| **Natural Area:** 23. Lincolnshire Marsh and Coast | **Geological Significance:** Notable **(provisional)** |
|---|---|

**General geological character:** The solid geology of the Lincolnshire Marsh and Coast Natural Area is dominated by Cretaceous chalk (approximately 97-83 Ma) although the later Quaternary deposits (the last 2 Ma) give the area its overall character. The chalk is only well exposed on the south bank of the Humber, where quarries and cuttings provide exposures of the Upper Cretaceous Chalk. The chalk is a very pure limestone deposited on the floor of a tropical sea.

During Quaternary times, the area was glaciated on several occasions and as a result the area is covered by a variety of glacial deposits, representing an unknown number of glacial ('Ice Age') and interglacial phases. The glacial deposits consist mainly of sands, gravels and clays in variable thicknesses. These are derived primarily from the erosion of surrounding bedrock and therefore tend to have similar lithological characteristics, usually with a high chalk content. The glacial deposits are particularly important because of the controversy surrounding their correlation with the timing and sequence in other parts of England, especially East Anglia. The Quaternary deposits are well exposed in coastal cliffs of the area.

**Key geological features:**

- Coastal cliffs consisting of glacial sands, gravels and clays
- Exposures of Cretaceous chalk

**Number of GCR sites:**

Oxfordian: 1 Kimmeridgian: 1 Aptian-Albian: 1 Quaternary of Eastern England: 1

**Geological/geomorphological SSSI coverage:** There are 2 (P)SSSIs in the Natural Area covering 4 GCR SILs which represent 4 different GCR networks. The site coverage includes South Ferriby Chalk Pit SSSI which contains an important Upper Jurassic succession, overlain by Cretaceous deposits. Here the fossiliferous clays include the stratigraphically significant boundary between the Oxfordian and Kimmeridgian Stages of the Upper Jurassic. This boundary dates from around 154.7 Ma, and is being considered as a candidate for an international stratotype designation (if this is accepted by the International Union of Geological Sciences then the geological significance of the Natural Area will increase to 'Considerable' grade). At South Ferriby Cliffs SSSI there are exposures of glacial deposits which are used in correlations of the glacial history of Eastern England.

**Key geological management issues:**

- Lack of inland geological exposures
- Need to safeguard important existing geological localities
- Threat to coastal exposures from coast protection works

**Key geological objectives:**

1. **Encourage the recording and conservation of new or temporary exposures**

2. **Conservation of the candidate stratotype** at South Ferriby

3. **Ensure coast protection works are part of an agreed shoreline management plan**

**Useful guides/references:**

JONES, R.L. & KEEN, D.H. 1993: Pleistocene Environments in the British Isles. Chapman and Hall, London.

KENT, P. 1980: British Regional Geology, Eastern England, Tees to the Wash. Institute of Geological Sciences. HMSO, London.

**Earth science (P)SSSIs in the Natural Area:**

- South Ferriby Chalk Pit
- South Ferriby Cliffs

| **Natural Area: 24. Middle England** | **Geological Significance:** Considerable **(provisional)** |
|---|---|

**General geological character:** This very large Natural Area shows a great geological diversity, with rocks ageing from the Lower Jurassic (208-178 Ma) through to the Quaternary (the last 2 million years). The Lower Jurassic rocks are dominated by fossiliferous marine clays within which there is a major sandstone formation (the 'Marlstone'). Where they outcrop, these sandstones form a topographic feature in the form of an escarpment. The marine clays were deposited on the floor of tropical seas when the climate of Britain was much warmer than today.

The Middle Jurassic rocks were laid down around 178-157 Ma and consist of sandstones, ironstones and limestones. The lowest part of the Middle Jurassic succession includes the well known and formerly economically important Northampton Sand Ironstone. This is overlain by the shallow water limestone of the Lincolnshire Limestone (showing affinities with those of the Greater Cotswolds Natural Area). In turn this is succeeded by the complex shallow water and swamp deposits of the Grantham and Rutland Formations. These have yielded dinosaur bones such as *Cetiosaurus*. The uppermost part of the Middle Jurassic includes the Oxford Clay which is internationally famous for its vertebrate fossils and important for its stratigraphy. It is also famous for providing the clay for the brick-makind industry. The rest of the Upper Jurassic (157-146 Ma) includes the Ampthill and Kimmeridge Clays both locally yielding important fossils. The Natural Area also includes early Cretaceous deposits belonging mainly to the Lower Greensand and Gault. The latter is a fossil-rich clay deposited in marine waters around 112-97 Ma. Between Cambridge and Arlesy (Bedfordshire) the upper part of the Gault consists of a thin phosphatic sandstone known as the Cambridge Greensand. This has yeilded a large vertebrate fauna, while phosphate extraction in the last century produced numerous small working which characterise this area. Upper Cretaceous chalk appears in the extreme southern part of the area, and is a very pure limestone deposited in tropical marine conditions. The area has been glaciated an unknown number of times during the Quaternary when ice sheets invaded the area from the north. These ice sheets eroded the underlying soft Jurassic and Cretaceous rocks and redeposited them as vast quantities of sands, gravels and glacial clays. These surficial deposits now mask the older underlying rocks over most of the Natural Area. Locally, along many of the river valleys there are extensive Quaternary terrace gravels. These often contain important fossil land vertebrate and invertebrate faunas, for instance in the Ouse and Nene Valleys. Fossil mammals found in these terrace gravels include elephant, rhinoceros, bison and hippopotamus, as well as the remains of plants and animals of both glacial (cold) and interglacial (warm) climates over the last 300,000 years or so.

**Key geological features:**

- Formerly economically important Ironstone deposits.
- Middle Jurassic limestones and clays showing a great variety of environments.
- Oxford Clay exposures in brickpits of importance for palaeontology and stratigraphy.
- Fossil rich-limestones and clays at the junction of the Oxford and Ampthill clays with rich faunas
- Exposures of well known fossiliferous Cambridge Greensand (Cretaceous) with diverse faunas including reptile bones.
- Quaternary glacial deposits.
- Quaternary river terrace gravels with important fossil faunas.

**Number of GCR sites:**

Quaternary of South Central England: 5 Bathonian: 4 Aptian-Albian: 2 Aalenian-Bajocian: 1
Cenomanian-Maastrichtian: 1 Pleistocene Vertebrata: 1

**Geological/geomorphological SSSI coverage:** There are 15 (P)SSSIs in the Natural Area containing 14 GCR SILs which represent 6 different GCR networks. Five sites represent the Middle Jurassic deposits of the area: eg. Cranford St John SSSI shows the Rutland Formation and Blisworth Limestone and the lateral transition between the two (the environmnetal transition from marine to brackish conditions). Double Arches SSSI shows the Cretaceous Greensand and its upper boundary with the Gault Clay. Six sites illustrate the Quaternary evolution of the Natural Area including the important deposits of Biddenham Pit SSSI with primitive stone implements of archaeological importance. Histon Road SSSI is a 'greenfield ' site showing interglacial deposits and Travellers Rest Pit SSSI is a site representative of the formation of Quaternary river terraces.

**Key geological management issues:**

- Threats by landfill to many quarry sites, especially disused ironstone workings
- Lack of protection for important Oxford Clay (eg Callovian and Oxfordian) sites
- Deterioration due to overgrowth of many key sites
- Depletion of Quaternary resource by gravel workings.

**Key geological objectives:**

1. **Work with mineral extraction and landfill industry** to ensure protection of important geological sites

2. **Establish conservation of representative Oxford Clay sites.**

3. **Establish principles of site recording/documentation at working sites** where the loss of resource is possible (eg. working gravel pits)

**Useful guides/references:**

SYLVESTER-BRADLEY, P.J. & FORD, T.D. 1968: Geology of the East Midlands. Leicester Univ. Press.

CHATWIN, C.P. 1961: British Regional Geology, East Anglia and adjacent areas, Institute of Geological Sciences, HMSO, London.

**Earth science (P)SSSIs in the Natural Area:**

- Cowthick Quarry
- Cranford St John
- Barrington Chalk Pits
- Barrington Pit
- Histon Road
- Travellers Rest Pit
- Nine Acres Pit
- Biddenham Pits
- Double Arches Pit
- Finedon Top Lodge Quarry
- Irchester Old Lodge Pit
- Thrapston Station Quarry
- Wing Water Treatment Works
- Blisworth Rectory Farm Quarry
- Roade Cutting

| **Natural Area: 25. Northamptonshire Uplands** | **Geological Significance:** Some **(provisional)** |
|---|---|

**General geological character:** The Northamptonshire Uplands Natural Area is mainly underlain by Middle Jurassic (approximately 178-161 Ma) limestones and clays representing a variety of marine and non-marine environments (with affinities to the succession within the Greater Cotswolds Natural Area). Rocks exposed include clays, silts, iron-rich sandstones and oolitic limestones of the Inferior Oolite (Aalenian-Bajocian Stages, approximately 178-166 Ma). The Inferior Oolite was initially dominated by a shallow sea which deposited the Northampton Sands, this was succeeded by estuarine conditions which formed sediments assigned to the Lower Estuarine Series. Overlying the Inferior Oolite is the Great Oolite Series (Bathonian Stage, approximately 166-161 Ma) which saw the persistence of estuarine conditions and the resultant deposition of the Upper Estuarine Series. Environmental conditions changed again and a rise in sea level caused the sedimentation of a limy/clayey facies now recognised as the marine Great Oolite Limestone and Clay. Physically, the area is dominated by the Jurassic scarp slope. Associated landslips, as seen at Rockingham, developed during late Pleistocene times (less than 1.5 Ma). The area was not glaciated during this time but was affected by extreme periglacial (tundra-like) erosion influencing the local drainage of rivers such as the Cherwell.

**Key geological features:**

- Middle Jurassic escarpment
- Important Middle Jurassic sequence (Inferior Oolite and Great Oolite) geologically linking Greater Cotswolds to Lincolnshire Limestone/Lincolnshire Clay Vales (via part of Middle England); i.e. key region for Jurassic stratigraphy
- Fluvial geomorphology of the Cherwell Valley

**Number of GCR sites:**

Fluvial Geomorphology of England: 1

**Geological/geomorphological SSSI coverage:** There is only 1 (P)SSSI in the Natural Area which represents a fluvial geomorphological interest (Upper Cherwell at Trafford House). The Cherwell valley at this site contains an 'underfit stream', the valley being created by what was formerly a larger river which has been reduced in size either by a change in river catchment or reduction in precipitation level.

Though there are no Jurassic sites selected potential interest (if any revisions were undertaken) would fall into the Aalenian-Bajocian and Bathonian GCR networks.

**Key geological management issues:**

- Integration with policies for Greater Cotswold, Middle England, Lincolnshire Limestone, Lincolnshire Clay Vales Natural Areas
- Potential loss of sites due to infill
- Maintain the operation of natural fluvial processes

**Key geological objectives:**

**1. Integrate with key objectives for adjacent natural area** (Greater Cotswolds).

**Useful guides/references:**

HAINS, B.A. & HORTON, A. 1975: British Regional Geology, Central England. Institute of Geological Sciences, HMSO. London.

SYLVESTER-BRADLEY, P.C. & FORD, T.D. 1968: Geology of the East Midlands. Leicester Univ. Press.

**Earth science (P)SSSIs in the Natural Area:**

- Upper Cherwell at Trafford House

| **Natural Area: 26. Bedfordshire Greensand** | **Geological Significance:** Some **(provisional)** |
|---|---|

**General geological character:** The Bedfordshire Greensand Natural Area is dominated by the sands of the Lower Greensand (Woburn Sands), which were deposited in shallow-tropical seas during the Cretaceous Period (approximately 124-112 Ma). These sands dip at a shallow angle to the southeast and form a low escarpment bounded to the south by the Chiltern Hills. The sands are capped by a thin layer of limestone extraordinarily rich in fossil marine shell species especially brachiopods - this is the famous Shenley Limestone.

During Cretaceous times this area formed a shallow shelf that fringed the East Anglian Massif to the northeast and areas of high ground to the west. Known as the 'Bedfordshire Straits', this shelf linked seas to the north and south, repeated marine flooding from the north depositing the marine Lower Greensand. Eventually the whole area was inundated, the straits lost their identity and the marine Gault Clay was deposited (approximately 112 to 97 Ma). The Gault Clay has a diverse marine fossil fauna including ammonites and various fish, in particular sharks (mainly represented by fossilised teeth).

Locally, extensive glacial clay deposits and associated sands and gravels overlie the Cretaceous rocks. These sediments were deposited during the Anglian glaciation (approximately 290,000 years BP) when the area was covered by an ice sheet from the north. Subsequently, the area was not covered by ice sheets of later glaciations but was affected by the fluctuating interglacial (temperate) and glacial (tundra-like) climate, the latter leading to extreme periglacial erosion.

**Key geological features:**

- Extensive quarries showing Greensand - Gault - Boulder Clay sequences
- Famous fossil faunas of the Shenley Limestone.

**Number of GCR sites:**

Aptian-Albian: 2

**Geological/geomorphological SSSI coverage:** There are 2 (P)SSSIs in the Natural Area covering 2 GCR SILs and representing 1 GCR network. The sites selected represents just two of the many existing or formerly existing sand pits in the area. Nine Acres Pit exposes the Lower Greensand Woburn Sands and Carstone (and a now rare exposure of the Shenley Limestone with its unique fauna and form of preservation). Double Arches Pit exposes the transition between the Lower Greensand and the overlying Gault Clay.

**Key geological management issues:**

- Loss of many sites due to infill
- Deterioration of existing conserved sites

**Key geological objectives:**

1. **Ensure adequate protection and management** of Greensand/Gault exposures

2. **Investigate educational use/interpretation possibilities** in area (and integration with RIGS)

3. **Assess other sites in the district and ensure important sites (temporary or permanent) are conserved or recorded** (eg. through integration with RIGS)

**Useful guides/references:**

Sherlock, R.L., 1960. London and Thames Valley. British Regional Geology,. HMSO.

Shepherd-Thorn, E.R., *et al.*,1994. Geology of the Country around Leighton Buzzard, Memoir of the British Geological Survey, Sheet 220 (England and Wales)

**Earth science (P)SSSIs in the Natural Area:**

- Nine Acres Pit
- Double Arches Pit

| **Natural Area: 27. Fenland** | **Geological Significance:** Considerable **(provisional)** |
|---|---|

**General geological character:** The solid geology of the area is dominated by Upper Jurassic clays including the Oxford, Ampthill and Kimmeridge clays (formed around 157-152 Ma). These deposits were laid down in relatively deep tropical seas and are often rich in fossils including important giant marine reptile remains and ammonites of international significance. Of particular note is an isolated and well known mass of richly fossiliferous Upper Jurassic limestone, including coral reef deposits, which outcrops around Upware.

Much of the geology of the Fenland Natural Area , however, is obscured by the more recent Quaternary deposits (the last 2 million years). The area was glaciated in the Anglian glaciation (around 300,000 to 250,000 years BP) and glacial erosion beneath the ice sheet is probably responsible for the scouring of the Fen Basin and area now occupied by The Wash. The ice sheet deposited glacial sands, gravels and clays across the area, and left a shallow basin in which later peats and marine clays accumulated. It is these deposits which give the Natural Area its distinctive character. The Quaternary deposits are extensive and the most recent of these record important fluctuations in sea level over the Holocene (the last 10,000 years). The deposits include a cyclic succession of peats, estuarine and marine clays deposited in both terrestrial and marine environmenta. The clays formed at periods when sea levels were higher in the recent geological past and also record the occasional presence of marine species (such as whales), up to 30 miles from the present coastline. The peats formed at times of lower sea levels when Fenland was predominantly terrestrial. The sequence of deposits in Fenland therefore demonstrate a detailed record of climatic changes over the last 10,000 years and are important for their contribution to discussions of future climate change and global warming.

**Key geological features:**

- Upper Jurassic clays and associated deposits with important fossil faunas.
- Upper Jurassic fossil-rich limestones including coral reefs and associated deposits at Upware.
- Complex sequences of Holocene deposits representing varied environments and recording a detailed story of recent sea level and climatic changes.

**Number of GCR sites:**
Holocene Sea Level: 8 Oxfordian: 3 Jurassic-Cretaceous Reptilia: 1 Pleistocene Vertebrata: 1
Quaternary of East Anglia: 1 Pollen Stratigraphy of England: 1 Coastal Geomorphology of England: 1

**Geological/geomorphological SSSI coverage:** There are 16 (P)SSSIs in the Natural Area covering 16 GCR SILs which represent 7 different GCR networks. The site coverage emphasises the importance of the area for the study of changing Holocene sea levels. The 8 sites which show these marine, estuarine and terrestrial deposits in Fenland include Adventures Land SSSI, Cowbit Wash SSSI and Holme Fen SSSI. These sites are almost exclusively 'greenfield sites', where the interest lies below the current land surface and where there is no visible exposure. The deposits at Wretton SSSI are famous for their rich fossil assemblage of vertebrates (including arctic fox, reindeer and bison) which represents cold climate conditions during the early Devensian Stage (Quaternary). The species of vertebrates present have been used to reconstruct the environment at this time. Four GCR sites represent the underlying Jurassic deposits and these include the famous Upware Limestone localities and Warboys Clay Pit SSSI. Gibralter Point SSSI is a good example of a migrating spit.

**Key geological management issues:**

- Lack of recording of temporary exposures in a poor exposed region.
- Changes of water levels leading to deterioration of Holocene deposits.
- Threats of infill to old pits and quarries showing Jurassic deposits.

**Key geological objectives:**

**1. Need to ensure that changes in water level management and farming practice do not lead to deterioration of Holocene sea level change sites.**

**2. Need to maintain integrity of existing geological sites** through removal of undergrowth, site clearances and prevention of tipping.

**3. Ensure recording of temporary excavations** to facilitate documentation of areas where exposures do not exist.

**Useful guides/references:**

LEWIS, S.G., WHITEMAN, C.A. and BRIDGLAND, D.R. (eds.) 1991: Central East Anglia and the Fen Basin. Field Guide. Quaternary Research Association, London.

CHAPWIN, C.P. 1961: Britiah Regional Geology, East Anglia and adjoining areas. Institute of Geological Sciences. HMSO. London.

**Earth science (P)SSSIs in the Natural Area:**

- Ouse Washes
- Roswell Pits
- Skippea Hill
- Upware Bridge Pit North
- Upware South Pit
- Wiggenhall St Germans
- Wretton
- Adventurers Land
- Bourne Fen
- Eye Gravel Pit
- Holme Fen
- Warboys Clay Pit
- Cowbit Wash
- Gilbralter Point
- Horbling Fen
- Woodhall Spa

| **Natural Area: 28. East Anglian Southern Chalk** | **Geological Significance:** Some **(provisional)** |
|---|---|

**General geological character:** The solid geology of the East Anglian Southern Chalk Natural Area is dominated by Upper Cretaceous Chalk. This very pure limestone was deposited on a clear tropical sea floor between 97 and 74 Ma. The East Anglian Southern Chalk Natural Area is the natural eastward extension of the Chilterns, although its topography is more subdued. This is because during the Quaternary (the last 2 million years) this area of East Anglia has been subjected to glacial erosion beneath an ice sheet on at least one occasion. These glaciations took place in the later parts of the Quaternary (notably in the Anglian glaciation, around 300,000 to 250,000 years BP). The ice sheet left substantial quantities of sands, gravels and clays (collectively known as "boulder clay" plastered onto the bedrock). This is notoriously chalky in nature since it is derived predominantly from the underlying and surrounding chalk bedrock. In some places substantial thicknesses of tufa have developed in the chalk. Tufa is a calcareous deposit precipitated from water flowing in springs within the chalk. This deposit is notably fossiliferous, and it often contains the remains of both plants and animals which lived around the springs. It is important because these remains provide a record of past climate and environmental change.

**Key geological features:**

- Rolling landscape dominated by low lying chalk hills.
- Tufa development.

**Number of GCR sites:**

Tufa: 1

**Geological/geomorphological SSSI coverage:** There is 1(P)SSSI within the Natural Area covering 1 GCR SIL which has been selected to represent the Tufa GCR network. The site coverage does not include localities which represent the underlying Cretaceous bedrock, At the tufa site, Oughtonhead Lane, Hitchin, a rich assemblage of fossil land molluscs is preserved in the tufa. These include species no longer found in this country, but which inhabit areas such as the present day Pyrenees. A temperate (interglacial) climate is therefore inferred for the formation of the tufa which is of either Cromerian or Honian age: more accurate dating of its age is important because it determines the relationship with glacial events in the area.

**Key geological management issues:**

- Protection of the tufa deposit from changes in water level management and mineral extraction.
- Identification, recording and protection of non-SSSI localities and temporary sections

**Key geological objectives:**

**1. Need to identify and assess new and temporary sites in the area.**

**2. Need to ensure RIGS system caters for localities of non-SSSI importance.**

**Useful guides/references:**

CHATWIN, C.P. 1961: British Regional Geology, East Anglia and adjoining areas; Institute of geological Sciences. HMSO, London.

WHITTOW, J.B. 1992. Geology and Scenery in Britain. Chapman and Hall, London.

**Earth science (P)SSSI in the Natural Area:**

- Oughtonhead Lane, Hitchin.

| **Natural Area: 29. Breckland** | **Geological Significance:** Notable **(provisional)** |
|---|---|

**General geological character:** The Breckland Natural Area is a low lying plateau between 30 and 55 metres above sea level, underlain by the Cretaceous Middle and Upper Chalk (a very pure limestone formed in shallow tropical sea between 100 and 65 Ma). The chalk bedrock is covered by variable thicknesses of a thin, sandy glacial drift deposited when the Anglian ice sheet covered this area around 300,000 years ago. In the much later Devensian glaciation (between 25,000 and 10,000 years BP) this drift was reworked in a periglacial climate when the Breckland was a tundra environment. This formed a more or less continuous cover of wind blown sands across the area, broken in places where the chalk bedrock is close to the surface. Where the two have been mixed by freeze/thaw activity and frost heave processes, the Breckland is characterised by alternating acidic and alkaline soils. Where the periglacial activity was most intense a complex arrangement of periglacial patterned ground has developed and the soils are organised into a series of polygons. The Breckland topography is characterised by alternating patches of sandy and calcareous strata, and these are accentuated by the consequent differences in natural vegetation. Relict periglacial features such as collapsed pingos (enclosed depressions formed by the collapse of former ice mounds) are also found in the area. These provide evidence for the existence of cold periods during the Pleistocene when periglacial (rather than glacial) conditions prevailed. Where the chalk outcrops at the surface of the Natural Area, karst landforms such as swallow holes are developed, and areas of flint have been exploited by early man as a source of stone implements.

**Key geological features:**

- Periglacial pingos, patterned ground and associated soils
- Glacial sands and gravels
- Karst landforms
- Geo-archaeological deposits and flint implements

**Number of GCR Sites**

Pleistocene/Quaternary of East Anglia: 4 Tufa: 1 Karst:1

**Geological/geomorphological SSSI coverage:** There are six (P)SSSIs in the Natural Area containing 6 GCR SILs representing 3 different GCR networks. The majority of sites are selected for their Plesitocene/Quaternary interest. Thetford Heath SSSI shows the important role which periglacial weathering and frost heave has had on the Breckland landscape, and contains the best developed patterned ground in Britain. Grimes Graves SSSI is also important for its patterned ground but is more famous for the Neolithic flint mines which were a major source of flint implements. Beeches Pit, West Stow SSSI shows sections through the glacial deposits of the Brecks and is therefore important for its Pleistocene stratigraphy. The site also contains deposits of tufa which are important for the interpretation of palaeoenvironments. Stanford Training Area SSSI provides good examples of the development of karst landforms such as chalk swallow holes.

**Key geological management issues:**

- Management of existing sites to promote and enhance geological exposures within the Natural Area
- Management of the Breckland soils to preserve the periglacial patterned ground
- Potential conflict between management of the Breckland for its geological and biological interests

**Key geological objectives:**

**1. Maintain and enhance the existing geological exposures within the Natural Area** and assess new sites in permanent or temporary exposures such as quarries and cuttings

**2. Encourage initiatives aimed at the joint management of the Breckland and its soils for both geological and biological interests** and to protect the areas of periglacial patterned ground

**3. Encourage projects aimed at joint promotion** of the geological, archaeological and biological interests of this Natural Area

**Useful guides/references:**

LEWIS, S.G., WHITEMAN, C.A. & BRIDGLAND, D.R. (eds) 1991: Central East Anglia and the Fen Basin. Quaternary Research Association, London.

WHITTOW, J.B. 1992: Geology and Scenery in Britain. Chapman and Hall, London.

**Earth Science (P)SSSIs in the Natural Area:**

- Beeches Pit, West Stow
- Cranberry Rough, Hockham
- Grimes Graves
- High Lodge, Mildenhall
- Stanford Training Area
- Thetford Heath

| **Natural Area: 30. North Norfolk** | **Geological Significance:** Outstanding **(provisional)** |
|---|---|

**General geological character:** The North Norfolk Natural Area consists of a sequence of uppermost Jurassic and Cretaceous rocks, capped throughout by Pleistocene sediments. North Norfolk exposes among the most complete sequences of late Jurassic to mid Cretaceous marine strata in Britain. This sequence of soft mudstones and sandstones forms a series of low N-S escarpments in the west of the area. These Mesozoic rocks were deposited by a rising sea; a shallow marine shelf in the Upper Jurassic Kimmeridge Clay (approximately 153 Ma), a shallow near shore environment in the Lower Cretaceous Sandringham, Dersingham and Carstone Formations (approximately 145-132 Ma) culminating in an overall rise in sea in the Upper Cretaceous (approximately 132-70 Ma) depositing Red and White Chalk.

These Mesozoic rocks are largely concealed by a complex sequence of Pleistocene glacial and interglacial sediments, the area being affected by glacial advance (from the west and northwest) on at least four occasions during the Beestonian, Anglian, Wolstonian and Devensian stages. Interglacials are also well documented, include the Cromerian, Hoxnian and Ipswichian. A complex sequence of sediments remains, in particular belonging to the Cromerian Interglacial Period (347-297,000 years BP) and following Anglian Glacial Period (297-251,000 years BP). Clays, sands and gravels (glacial till or boulder clay) have been left by glacial erosion and deposition (eg. Blakeney Esker) while fossil-rich sediments (eg. Cromer Forest Bed), silts and muds are associated with the warmer, fluvial and estuarine interglacials. Complex deformation structures, the result of ice advance contorting underlying sediments, are seen in Anglian sediments (the 'Contorted Drift'). Relict periglacial features such as collapsed pingos (enclosed depressions formed by the collapse of former ice mounds) are also found in the area. These provide evidence for the existence of cold periods during the Pleistocene when periglacial (rather than glacial) conditions prevailed. Present-day processes are also important in the area, in particular, modern coastal geomorphology and salt marsh development as well as rotational landslips in the poorly consolidated glacial sediments.

**Key geological features:**

- Lower and Upper Cretaceous stratigraphy and palaeoenvironments
- Pleistocene stratigraphy, palaeontology and palaeoenvironments
- Modern coastal geomorphology (including saltmarsh development and land slips)

**Number of GCR sites:**

Pleistocene/Quaternary of East Anglia: 20 Berriasian-Barremian: 4 Pleistocene Vertebrata: 3 Cenomanian-Maastrichtian: 2 Holocene Sea Level Rise: 2 Mass Movement: 1 Aptian-Albian: 1 Coastal Geomorphology of England: 1 Salt Marsh Morphology: 1

**Geological/geomorphological SSSI coverage:** There are 27 (P)SSSIs in the Natural Area containing 35 GCR SILs representing 9 different GCR networks. At least two of the sites are considered to be of international importance; West Runton Cliffs and Sidestrand to Trimmingham Cliffs. The SSSIs can be broadly divided into a number of groups:-

*Lower Cretaceous* - Inland (man-made) sections including the type locality for the Dersingham Formation (Dersingham Bog), sand pits such as Blackborough End Pit (Carstone and Sandringham Formations) and brick pits such as Heacham (Sandringham and Dersingham Formations).

*Upper Cretaceous* - Hunstanton Cliffs provides the best exposure (Hunstanton Formation (Red Chalk) overlain by Ferriby Chalk Formation) while the Sidestrand to Trimmingham foreshore provides the UK's youngest exposure of Cretaceous Chalk (Maastrichtian).

*Pleistocene* - There are a number of type localities including Beeston Cliffs (Beestonian), West Runton Cliffs (Cromerian stratotype), Weybourne Cliffs (Weybourne Crag) and Bawsey (Bawsey Calcareous Till). West Runton is the UK's richest Pleistocene vertebrate locality (recent discovery of the West Runton elephant). Glacial deformation structures are well displayed at Overstrand and Sidestrand to Trimmingham while glacial landforms are present at Wiveton (Blakeney Esker and other glacial landforms) and Hunstanton Park Esker.

*Coastal Geomorphology* - The North Norfolk Coast has the UK's finest salt marsh development, the best documented in the world and important coastal features including barrier islands (eg. Scolthead Island) and spits (eg. Blakeney Point). Rotational landslips at Sidestrand to Trimmingham are also internationally important.

**Key geological management issues:**

- Maintain and enhance existing exposures
- Maintain natural coastal processes
- Agree conservation sections in working quarries
- Assess new sites (temporary or permanent)
- Promote the educational value of the geological resource

**Key geological objectives:**

**1. Maintenance and enhancement of the geological resource** through a) continued maintenance of natural coastal processes (Shoreline Management Plans), b) development of local conservation strategies that include geology, c) continued assessment of educational/research value of new sites (in particular, inland quarries and cuttings, temporary or permanent).

**2. Promotion of geological resource** through a) assessment and promotion of site educational value (e.g. West Runton Cliffs), b) on-site interpretation (eg. sign boarding (see Hunstanton Cliffs), trail guides, leaflets), c) promotion of the influence of geology on local habitats and scenery (eg. Eskers).

**Useful guides/references:**

LARWOOD, G.P. & FUNNEL, B.M. 1961: The Geology of Norfolk. Transactions of the Norfolk and Norwich Naturalists' Society, 19(6).

GIBBARD, P.L. & ZALASIEWICZ, J.A. 1988: Pliocene-Middle Pleistocene of East Anglia. Quaternary Research Association, Cambridge.

**Earth science (P)SSSIs in the Natural Area:**

- North Norfolk Coast
- Weybourne Cliffs
- Beeston Cliffs
- West Runton Cliffs
- Hunstanton Cliffs
- East Runton Cliffs
- Overstrand Cliffs
- Sidestrand-Trimmingham Cliffs
- Mundesley Cliffs
- Happisburgh Cliffs
- Bilsey Hill
- Briton's Lane Gravel Pit
- Glandford Hurdle Lane
- Glandford, Letheringsett Road
- Morston Cliff
- Weybourne Town Pit
- Wiveton Downs
- East Walton Common
- Grimston Pit
- Holkham Brickpits
- Setchley
- Wells Chalk Pit
- Bawsey
- Blackborough End Pit
- Dersingham Bog
- Heacham Brick Pit
- Hunstanton Park Esker

| **Natural Area: 31. Broadland** | **Geological Significance:** Notable **(provisional)** |
|---|---|

**General geological character:** The Broadland Natural Area is underlain almost exclusively by the shelly, muddy and sandy sediments known as the Crag. The most extensive of these is the Early Pleistocene Red Crag Formation (deposited around 2.3 million years BP). These are marine sediments deposited in relatively shallow water, of a cool or temperate nature. The Crag deposits are noted for their abundant marine fossils, which indicate how the relatively mild climatic conditions of preglacial times (Pliocene to Mid Pleistocene) degenerated through several oscillations of temperature into the cold glacial climates of the Middle and Late Pleistocene. The effects of the subsequent Anglian glaciation (at around 300,000 years BP) are shown by the existence of substantial quantities of boulder clay and chalky till, derived form the underlying Cretaceous strata to the north and west. The Anglian ice sheet removed vast quantities of chalk and clay from the North Sea basin and deposited these on land as chalky till. The chalky till is best exposed in coastal sections to the east of the Natural Area. Following deglaciation, climate has continued to oscillate with varying sequences of peats forming in times of climatic amelioration. The Broads themselves are a series of artificial hollows created by peat digging in the eleventh to thirteenth centuries during times of relatively low sea level. A combination of crustal tilting and continued Holocene sea level rise has now flooded these excavations to produce the familiar scenery of Broadland. Exposures of the underlying geological strata are therefore rare except at the coast.

**Key geological features:**

- Exposures of preglacial Crag deposits and Anglian chalky till in coastal sections
- The Broadland landscape

**Number of GCR sites:**

Pleistocene/Quaternary of East Anglia: 1 Pleistocene Vertebrata: 1

**Geological/geomorphological SSSI coverage:** There is only 1 (P)SSSI in the Natural Area which contains 2 GCR SIIs. This site is Bramerton Pits which is important because it is regarded as the type site for the early Pleistocene Norwich Crag. The pits have also yielded important vertebrate remains (sush as otter bones) as well as the remains of fish and marine fossils.

**Key geological management issues:**

- Threats to coastal exposures from coastal defences and coast protection schemes
- Potential for promoting links between geology and landscape in this poular recreational and scenic area

**Key geological objectives:**

1. **Maintain and enhance the geological exposures** in the Natural Area

2. **Maintain the operation of natural processes in the rivers and coast** of the Natural Area

3. **Encourage links** between geology, scenery, recreation and tourism in the Broads

**Useful guides/references:**

ELLIS, E.A. 1965: The Broads. Collins

GIBBARD, P.L. and ZALASIEWICZ, J.A. 1988: Pliocene-Middle Pleistocene of East Anglia. Quaternary Research Field Guide. QRA, Cambridge.

**Earth science (P)SSSIs in the Natural Area:**

- Bramerton Pits

| **Natural Area: 32. Suffolk Coast and Heaths** | **Geological Significance:** Outstanding **(provisional)** |
|---|---|

**General geological character:** The Suffolk Coast and Heaths Natural Area is a generally low-lying area underlain almost exclusively by the shelly, muddy and sandy sediments known as the Crag. The most extensive of these is the Early Pleistocene Red Crag Formation (deposited around 2.3 million years BP). These are marine sediments deposited near the western margin of the southern North Sea in relatively shallow water, of a cool or temperate nature. The Crag deposits are noted for their abundant marine fossils, which indicate how the relatively mild climatic conditions of preglacial times (Pliocene to Mid Pleistocene) degenerated through several oscillations of temperature into the cold glacial climates of the Middle and Late Pleistocene. The Crag is generally divided into 3 broad groups: the Coralline Crag Formation, the Red Crag Formation and the Cromer Forest Bed Formation. Of these, the first two are widespread in the Natural Area and the third is absent. Following the deposition of the Crag sands, the effects of the subsequent Anglian glaciation (at around 300,000 years BP) are shown by the existence of substantial quantities of boulder clay and chalky till, derived form the underlying Cretaceous strata to the north and west. The Anglian ice sheet removed vast quantities of chalk and clay from the North Sea basin and deposited these on land as chalky till. The chalky till is best exposed in coastal sections in the east of the Natural Area, although it is also found in man-made excavations such as quarries. The Suffolk coast is noted for its coastal geomorphological landforms such as Orford Ness.

**Key geological features:**

- Inland and coastal exposures of Crag sediments and contained fossil faunas
- Inland and coastal exposures of glacial sediments and boulder clays
- Coastal geomorphological features

**Number of GCR sites:**

Pliocene: 12 Quaternary of East Anglia: 7 Coastal Geomorphology of England: 1
Tertiary Mammalia: 1

**Geological/geomorphological SSSI coverage:** There are 21 (P)SSSIs in the Natural Area containing 23 GCR SILs representing 4 different GCR networks. The majority of these sites exhibit the sediments of the Crag seas and their contained fossils. These exposures are in both coastal sites (eg. Ramsholt Cliff SSSI) and in man-made excavations (eg. Chillesford Church Pit SSSI). Sites such as Crag Pit, Aldeburgh SSSI provide good exposures of the Pliocene Coralline Crag, whilst Aldeburgh Brick Pit SSSI is an example of an exposure in the Pleistocene Red Crag Formation. All these sites have yielded numerous marine fossils. At sites such as Neutral Farm Pit, Butley SSSI and Waldringfield SSSI the relationship of the Crag deposits to the overlying river gravels and glacial sediments can be seen. Ferry Cliff, Sutton SSSI is an important site for Tertiary mammals, yielding the remains of fossil ground mammals including rodents. Corton Cliffs SSSI is the type locality for the Anglian glaciation in England, and shows a sequence of chalky tills derived from both the North Sea basin and from inland Norfolk overlying preglacial Crag deposits.

**Key geological management issues:**

- Threats to coastal exposures and coastal geomorphological landforms from coastal defences and coast protection schemes
- Threats to the scientific interest of former Crag pits through disuse and neglect

**Key geological objectives:**

1. **Maintain the operation of natural coastal processes** in the Natural Area
2. **Maintain the inegrity of the inland exposures** through vegetation control at former Crag pits and targetted programme of site clearance
3. **Promote and encourage the scientific and educational resource of the geology** of the Natural Area by implementing a thematic "Crag trail" and interpretation guide for visitors to the area

**Useful guides/references:**

GIBBARD, P.L. and ZALASIEWICZ, J.A. 1988: Pliocene-Middle Pleistocene of East Anglia. Quaternary Research Field Guide. QRA, Cambridge.

**Earth science (P)SSSIs in the Natural Area:**

- Neutral Farm Pit, Butley
- Alde-Ore Estuary
- Aldeburgh Brick Pit
- Aldeburgh Hall Pit
- Benacre to Easton Bavents
- Bawdsey Cliff
- Buckanay Farm Pit, Alderton
- Chillesford Church Pit
- Corton Cliffs
- Crag Farm Pit, Sudbourne
- Crag Pit, Aldeburgh
- Ferry Cliff, Sutton
- Gedgrave Hall Pit
- Ramsholt Cliff
- Redhouse Farm Pit, Sudbourne
- Richmond Farm Pit, Gedgrave
- Rockhall Wood Pit, Sutton
- Round Hill Pit, Aldeburgh
- Sudbourne Park Pit
- Valley Farm Pit, Sudbourne
- Waldringfield Pit