Quaternary deposits

Quaternary deposits are sediments that were deposited during the Quaternary episode of earth history, between 2.5 million years ago and the present day. The Quaternary is divided into two periods: the Pleistocene Period dates from 2.5 million years ago till 11,500 years ago and the Holocene continues to the present day.

Quaternary deposits in Great Britain

At the start of the Quaternary, which is commonly referred to as the 'Ice Age', an episode of global cooling caused polar ice sheets to extend southwards to cover much of Great Britain and Northern Europe. During the Quaternary the climate oscillated between colder (glacial) and warmer (interglacial) stages. Study of sediments, landforms and fauna onshore and offshore have identified 14 to 17 stages of alternating cold glacial and warm interglacial conditions in Great Britain. The most recent glaciation ended around 11,500 years ago. The extensive ice sheets, which in places were over 1 km thick, resulted in erosion and modification of the existing landscape. The effects of persistent freeze-thaw action in ground which was often very deeply frozen, and the deposition of a variety of glacial sediments further modified this pre-existing landscape.

The deposits of the Holocene Period, reflect erosion and deposition in a varied succession of environments during much milder climatic conditions.

The distribution of Quaternary deposits varies depending on the processes active at the time and the pre-existing landscape. (Figure 23) shows the maximum extent of the last regional glaciation in Great Britain and hence the areas that are wholly or partially covered by glacial deposits. Older, weathered and dissected glacial deposits occur as far south as London.

More recent, Holocene, fluvial deposits occur in almost all valleys or river courses and are still forming. These include a wide range of deposits including clays, silts, sands and gravels. Landslips occur in many areas and are not necessarily limited to steep slopes or hillsides. Peat deposits also developed during the Holocene after the glaciers retreated and occur both in local topographic lows in the deglaciated landscape and as extensive expanses of blanket bog over areas of high ground. Such peat deposits are particularly extensive in the Southern Uplands of Scotland, the Pennines and Dartmoor.

Quaternary deposits and their interpretation provide a wealth of information on the environments of the recent geological past. Information from glacial landforms and the nature and morphology of glacial deposits is essential to understanding these climatic conditions and may provide valuable insights into likely future environmental changes related to global warming.

The study of Holocene fluvial sediments allows interpretation of the evolution of rivers or streams, including extreme events such as flooding. In places, such deposits may also record the influence of human activities.

Geological SSSIs

A number of additional SSSIs in Quaternary deposits are listed under the landforms section.

SSSI Name/GCR Name/Grid Reference/GCR Block

Durham Coast/Shippersea Bay, Easington/[NZ 443 453]/Quaternary of North East England

Durham Coast/Warren House Gill/[NZ 436 426]/Quaternary of North East England

Durham Coast/Marsden Bay/[NZ 400 650]/Coastal Geomorphology of England

Upper Teesdale/Upper Teesdale, Red Sike Moss/[NY 819 290]/Pollen stratigraphy of England

Durham County geological sites

Knotty Hill (and Hoppyland Kames) [NZ 084 319]–[NZ 102 321]

Castle Eden Dene [NZ 422 397]–[NZ 440 400]

Easington Raised Beach [NZ 443 453]

Sacriston Subglacial Channels [NZ 23 49] and surrounding area

Part of Sheraton Kame moraine [NZ 440 367] (A19 road cutting account in literature)

Quaternary deposits in County Durham

Quaternary deposits are widespread over County Durham. They conceal the bedrock in many of the upland valleys and cover substantial areas of the lowland parts of the county (see figure 24). Detailed mapping of Quaternary deposits in County Durham is incomplete. Except for geological mapping undertaken within the past three to four decades, the extent of superficial deposits is significantly under-represented on Geological Survey maps, as older surveys paid most attention to delineating the bedrock.

In County Durham, as in much of Great Britain, the surviving deposits date mainly from the last, Devensian, cold stage, with only very limited evidence preserved of earlier cold and interglacial stages. However, the deposits found within the county are varied and complex reflecting the dynamic conditions during this period of time.

Glacial deposits

Fissure fills in the Magnesian Limestone coastal cliffs may represent the oldest deposits in the area, likely to have formed in the Lower and Middle Quaternary. The fissures contain a variety of boulders, fragments of rock and clay that have been forced in from above by later glaciations. Fossil material in some of the fissure fill from Blackhall Colliery and Warren House Gill includes shells, peat, tree trunks, insects, rodent teeth and the vertebra of an elephant resembling Mammuthus meridionalis. Some of the fissures contain exotic rocks similar to those within the later Scandinavian Drift.

Till (or boulder clay) usually consists of a heterogeneous mixture of grey silty clay with rock fragments ranging in size from gravel and pebbles to boulders: lenses of silt, sand and gravel may be present locally. Till may form drumlins or moraines (see Landforms). Till covers nearly all the bedrock in the eastern and central parts of the county. The deposits in the western area are discontinuous up to 615m above sea level. A common feature of several Northern Pennine valleys is the asymmetrical cover of till. Typically till cover is more or less continuous and comparatively deep on valley sides facing away from the direction of ice flow (known as the lee side). The opposite slopes are commonly free, or almost free, of till cover. Examples may be seen in parts of the Rookhope, Middlehope and Swinhope valleys in Weardale.

A variety of tills have been identified within the county, formed at different times within the Quaternary period:

Scandinavian drift — Warren House Till has been identified as a deposit that may have formed before the last glaciation. The deposits contain exclusively Scandinavian rocks save for some local Permian limestone. The ice mass from which this till was deposited originated in Norway, crossed the North Sea and covered the coastal parts of the county, but it is unlikely that the ice travelled further inland. This glacial deposit, the oldest in the area, is found in the base of buried valleys and topographic lows, the clearest exposures of which are found on the coast at such localities as Warren House Gill.

Lower tills and gravel containing North British rocks including Lake District and Scottish rocks were deposited by the British ice sheet after the Scandinavian ice sheet retreated. It is possible that there is a complete climatic cycle between the deposition of the Scandinavian and British Drift deposits.

The Upper till overlies both the Lower Till and the Scandinavian drift, the Easington Raised Beach and some sand and gravel deposits described below. The deposit is widespread and was deposited during the last glaciation.

Erratics are boulders or larger blocks of rock, most commonly within till, that have been transported by glaciers and deposited far from their original source. They therefore give clear evidence of the direction of ice flow. Within County Durham erratics of a variety of distinctive Lake District rock types may be found. As described above, the different tills present in the county contain boulders with a variety of origins. These provide evidence for successive ice sheets which originated in Scandinavia, Southern Scotland, the Lake District and within the Pennines. A common feature of erratic boulders, especially when freshly exposed from the surrounding till, is the striking scratches or striations, created by grinding against other boulders within and beneath the ice sheet. Good examples of erratic boulders include the 'Devil's Stones' in the public gardens in the centre of Crook.

Glacial rafts may be considered as giant glacial erratics. Rafts are defined as bodies of sediment that have been transported by the ice, plucked from their original position and deposited elsewhere as the sediment freezes on to the base of the ice sheet. Several striking examples of large Dinantian Limestone erratics up to many metres across may be seen on Herdship Fell, Upper Teesdsale. Many large glacial rafts were revealed in opencast coal workings, notably in the Tow Law area, that have since been infilled. Rafts of peat incorporated into the till were exposed in a temporary road cutting at Hutton Henry. Borings for coal elsewhere in the north of the county have proved rafted masses of Coal Measures rocks within the drift. In some cases opencast coal workings have been entirely in such rafts.

Sand and gravel deposits are variable, occurring in a number of different settings within the Quaternary deposits of County Durham. In some areas these deposits have been identified as glaciofluvial deposits (described below) and are recorded as such on the Geological Survey maps. The mechanism of deposition of other sand and gravel deposits has not been differentiated on these maps. In parts of the county a tripartite division in the Devensian (last glacial) sediments has been recognised. This consists of the Lower and Upper tills, separated by an intervening body of sand and gravel referred to as the Middle or Ryhope Sands. These deposits may have been deposited by meltwaters from the retreat of the western ice back to the Lake District and Southern Uplands. Other bodies of sand and gravel include more recent deposits overlying the upper till and locally a group of basal sands and gravels.

Glaciofluvial deposits are bodies of sand and gravel that are the products of meltwater discharging from ice sheets and formed in a similar way to modern braided streams. Glaciofluvial sand and gravel deposits occur in the valleys and the eastern part of the county. During deglaciation, following the last glacial maximum, the ice thinned and it began to follow the influence of the underlying relief, becoming confined to the lower parts of the valleys. It is in these valleys that extensive sands and gravels were deposited.

Glaciolacustrine deposits usually consist of sands, silts and clays deposited in a lake adjacent to a glacier. In Durham during deglaciation following the last glacial maximum, large quantities of meltwater formed lakes. Water flowing to the east was blocked by the North Sea ice lobe creating the large glacial Lake Wear. Within this was deposited a widespread succession of laminated silty clays, fine-grained sands, stony clays and some basal gravels, known as the Tyne-Wear complex. Although this sequence is not distinguished on most BGS maps, its constituent lithologies are recorded as Laminated Clay or Glacial Sand and Gravel. The complex formed at the same time as the Middle or Ryhope Sands and may be found in the sequence between the Upper and Lower tills.

Pelaw Clay is a thin heterogeneous layer of clay, overlying the clays deposited by glacial lakes and may have resulted from periglacial mass flow processes.

Buried valleys within County Durham are the pre-glacial valleys of the modern rivers which are now choked by, and concealed beneath, substantial thicknesses of till and other glacial deposits. The county has striking examples of such buried valleys clearly visible at Cauldron Snout, where the till-choked pre-glacial valley of the River Tees lies a few tens

of metres west of the present river course, the valleys on the coast at Warren House Gill and Hawthorne Dene, the buried valley of the river Wear to the north of Chester-Le-Street and the diversion of the Wear through Sunderland.

Raised marine deposits are fossil beach deposits found elevated above the modern sea level. Easington Raised Beach is a fine example of a raised beach. The partly cemented gravels are over 30m above the modern sea level and the deposit contains marine shells as well as pebbles bored by marine molluscs and worms.

Peat deposits include both extensive blanket bogs, generally in the uplands in the western part of the county, and basin peats. These latter deposits occupy hollows or depressions in glacial drift or ice-eroded bedrock and are found in isolated patches in the central and eastern parts of the county. Generally blanket peat is up to two metres thick whereas basin peat may locally be much thicker.

Periglacial deposits

Under **periglacial** conditions the modification of existing deposits and rockhead occurs by various processes. Those affecting the deposits at the surface include solifluction and freeze-thaw action generating deposits of head and scree.

Head is the term used to describe spreads of poorly sorted angular rock debris mantling hillslopes and deposited by gelifluction. This process is the flow of water-saturated bodies of debris over frozen ground and only occurs in the uppermost 3 metres of superficial deposits. Such material is almost certainly present over many hillsides within the county, though it has not been separately delineated on published geological maps of the county.

Scree, also called talus, consists of accumulations of broken rock fragments which have been moved by gravity down steep slopes. Examples occur near the foot of the Whin Sill Crags on Cronkley Fell.

Permafrost conditions

Modification of the subsurface structure of deposits and sediments occurs in zones of permafrost. This defines areas where ground is permanently frozen for a substantial period of time and the penetration of ground ice is deep. Two features that formed under these conditions in County Durham have been recognised:

Involution is the distortion and twisting of unconsolidated sediments. This occurs due to changes in density and pressure associated with the presence of a frozen layer overlying unfrozen sediments. Such movement is also referred to as cryoturbation. Distorted deposits demonstrating the process of involution are exposed in sand and gravel deposits found in the coastal cliffs near Whitburn.

Ice-wedge casts are features formed as the result of cracking of the ground due to contraction during periods of extreme cold, followed by water penetration and freezing within the crack. Upon melting the ice is replaced by material falling in from the top and sides so that a cast or pseudomorph of the original ice wedge is preserved. Ice wedge casts have been noted in some localities such as in Coal Measures mudstone at an opencast site near Leamside and in gravel NE of Sherburn.

Holocene deposits

Lacustrine deposits are sediments, usually consisting of laminated silty clays and fine-grained sands, deposited in former lakes. Extensive areas of such deposits are found in the southeast of the county forming flat areas of ground. Areas of peat may be associated with such areas. These distinct landscapes are referred to as 'carrs', excellent examples of which can be seen in the area to the south of Bradbury [NZ 312 254].

Holocene fluvial deposits include a variety of alluvial sediments, ranging from silts and clays to coarse sands and gravels, which form flat spreads adjoining streams and rivers. Such deposits may accumulate as flat sheets on river or stream floodplains. Fluvial deposits occur extensively in close proximity to current river and stream channels and many abandoned channels.

River terraces deposits are dissected remnants of former floodplain deposits lying above the modern flood level. They represent accumulations of alluvial material deposited during earlier phases of river development, and record changes in base level and may reflect climatic conditions during Late-glacial and Holocene times.

Beach deposits comprise accumulations of sand and shingle exposed between the high and low water marks. In addition to boulders and pebbles of Magnesian Limestone, a high proportion of the naturally occurring beach material on the Durham coast appears to have been derived from the Quaternary deposits eroded from the cliffs. A variety of glacially transported rock types can be seen in most accumulations of beach shingle. Most prominent are boulders of Carboniferous limestones and sandstones, with smaller quantities of Whin Sill dolerite, some Cheviot volcanic rocks and rocks derived from southern Scotland and the Lake District.

Many years of dumping of colliery spoil particularly from collieries in the Dawdon and Easington area led to huge and disfiguring accumulations of Coal Measures shale, sandstone, pyrite and some coal on the Durham beaches. Long-shore drift spread much of this material southwards along the coast. Through the recent 'Turning the Tide' project, Durham County Council have removed much of this contamination and many of the county's beaches are now approaching their original composition. Concentrations of colliery spoil remain locally, notably in the Dawdon and Hawthorn areas where the beach deposits locally contain high concentrations of pyrite.

Storm beach deposits are accumulations of beach material built up by storms and high tides well above normal high tide level. Substantial deposits of colliery spoil at Dawdon Blast Beach and at Hawthorn Hive are, in effect, storm beach deposits, albeit composed of tipped material.

Blown sand occurs as coastal dunes in the extreme south of the county around Crimdon. The largest patches of Blown Sand are up to 2 metres thick.

Influence on the landscape

Apart from modifications due to human intervention, virtually the entire present day landscape of County Durham is the result of erosion and deposition during Quaternary times. The most important of these processes date from the major glacial episodes though it is important to appreciate that, in common with all natural landscapes, that of County Durham is dynamic and still evolving in response to natural processes.

In parts of the Durham Dales, the prominent bench features associated with the cyclical deposits of the Carboniferous limestones, sandstones and shales, locally contrast dramatically with much more subdued rounded till-mantled slopes. The characteristic 'half egg' shaped hills, known as drumlins, are characteristic of till in parts of Weardale, Teesdale, around Easington and the City of Durham.

In the lowlands, Quaternary deposits mantle the pre-glacial bedrock topography. As a result, variation in the relief of the surface may be less than that of the underlying bedrock. The bedrock surface may locally be below present day sea level. Thus some coastal areas are only above sea level due to the presence of glacial drift.

Glacial sand and gravel deposits form features such as kame terraces (see Landforms).

Lacustrine deposits form extensive areas of open, largely flat 'carrs' such as Bradbury, Preston and Mordon Carrs.

Holocene fluvial deposits form flat ground adjoining rivers and streams.

Influence on biodiversity

Where Quaternary deposits mantle the solid rock, the soils are significantly influenced by the composition of the 'drift' rather than the bedrock.

These deposits also influence infiltration of water and the movement of water as groundwater. Sand and gravel deposits have characteristics different from clayey tills creating areas of well- or poorly-drained ground which may be reflected by variations in vegetation.

Extensive spreads of comparatively impervious till may have encouraged the development of blanket peat.

River terraces and alluvial deposits support a characteristic flora. Shingles are well drained and such areas may be subject to rapid erosion and flooding. Some plant communities are reliant on unstable, or rapidly eroding, conditions thereby eliminating or limiting competition from more vigorous species.

Some fluvial deposits in the west of the county, that contain high concentrations of heavy metals, support specialised metallophyte plant communities including Alpine pennycress (*Thlaspi alpestre*) and Spring sandwort (*Minuartia verna*) (see Mineral Veins). Metalliferous mining not only influenced the metal content of sediment and water, but also resulted in modification to the morphology of many rivers and streams.

Flooded abandoned sand and gravel workings are prominent in parts of the Wear valley, notably at Low Barns Nature Reserve, where they provide important habitats for a wide range of wildlife species, including migratory and wading birds.

Economic use

Glacial sand and gravel deposits have been worked in several parts of the county. Glaciolacustrine deposits have been worked in the past as a source of brick clay. Hill peat has locally been worked as a fuel, notably for lead smelting. In addition erratic boulders and clearance stones, derived from glacial deposits, have been employed in drystone walls and vernacular architecture (see Built Environment).

In the 18th and 19th centuries glacial laminated clays were dug for the manufacture of bricks, tiles and pipes in many large pits between Durham and Finchale Priory, between Thornley and Shotton and between Wellfield and Station Town. Bricks and tiles were also formerly manufactured from till for example southeast of Tursdale Colliery and between Nunstainton East and Sedgefield.

Wider impact

Several sites exhibiting sections through glacial deposits within the county are designated as GCR sites for their importance in interpreting glacial periods and processes, recognising interglacial periods and the relationship between these for the history of the northeast coast.

Selected references

Boulton et al. 1985; Brigland et al. 1999; Burgess and Holliday, 1979; Gregory, 1997; Gregory et al. 2002; Huddart and Glasser, 2002; Johnson, 1970, 1995; Johnson and Dunham, 1963; Mills and Holliday, 1998; Mills and Hull, 1976; Pounder, 1989; Smith, 1994; Smith and Francis, 1967; Taylor et al. 1971.

Figures and photographs

(Figure 23) Maximum extent of ice in Great Britain during the Devensian glaciation.

(Figure 24) Distribution of Quaternary deposits in County Durham .

(Photo 49) Shippersea Bay, Easington. Quaternary debris filling fissure in Magnesian Limestone. B Young, BGS, ©NERC, 2004.

(Photo 50) Haugh Hill, Harwood, Teesdale. Till overlying striated pavement of Whin Sill dolerite. B Young, BGS, ©NERC, 2004.

(Photo 51) Devil's Stones, Crook. Erratic boulders of volcanic rocks from the Lake District. DJD Lawrence, BGS, ©NERC, 2004.

(Photo 52) Herdship Fell, Teesdale. Large erratic mass of Dinantian limestone. B Young, BGS, ©NERC, 2004.

(Photo 53) Cauldron Snout, Teesdale. The pre-glacial channel of the River Tees, now plugged with till, can be seen in the river bank. B Young, BGS, ©NERC, 2004.

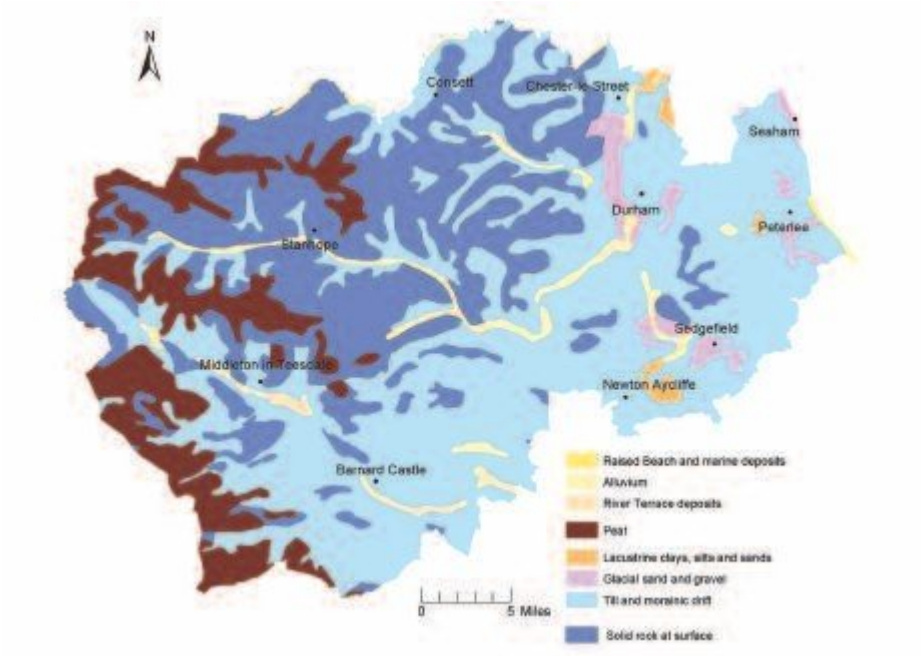
(Photo 54) Shippersea Bay, Easington.The Easington Raised Beach. B Young, BGS, ©NERC, 2004.

(Photo 55) Hawthorn Hive. Pyrite-rich sand derived from colliery spoil. B Young, BGS, ©NERC, 2004.

(Photo 56) Durham Gravel Pit. Glacial sands and gravels. Photographed 1965. BGS, ©NERC, 2004.

Full references

(Figure 23) Maximum extent of ice in Great Britain during the Devensian glaciation.



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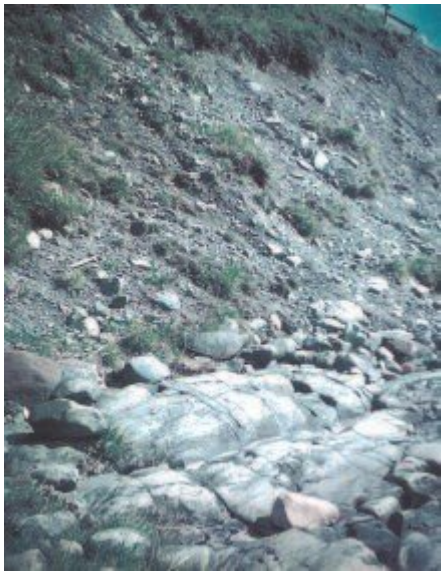

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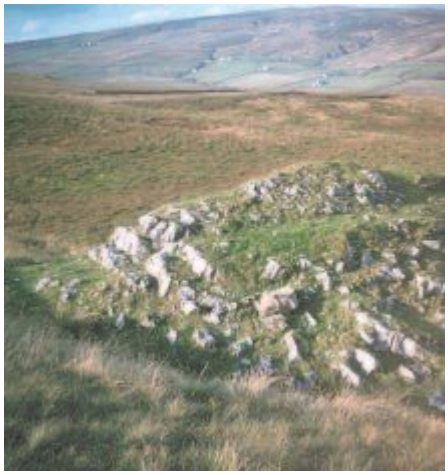

(Photo 52) Herdship Fell, Teesdale. Large erratic mass of Dinantian limestone. B Young, BGS, ©NERC, 2004.

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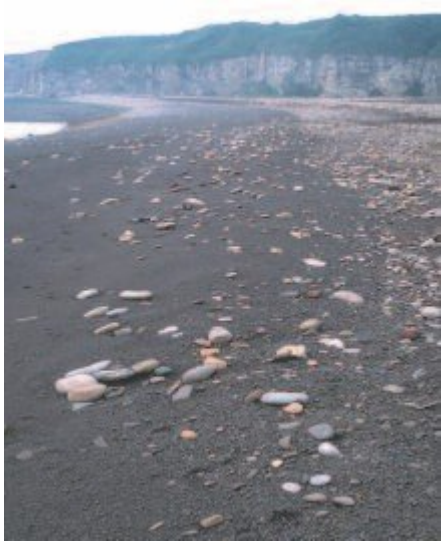

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