste and other compatible waste
iii	Inert Waste

** This classification is not recommended for mapping of artificial ground due to the possibility of mixing materials during uncontrolled fill

Table 3 Guidelines for symbols used on BGS 1:10 000 series maps (BGS, 1995).

The basic graphic symbols may be embellished as appropriate using the following guidelines:



Prefix As a general rule an attempt should be made to incorporate information on the lithological character of the deposit within the symbol it if is not adequately covered in the legend. In some cases, such information is implicit in the meaning of the basic graphic symbol, for example, Shell Marl. Where this is not the case, and where the predominant lithology is known, or has been interpreted with confidence, that lithology (or, if necessary, lithologies) should be indicated as a letter prefix to the graphic symbol, using small capitals according to the following code for the common lithologies:

c	clay
z	silt
M	silt and clay (mud of marine usage)
s	sand
G	gravel
B	boulders

Combination of the letter codes may be used as appropriate, for example:

SG	sand and gravel
CB	clay and boulders

Superscript If named lithostratigraphical units can be recognised only locally, then the approved letter symbol for that unit (or an abbreviation) should be a superscript. The superscript may also be used to identify specific terrace deposits by number or letter symbol as appropriate.

Subscript Where there is a need to convey information on the inferred age of a deposit, this may be shown as a subscript, example F for Flandrian LD for Late Devensian, in small capitals.

Suffix If the depositional environment is not implicit in the basic graphic symbol and not explained in the legend, then this information may be conveyed by the use of a suffix in small capitals according to the following codes.

A	Active
B	Bank
BA	Basin
BL	Blanket
BU	Buried
C	Channel
CB	Coastal Barrier Complex
D	Deformation
DV	Dry Valley
E	Estuarine
F	Fen
FT	Flat
FW	Flow
GS	Gravitational Slide
H	Hill
I	Inactive
IC	Ice Contact
IM	Ice Marginal
IN	Intertidal
IT	Ice Thrust
L	Lodgement
MO	Melt-out
O	Overflow
R	Regolith
RI	River or Creek
S	Shoreface
SB	Storm Beach
SF	Submerged Forest
SG	Subglacial
SM	Saltmarsh
ST	Sheet or Tabular
SU	Subtidal
T	Terrace
W	Warp
WO	Washover
Δ	Fan or Delta

Table 4a Genetic subdivisions of natural superficial deposits.

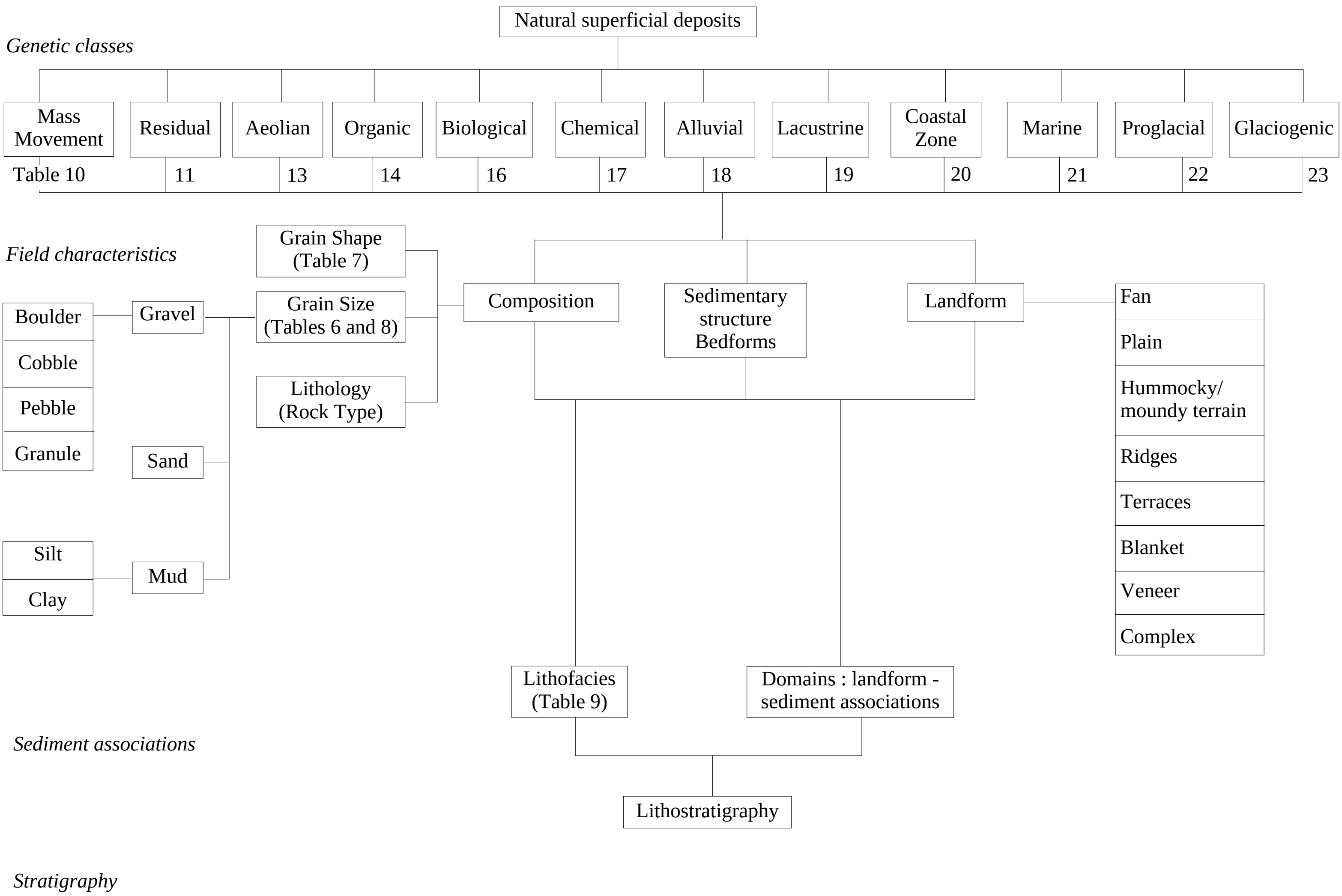


Table 4b Classification of deposits of unclassified origin.

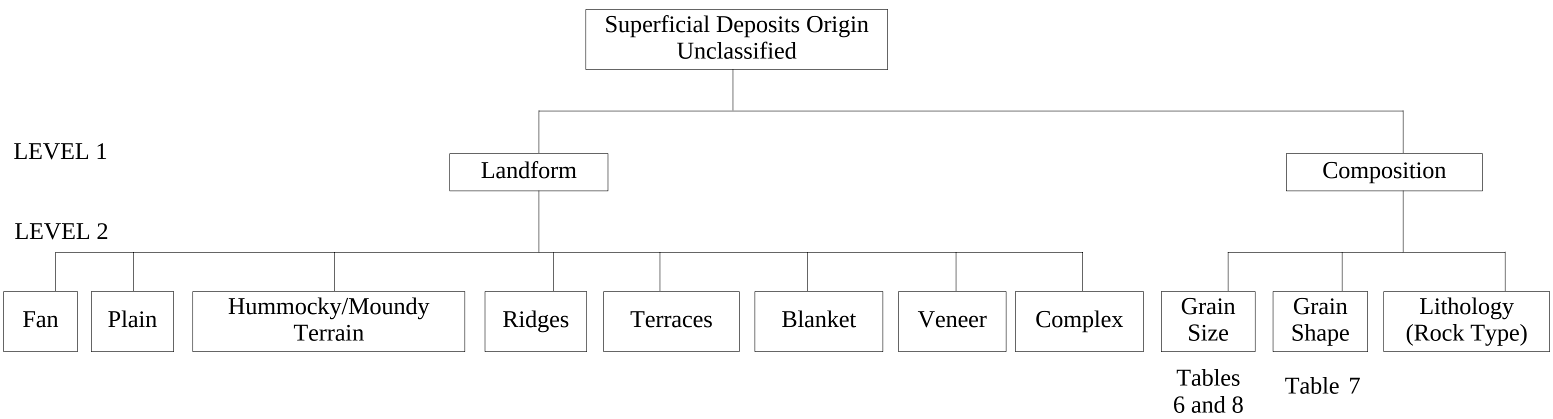


Table 5 Classification of natural superficial deposits and BGS (1995) mapping specification categories.

Notes:

1 Nongenetic textural classification (see below) ‘Deposits of unclassified origin’ may be applied to definitions of the genetic terms.

2 Interglacial deposits are classified under the appropriate categories of Alluvial, lacustrine and coastal zone deposits

Level 1 Genetic class	Level 2	Level 3	BGS (1995) genetic class	BGS (1995) map specification: category (depicted by basic symbol)	Synonyms
Mass movement deposits	*Landslip*	*Falls*	Mass movement, gravitational accumulates and residual deposits	Landslip	Landslide
		Topples			
		Slides			
		Spreads			
		Flows			
		Complex			
	(not superficial deposits)			Foundered strata	
				Rock creep	
	Talus (scree)	*Talus sheet*		Scree	Talus *sensu lato*
		Talus cone		Debris cone	Talus cone
	Head	*Hillwash deposits* (Colluvium)		Head	
		Coombe deposits (Coombe rock, where cemented)		Coombe deposits	Combe deposits
		Dry valley deposits (may include of fluvially-derived component)		Dry valley deposits (currently classified as Fluvial Deposits in the 1:10k Spec.)	Nailborne deposits
Residual deposits	*Blockfield*			Blockfield	
	Regolith (blanket head)	*Weathered rock* (Weathering Grades II - VI in situ		Blanket head	Regolith
		Saprolite (Weathering Grades IV - V)			
	Clay-with-flints			Clay-with-flints	
	Duricrust	*Calcrete*		Calcrete (shown with lower case letters as a rock unit)	Caliche
		Gossan		categories not currently shown on BGS Onshore 1:10k series maps	
		Ferricrete			Iron laterite, Iron pan

Table 5 ***Page 2***

Level 1 Genetic class	Level 2	Level 3	BGS (1995) genetic class	BGS (1995) map specification: category (depicted by basic symbol)	Synonyms
	Blown Sand (Aeolianite, where cemented)	*Beach dune sand*		Blown sand	
	Older blown sand	*Coversands*		Older blown sand	
Aeolian deposits		*Niveo-aeolian sand*	Aeolian deposits		
	Loess			Loess	
	Fluvio-aeolian silt			Brickearth	
				Peat, undifferentiated	
		Blanket bog peat		Blanket peat	
	Peat	*Hill peat*		Hill peat	
Organic deposits		*Raised bog peat*			
		Basin peat		Basin peat	
		Fen peat		Fen peat	
		Peat flow		Peat flow	
	(not a superficial deposit)	deposits	Organic submerged forest		
	Shell marl			Shell marl	Shell-rich gyttja
	Diatomite			Diatomite	
Biological deposits	*Shell bank deposits*			Shell bank (shown as a Marine Deposits ornament)	
	Bioclastic sand deposits			Carbonate-rich sand (shown as a Marine Deposits ornament)	
	Tufa	*Calcareous tufa*		Tufa	Travertine Sinter
Chemical deposits		*Siliceous tufa*	Chemical deposits		
	Manganiferous/ ferruginous deposits	*Bog iron ore*		Bog iron ore	

Table 5 ***Page 3***

Level 1 Genetic class	Level 2	Level 3	BGS (1995) genetic class	BGS (1995) map specification category (depicted by basic symbol)	Synonyms
Alluvial deposits	*Fluvial deposits*		Fluvial deposits	Alluvium, undifferentiated	
		Fluvial terrace deposits		River terrace deposits (numbered as superscript in order of increasing age)	
				River terrace deposits, undifferentiated	
	Alluvial fan deposits			Alluvial fan deposits	Alluvial cone deposits
	(not classified as a separate category)			Warp	Artificially induced alluvium
	(See **mass movement deposits**)			Dry valley deposits	Nailborne deposits (obsolete)
Lacustrine deposits			Lacustrine deposits	Undifferentiated	
	Lacustrine deltaic deposits			Lacustrine delta deposits	
	Lacustrine beach deposits			Lacustrine shoreface and beach deposits	
	Lacustrine shoreface deposits				

Table 5 ***Page 4***

Level 1 Genetic class	Level 2	Level 3	BGS (1995) genetic class	BGS (1995) map specification category (depicted by basic symbol)	Synonyms
Coastal zone deposits			Marine Deposits	Undifferentiated	
	Intertidal deposits	*Beach deposits*		Shoreface & beach deposits	
		Tidal river or creek deposits		Tidal river or creek deposits	Tidal channel deposits
		Tidal flat deposits		Tidal flat deposits	
		Saltmarsh deposits	Saltmarsh deposits		
	Supratidal deposits	*Storm beach deposits*		Storm beach deposits	
		Washover fan		Washover deposits	
		Coastal barrier deposits		Coastal barrier deposits	
		Chenier deposits		Chenier shell bank (shown as an Marine deposits ornament)	
	Deltaic deposits (mapping classification is normally applied only to lacustrine, glaciolacustrine and glaciomarine deposits)			(Δ suffix to basic symbol)	
Marine Deposits (deposits of the subtidal zone and continental shelf)	Classified lithologically (Folk, 1954; see below 'Deposits of unclassified origin')	subdivided into bedforms: sandwave field megaripple field sand ribbons sand patches sand banks		Bank deposits (shown with the suffix B to marine deposits symbol) Tabular or sheet deposits(shown with the suffix ST to marine deposits symbol)	

Table 5 ***Page 5***

<table>
<tr><th>Level 1
Genetic class</th><th>Level 2</th><th>Level 3</th><th>BGS (1995)
genetic class</th><th>BGS (1995)
map specification
(depicted by basic symbol)</th><th>Synonyms</th></tr>
<tr><td rowspan="8">Proglacial deposits</td><td rowspan="2">Glaciofluvial sheet and channel deposits</td><td></td><td rowspan="17">Glacial deposits</td><td>Glaciofluvial deposits</td><td>Fluvioglacial</td></tr>
<tr><td>Outwash deposits (sandur)</td><td>Glaciofluvial sheet deposits</td><td></td></tr>
<tr><td rowspan="3">Glaciolacustrine deposits</td><td>Beach deposits</td><td>Glaciolacustrine deposits</td><td>Glacial lake deposits</td></tr>
<tr><td>Deltaic deposits</td><td rowspan="3">Glaciofluvial deltaic (and/or subaqueous fan) deposits</td><td rowspan="3"></td></tr>
<tr><td>Subaqueous fan deposits</td></tr>
<tr><td rowspan="3">Glaciomarine deposits</td><td>Deltaic deposits</td></tr>
<tr><td>Beach deposits</td><td rowspan="2">Glaciomarine deposits</td><td rowspan="2">Glacimarine deposits</td></tr>
<tr><td>Subtidal sea-bed deposits</td></tr>
<tr><td rowspan="9">Glacigenic deposits</td><td rowspan="2">Glaciofluvial ice-contact deposits</td><td>Kame and kettle deposits</td><td rowspan="2">Glaciofluvial ice-contact deposits</td><td rowspan="2"></td></tr>
<tr><td>Esker deposits</td></tr>
<tr><td rowspan="4">Till (glacial diamicton)</td><td>Lodgement till</td><td rowspan="4">Till</td><td rowspan="4">Boulder clay</td></tr>
<tr><td>Deformation till</td></tr>
<tr><td>Flow till</td></tr>
<tr><td>Melt-out till</td></tr>
<tr><td rowspan="2">Morainic deposits</td><td>Hummocky moraine</td><td>Hummocky (moundy) deposits</td><td>Hummocky moraine</td></tr>
<tr><td>Push moraine</td><td></td><td rowspan="2"></td></tr>
<tr><td></td><td></td><td>Undifferentiated Glacial deposits</td></tr>
</table>

Table 5 ***Page 6***

Level 1 Genetic class	Level 2	Notes	BGS (1995) genetic class	BGS (1995) map specification (depicted by basic symbol)	Notes
Deposits of unclassified origin	*Diamicton*	May be subdivided on sand to mud ratio of matrix and gravel content (Hambrey, 1994) (Table 24) or by lithofacies (Eyles et al, 1983) (Table 9)	Miscellaneous deposits (nongenetic terms)	* Diamicton	* in the BGS (1995) map specification only terms marked with an asterisk are depicted by a basic symbol: other terms are shown by use of a prefix letter code
	*Sand and gravel***	** gravel may include cobble and boulder grade material		* Sand and gravel (of uncertain age/origin)	
	Boulders	Qualified by grain-size distribution (Table 6). Different ratios and grain-size definitions have been applied to BGS sand & gravel resource assessments based on ‘fines’ (silt & clay), sand and gravel end members (see Table 8a,b) ** gravel may include cobble and boulder grade material		Boulders	
	Cobbles			Cobbles	
	Silt			Silt	
	Clay			Clay	
	Mud (silt and clay)			Mud (silt and clay)	these sediment classification terms (modified after Folk, 1954) are used on BGS Offshore sea-bed sediment maps, Table 8c
	Sandy mud			Sandy mud	
	*Gravelly mud***			Gravelly mud	
	Sand			Sand	
	Muddy sand			Muddy sand	
	*Gravelly muddy sand***			Gravelly muddy sand	
	*Gravelly sand***			Gravelly sand	
	*Gravel***			Gravel	
	*Muddy gravel***			Muddy gravel	
	*Muddy sandy gravel***			Muddy sandy gravel	
	*Sandy gravel***			Sandy gravel	

Table 6 British Geological Survey Grain Size Scheme

Phi units	Clast or crystal size in mm log scale	Sedimentary clasts		Volcaniclastic fragments or Sedimentary	Crystalline rocks Igneous, Metamorphic
		boulders		blocks & bombs	very-coarse grained
-8	256	cobbles			
-6	64	pebbles	G R A V E L	lapilli	very-coarse crystalline
-4	16				coarse-grained
-2	4	granules			coarse-crystalline
-1	2	very-coarse-sand	S A N D	coarse-ash-grains	medium-grained
0	1	coarse-sand			
1	0.5 (1/2)	medium-sand			medium-crystalline
2	0.25 (1/4)	fine-sand			fine-grained
3	0.125 (1/8)	very-fine-sand			fine-crystalline
5	0.032 (1/32)	Silt	M U D	fine-ash-grains	very-fine-grained very-fine-crystalline
8	0.004 (1/356)	clay			cryptocrystalline

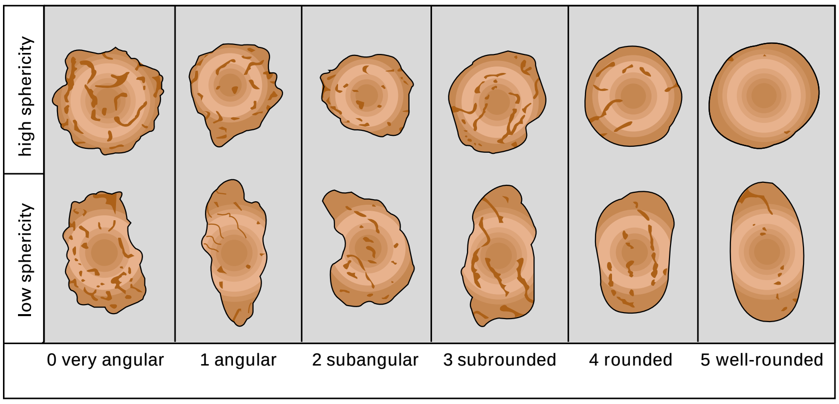
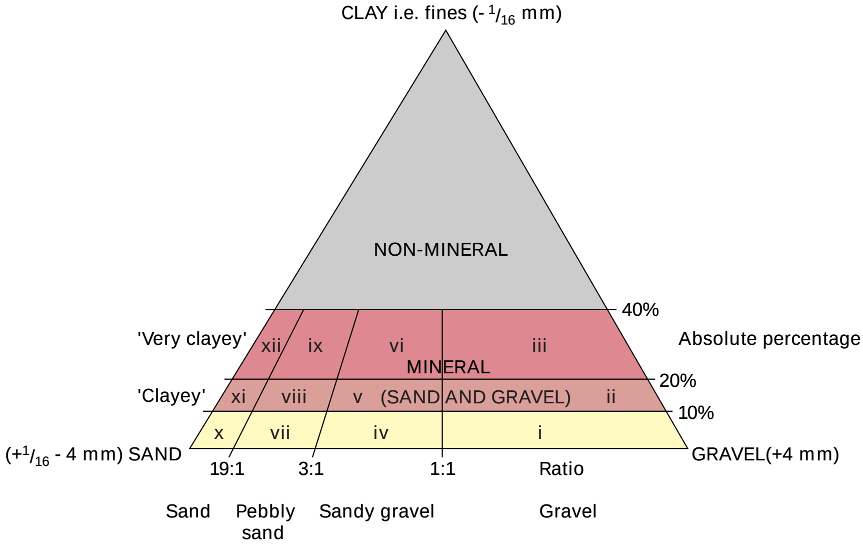


Table 7 Categories of roundness for sediment grains (after Powers, 1953; Tucker, 1991 and Pettijohn et al., 1987).

a.

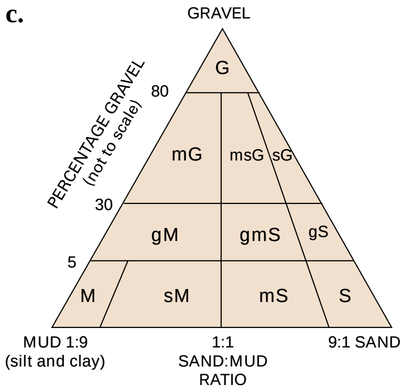
Size limits	Grain size description	Qualification	Primary classification
	Cobble		Gravel
64 mm	Pebble	Coarse	
16 mm		Fine	
4 mm	Sand	Coarse	Sand
1 mm		Medium	
$^1/_4$ mm		Fine	
$^1/_{16}$ mm	Fines (silt and clay)		Fines

b.



i Gravel	iv Sandy gravel	vii Pebbly sand	x Sand
ii 'Clayey' gravel	v 'Clayey sandy gravel	viii 'Clayey'pebbly sand	xi 'Clayey' sand
iii 'Very clayey' gravel	vi 'Very clayey' sandy gravel	ix 'Very clayey' pebbly sand	xii Very 'clayey' sand

c.



M Mud
sM Sandy mud
gM Gravelly.mud
S Sand
mS Muddy sand
gmS Gravelly muddy sand
gS Gravelly sand
G Gravel
mG Muddy gravel
msG Muddy sandy gravel
sG Sandy gravel

Table 8

a. Classification of gravel, sand and fines for BGS sand and gravel resource assessment (modified after Udden, 1926 and Wentworth, 1922).

b. Descriptive categories used in the classification of sand and gravel for resource assessment.

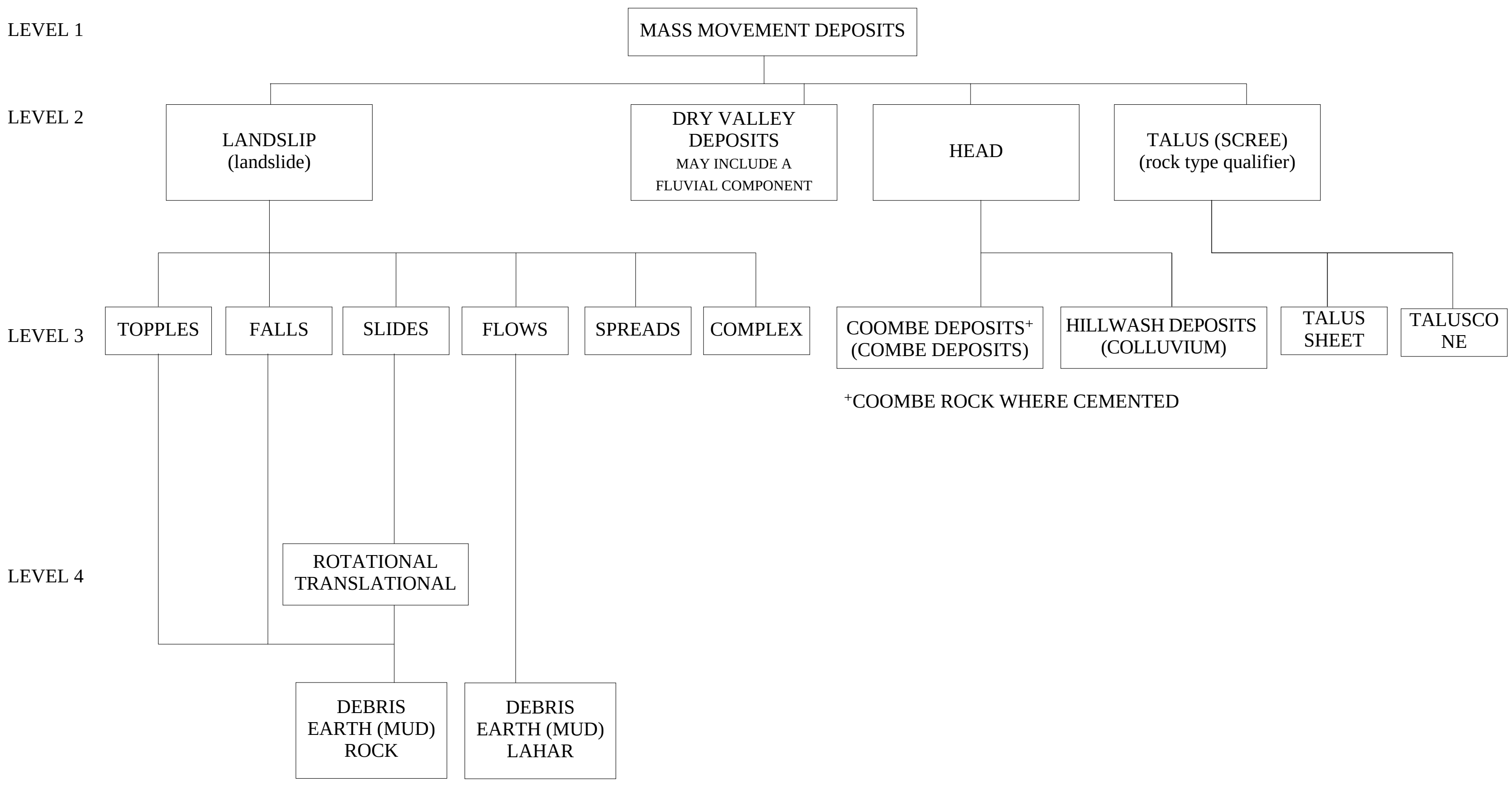
c. Sediment classification used on BGS offshore sea-bed sediment maps (modified after Folk, 1954).

Table 9 Lithofacies codes (modified after Miall, 1978 and Eyles et al., 1983).

Facies code	Lithofacies	Sedimentary structures
GRAVEL, G:		
Gm	gravel, unstratified or crudely bedded, clast-supported	horizontal bedding imbrication
Gt	gravel or sandy gravel, stratified	trough cross-beds, channel fills
GP	gravel or sandy gravel, stratified	planar cross-beds
Gp	gravel or sandy gravel, stratified	large-scale (deltaic) foresets
Gms	massive, matrix-supported gravel or sandy gravel	none
Gc	gravel, clast-supported	
Gco	gravel, clast-supported, openwork (shingle)	mainly used where deposits are poorly exposed
Gb	breccia	
B	boulder gravel	
s & g	sand and gravel	
SAND, S		
St	sand, medium to very coarse, may be pebbly	solitary (theta) or grouped (pi) trough cross-beds
Sp	sand, medium to very coarse, may be pebbly	solitary (alpha) or grouped (omicron) planar cross-beds
SP	sand, medium to very coarse, may be pebbly	large-scale (deltaic) foresets
Sr	sand, very fine to coarse	ripple marks of all types including climbing ripples
Sh	sand, very fine to very coarse, may be pebbly	horizontal lamination, parting or streaming lineation
Sl	sand, fine	low-angle (<10˚) cross-beds
Se	sand, fine to coarse, with	crude cross-bedding intraclasts erosional scours
Ss	sand, fine to coarse, may be pebbly	broad, shallow including eta cross-stratification
Sm	silty sand, massive	dish structures
Sd	sand, deformed	soft-sediment deformation, convolute bedding etc
Sc	sand, contorted	cryogenic and/or glacitectonic structures
Sg	sand, graded	erosional bases common

Facies code	Lithofacies	Sedimentary structures
FINES, F:		
Fl	Fine sand, silt mud	wavy to parallel horizontal) lamination low-amplitude ripples
Fh	Silt, mud	parallel (horizontal) lamination
Fm	mud, silt	massive desiccation cracks
F-d	pebbly silt, mud	dropstones
Fmd	diamictic mud	massive, clasts dispersed
DIAMICTON, D		
Dm	diamicton, matrix-supported	none
Dc	diamicton, clast-supported	none
Dmm	diamicton, matrix supported massive	structureless, very poorly sorted mud/sand/gravel admixture, dispersed clasts, glacially bevelled and scratched clasts common
Dmm(c)	Dmm with evidence of current reworking	laterally discontinuous wispy laminae of fine sand/silt produced by traction currents
Dm-(r)	Dm with evidence of	fold noses, rafts resedimentation of deformed silt/clay laminae, rip-up clasts
Dms	Diamicton, matrix-supported stratified	stratification is pronounced and more than 10% of unit thickness, generally graded, and with laterally discontinuous stacked beds, pronounced winnowing, lenses of water-sorted, stratified sand and gravel
Dmg	Diamicton, matrix-supported, graded	clast content generally graded

Table 10 Genetic subdivisions of mass movement deposits.



For definition of terms, see Appendix 2.1

Table 11 Genetic subdivisions of residual deposits.

LEVEL 1
- RESIDUAL DEPOSITS

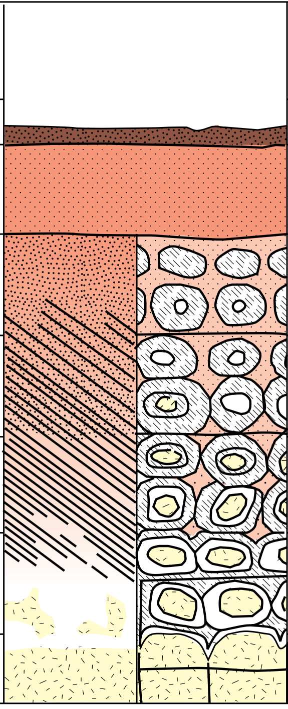
LEVEL 2
- DURICRUST
- BLOCKFIELD
- CLAY-WITH-FLINTS
- REGOLITH

LEVEL 3
- DURICRUST
  - CALCRETE
  - FERRICRETE (Iron laterite Iron pan)
  - GOSSAN
- REGOLITH
  - WEATHERED ROCK*
  - SAPROLITE**

* relatively uniform materials which weather gradationally and may be described in terms of Weathering Grades II to VI

** highly to completely weathered rock which has been altered and decomposed by chemical weathering processes but which retains textural and structural features of the parent material: Weathering Grades IV to V

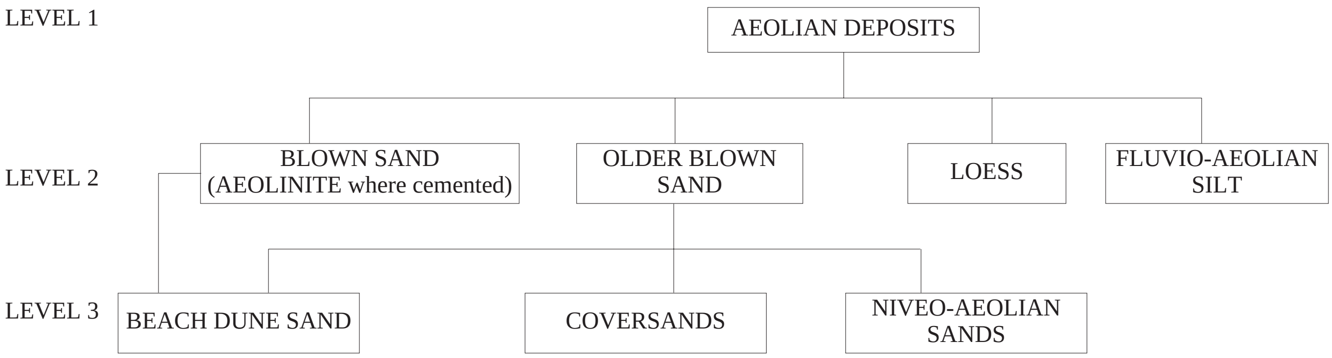
For definition of terms, see Appendix 2.2



Weathering Grade	Mass description
Humus/topsoil	
VI Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.
V Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
IV Highly weathered	More than half of the rock material is decomposed or disintegrated to a soil. Fresh or discoloured rock is present either as a continuous framework or as corestones.
III Moderately weathered	Less than half of the rock material is decomposed or disintegrated to a soil. Fresh or discoloured rock is present either as a continuous framework or as corestones.
II Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discoloured by weathering.
I Fresh	No visible sign of rock material weathering; perhaps slight discolouration on major discontinuity surfaces.

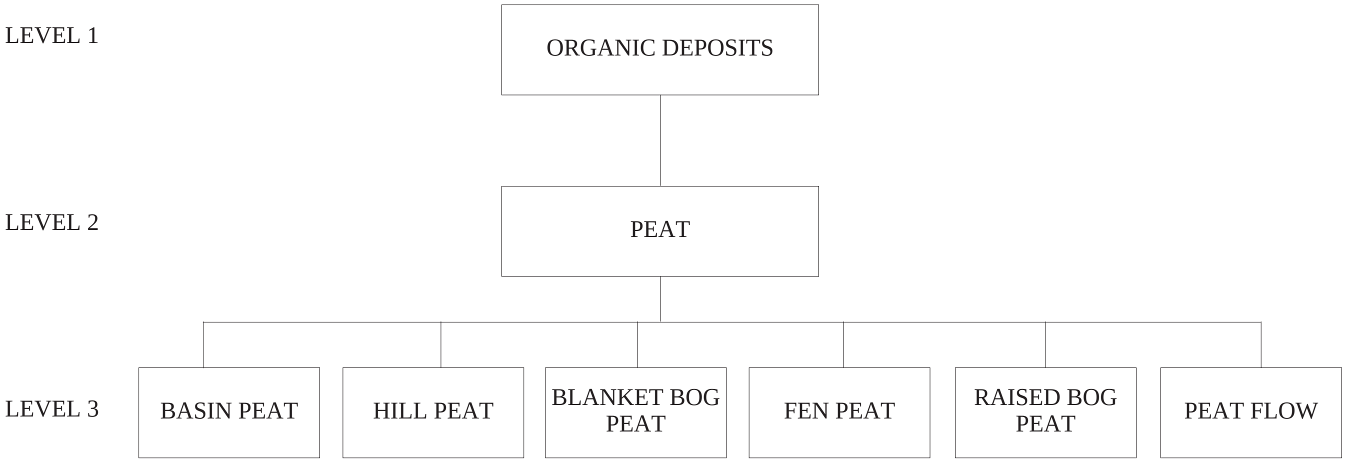
Table 12 Scale of rock weathering grades (based on BS 5930, 1981).

Table 13 Genetic subdivisions of aeolian deposits.



For definition of terms, see Appendix 2.3

Table 14 Genetic subdivisions of organic deposits.



For definition of terms, see Appendix 2.4 and Hallsworth and Knox (1999)

Table 15 Organic deposits classification (after West, 1979 with modifications after Lindsay, 1995).

<table>
<tr><th colspan="2">Position of formation
(growth position of peat-forming plants)</th><th>Provenance of sediments</th><th>Minerotrophic mires (supply of inorganic mineral nutrients from groundwater)</th><th>Ombotrophic mires (water supply from precipitation: little or no supply of inorganic mineral nutrients)</th></tr>
<tr><td rowspan="2">Limnic deposits</td><td rowspan="2">below low water level (i.e. water-filled depressions)</td><td>sedimentary (allochthonous deposits)</td><td>examples include gyttja, dy and
DIATOMITE*
SHELL MARL*</td><td></td></tr>
<tr><td rowspan="3">Sedentary (autochthonous deposits) peats</td><td>FEN PEAT
BASIN PEAT
Examples include phragmites (reed swamp) peat</td><td></td></tr>
<tr><td>Telmatic deposits</td><td>between low and high water levels</td><td>Examples include moss peat,
Cladium peat,
Magnocaricetum peat</td><td>Examples include Sphagnum cuspidatum peat</td></tr>
<tr><td>Semi-terrestrial deposits and terrestrial deposits</td><td>at or above high water level</td><td>Examples include fen-wood peat,
Parvocaricetum peat</td><td>BLANKET PEAT
HILL PEAT
RAISED BOG PEAT
Examples include
Sphagnum peat,
Shrub bog peat
Birch bog peat</td></tr>
</table>

Deposits in italics and capitals are included in Section 4 (Natural superficial deposits)

* Deposits included in Section 4.10 Biological Deposits.

Table 16 Genetic subdivision of biological deposits.

- LEVEL 1: BIOLOGICAL DEPOSITS
  - LEVEL 2: DIATOMITE
  - LEVEL 2: BIOCLASTIC SAND DEPOSITS
  - LEVEL 2: SHELL BANK DEPOSITS
  - LEVEL 2: SHELL MARL

For definition of terms, see Appendix 2.5

Table 17 Genetic subdivisions of chemical deposits.

- LEVEL 1: CHEMICAL DEPOSITS
  - LEVEL 2: DURICRUST — see Table 11
  - LEVEL 2: NON-CARBONATE SALTS — see Hallsworth and Knox, 1999
  - LEVEL 2: TUFA (sinter)
    - LEVEL 3: CALCAREOUS
    - LEVEL 3: SILICEOUS
  - LEVEL 2: MANGANIFEROUS/ FERRUGINOUS DEPOSITS
    - LEVEL 3: BOG IRON ORE

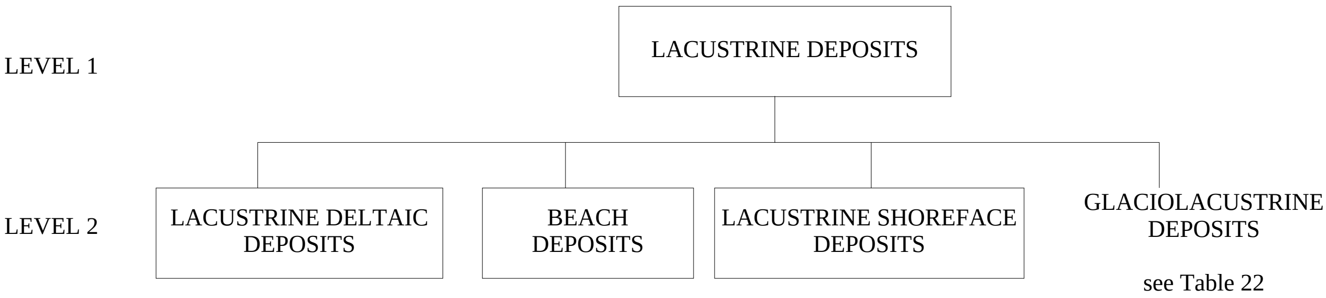
For definition of terms, see Appendix 2.6

Table 18 Genetic subdivisions of alluvial deposits (alluvium).

- LEVEL 1: ALLUVIAL DEPOSITS (ALLUVIUM)
  - LEVEL 2: FLUVIAL DEPOSITS
    - LEVEL 3: FLUVIAL TERRACE DEPOSITS
  - LEVEL 2: ALLUVIAL FAN DEPOSITS

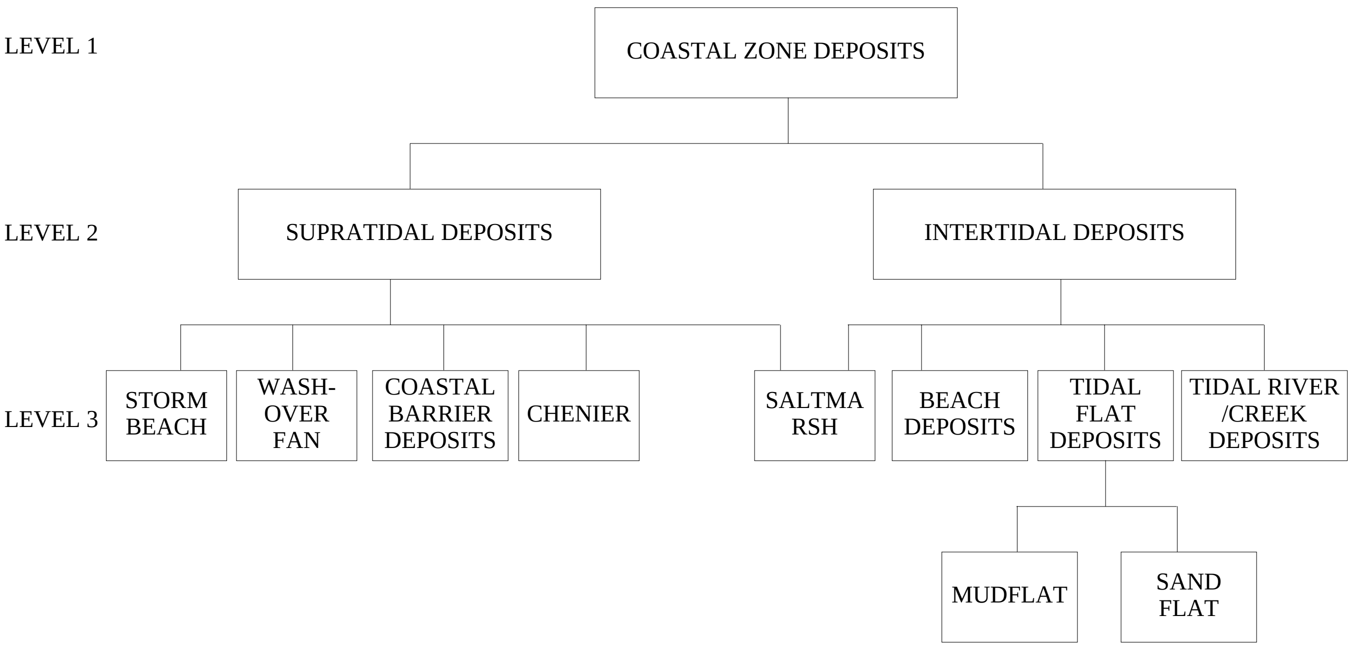
For definition of terms, see Appendix 2.7

Table 19 Genetic subdivisions of lacustrine deposits.



For definition of terms, see Appendix 2.8

Table 20 Genetic subdivisions of coastal zone deposits.



For definition of terms, see Appendix 2.9

For coastal dune deposits see Table 13

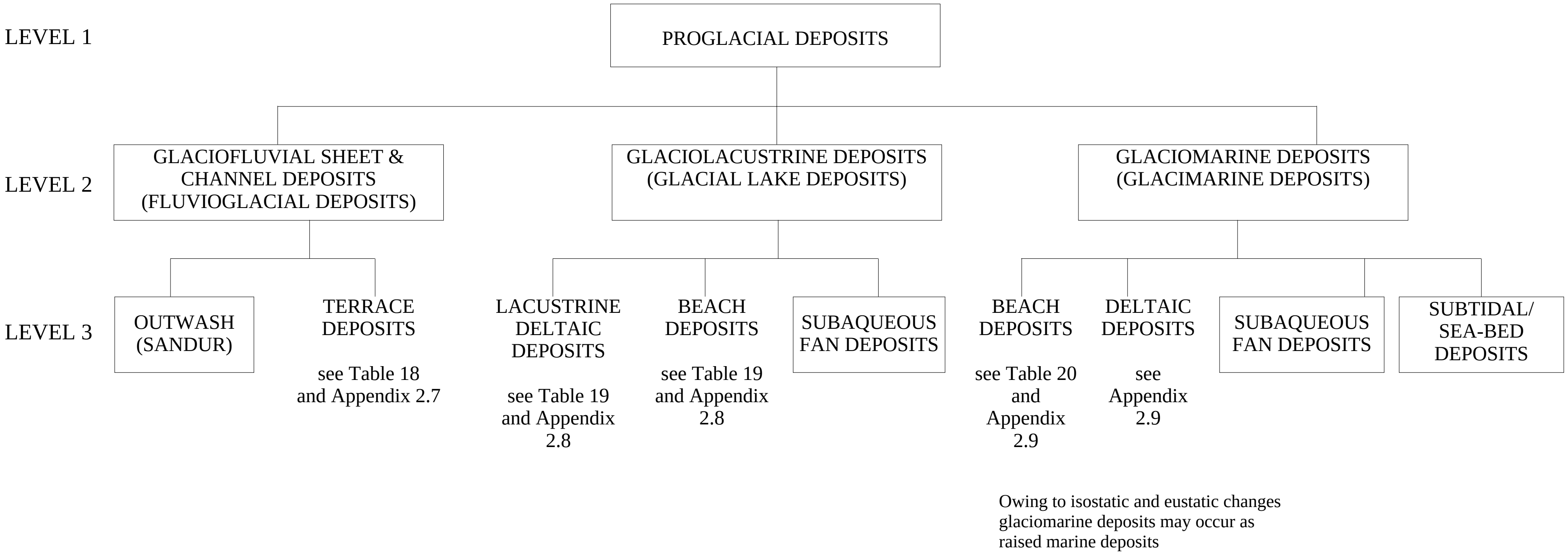
For marine deposits of the subtidal zone and adjoining continental shelf see Table 21

Table 21 Lithological and bedform classification of marine deposits.

LEVEL 1	MARINE DEPOSITS	
LEVEL 2	Classified according to grain size in terms of proportion of mud, sand and gravel (Folk, 1954)	SEE TABLE 8c
LEVEL 3	Classified according to bedform where sufficient acoustical data are available: sand wave field; megaripple field; sand ribbons; sand patches; sand banks	

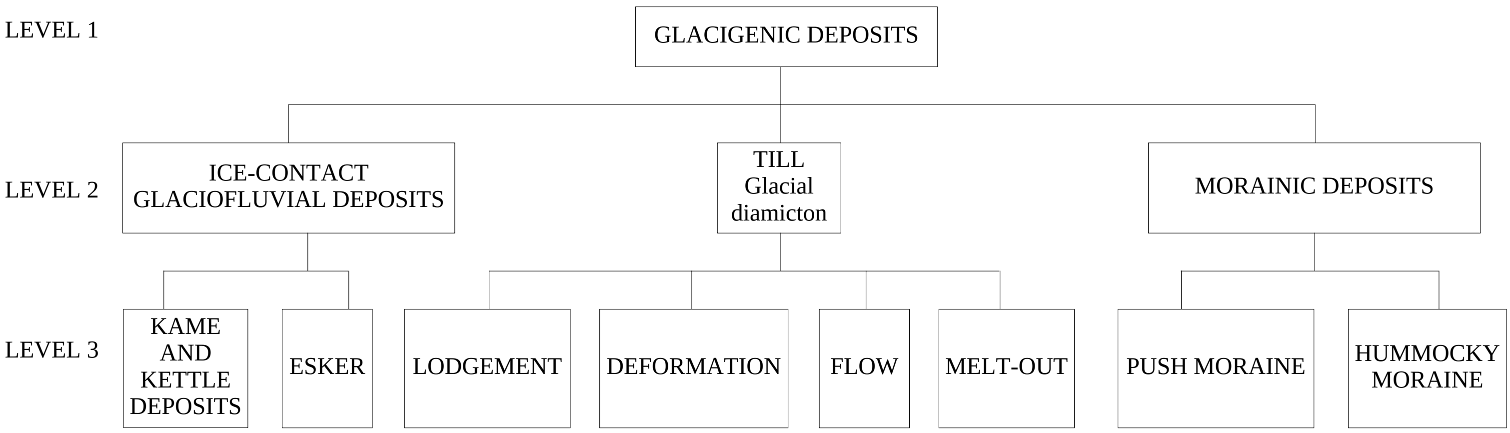
For definition of marine deposits, see Appendix 2.10

Table 22 Genetic subdivisions of proglacial deposits.



For definition of terms, see Appendix 2.11

Table 23 Genetic subdivisions of glacigenic deposits.



For definition of terms, see Appendix 2.12

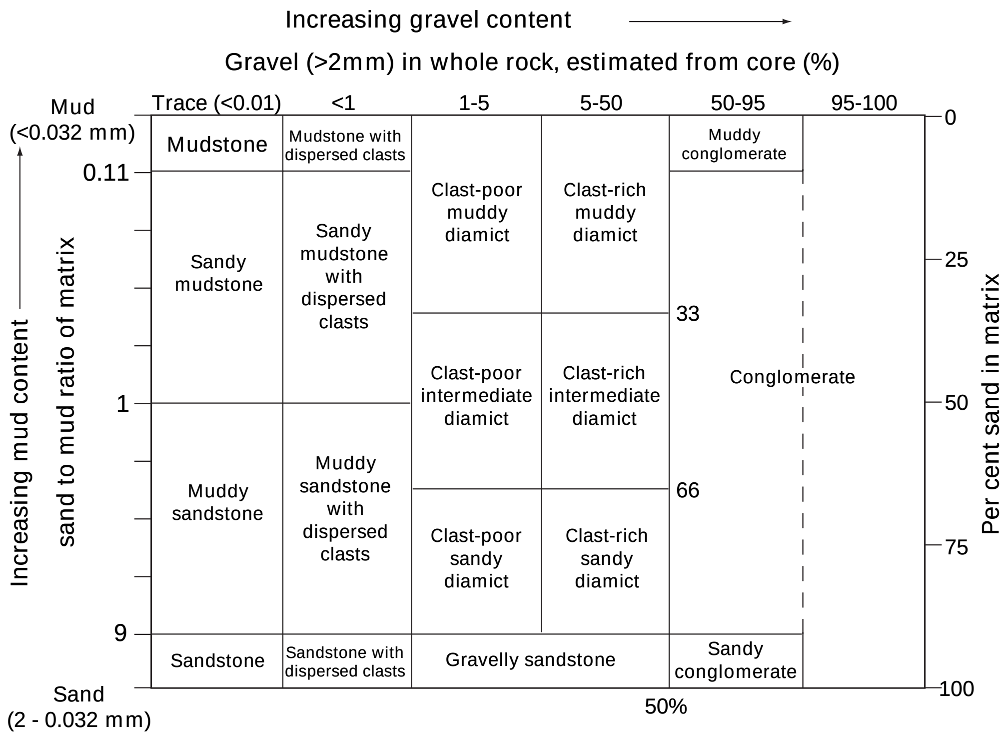


Table 24 Non-genetic classification of poorly sorted sediments and diamicts (after Moncrieff, 1989 and Hambrey, 1994).

Non-genetic classification of poorly sorted sediments, based on Moncrieff (1989), but with maximum proportion of gravel in diamict reduced from 80 to 50% for compatibility with the Ocean Drilling Progam's definition of diamict and conglomerate/breccia (Barron et al., 1989). The term 'diamict' embraces both diamicton and diamictite. 'Mud', as used in this context, covers all fine sediment, i.e. mixtures of clay and silt. Grain-size definitions follow the BGS scheme (Table 6).

Table 25 Summary of the main sedimentary characteristics of till (Bennett and Glasser, 1996).

A	Lodgement till	Subglacial melt-out till	Deformation till
Particle shape	Clasts show characteristics typical of basal transport: rounded edges, spherical form, and striated and faceted faces. Large clasts may have a bullet-shaped appearance.	Clasts show characteristics typical of basal transport, being rounded, spherical, striated and faceted. These characteristics are less pronounced than those of lodgement till.	Dominated by the sedimentary characteristics of the sediment which is being deformed, although basal debris may also be present.
Particle size	The particle size distribution is typical of basal debris transport, being either bimodal or multimodal.	The particle size distribution is typical of basal debris transport, being either bimodal or multimodal. Sediment sorting associated with dewatering and sediment flow may be present.	Diverse range of particle sizes reflecting that found in the original sediment. Rafts of the original sediment may be present, causing marked spatial variability.
Particle fabric	Lodgement tills have strong particle fabrics in which elongated particles are aligned closely with the direction of local ice flow.	Fabric may be strong in the direction of ice flow, although it may show a greater range of orientations than that typical of lodgement till.	Strong particle fabric in the direction of shear; this may not always be parallel to the ice flow direction. High-angle clasts and chaotic patterns of clast orientation are also common.
Particle packing	Typically dense and well-consolidated sediments.	The sediment may be well-packed and consolidated, although this is usually less marked than in a lodgement till.	Densely packed and consolidated.
Particle lithology	Clast lithology is dominated by local rock types.	Clast lithology may show an inverse superposition.	Diverse range of lithologies reflecting that present within the original sediments.
Structure	Massive structureless sediments, with well-developed shear planes and foliations. Sheared or brecciated clasts (smudges) may be present. Boulder clusters or pavements may occur within the sediment, along with evidence for ploughing of clasts.	Usually massive but if it has been subject to flow it may contain folds and flow structures. Crude stratification is sometimes present. The sediment does not show evidence of shearing and overriding during formation.	Fold, thrust and fault structures may be present if the level of shear homogenisation is low. Rafts of undeformed sediment may be included. Smudges (brecciated clasts) may also be present.

B	Supraglacial melt-out (moraine) till	Flow till	Sublimation till
Particle shape	Usually dominated by sediment typical of high-level transport, but subglacially transported particles may also be present. The majority of clasts are not normally striated or faceted.	Broad range of characteristics, but dominated by particles which are angular and have a non-spherical form. The majority of clasts are not striated or faceted.	Clasts typical of basal transport, being rounded, spherical, striated and faceted.
Particle size	The size distribution if typically coarse and unimodal. Some size sorting may occur locally where meltwater reworking has occurred.	The size distribution is normally coarse and unimodal, although locally individual flow packages may be well sorted.	The particle size distribution is typical of basal debris transport, being either bimodal or multimodal.
Particle fabric	Clast fabric is unrelated to ice flow, is generally poorly developed and is spatially highly variable.	Variable particle fabric; individual flow packages may have a strong fabric, reflecting the former palaeo-slope down which flow occurred.	Strong in the direction of ice flow, although it may show a greater range in orientation than a typically lodgement till.
Particle packing	Poorly consolidated, with a low bulk density.	Poorly consolidated with a low bulk density.	Typically has a low bulk density and is loose and friable.
Particle lithology	Clast lithology is usually very variable, and may include far-travelled erractics.	Variable, but may include far-travelled erractics.	Clast lithology may show an inverse superposition.
Structure	Crude bedding may occur but generally it is massive and structureless.	Individual flow packages may be visible. Crude sorting, basal layers of tractional clasts, may be visible in some flow packages. Sorted sand and silt layers may be common, associated with reworking by meltwater. Individual flow packages may have erosional bases. Small folds may also be present.	The deposit is usually stratified and may preserve englacial fold structures.

Table 26 Summary of the principal moraine landforms (Bennett and Glasser, 1996).

Seasonal push moraines	Morphology: usually ridges of low sediment transverse to the direction of ice flow. Indicative of the position of the ice margin and of warm-based ice in a maritime climate. They occur where winter ablation is less than winter ice velocity at the snout. Moraine spacing is usually a function of summer ablation and therefore air temperature. The number of moraines along a flow line may provide an estimate of the rate of retreat, assuming annual moraine formation.
Composite push moraines	Morphology: large multi-crested ridges transverse to the ice flow; the ice was not located along the crest of each ridge. Indicative of the position of the ice margin: may also suggest surging behaviour or strong ice compression at the ice margin either due to thermal variation at the snout or due to the presence of a focus for frontal tectonics.
Thrust moraines	Morphology: when ice-cored they consist of single or multi-crested ridges transverse to the ice flow. Indicative of the tectonic structure, thrust and shear zones, within the ice. They do not provide direct evidence of ice-marginal positions.
Dump moraines	Morphology: usually steep-sided ridges with well-developed scree-like bedding within them. Their morphology may be affected significantly by the withdrawal of lateral ice support. Indicative of the position of the ice margin. Common as lateral moraines around the margins of warm-based glaciers, although they may occur as frontal moraines, particularly where the ice is cold-based. Cross-valley asymmetry in moraine size may indicate the patterns of debris supply within the glacier basin. Some moraines contain a distinct stratification which may be seasonal in nature.
Ablation moraines	Morphology: variable, ranging from well-defined ridges to belts of mounds, ridges and enclosed hollows. Morphological form may be very strong and organised while buried ice persists and may reflect the structure of thrust and shear planes within the ice. Indicative of the position of the ice margin. They result from high supraglacial debris content, high englacial debris content due to a mixed basal thermal regime and freezing-on of abundant debris, or are due to strong compressive thrusting at the ice margin transferring basal debris to the ice surface.
Hummocky moraine	Morphology: mounds, ridges and enclosed hollows with an irregular plan form distribution composed in part of supraglacial till. Indicative of ice-marginal areas in which the surface cover of debris has prevented ablation.This may result from high supraglacial debris content, high englacial debris content due to a mixed basal thermal regime and freezing on of abundant debris; or due to strong compressive thrusting at the ice margin transferring basal debris to the ice surface. It may form as a single area of hummocks or in increments at the ice margin. It is not indicative of widespread glacier stagnation. Any uniform pattern or organisation within the mound reflects the debris structure on or within the ice margin.
Flutes	Morphology: low linear sediment ridges formed in the lee of boulders or bedrock obstacles (L/W>50). Indicative of local ice flow directions; thin ice, and the presence of warm-based ice.
Megaflutes	Morphology: linear sediment ridges which may or may not be formed in the lee of bedrock obstacles (L/W>50). Indicative of local ice flow directions; thin ice, and the presence of warm-based ice.

Table 26 *continued.*

Drumlins	Morphology: smooth oval-shaped or elliptical hills composed of glacial sediment (L/W<50). Drumlins may possess other bedforms superimposed upon them, such as small drumlins, megaflutes and flutes. Indicative of local ice flow directions, subglacial deformation, and warm-based ice. Superimposed drumlins may record changes in subglacial conditions and ice flow directions.
Rogens	Morphology: streamlined ridges of glacial sediment orientated transverse to the direction of ice flow. The ridge may have a lunate form and be drumlinised. Indicative of subglacial deformation and warm-based ice. May provide a record of changing ice flow patterns.
Mega-scale glacial lineations	Morphology: broad, low ridges of glacial sediment which can only be recognised clearly on satellite images (L/W>50). May possess smaller bedforms superimposed upon them. Indicative of regional ice flow patterns, subglacial deformation and probably the presence of warm-based ice. Superimposed bedforms record changes in subglacial conditions and ice flow directions.
Crevasse-squeezed ridges (Geometrical ridge network)	Morphology: low usually straight ridges, with a rectilinear pattern in plan form. Indicative of stagnant ice often associated with surging glacier lobes, but may be preserved under cold ice if a rapid change in basal thermal regime occurs post-formation. They may also be used to reconstruct crevasse patterns.

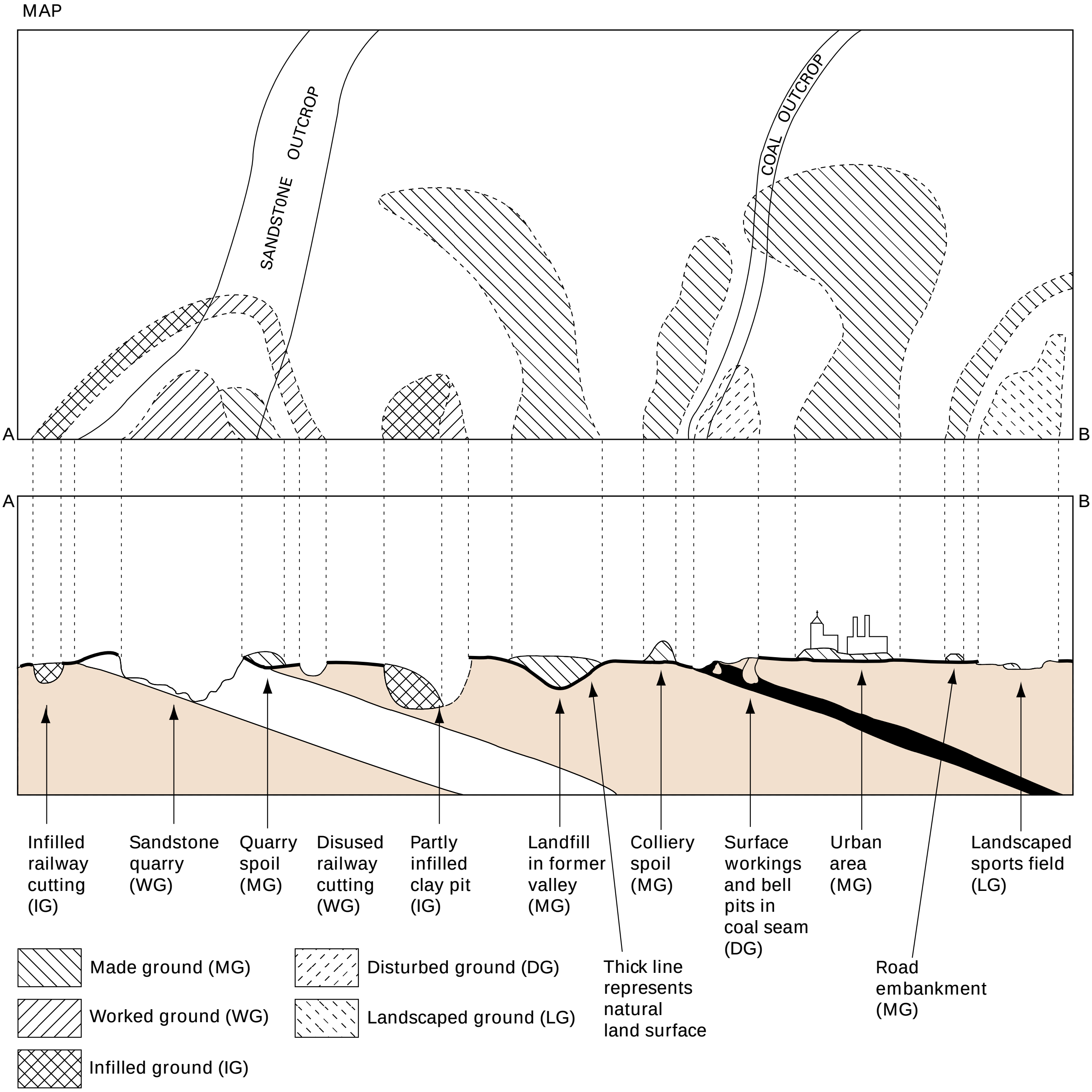


Figure 1 Schematic map and cross-section (A-B) illustrating types of artificial ground.

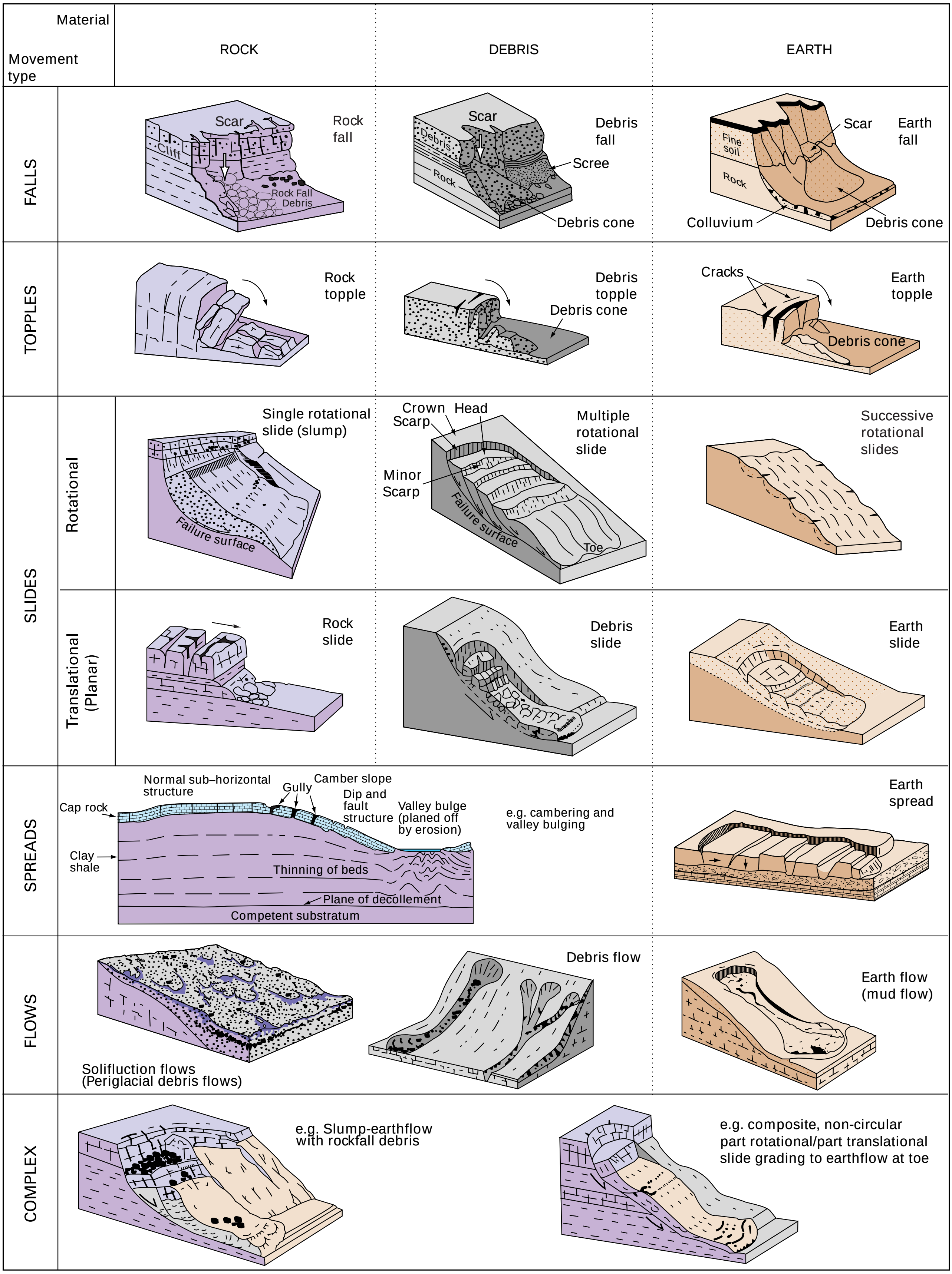


Figure 2 Classification of type of landslip (modified after Varnes, 1978 and DoE., 1990).

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 forward rotation about a pivot point.
Rotational slides sliding outwards and downwards on one or more concave-upward failure surfaces.
Translational (planar) slides sliding on a planar failure surface running more-or less parallel to the slope.
Spreads fracturing and lateral extension of coherent rock or soil materials due to liquefaction or plastic flow of subjacent material.
Flows slow to rapid mass movements in saturated materials which advance by viscous flow, usually following initial sliding movement. Some flows may be bounded by basal and marginal shear surfaces but the dominan movement of the displaced mass is by flowage.
Complex slides slides involving two or more of the main movement types in combination.

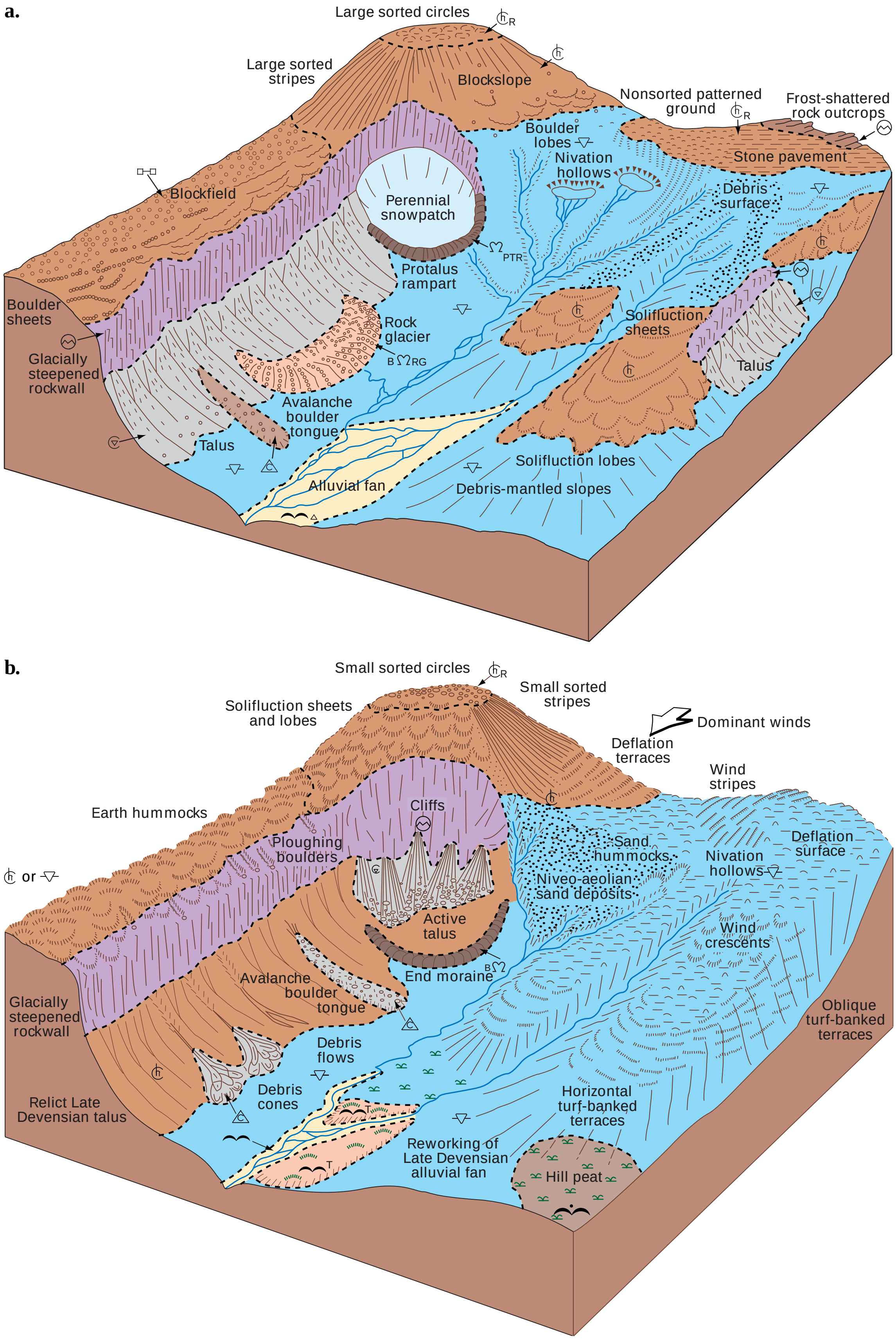


Figure 3 Schematic representation of:
a. The range of Late Devensian periglacial features on Scottish mountains (after Ballantyne, 1984) with recommended BGS drift symbols.
b. Active present-day periglacial phenomena on British mountains (after Ballantyne, 1987) with recommended BGS drift symbols.

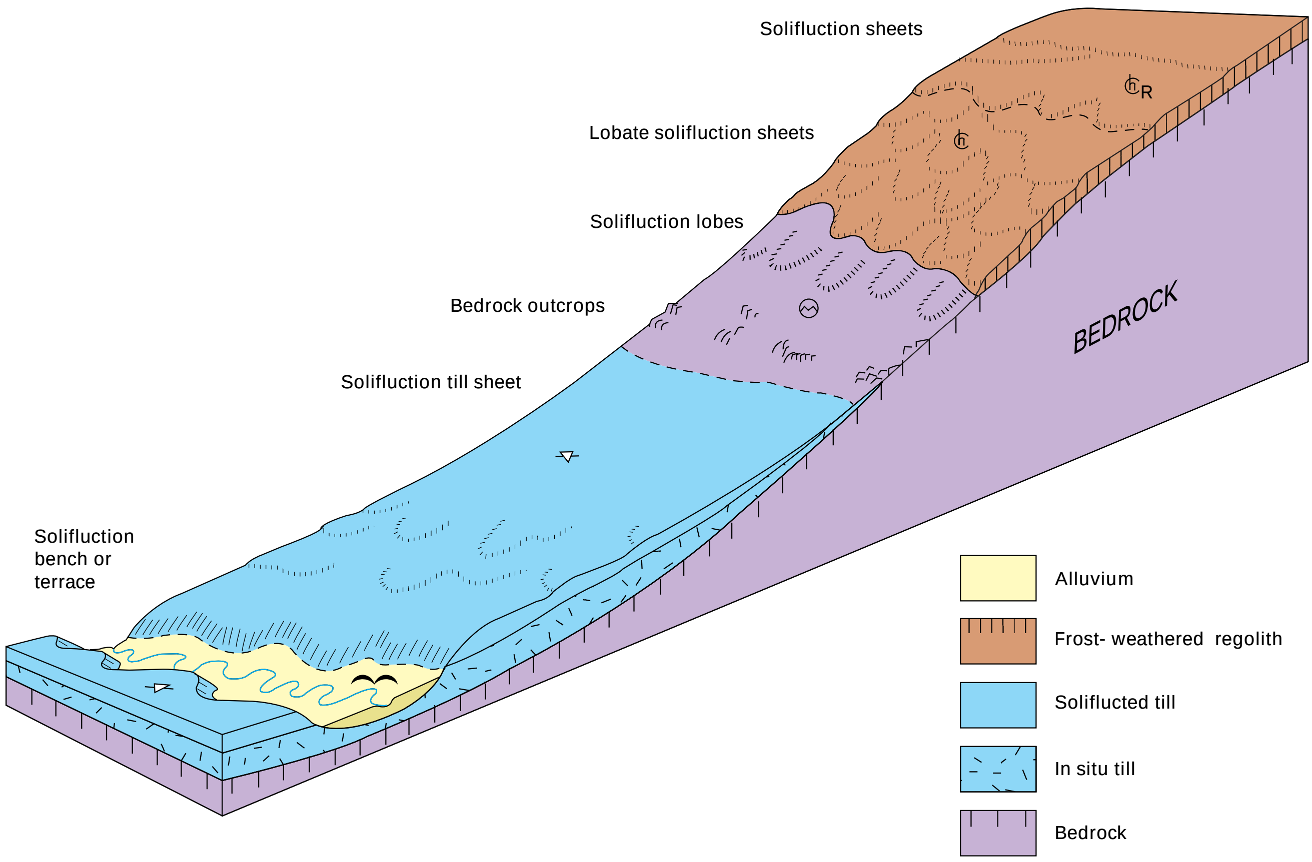
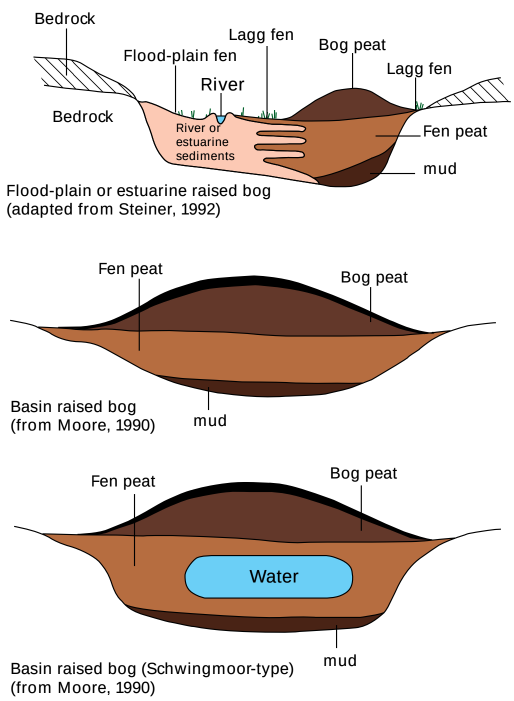


Figure 4 A catena of solifluction phenomena typical of those found on the slopes of British mountains (after Ballantyne and Harris, 1994) with recommended BGS drift symbols.

a.



b.

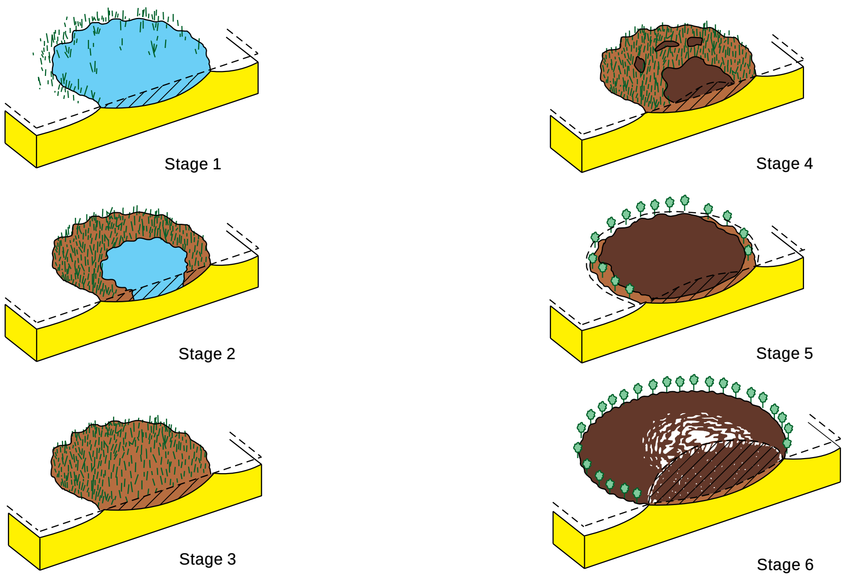


Figure 5 The main types of raised bog and their development.

a. The main types of raised bog (after Lindsay, 1995). Flood-plain and estuarine raised bogs show the same general profile, except in the former there is evidence of freshwater incursion whereas the latter contains intermittent marine sediments. Schwingmoor is a special form of basin raised bog which retains an occluded lens of water.

b. Generalised sequence of raised bog development (after Lindsay, 1995). Vegetation and raised bog are not shown at the same scale – typically a site may extend to a kilometre or more in diameter.

Stage 1 Water filled depression (lake/loch) with emergent fen vegetation around the edge.

Stage 2 Gradual infilling of lake/loch with fen peat.

Stage 3 Depression completely infilled with fen peat - feeding is still minerotrophic and the vegetation consists of fen species.

Stage 4 Initiation of bog formation as the predominant inputs of water and inorganic ions switch from minerotrophic to ombrotrophic sources.

Stage 5 Raised oligo/ombrotrophic elements coalesce.

Stage 6 Raised bog dome showing typical features including central microform patterning, steep rand and marginal lagg fen. Prominent bog pools are more typical of Irish, rather than British, raised bogs.

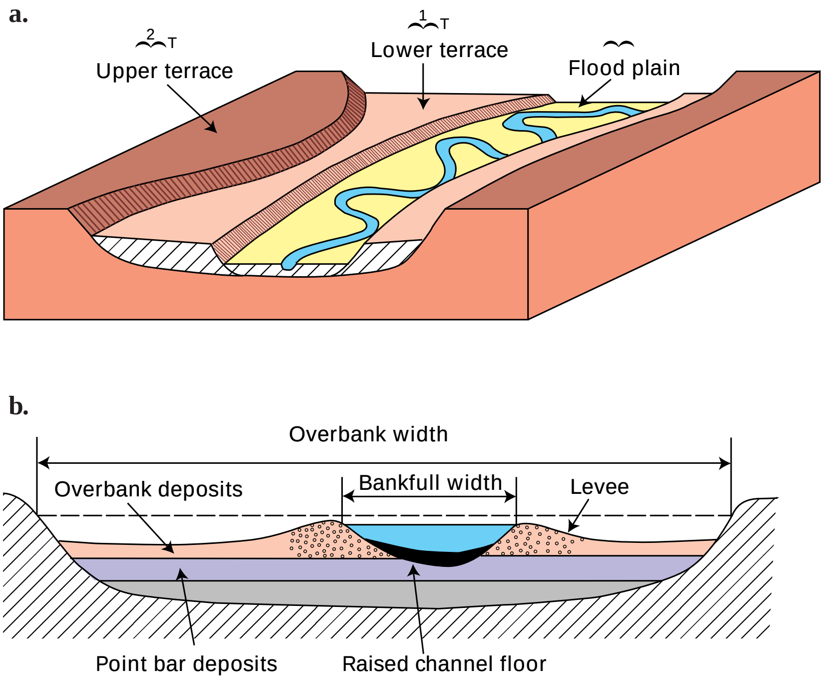


Figure 6
a. River terraces (after Clowes and Comfort, 1982) with recommended BGS drift symbols.
b. The formation of the flood plain.

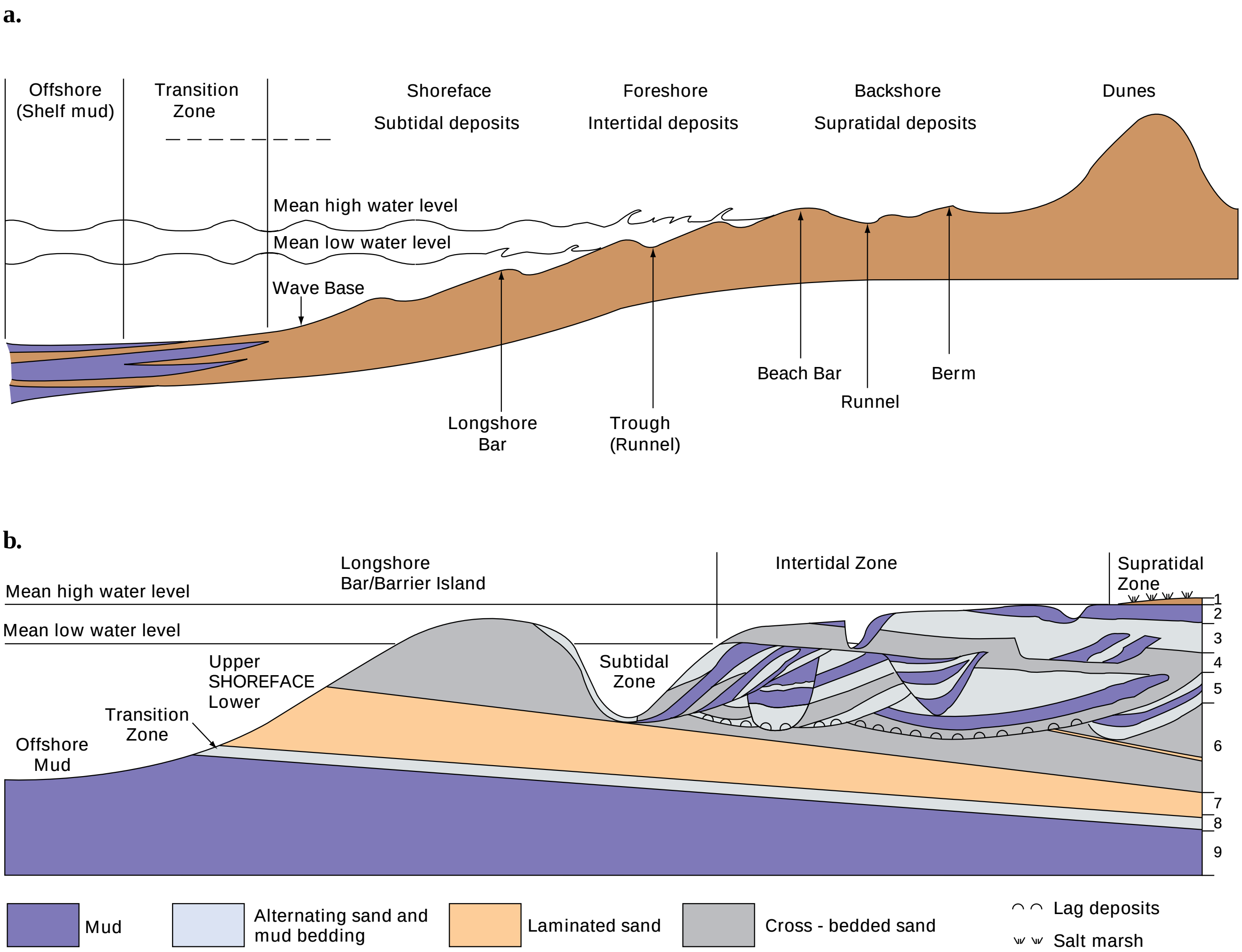


Figure 7

a. Schematic representation of the terminology of the various geomorphical units of a beach profile (after Reineck and Singh,1973).

b. Schematic cross-section across the tidal flats of the North Sea (after Reineck and Singh, 1973) in a situation of an hypothetical prograding shore line. In reality the North Sea tidal flats are resting on the Pleistocene and Holocene deposits. The section is based on the information of Van Straaten (1964) with additional new data.

1 *Salt marsh (supratidal zone).* Very fine-grained sand and mud, interbedded shell layers, plant roots, irregular wavy bedding.

2. *Mud flat (intertidal zone).* Mud, some very fine-grained sand layers, lenticular bedding with flat lenses, strong bioturbation.

3. *Mixed flat (intertidal zone).* Sandy mud, thinly interlayered sand/mud bedding, lenticular bedding, flaser bedding, shell layers, bioturbation strong to weak.

4. *Sand flat (intertidal zone).* Very fine-grained sand, small-ripple bedding, some of herringbone structure, flaser bedding, laminated sand some strong bioturbation.

5. *Subtidal zone.* Medium-to coarse-grained sand, mud pebbles, megaripple bedding, small-ripple bedding, laminated sand, weak bioturbation.

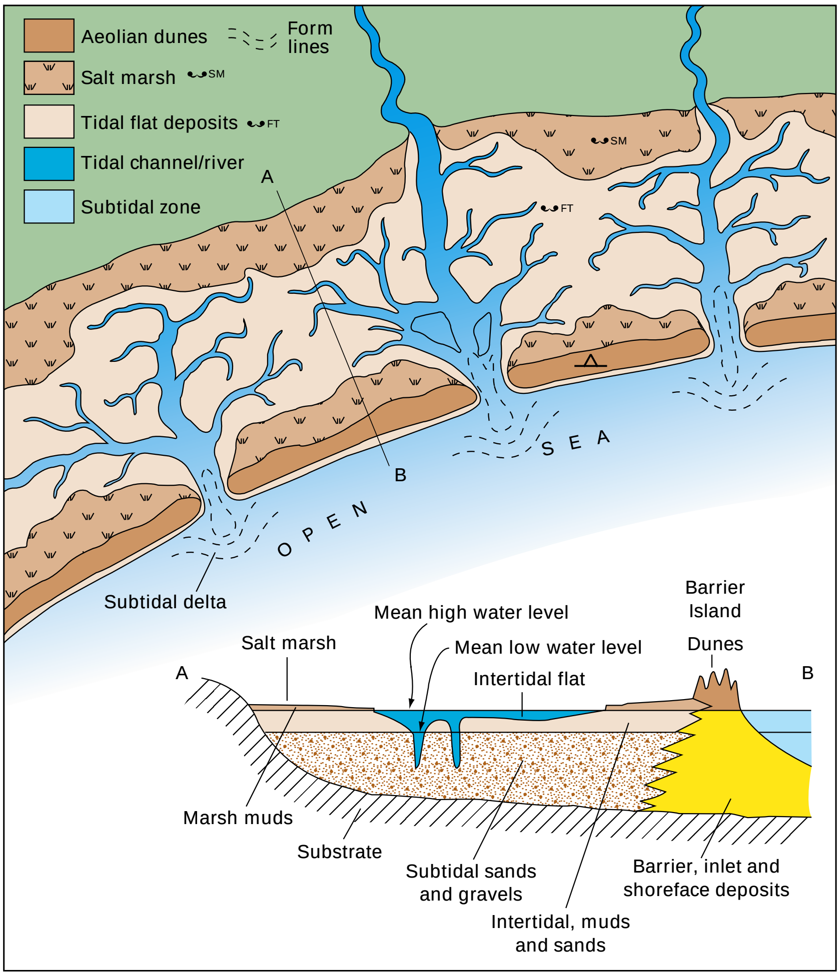
6. *Upper shoreface.* Beach, bar and ripple cross-bedding, laminated sand, weak bioturbation.

7. *Lower shoreface.* Laminated sand, bioturbation stronger than in the upper shoreface.

8. *Transition zone*. Alternating sand/mud bedding, flaser and lenticular bedding, thinly and thickly interlayered sand/mud bedding, moderate bioturbation.

9. *Shelf mud.* Mud with storm silt layers, moderate biotubation.

a.



b.

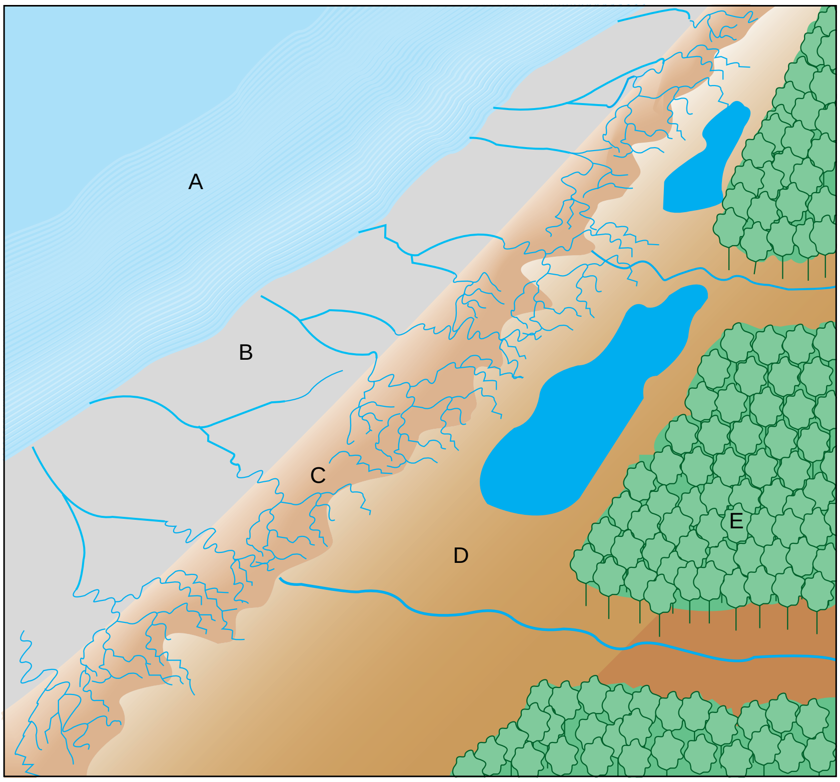


Figure 8

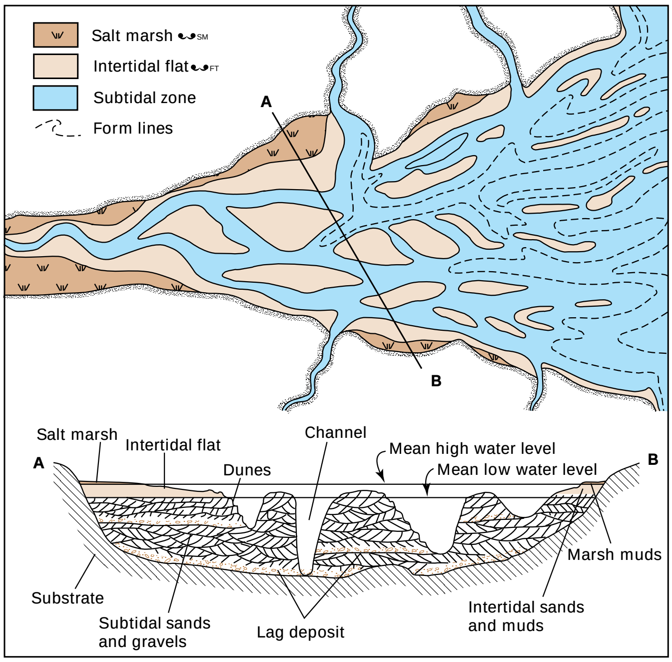
a. Model of sedimentation in an idealised estuary (after Allen, 1970) with recommended BGS drift symbols.

b. Presumed depositional environments of the Flandrian (Recent) deposits of the Fenland part of the Wash, East Anglia (Gallois, 1994).

Key to depositional environments and sediment types:

A Subtidal – mostly sand
B Intertidal flat – silt with clay
C Salt marsh – clay with silt
D Peat fen and meres – peat and shell marl
E Deciduous forest – erosional area

a.



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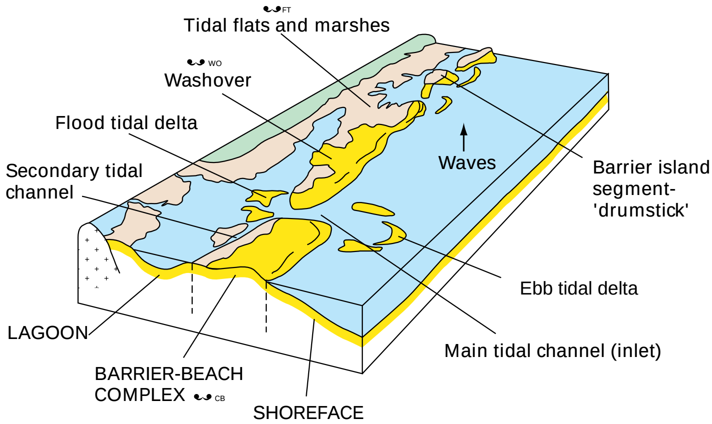


c.

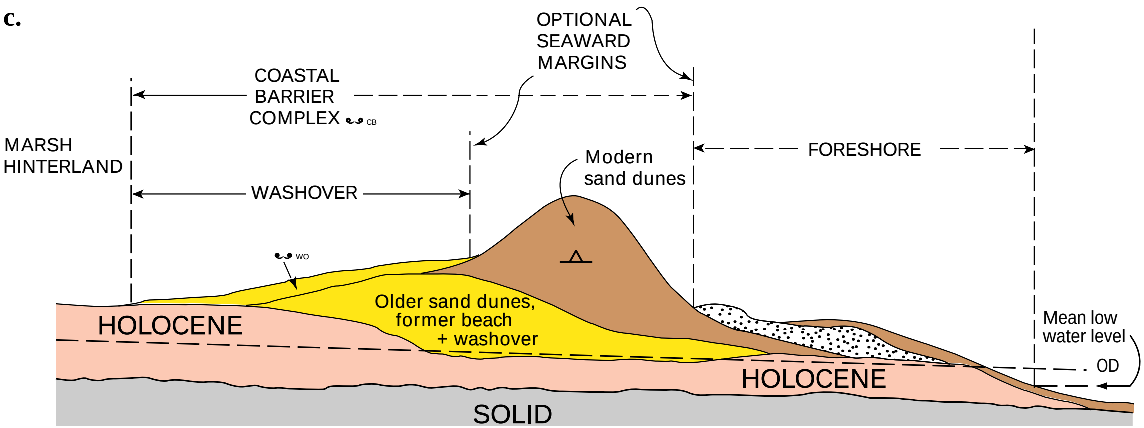


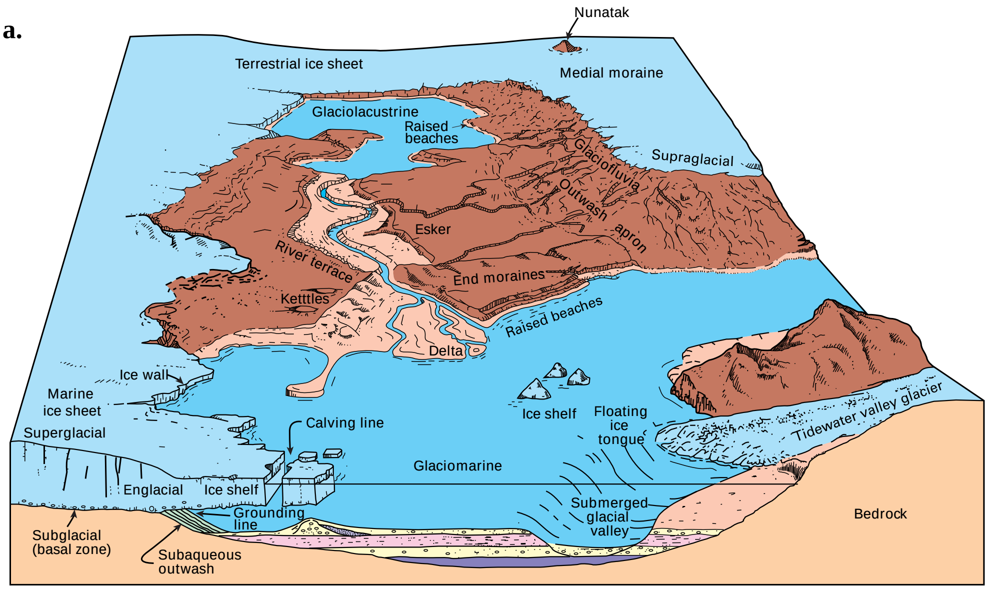
Figure 9

a. Model of sedimentation in an idealised tidal flat protected by a barrier island chain (Allen, 1970) with recommended BGS drift symbols.

b. Main geomorphological elements and subenvironments in a barrier island system (Reading, 1986) with recommended BGS drift symbols. The part in the background represents a mixed wave-tide system consisting of short barrier segments with a characteristic drumstick shape (Hayes, 1979) separated by numerous tidal inlets. The foreground is more wave-dominated and has a more continuous barrier-beach complex sheltering a well-developed lagoon.

c. Schematic block diagram of coastal barrier complex and washover fan with recommended BGS drift symbols.

a.



b.

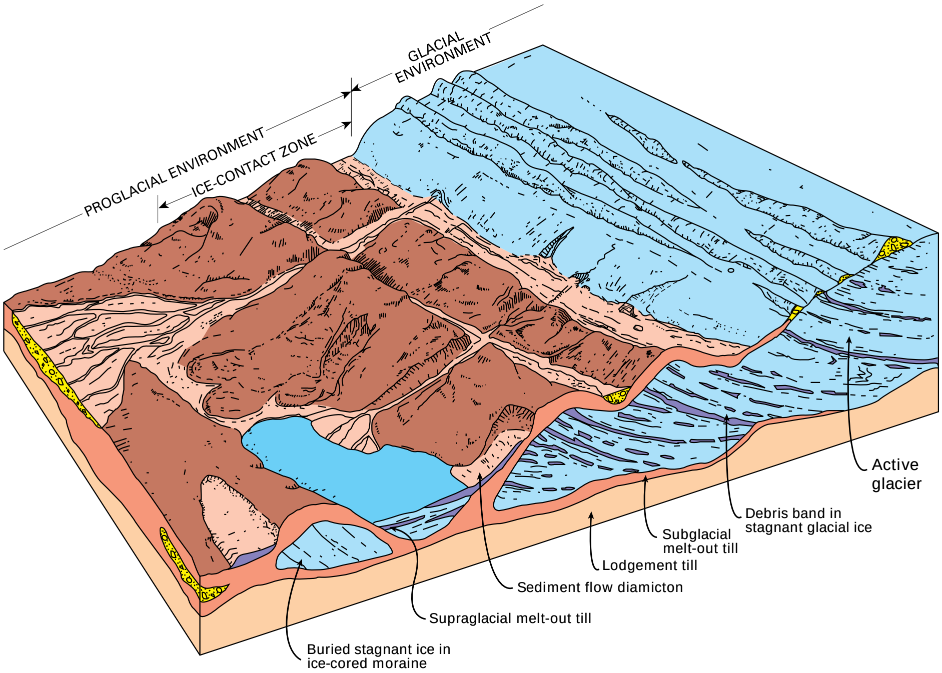


Figure 10

a. The types of glaciers, glacial environments and glacial landforms (Reading, 1986).

b. Sedimentation in the supraglacial and ice-contact proglacial zones of a slowly retreating, subpolar glacier (Reading, 1986). Subglacial material is brought into the glacier by basal freezing and thrusting. This debris is released at the surface as the enclosing glacial ice gradually melts. The till is rapidly reworked by flowing meltwater, and may slump and flow downslope to form flow diamictons. Diamicton beds can be intercalated with proglacial stream or lake deposits, and may be extensively reworked (modified from Boulton, 1972).

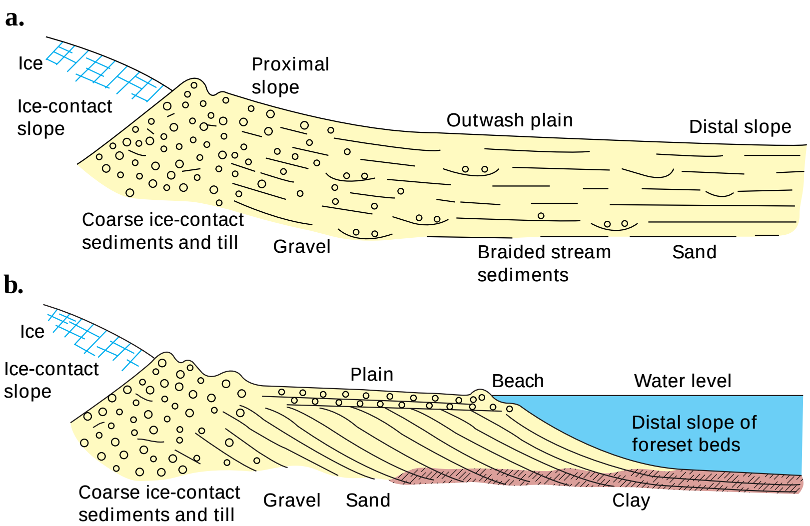


Figure 11
Proglacial landforms and deposits (West, 1979).
a. Section through an outwash plain.
b. Section through a marginal delta.

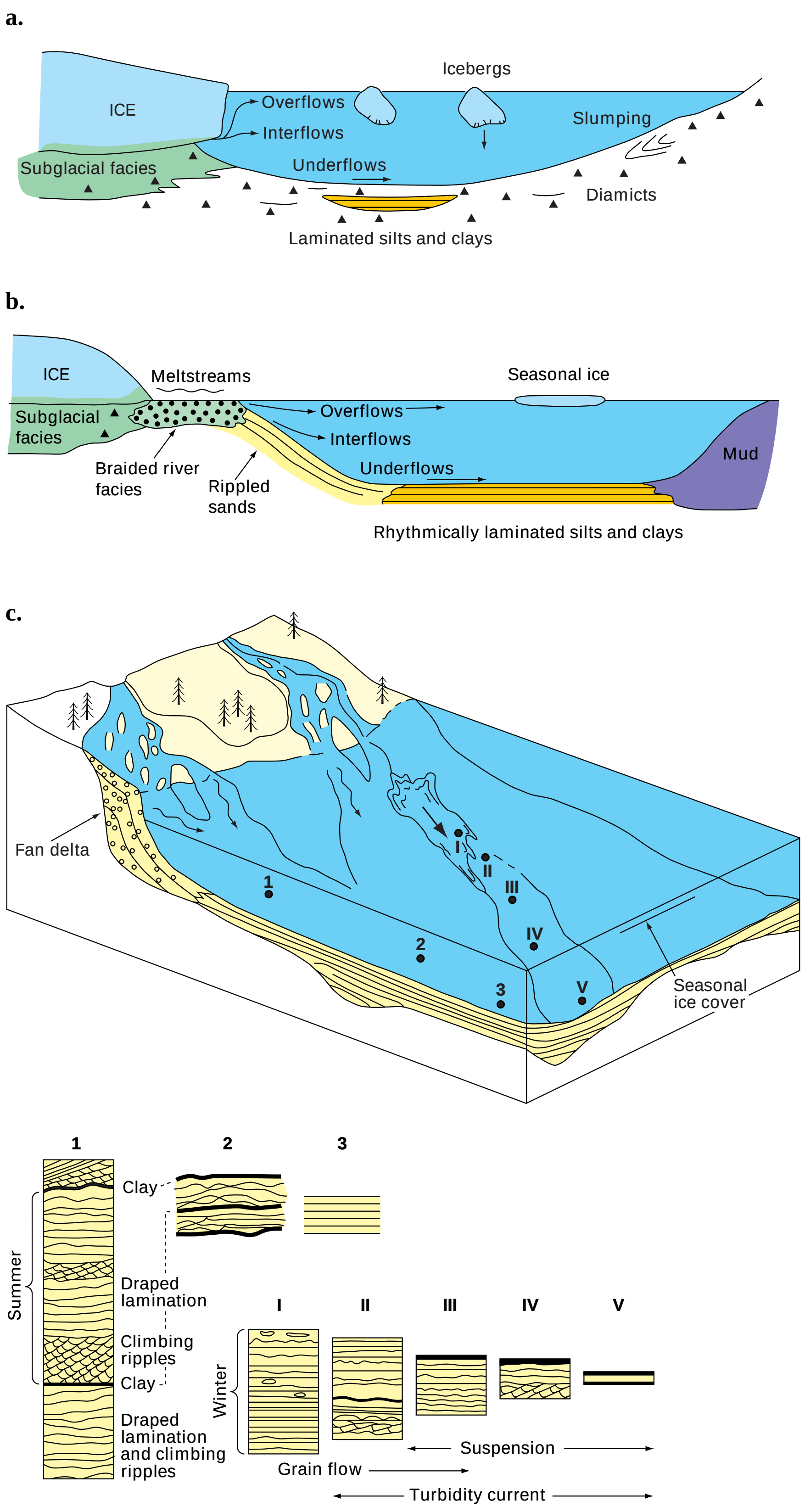


Figure 12 Deposition of seasonally controlled (varved) sediments (after Eyles and Eyles, 1992).
a. Ice-contact lake.
b. Non ice-contact lake.
c. Block diagram showing the likely sedimentary sequences in non ice-contact lakes. There is a proxial to distal (1, 2, 3) trend from thick (cm to m) variably rippled sands to thin (cm) silts bounded top and bottom, by a winter clay layer. Slope failure of the delta front in winter may result in more complex successions (I-V; see Shaw, 1977).

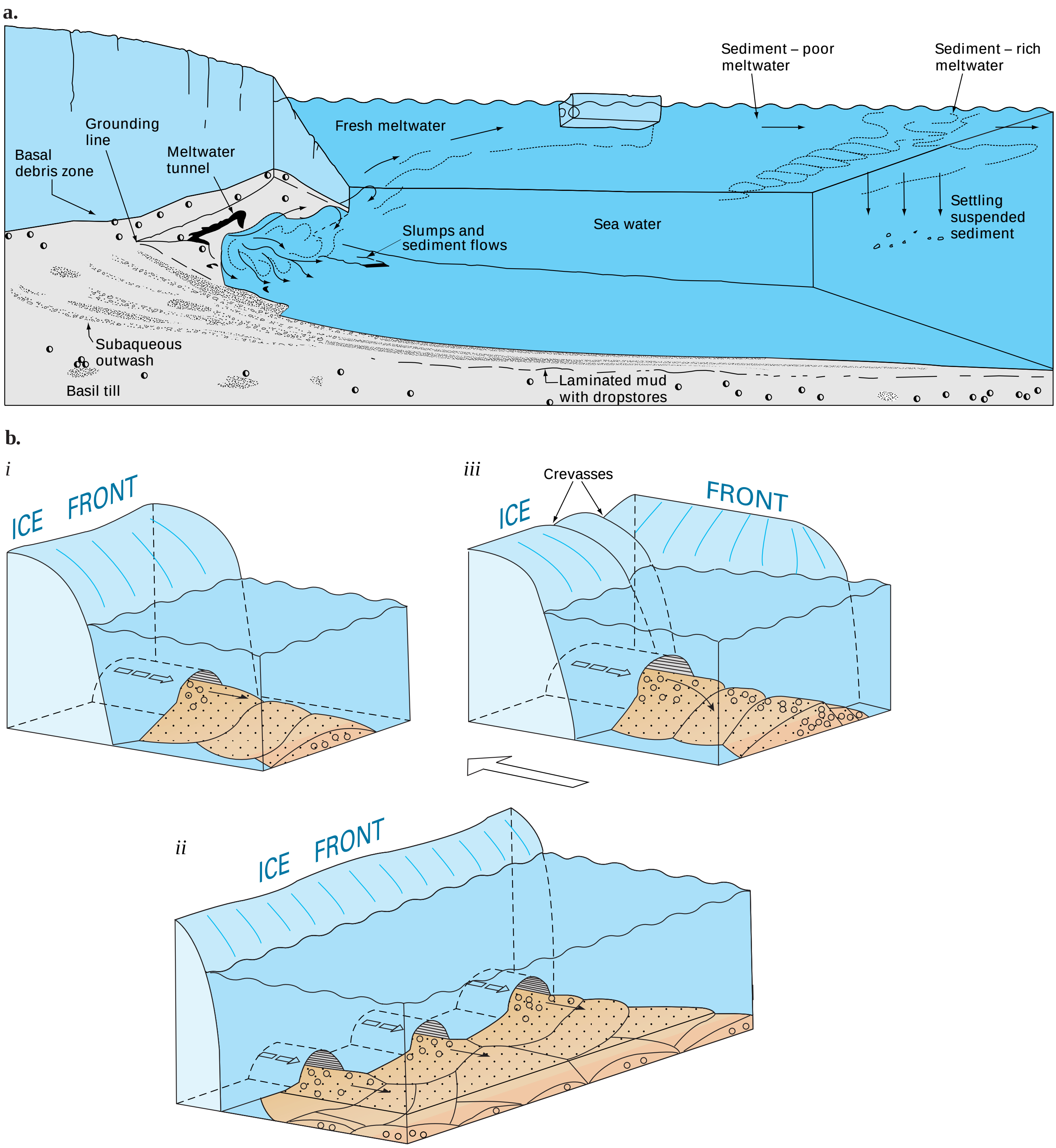


Figure 13
a. Glaciomarine sedimentation in front of a wet-based, tidewater glacier (Reading, 1986). Coarse sediment rapidly falls to the bottom near the glacier margin, where it may be further transported by either high-density underflows or sediment gravity flow. Fine-grained sediment is carried away from the glacier margin in an overflow plume. Variations in suspended sediment concentration in the overflow plume may lead to the formation of graded laminae on the sea bottom.

b. Depositional models for subaqeous outwash (Rust and Romanelli, 1975).
Large arrow indicates direction in which ice front retreats:
i. Sediment is transported down a subglacial tunnel; steady retreat of the ice front produces a series of esker fans overlapping longitudinally.
ii. Sediment transported down several ice tunnels gives rise to a series of laterally overlapping esker fans. Stagnation of the ice front in one position for an extended period would give rise to a ridge of subaqueous outwash formed against it.
iii. Sediment is transported down subglacial tunnels located along crevasses in the ice, which also cause a step in the ice front. Subaqueous outwash forms a series of longitudinally overlapping esker fans restricted by ice on one side. Flow diverges away from this side, facies are deposited asymmetrically, and ice-contact effects are located principally in the gravels, against the ice wall.

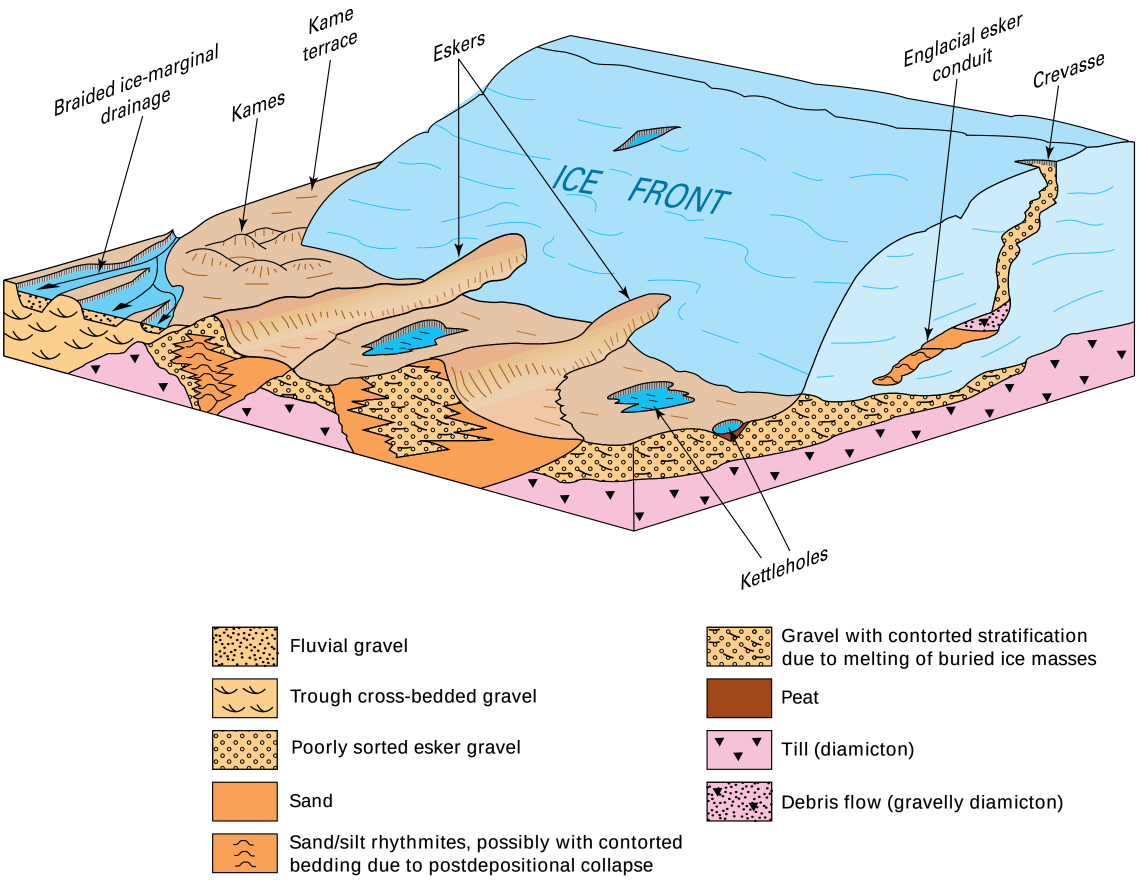


Figure 14 Schematic block diagram showing landforms and sediments at a retreating ice-margin (after Auton, 1992).

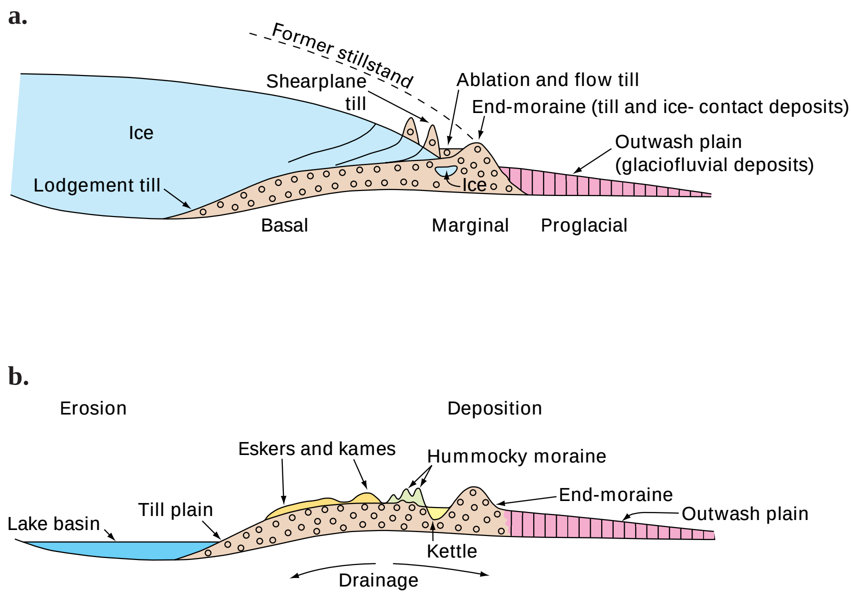


Figure 15 Features associated with ice standstill and retreat (after West, 1979).

a. Ice margin near maximum: zones of basal, marginal and proglacial deposition are distinguished.

b. After retreat: hummocky moraines of till and ice-contact deposits have been formed.

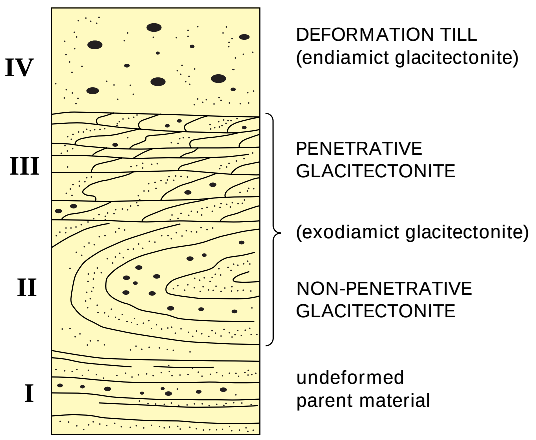


Figure 16 Idealised vertical sequence of subglacially deformed materials (after Banham, 1977; Benn and Evans, 1996).

I Parent material.

II Glacitectonite with non-penetrative deformation.

III Glacitectonite with penetrative deformation.

IV Endiamict glacitectonite (Till).