Norfolk's Earth Heritage - valuing our geodiversity

Published by the Norfolk Geodiversity Partnership

Contact jennygladstone@aol.com

Text by Tim Holt-Wilson
Design and layout by Su Waldron, NBIS
Printed in Great Britain by Interprint, Norwich NR1 2DL

The Norfolk Geodiversity Partnership gratefully acknowledges the financial support of Breckland District Council, the Geological Society of Norfolk, Natural England, Norfolk Biodiversity Information Service and the Strategic Waste Section at Norfolk County Council in the preparation of this document, and the many comments from and discussions with various individuals and organisations which have gone into its drafting and production. We also thank the various individuals and institutions for permission to use their photographs and images. We acknowledge the conceptual contribution of GeoSuffolk in shaping this document.

ISBN 978-1-84754-216-8

Cover photograph of wave-cut platform at Trimingham © Caroline Markham
Back cover photograph of 'The Marl Pit' by JS Cotman, c.1810
© Norfolk Museums and Archaeology Service (Norwich Castle Museum and Art Gallery)

Norfolk's Earth Heritage
Valuing Our Geodiversity

Foreword

"Norfolk doesn't have any geology" is the response I sometimes receive when I mention the work of the Geodiversity Partnership. As this new publication makes clear, nothing could be further from the truth. Norfolk possesses a remarkable range of geodiversity, from the dramatic shingle spit at Blakeney Point to the vertebrate fossils of Shropham Pit. Norfolk is also at the centre of some of the most lively and contentious geological debates of our time, particularly those surrounding the interpretation of the complex 'superficial geology' or 'drift' which overlies the county's bedrock.

Geodiversity is a critically important resource, but it remains misunderstood, under-valued and under-appreciated – in much the same way as biodiversity has been, until perhaps very recently. Yet geodiversity literally and figuratively underpins our society. It provides our minerals, fuels and soils; it influences our agricultural systems and our landscapes; and it has a profound impact on habitats and species. Fossils offer vital insights into evolution, adaptation and extinction – insights which can help guide our own actions as we grapple with challenges such as climate change.

For all these reasons, I am delighted by the publication of Norfolk's Earth Heritage. It represents the culmination of many months of dedicated effort and research by the Norfolk Geodiversity Partnership, and in particular Tim Holt-Wilson. It also addresses a longstanding gap in the county's natural history literature: for the first time, we have a readily accessible overview of the county's geodiversity, and I have no doubt that the booklet will be an invaluable reference.

Scott Perkin, PhD
Biodiversity Services Co-ordinator
Norfolk Biodiversity Partnership

Summary

'Norfolk's Earth Heritage' is a landmark publication on Norfolk's Earth heritage and the need to conserve it.

- It is a concise yet readable introduction to Norfolk's geodiversity and why it is an important resource for life today.
- It explains the business of geoconservation, and promotes a Geodiversity Action Plan for the county, calling for a partnership of like-minded organisations and individuals to take it forward.
- It includes a range of useful resources, including advice for planners and a list of geological SSSIs.

We hope that Norfolk's Earth Heritage will provide an interesting source of information and inspiration for years to come.

1 Introduction

What is geodiversity?

Geodiversity may be defined as the natural range (diversity) of geological features (rocks, minerals, fossils, structures), geomorphological features (landforms and processes), soil and water features that compose and shape the physical landscape.

Geodiversity influences every aspect of our lives. It provides our drinking water, our soils, our building stones, and the minerals we need to produce everything from tin cans to television sets and the fuels that drive our economy. It has determined many of our historical choices: the waterside locations of towns and villages, the types of agriculture we practice, our transport routes, for example. It determines our physical landscapes and wildlife habitats, and the climate and weather we experience.

Nature conservation has been defined as 'the protection, preservation, management or enhancement and the improvement of understanding and appreciation of flora, fauna and geological and geomorphological features'*. Geodiversity is thus the physical, abiotic part of nature; our Earth heritage. It is the setting, the stage for life itself.

Importantly, geodiversity includes the sediments and fossils associated with the archaeological evidence for human occupation. This palaeo-environmental material provides vital contextual information for archaeologists interpreting the evidence for human life in the past.

The time has come for geodiversity to be seen and valued more widely in Norfolk.

* Definition from Glossary of 'Planning for Biodiversity and Geological Conservation - A Guide to Good Practice' (ODPM 2006).

BACKGROUND

Action for geodiversity

Norfolk's Earth Heritage – Valuing our Geodiversity takes as its scope the county’s rich heritage of geology, landscape and landforms, soils and water. It includes the sedimentary context of the county’s archaeology.

Norfolk's Earth Heritage summarises the county's geodiversity and the threats it faces; it explains the business of geoconservation; it sets out a vision for conserving and promoting the county’s geodiversity. It is intended as a resource for explanation, planning and consultation.

Importantly, *Norfolk's Earth Heritage* also seeks to communicate the richness of the county’s geodiversity, and to inspire its readers to discover it for themselves.

The aim is to bring about a qualitative change in the way that Norfolk's Earth heritage is understood, communicated and conserved, for the benefit of present and future generations of people - and all living things.

Our vision is that

- the contribution of geodiversity to the landscape, biodiversity, economy and culture of Norfolk will be valued and understood;
- the geodiversity of Norfolk will be protected and enhanced for the sustainable use and enjoyment of all living things.

2 Geodiversity in Norfolk

2.1 Valuing our geodiversity

Norfolk's geodiversity is valuable for economic, scientific, educational and cultural reasons. It is also valuable in itself, as a key component of the natural world.

Outstanding features of the county's geodiversity include:

- the North Norfolk coast – an outstanding assemblage of dynamic coastal landforms, including the shingle spit at Blakeney Point, the offshore barrier island at Scolt Head and the dunes at Holkham and Wells-Next-The-Sea.
- Happisburgh Palaeolithic site – a handaxe and other flint tools from sediments of the Cromer Forest-bed Formation dated over 800,000 years ago are the earliest and northernmost evidence of human expansion into Eurasia.
- the Cromer Ridge – an outstanding assemblage of lowland glacial depositional landforms, including the Blakeney Esker and Kelling Heath outwash plain. The internal, geological structure of the Ridge is visible in the cliffs from Weybourne to Mundesley.
- Maastrichtian Chalk at Sidestrand - the youngest Cretaceous Chalk strata in Britain.
- the West Runton Elephant – the largest, most complete skeleton of the Steppe Mammoth ever found.
- the Lynford Neanderthal site – a rare example of an open-air Middle Palaeolithic site comprising river channel deposits with Mousterian flint tools and the bones of eleven Woolly Mammoths.
- The Broads – the UK's largest nationally protected wetland area.
- Hunstanton Cliffs – famous brown, red and white colour banded cliffs.
- Sheringham and West Runton beach - the only well-developed Chalk reefs found between North Yorkshire and Kent.
- the Happisburgh Formation – geological evidence of the earliest lowland glaciation in the UK.
- Norton Subcourse quarry – evidence for extinct hippopotamus and hyaena living in a tributary of the ancestral River Thames.
- Shropham Pit – the most prolific findspot in the UK for vertebrate fossils of the Ipswichian (last) interglacial.
- West Runton cliffs – the most prolific findspot for vertebrate fossils of the Cromerian interglacial.

Photo © Norfolk Museums and Archaeology Service

The West Runton Elephant reconstructed

- lowland periglacial landforms – the best examples of patterned ground ('Breckland Stripes') and relict pingos / palsas in the UK are found in West Norfolk.
- Breckland meres – a group of natural lakes developed in Chalk solution hollows, with distinctively fluctuating water-levels linked with groundwater.
- Pliocene/Pleistocene stratigraphy – Norfolk has contributed many Stage names to the stratigraphy of the UK, including the Ludhamian, Thurnian, Antian, Bramertonian, Pastonian, Beestonian and Cromerian.

Despite all these special features, it is easy to overlook the importance of Norfolk's geodiversity, and it is very difficult to place a value on it. It is, and always has been, a vital resource for life.

Geodiversity provides varied habitats for living things (biodiversity) through soils and topography.

It has contributed many resources for economic life in Norfolk:

- soil for farming;
- water for domestic, agricultural and industrial consumption;
- building materials (freestone and flint, clunch, brickearth, aggregates, clay lump, etc.);
- flint for making gunflints and prehistoric tools;
- glass-making and foundry sand;
- agricultural lime and marl;
- ironstone for smelting, as in the Roman period;
- salt, in Mediaeval times;
- marl for making cement, in the 19th century;
- fuels (peat).


Photo © Tim Holt-Wilson

Mill Drove Quarry, Middleton. Lower Cretaceous Carstone is extracted here for use as hardcore and building material.


Photo © Sara Muldoon

Winfarthing is located in the prime arable landscape of the South Norfolk till plateau. Darker alluvial soils floor the shallow valley (right), a tributary of the Frenze Beck.

Geodiversity performs other useful functions, for example:

- freshwater storage in aquifers and surface waters;
- carbon storage in waterlogged peat;
- water filtration and purification via rock and soil;
- flood storage areas.

Geodiversity is the background for human culture and well-being in Norfolk, providing:

- open spaces, hills, rivers, beaches and other 'green infrastructure' resources;
- information for scientific research and education;
- material for folklore, artistic and spiritual inspiration and a 'sense of place'.

The following pages provide an introduction to the geology, geomorphology, landforms, soils and water of Norfolk.

In Mediaeval times Norfolk was densely populated and prosperous, with a high demand for peat as a fuel. The Broads originated as peat diggings, before being flooded by rising water levels in the 14th century. Seen here, the Trinity Broads (Ormesby, Rollesby, Ormesby Little, Lily and Filby). The straight edges of some Broads mark the edges of former peat diggings.

2.2 Introducing the geology of Norfolk

The geology of Norfolk is a unique record reaching back through some 160 million years of Earth history. The oldest exposed rocks date back to the Jurassic period, although much older rocks are present at depth, and fragments of rocks from different sources have been transported here during the Ice Age.

The structure of Norfolk's bedrock geology is relatively simple: it dips gently towards the North Sea basin, becoming younger eastwards. By contrast, the overlying superficial geology is notoriously complex, and continues to excite lively discussion among geologists.

Norfolk's geology is best exposed in cliffs, quarries and cuttings, but temporary exposures, wells and boreholes also provide much useful information. Sediments and fossils provide an archive of information about environmental change over time; they are particularly important for telling the story of the last two million years, with its extreme changes in climate and wildlife, and repeated phases of human occupation over the last 700,000 years.

The geology of Norfolk may be mapped as two layers: the bedrock deposits (otherwise known as the 'solid' geology) and superficial deposits (otherwise known as the 'drift'). The superficial deposits are those dating from the Pleistocene and Holocene periods which have been laid down over approximately the last 1.8 million years. Both layers are represented in the simplified geological maps and cross-section shown here. For information on the terminology please see Appendix 3.

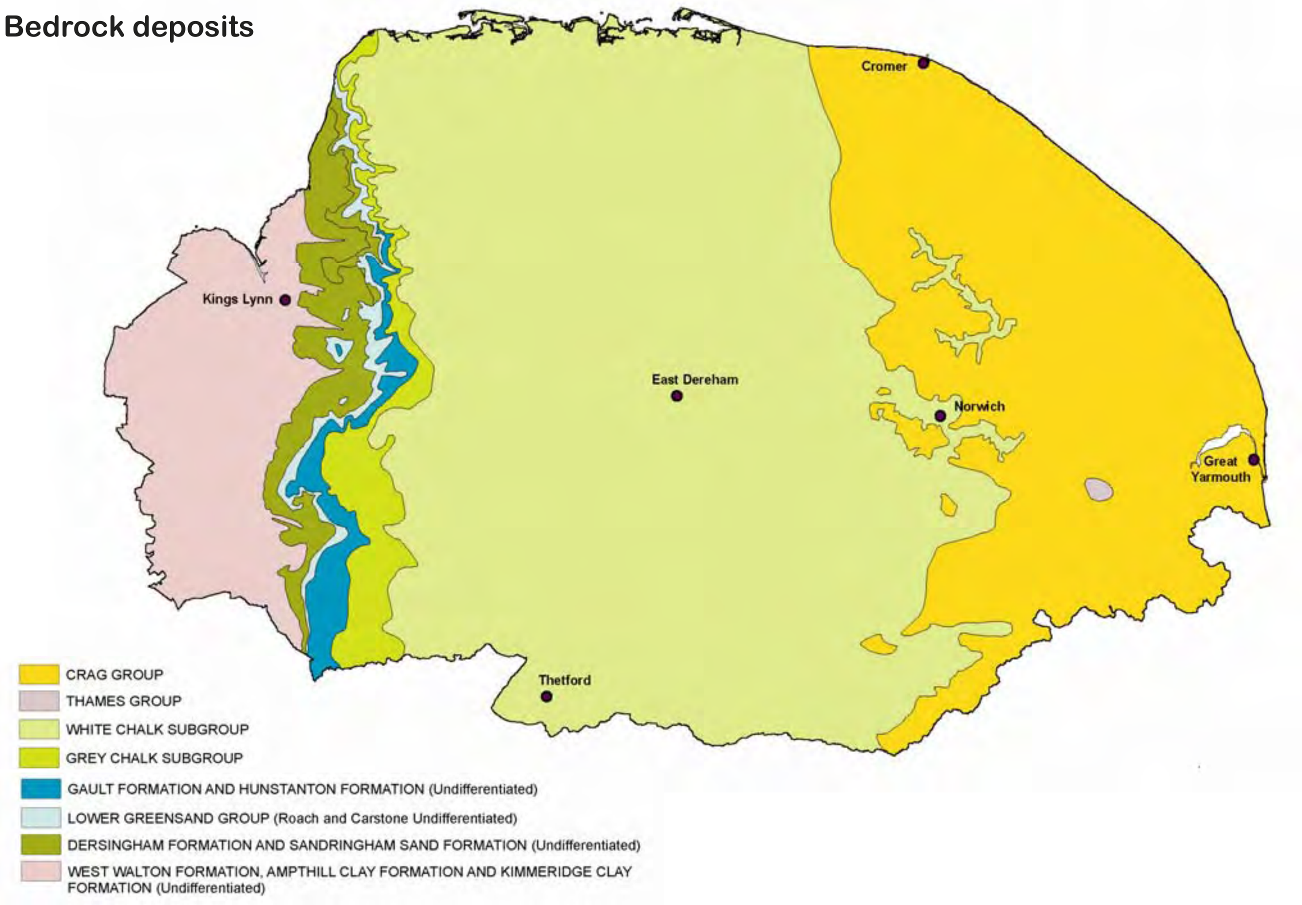
Photo © Tim Holt-Wilson

Marine erosion and deposition in action: intertidal sands at Wells-next-the Sea, showing asymmetrical current ripples with sinuous crests interrupted by tidal scour.

Photo © Phil Crabb (NHM) 2006

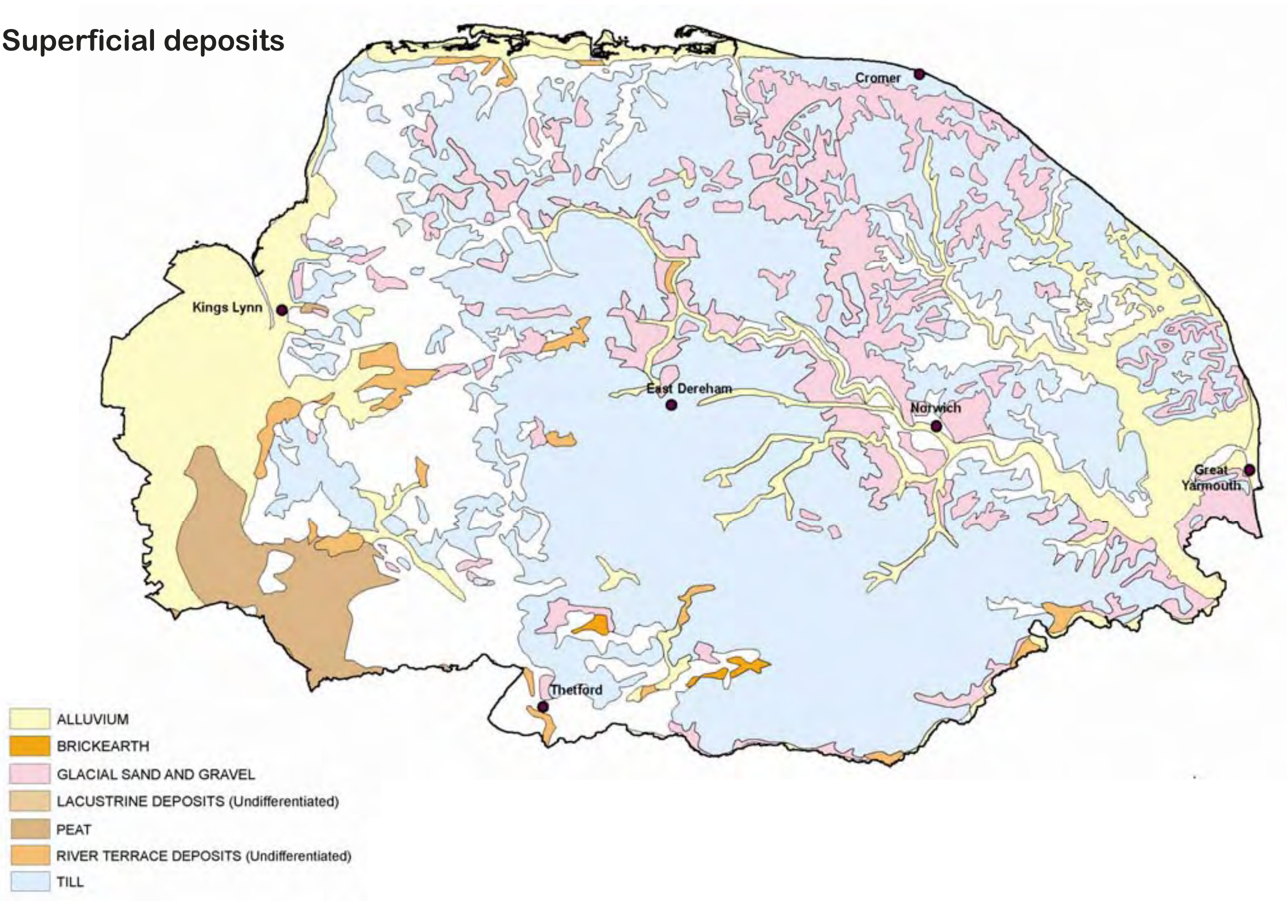
Excavations at Happisburgh, 2006, as part of the Ancient Human Occupation of Britain project. Early Pleistocene gravels have yielded evidence of the earliest and northernmost human occupation in Eurasia.

Bedrock deposits

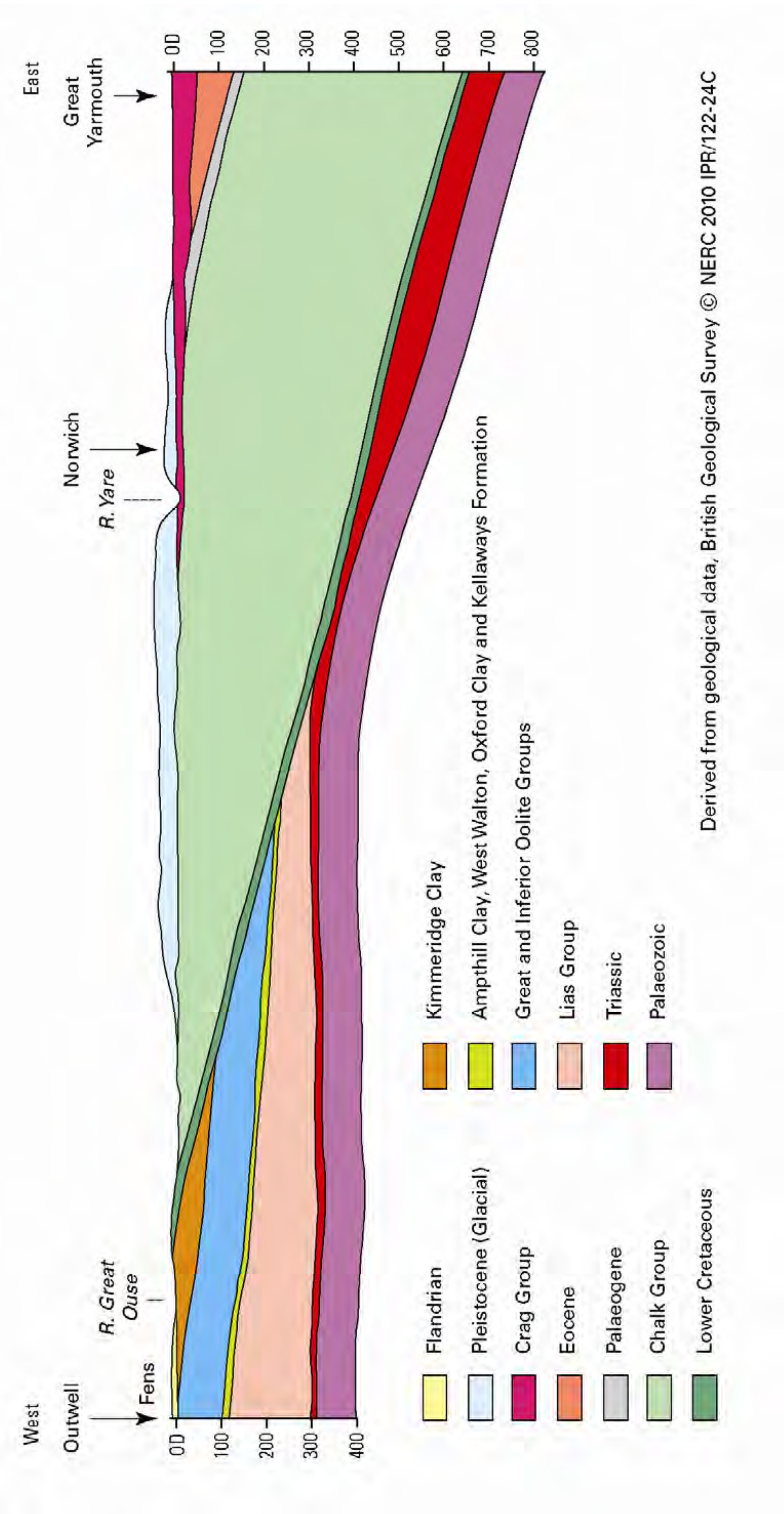


Geological Mapping derived from DiGMapGB-50.
British Geological Survey © NERC 2009. IPR/118-46C.

Superficial deposits



Geological Mapping derived from DiGMapGB-50.
British Geological Survey © NERC 2009. IPR/118-46C



Simplified geological cross-section of Norfolk, showing bedrock and superficial deposits

Derived from digital geological data at 1:50,000 scale, British Geological Survey © NERC 2009. IPR/120-16C

The following pages present a simplified summary of the geology of Norfolk, and use informal names for the rock units.

a) Bedrock deposits

Periods	Age (million years ago)	Informal names of rock units
Pleistocene		Wroxham Crag
	1.8	
Pliocene		Norwich Crag
	2.2	
		[A gap in time from which no deposits are preserved]
Eocene	40	London Clay
		[A gap in time from which no deposits are preserved]
	65	
Upper Cretaceous		Chalk
	99	
Lower Cretaceous		Red Chalk
	105	Gault
	110	Carstone
	115	Roach
	130	Dersingham Beds
	135	Mintlyn and Leziate Beds (Sandringham Sands)
	144	Roxham and Runcton Beds (Sandringham Sands)
Jurassic	153	Kimmeridge Clay
	159	Ampthill Clay
	161	West Walton Beds

See Appendix 3 for information on the formal stratigraphic terminology used by the British Geological Survey.

b) Pleistocene superficial deposits

Age (yrs ago)	West and NW Norfolk	North and Central Norfolk	South and East Norfolk
20,000	Hunstanton Till		
125,000	Ipswichian interglacial deposits	Ipswichian interglacial deposits	Ipswichian interglacial deposits
380,000	Tottenhill Gravels		
400,000	Hoxnian interglacial deposits	Hoxnian interglacial deposits	
450,000	Lowestoft Till	Lowestoft Till	Lowestoft Till
630,000			Happisburgh Till & Corton Till
780,000		West Runton Freshwater Bed	Ingham Sand & Gravel

Basement rocks

Norfolk's bedrock geology is founded on a basement of much older Permo-Triassic and Silurian rocks, identified only from boreholes.

Jurassic

The oldest bedrock strata encountered in Norfolk are of Upper Jurassic age. They are found beneath superficial deposits in the Fenland basin and The Wash embayment, but are not exposed at the surface. The **West Walton Beds** are calcareous silty and shelly marine mudstones, with cementstone concretions. The **Ampthill Clay** has a similar lithology but the rock is softer and contains more clay; it was laid down in a shallow shelf sea not far from land. Both units contain fossil ammonites, bivalves, foraminifera and plant debris.

The **Kimmeridge Clay** is a blue-grey, marine mudstone rich in fossils and it contains cementstone concretions. It is the oldest rock exposed at the surface, principally in the eastern part of Fenland as far north as the Wash, where it forms low-lying land bordering and underlying the Fens. In places the Kimmeridge Clay has

Photo © Mike Hurn

A polished section of an ammonite from the Kimmeridge Clay at Crimplesham quarry.

Photo © Mike Hurn

Calcite crystals in a cavity from a Kimmeridge Clay mudstone concretion from Crimplesham quarry.

layers of bituminous oil shale, and attempts were made at Setchey c.1920 to exploit it as a source of fuel oil. The resource was judged to be commercially non-viable.

A sequence of greenish-coloured marine sandstones, the **Roxham and Runcton Beds** (part of the Sandringham Sands), span the boundary between the Upper Jurassic and Lower Cretaceous. They have been exposed from time to time in the King's Lynn area of West Norfolk.

Cretaceous

The Lower Cretaceous **Mintlyn and Leziate Beds** (part of the Sandringham Sands) and the **Dersingham Beds** are a succession of sands and sandstones interbedded with mudstones. They underlie tracts of heathland in West Norfolk, and are an important source of sand for glass making and foundry moulding, as at Leziate.

The **Roach** is a grey and brown pebbly mudstone containing nodules of ironstone. It has been found in excavations beneath Hunstanton beach, and in areas to the south beneath superficial deposits.

The **Carstone** is a brown, iron-rich sandstone which outcrops in west Norfolk and is quarried for building stone. It is a local equivalent of the Lower Greensand beds found elsewhere in England.

Photo © Robin Stevenson

A degraded former cliff-line at Dersingham Bog showing white sands of the Leziate Beds (Sandringham Sands) underlying iron-rich sands of the Dersingham Beds.

Photo © Tim Holt-Wilson

Wicken South pit at Leziate is developed in the Sandringham Sands Leziate Beds. The white, grey and yellow colours reflect variations in iron content and the effects of leaching.

Photo © Tim Holt-Wilson

A Carstone wall at Snettisham. Carstone is a useful building stone which tends to harden with age. It is also quarried to supply hardcore for roads.

Photo © Jenny Gladstone

Carstone outcrops at the base of Hunstanton cliffs and on the foreshore. It forms a strange pattern of 'tuffets', where the sea has preferentially eroded joints in the rock.

Photos © Val Vannet (left) and Jenny Gladstone

The Red Chalk forms a distinctive band in Hunstanton Cliffs, sandwiched between Chalk and Carstone. Both this rock and the overlying Grey Chalk show evidence of extensive disturbance by boring and burrowing organisms.

The **Red Chalk** is a red limestone rich in fossils which outcrops only in north-west Norfolk; it is spectacularly displayed in Hunstanton Cliffs. It is the same age as the **Gault**, fossil-rich mudstones which outcrop in other parts of West Norfolk. Parts of the Gault show interesting rhythmically deposited layers.

The **Chalk** is a white or grey limestone formed from the microscopic shells of planktonic organisms. The Chalk is over 460m thick in Norfolk, and the county has the greatest range of Chalk strata of anywhere in Britain, making it important for scientific research. It principally outcrops as a low, rolling plateau in West Norfolk, also along the north Norfolk coast as well as near Norwich where the rivers Yare and Wensum have cut down through overlying beds to expose it.

Flints originate in the Chalk, and have been widely used in Norfolk as a building stone; they were valued in prehistoric times for tool making and more recently for making gunflints.

Photo © Tim Holt-Wilson

Caistor St Edmund chalk pit. Chalk is extracted here, using disc harrows, to make agricultural lime. Norwich Crag sands overlie the Chalk.

Photo © Tim Holt-Wilson

The gallery of a Neolithic flint mine at Grimes Graves, Weeting. The miners extracted huge tabular nodules of black flint from the Brandon Flint Series of the Turonian Chalk.

Individual flint bands may often be followed across country for many kilometres. Chalk has been extensively quarried over the centuries for agricultural and building lime, and harder layers have been used as building stone known as 'clunch'. Today, the Chalk aquifer is the county's most important source of drinking water.

Photo © Tim Holt-Wilson

Cottage walls at Thorpe St Andrew, built from contrasting panels of knapped (broken) and nodular flint.

Photo © British Geological Survey P249701

Circular flints known as paramoudras may be seen at Runton beach. They are thought to have formed by precipitation of silica around vertical tubes or burrows in the Chalk sediment. These specimens were photographed in 1923.

Eocene

A small subcrop of London Clay has been identified from boreholes beneath Holocene deposits in the Yare valley near Cantley. The London Clay was deposited in brackish water on the margins of a tropical sea about 40 million years ago.

Pliocene

The Crags are a sequence of sandy, marine deposits laid down in the gradually cooling climatic conditions leading up the 'Ice Age'. They outcrop in the eastern parts of Norfolk. The **Norwich Crag**, dated about 2 million years old, contains the fossil remains of mammals such as mastodon, sabre-tooth and whale, and also molluscs.

Photo © Jenny Gladstone

A tooth of the Southern Elephant (*Mammuthus meridionalis*) originating from the Norwich Crag, found in Pleistocene sands and gravels at Aldeby.

Photo © Tim Holt-Wilson

A section of Pliocene seafloor exposed in Caistor St Edmund chalk pit: marine sands of the Norwich Crag resting on an eroded surface of Cretaceous Chalk. Fossil mammal bones are often found in this basement bed.

A section at Blake's Pit, Bramerton. This is the type-site of the Norwich Crag Formation and Bramertonian Stage of the Pliocene. Silty clays and cross-bedded sands were laid down in an inshore marine environment.

Photo © Peter Riches

Pleistocene

The Pleistocene 'Ice Age' is a complex series of cold glacial and warm interglacial climatic periods which began 1.8 million years ago[1]. It has left an important legacy of superficial deposits across Norfolk.

These have been the subject of intensive scientific research for over a century, and many of the classic geological sites and borehole sequences for understanding the environment and climatic changes of the Pleistocene are found in the county. This knowledge may help us to anticipate some of the changes which may occur as a result of global warming.

During early Pleistocene times two major rivers flowed through Norfolk into the North Sea basin: a large river from Lincolnshire (the 'Ancaster River'), and one from the Midlands (the 'Bytham River') which flowed north-eastwards across the south-eastern part of the county. We may track the course of the Bytham River using its distinctive suite of river terrace deposits known as the **Ingham Sands and Gravels**; these are dated between 1.0 and 0.5 million years ago. Meanwhile shallow marine deposits known as the **Wroxham Crag** were being laid down off the Norfolk coast, which reached as far west as Norwich at that time. Recent research suggests ice sheets may have reached Norfolk as early as 630,000 years ago and deposited the **Happisburgh Till** and **Corton Till**, though this date is disputed.

[1] The exact timing of the transition between the Pliocene and Pleistocene is subject to ongoing debate among geologists. For the purposes of this document it is taken to be marked by the end of the continental Tiglian C4c substage, the MIS 64/65 boundary and the end of the Olduvai magnetostratigraphic event. However, in 2009 the International Union of Geological Sciences revised the transition downwards to the base of the Gelasian Stage, being the MIS 103/104 boundary and the end of the Gauss event, at 2.58 million years - thus effectively placing the Norwich Crag in the Pleistocene.

Photo © Tim Holt-Wilson

Weybourne Cliffs SSSI, showing gravelly 'Weybourne Crag' (folded by glacial tectonic action) overlying Chalk bedrock. Anglian glacial deposits cap the cliffs.

Photo © Martin Warren

Happisburgh Cliffs show an important sequence of Anglian and pre-Anglian sediments spanning five stages in the Pleistocene period. This site has produced evidence of the earliest humans in north-west Europe.

The coldest glacial period, the Anglian, saw ice sheets spreading across Norfolk from the north and north-west around 450,000 years ago; they gouged out the broad depression that is now Fenland and swept over and eroded a former range of Chalk hills in the west of the county. They left behind thick layers of chalky 'boulder clay' known as the **Lowestoft Till** and associated sandy outwash deposits that underlie many parts of Norfolk, and which form much of its best corn-growing farmland. Much of the Cromer Ridge is thought to have formed at this time. Meltwater under pressure beneath the ice sheet eroded the bedrock and carved out tunnel valleys which later filled with sediment; one under the Thet valley at Snetterton is over 50m deep.

There is evidence that ice sheets also reached Norfolk in later cold periods: glacial outwash deposits at Tottenhill in the Nar Valley may be date from about 340,000 years ago, while the most recent glaciation took place 20,000 years ago, when a brown 'boulder clay' known as the **Hunstanton Till** was deposited along parts of the north coast.

Photo © Jeannie Harris

The Village Stone at Great Hockham, an erratic boulder brought to the area during the Anglian glaciation. It is ritually turned over to commemorate important events in the life of the village.

Photo © Martin Warren

Sidestrand Cliffs dramatically shows slices of Cretaceous chalk which have been sheared up by an Anglian ice sheet and rafted into glacial till.

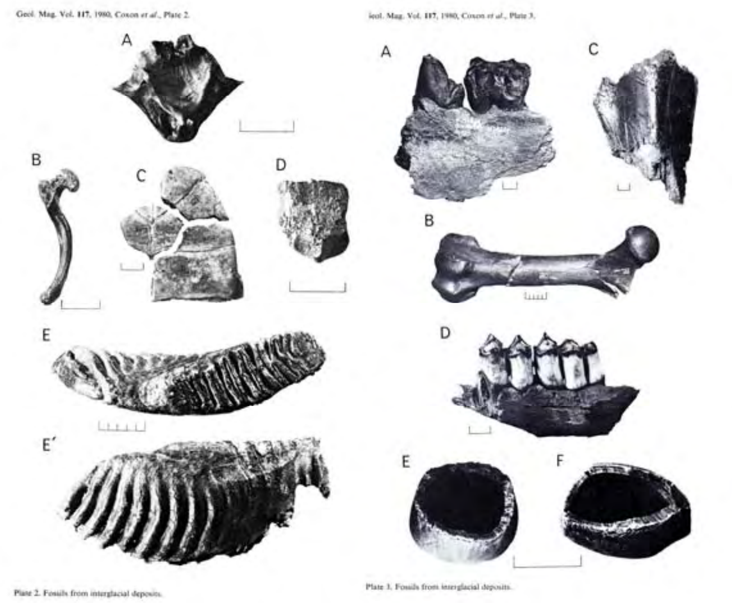
During cold periods when the landscape was not covered by an ice sheet, it was affected by permafrost and periglacial freeze-thaw action which mobilised soil and surface layers and modified slopes. Distinctive **patterned ground** developed in western Norfolk during the last cold period about 18,000 years ago, where frost action sorted chalky subsoil and sandy drift into polygonal or striped patterns. Superficial deposits known as **head** accumulated on slopes, valley flanks and floors by mass movement downhill. Meltwater rivers deposited thick **sand and gravel** sequences in valleys such as the Thet, Waveney and Wensum; these provide valuable resources for today's aggregates industry. Plants and animals, including humans, were able to colonise the region during warmer interglacial periods.

Photo © Tim Holt-Wilson

Slumping of glacial sands and clays of Anglian age in the cliffs at Overstrand SSSI. Three different ice advances are represented here. The unstable ground provides a notable range of wildlife habitats, with rare beetle species present.

Norfolk is rich in such warm phase deposits; the most famous being the **West Runton Freshwater Bed**, which has yielded the spectacular fossil remains of an elephant dating back perhaps 780,000 years. River-channel deposits at Happisburgh have yielded flint tools made by the earliest humans in northern Europe, dating back over 800,000 years. Norton Subcourse quarry is another important site from the early Pleistocene, with evidence of extinct hippopotamus. Interglacial deposits of Hoxnian and Ipswichian age (c.420,000 and 125,000 years ago respectively) have been found in Norfolk river valleys, and are typically rich in environmental evidence including vertebrate, beetle and plant remains.

Picture courtesy of Coxon et al. in Geological Magazine 117 (1980).



Fossils of Ipswichian interglacial age from Swanton Morley gravel pits, including pond turtle, straight-tusked elephant, hippopotamus and spotted hyaena. Gnawed hazelnut shells are pictured lower right.

Photo © Tim Holt-Wilson, courtesy John Lord

A handaxe found at Lynford gravel pit of a type used by Neanderthal humans. 47 handaxes have been found associated with bones of mammoth, horse and reindeer in sediments dated over 60,000 years old.

Photo © Tim Holt-Wilson

Grey, organic-rich deposits at Norton Subcourse quarry were laid down in a riverside environment, perhaps 680,000 years ago. They are underlain by shallow water marine sediments (yellow sands and gravels).

Photo © Martin Warren

Most of the fossil skeleton of a Steppe Mammoth (*Mammuthus trogontherii*) was excavated from West Runton cliffs in 1995. Seen here, the excavated right tusk and part of the skull are encased in a plaster jacket ready for removal.

Holocene

The last 10,000 years are part of the Holocene, which is the name for the present interglacial warm period which began at the end of the last Ice Age. Unlike previous periods, human influence has spread throughout the landscape and has modified and shaped it in new ways, through settlement, forest clearance, farming, drainage, earth moving and other activities.

In common with earlier periods, a range of marine, freshwater and terrestrial sediments have been, and continue to be, deposited by active geomorphological processes, notably in coastal areas and river valleys. Deposits include dune sands, shingle banks and sandbanks, estuarine saltmarshes and mudflats, river terraces and layers of floodplain peat and alluvium. Thus sediments continue to be laid down for the future.

Holocene wetland sites contain valuable palaeo-environmental archives in the form of stratified sediments and microfossils, including plants, beetles, molluscs and ostracods. Core samples may be analysed and the results used to provide evidence of environmental change over the last 10,000 years. Peat-rich wetland areas such as Broadland and Fenland may also be valuable for the ecosystem function they perform as natural sinks for storing carbon.

Photo © Tim Holt-Wilson

Alluvial silts underlie the Ouse Washes at Welney. This floodplain was created by drainage work in the Fens 400 years ago, and is now used as a winter floodwater storage area.

Photo © Norfolk Museums & Archaeology Service

Holocene peat beds are exposed along the North Norfolk coast. Seen here, a Bronze Age ceremonial structure ('Seahenge') at Holme-next-the-Sea was once situated in woodland. Sea levels have risen since then and the site is now intertidal.