Reading Geological Society

Lincolnshire Field Trip Report

Monday June 12th 2023 – Thursday June 15th 2023

Led by Professor Peter Worsley (RGS)

with Day 2 in part led by Dr Mick Oates

Introduction

The field meeting was led by Professor Peter Worsley with the objective of introducing RGS members to the geology of Lincolnshire and in particular to consider the evidence and challenges for deciphering the glacial and interglacial events following the Anglian cold stage.

Lincolnshire is a large county (as we found out driving across it) with stratigraphy at out crop extending from the Triassic (Mercian Mudstone) in the west to the Upper Cretaceous (Chalk Group) in the east (Figure 1, Figure 2). There is a complex and partial cover of glacial and interglacial deposits. The bedrock dips gently to the east resulting in a series of scarps produced by the harder limestone and chalk-dominated formations (Figure 1), but from south to north the Mesozoic successions are attenuated onto the long lived Market Weighton High. The High was of particular significance during the early Cretaceous and the Lower Cretaceous formations thin and pinch out northwards (Figure 1).

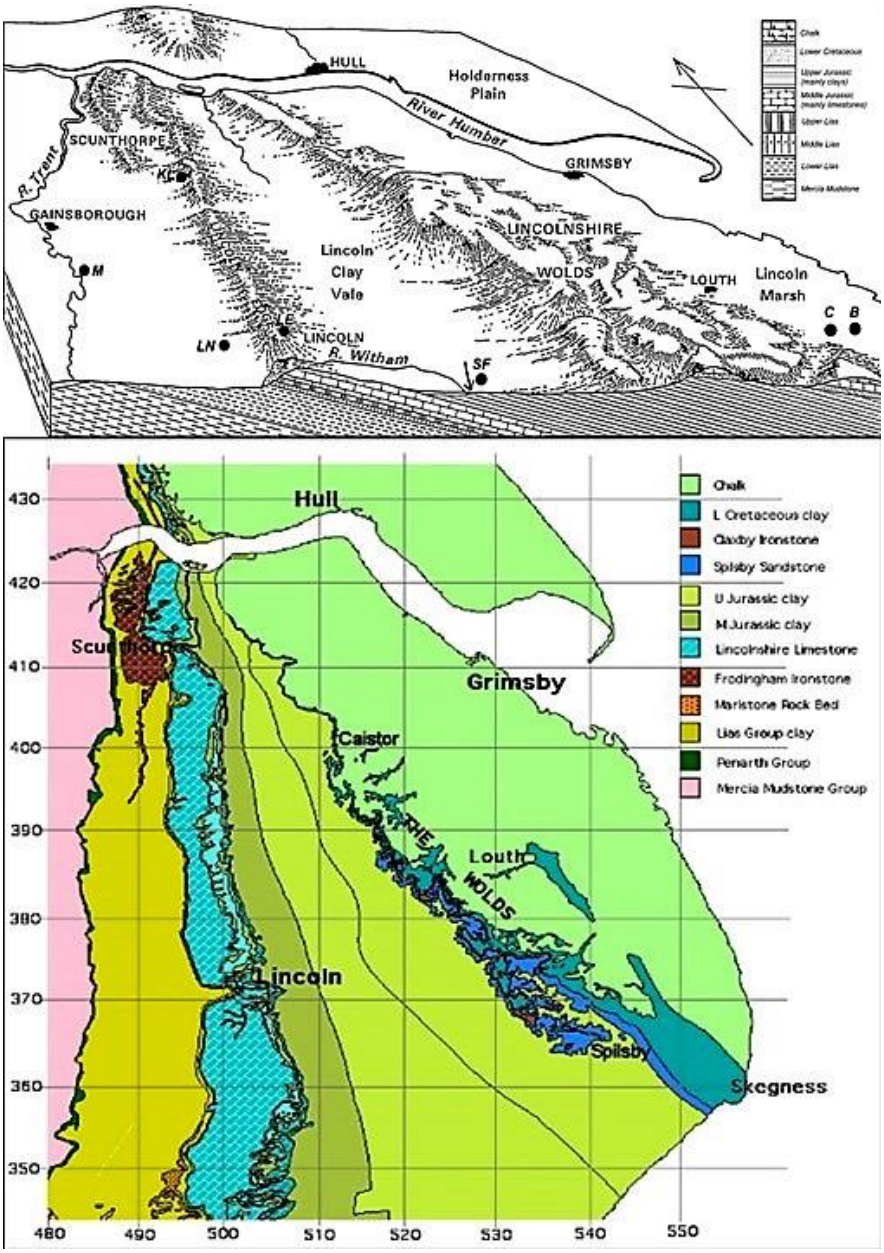


Figure 1 *Shows the simplified solid geology of Lincolnshire augmented with a physiographic block diagram showing the relationship of the landform, geological succession and structure of north and central Lincolnshire.*

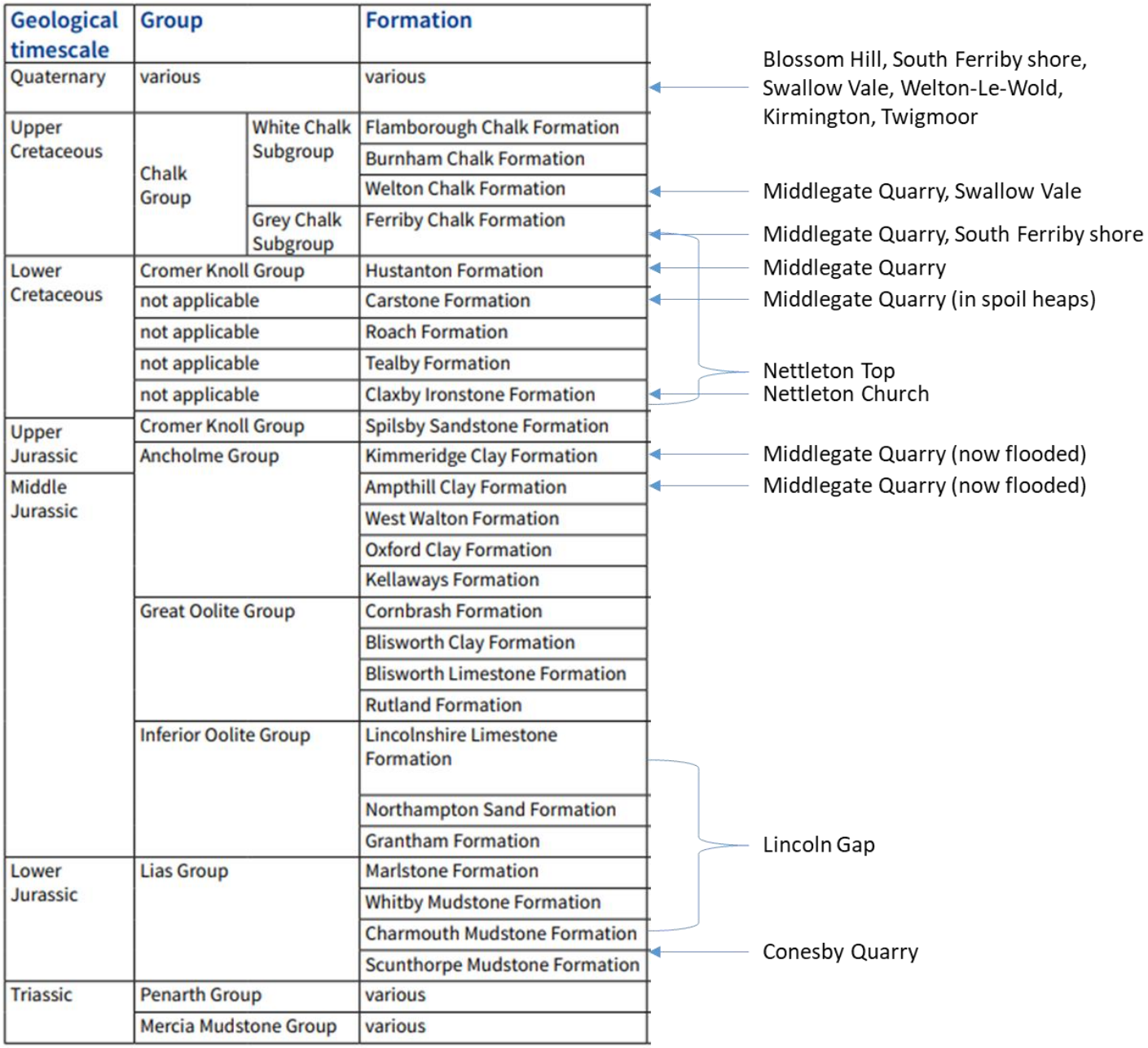


Figure 2 *The pre-Quaternary stratigraphy of Lincolnshire and units and locations visited during the field trip.*

Glacial advances and retreats were described by Peter in his recent talk to the RGS (Figure 3, Figure 4). These, combined with the bedrock geology have created a distinctive range of topographic regions across the county which strongly influence nature, agriculture and transportation paths (Figure 5).

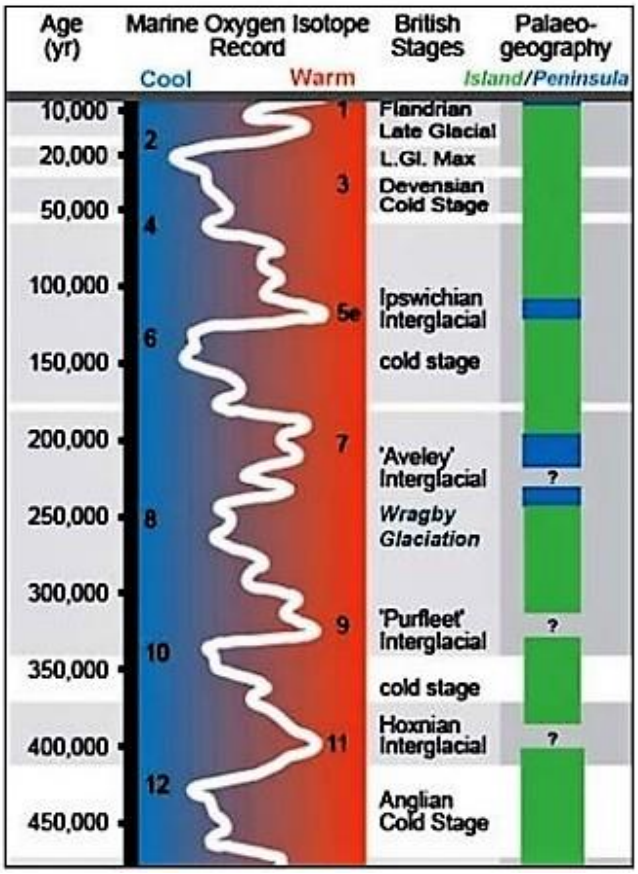
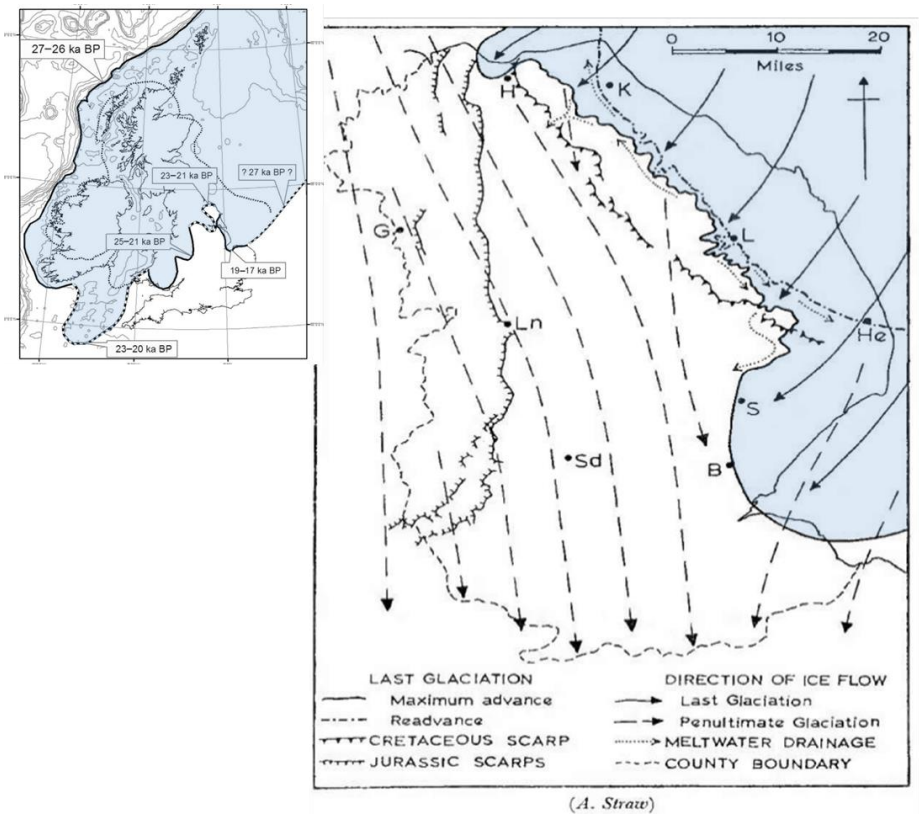


Figure 3 *The generalised marine oxygen isotope record for the later part of the Pleistocene, with suggested stage names (MOIS) from the British terrestrial succession (from Straw & Worsley, 2016).*



H = Horkstow
K = Kirmington
L = Louth
He = Hogsthorpe
S = Stickney
B = Boston
Ln = Lincoln
Sd = Sleaford
G =Gainsborough

Figure 4 *The extent of the last and 'penultimate glaciations in Lincolnshire (after Allan Straw).*

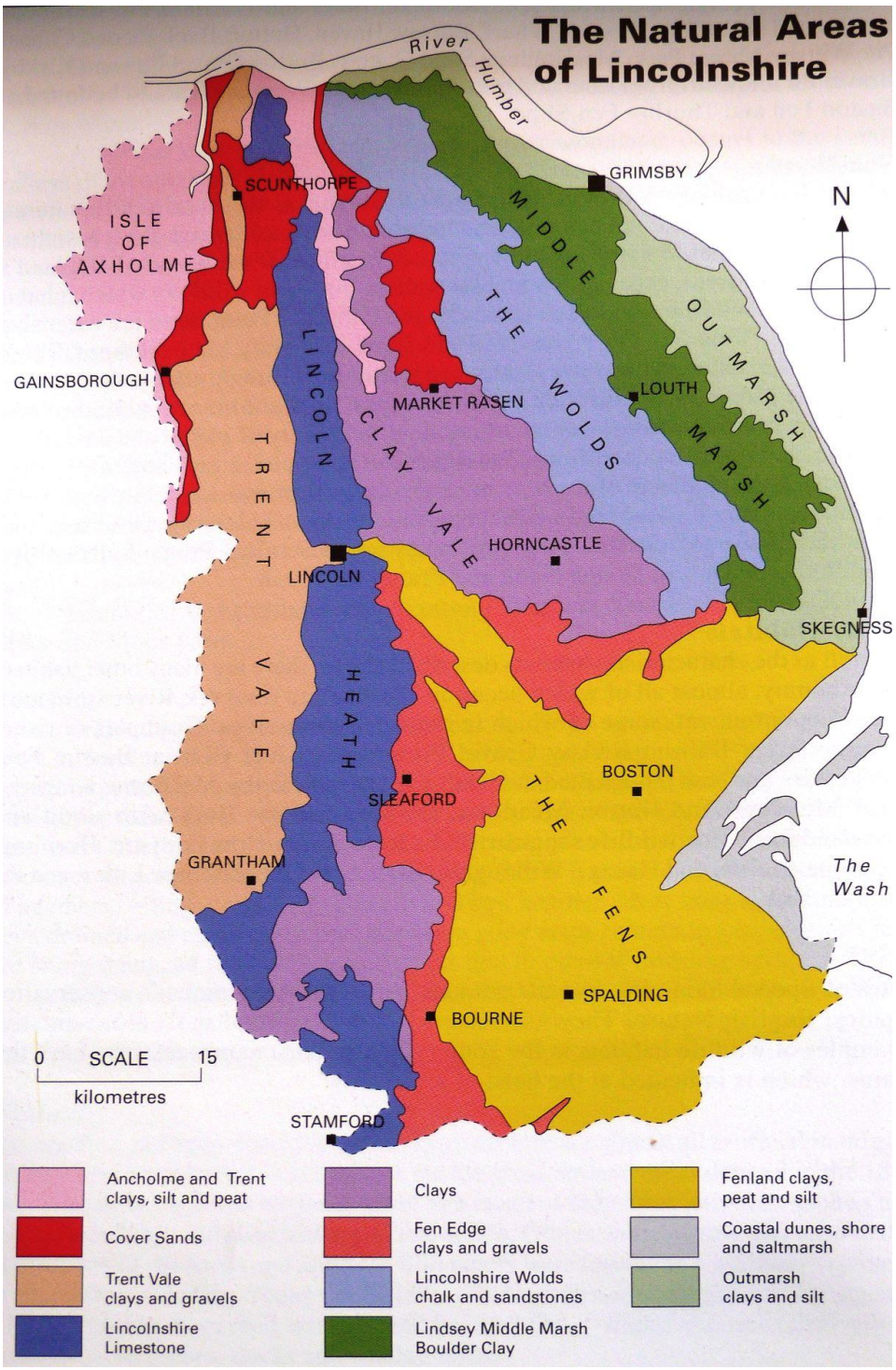


Figure 5 *Shows the natural regions of the county.*

Monday 12th June

The field meeting convened in Stamford and the afternoon encompassed a traverse south-west to north-east across the county from Stamford to Cleethorpes.

Uffington, Blossom Hill

Grid reference: TF 0641 0900; Postcode: PE9 4QE; What3Words: ///chopper.tenure.combos

The site, Blossom Hill, is an old gravel pit in a low hill of about 5 m in height and 300–400 m in diameter, with a good exposure of coarse-grained gravels, exhibiting well-defined cross bedding (Figure 6).

Figure 6 *Large scale, cross bedded gravels in Blossom Hill pit.*

It was suggested that this section should be interpreted as a Gilbert-style delta, with the palaeo-current flowing from the north. The delta was aggrading into a lake. Peter introduced us to the views of Allan Straw, of whom we were to hear more during the week. Peter thought that this sequence had formed in an ice-marginal setting whereas earlier Allan had thought that it was an erosional residual of a much larger fluvio-glacial feature. The bedding was exceptionally well defined, at an angle of about 30° and we discussed delta-switching and cross-cutting concepts.

The group was divided into two and a “competition” commenced to find diagnostic erratics within the sediments. A great variety of “exotics” was found by both groups, “Bunter Pebble Bed” material from the Permo-Triassic, weathered Jurassic fossils such as *Gryphaea* and belemnites, vein quartz, flint, ironstone, chatter-marked pebbles, dolerite, well-cemented gravelly chunks and mudstones, to name a few. An interesting archaeological find was made by a member of the group. It is the tip of an Acheulian hand axe. It was found on the floor of the pit, but had fallen from the gravel face at some stage. (Figure 7).

Figure 7 *Tip of an Acheulian hand axe (left) found at Blossom Hill with comparison with an identified Acheulean hand axe.*

The gravels were overlain by a diamict and the junction between this unit and the gravels corresponds to a decalcification front (Figure 8).

Figure 8 *Loamy diamict at the top of the Blossom Hill quarry with irregular decalcification front.*

The age of the diamict is part of the debate on the post-Anglian, pre-Devensian glaciations of Lincolnshire, which we were to hear about later in the field meeting. Peter was quite excited to find what might be an ice-wedge cast indicative of a former permafrost phase after the deposition of the delta (Figure 9).

Figure 9 *Possible ice-wedge cast between the dashed white lines with structureless gravels. Note the clearly cross bedded gravels of the undeformed delta deposits to the left.*

Casewick Cutting

Grid reference: TF 0753 1007; Postcode: PE9 4RY; What3Words: ///placidly.report.sonic

Currently there are no exposures at this site; we viewed the cutting from the road bridge over the railway (Figure 10).

Figure 10 *Casewick railway cutting which is the location of a channel filled with freshwater deposits.*

Peter reiterated how historical records are important to current day understanding. During the construction of the Great Northern Railway in the 1850s an excavation was made which has been described by J. W. Judd in “The Geology of Rutland” memoir. Fluvio-glacial sands and gravel as seen at Blossom Hill overlie the sandy and silty mudstones of the Kellaways Formation. Within the fluvio-glacial unit are freshwater deposits infilling a channel incision about 3 to 7 m wide. The channel was seen on both sides of the railway cutting indicating a N-S to NE-SW channel orientation.

This is an important site as there is a dearth of interglacial sites in Lincolnshire. 23 species of molluscs along with seeds and plant remains where collected from this site but although they indicate a temperate environment, they are unfortunately not fully diagnostic of a particular interglacial period. There has been an attempt in the past by Royal Holloway University to drill through the sequence from an adjacent field but unfortunately the well got stuck so no samples were obtained for optical dating.

Surfleet and Bicker Haven

Surfleet - Grid reference: TF 2512 2823; Postcode: PE11 4AB; What3Words: ///melon.alright.shrugging
Bicker Haven - Grid reference: TF 2440 3470; Postcode: PE11 4FB; What3Words: ///piston.grants.encourage

The next stop on this south-west to north-east traverse was in Surfleet in the Fens. We passed through Baston, past various pits now not open, where Peter had worked in the past finding two horizons of ice-wedge casts, probably early and late Devensian (Straw & Worsely 2016). The lower horizon could be pre-Ipswichian, before the last interglacial, and be again part of the debate on the post-Anglian, pre-Devensian glaciations of Lincolnshire.

The church in Surfleet, located on the north bank of the River Glen, shows “strange” angles. This is as a result of the drainage of the Fenland basin since 16th century, but particularly in the 19th and 20th centuries; subsidence has been caused by the shrinkage of peat (Figure 11).

Figure 11 *The tower and spire of St Lawrence church at Surfleet which shows evidence of subsidence.*

Travelling north-east from Surfleet, we stopped briefly at Bicker Haven – an area which was a former estuary of the sea in medieval times. Here there is evidence of salt extraction from evaporation pits - small low mounds called salterns rise from the reclaimed land composed of the waste material from the extraction of the salt from the tidal silts. Artefacts found date these to 13th or 14th century. Unfortunately crops almost obscured the salterns.

Holland Fen

Grid reference: TF 2260 4650; Postcode: PE20 3RN; What3Words: ///shaver.tweed.funds

The stop was at a viewpoint across Holland Fen (Figure 12). The fields across to a farmhouse were part of a farm owned by Charles Darwin. It was tenant-farmed and one of four or five his family owned in Lincolnshire. Peter had given us all a copy of his book “The Darwin Farms” and encouraged us to read it for our bedtime reading. We discussed the fen drainage and how this all became reclaimed land in the late eighteenth century.

Figure 12 *View across the fen farmland that once belonged to Charles Darwin and the evidence of continuing subsidence in this former inter-tidal swamp.*

Dogdyke

Grid reference: TF 2088 5549; Postcode: LN4 4JU; What3Words: ///ourselves.bring.editor

The last stop of the first day was at the confluence of the rivers Bain and Witham (Figure 13). Both rivers are contained within high levees which were necessary to enable the fenland to be reclaimed. Pumping is necessary to maintain low water levels in the former fenland. Just off the view in Figure 13 is the preserved Dogdyke steam powered pumping station. This was erected in 1855 and it drained 2,500 acres.

We saw the valley of the Witham at the last stop on Day 4 where it cuts through the Lincolnshire Limestone edge at Lincoln Gap and flows to the sea at Boston.

From here we continued into Tattershall then on to Cleethorpes for the next three nights.

Figure 13 *Confluence of the canalised River Bain (centre) and the River Witham (flowing from left to right).*

Report by Hilary Jenson

Pictures - Hilary Jensen and Peter Worsley

Tuesday 13th June

Middlegate Quarry at South Ferriby

Grid reference: SE 9901 2046; Postcode: DN18 6HB; What3Words: ///booklets.marshes.gloom
Leader: Dr Mick Oates

After an early breakfast we set off to our first site of the day; Middlegate Quarry at South Ferriby and to meet our leader for the day Dr Mick Oates. To start, Mick gave us a brief history of the quarry and summarised the geology.

The quarry, owned and operated by Rugby Portland Cement Ltd, was used to supply raw material for the Cemex cement works to the west of South Ferriby. The quarried chalk and clay were moved to the cement works via a conveyor belt over a distance of nearly 2 kms. The quarry closed in 2020 with the lower section now flooded to a depth of some 30 m (Figure 14).

Figure 14 *Middlegate Quarry, South Ferriby view to the south. The lower chalk is visible on the quarry walls, but originally the quarry extended down into the Upper Jurassic Kimmeridge and Ampthill Clays.*

The stratigraphy of the quarry is as follows:

Upper Cretaceous - Middle chalk	Welton Chalk
Upper Cretaceous - Lower chalk	Ferriby Chalk
Lower-Upper Cretaceous	Hunstanton Red Chalk
Lower Cretaceous	Carstone

~~~~~~~~~~~ Unconformity~~~~~~

Upper Jurassic	Kimmeridge Clays
Upper Jurassic	Ampthill Clay

The Red Chalk and Carstone were not suitable for cement making and so were used as backfill in the quarry.

Two ‘beds’ were of particular interest; the Black Band Member (BBM) and the Carstone. The BBM is the northern equivalent of the Plenus Marls in the south of England that members are very familiar with.

The BBM marks the boundary between the Welton Chalk of the Middle Chalk and the Ferriby Chalk of the Lower Chalk (Figure 15). It is of Cenomanian age (93.9-100.5 Ma) and Turonian age (89.4-93.9my); about the time of the Cretaceous Hot Greenhouse at about 92 Ma. The BBM is a dark carbonaceous, calcareous mudstone with interbedded calcareous mudstone beds (marl).
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The upper boundary of the Carstone is the Hunstanton Red Chalk while the lower boundary marks the unconformity between the Jurassic and Cretaceous. The Carstone is of Albian age (100.5-113.2 Ma) and wedges out to the north. At South Ferriby, the Carstone is about 1 metre thick and is a brown ferruginous sandstone comprising sands, various pebbles and geothitic ooliths (Figure 16). It is medium to coarse grained.

Figure 15 *The Black Band Member, Middlegate Quarry, South Ferriby. The base of the ranging pole rests in the BBM, with the overlying Welton Chalk.*

Figure 16 *The pebbly Carstone present below the Hunstanton Red Chalk.*

Eagle eyed Peter Sergeant found a fish scale and Mick mentioned that paramoudras had been found in this section of the quarry.

We then moved on to the lower quarry. Here we searched for fossils and found brachiopods, crinoids and belemnites as well as a few bivalves (Figure 17).

Figure 17 *Searching the Hunstanton Red Chalk, Carstone and Kimmeridge Clay spoil that forms the bunge to water ponded in the disused quarry.*

North Lincolnshire Museum, Scunthorpe

Grid reference: SE 8917 1091; Postcode: DN15 7BA; What3Words: ///paying.probe.costs
Leaders: Peter Worsley and Mick Oates

Our second site of the morning was the North Lincolnshire Museum. We were privileged to be shown flint artefacts from the Lower / Middle Palaeolithic brought out of the museum store especially for us to view and handle. These had been found in the Cannon Shot Gravels of the Kirmington interglacial deposits (see first location on Thursday). There was much discussion; some were clearly artefacts such as axes and scrapers but others were less obvious so their origin was called into doubt. Unfortunately, the museum staff were equally unsure!

This was followed by a look round the museum exhibits. The geology section concentrated on the Jurassic and there were a large fossil exhibit with ammonites and ichthyosaur fossils on display. A large example of the Frodingham Ironstone from the early Jurassic was the focus of some

attention. This deposit had been used in the iron and steel industries in the 19th century. The rock comprises a grey mudstone, hard yellow calcite cemented ferruginous oolite and ferruginous oolites in a clay matrix.

Report and pictures by Ailsa Davies

Conesby Quarry, Dragonby

Grid reference: SE 8984 1456; Postcode: DN15 0BE; What3Words: ///sings.worth.wipe
Leader: Mick Oates

Purpose: to view the exposure of the Frodingham Ironstone.

Frodingham Ironstone is a Lower Jurassic Lias deposit and has been mined in the Scunthorpe area since Roman times. Significant quarrying and mining recommenced in 1858 and it formed the basis of the Scunthorpe steelworks.

The Conesby Quarry at Dragonby was the last exposure of Frodingham Ironstone to be mined, and was closed in the early 1980s The ironstone itself is at the top of the Scunthorpe Mudstone Formation (Figure 18), and is rich in fossils especially ammonites. *Gryphea* from the Scunthorpe Mudstone are very common on the floor of the quarry, and indeed has been incorporated into the town's arms (together with a blast furnace).

The iron ore beds are 6-8 m thick in this location (Figure 19), consisting of muddy or calcareous ooidal ironstone. According to a BGS report, the better quality ore contained 35% limonite ooids ($FeO.OH\ nH_2O$), 17% siderite ($FeCO_3$) and 18-13% chamosite (Fe-rich chlorite) with 20% calcite in the form of shells and cement (from Whitehead et al. 1952).

Figure 18 *Committee members examining the Frodingham Ironstone at Conesby Quarry.*

Figure 19 *Outcrop of the Frodingham Ironstone at the top of the Scunthorpe Mudstone Formation in Conesby Quarry.*

Alkborough

Grid reference: SE 8802 2176; Postcode: DN15 9JN; What3Words: ///cook.timed.chiefs
Leader: Peter Worsley

From Scunthorpe, we drove northwards towards the Humber. The hill on the Lower Jurassic scarp at Alkborough provides a view across the Trent valley and the confluence of the Trent and the river Ouse, where they join to form the Humber Estuary (Figure 20). During the last Devensian glaciation, ice plugged the Humber Estuary to the east of Alkborough (see the South Ferriby shore location) forming a glacial lake in the low land below the scarp. Peter described the on-going debate about the extent of the Devensian glaciation. There is controversy over the extent of Devensian ice in the Vale of York and whether the limit is the Escrick moraine (10 km south of York) or an ill-defined zone without any landform located around the southern end of the Vale of Axholme near Epworth. Allan Straw and Peter believe that Escrick is more likely.

Figure 20 *View of the confluence of the river Trent and the Ouse to the west of Alkborough.*

South Ferriby Coast Section

Grid reference: SE 9938 2192; Postcode: DN18 5RH; What3Words: ///book.obscuring.banana
Leader: Peter Worsley

Purpose: to view the South Ferriby Coastal Section and evidence of a glacial lake during the Devensian.

This is the only cliff section with glacial deposits in Lincolnshire, and is in two sections on the southern shore of the Humber estuary. Inland of the eastern section is an abandoned chalk quarry, and inland of the western section there was a Roman villa, so both sections may have been disturbed by human activity.

Eastern Section

The eastern section comprises a low cliff of diamictite which rests on shattered chalk. The diamictite: a poorly sorted deposit with no stratification, and much chalk and clay with matrix supported clasts (Figure 21). A wide mixture of clasts where identified including dolerite, basalt, granite, sandstone and flint. A large cobble with glacial striations attested to the presence of glacial ice (Figure 22).

The diamictite is a glacial till deposited from the ice-sheet which blocked the Humber Gap and formed a glacial lake to the west. Below the till on the beach a chalk breccia was observed, and above a sandstone devoid of clasts, which has been interpreted as a glacial lake deposit.

Figure 21 Marsh Till (Devensian) with glacial erratics on the eastern coastal section at South Ferriby.

Figure 22 Glacial striations on a dolerite bolder from the Marsh (Skipsea) Till.

Western section

The eastern and western sections of the foreshore are markedly different in character. The western section comprises a low cliff of gravel capped by dark agricultural loam deposits (Figure 23). Underneath the loam are flint-rich gravels with chalk which appear to be above the till seen on the eastern section. The gravels comprise sub-rounded platey pebbles of flint in a sand matrix. Erratics were either rare or not present. The top of the gravels beneath the loam are decalcified with solution pipes. The gravels contain lenses of sand and are interbedded with clays on the western end of the outcrop.

The uniform composition of the gravels suggests local derivation from the adjacent chalk hills.

This long day ended with dinner at the Haven Inn at Barrow Haven and then a visit Mick Oates's personal Geological Museum which had a tremendous range of ammonites and other fossils of all ages.

Figure 23 *Chalk and flint rich gravels with decalcification solution pipes at the top of the section below the dark loam, South Ferriby shore line, western section.*

Report and pictures by Edmund Shirley and Ross Garden

Wednesday 14th June

Aylesby Blow Well

Grid reference: TA 2260 0756; Postcode: DN37 7ED; What3Words: ///identity.blackbird.jiggle

Wednesday morning took the group to the Laceby Beck near Aylesby. The Laceby Beck is the local name for the River Freshney which reaches the sea at Grimsby. We walked along the banks of the river to a small copse of trees surrounding a shallow hollow approximately 10 m in diameter (Figure 24). From the hollow a spring was issuing from the Devensian Marsh (Skipsea) Till and discharging into the Laceby Beck (Figure 25). The Laceby Beck rises 3.5 km to the SSW below Wellbeck Hill at the foot of a marked ridge in the Wolds which was the position of a former chalk cliff line. The cliff line pre-dated the Devensian glaciation since the Marsh Till is banked against the scarp and the till pinches out rapidly westwards across the Wolds.

Figure 24 *RGS members looking into the Aylesby Blow Well. In June the hollow is overgrown.*

Peter explained that this was an example of a blow well where the hydraulic head associated with meteoric water recharge into the chalk on the Lincolnshire Wolds to the west was sufficient to drive artesian water through the aquaclude produced by the till. The recharge may be from water movement through fractured chalk, the weathered and broken chalk beneath the till or through fluvio-glacial sandstones in the till (Figure 26). The group discussed the hydrodynamics. The blow well is at 7 m AOD in an area where the Marsh Till (ca 15m thick) covers the chalk. The chalk crops out some 6 km to the west where the water table is ca 15m above AOD.

Figure 25 *Water flowing from the blow well into the Laceby Beck.*

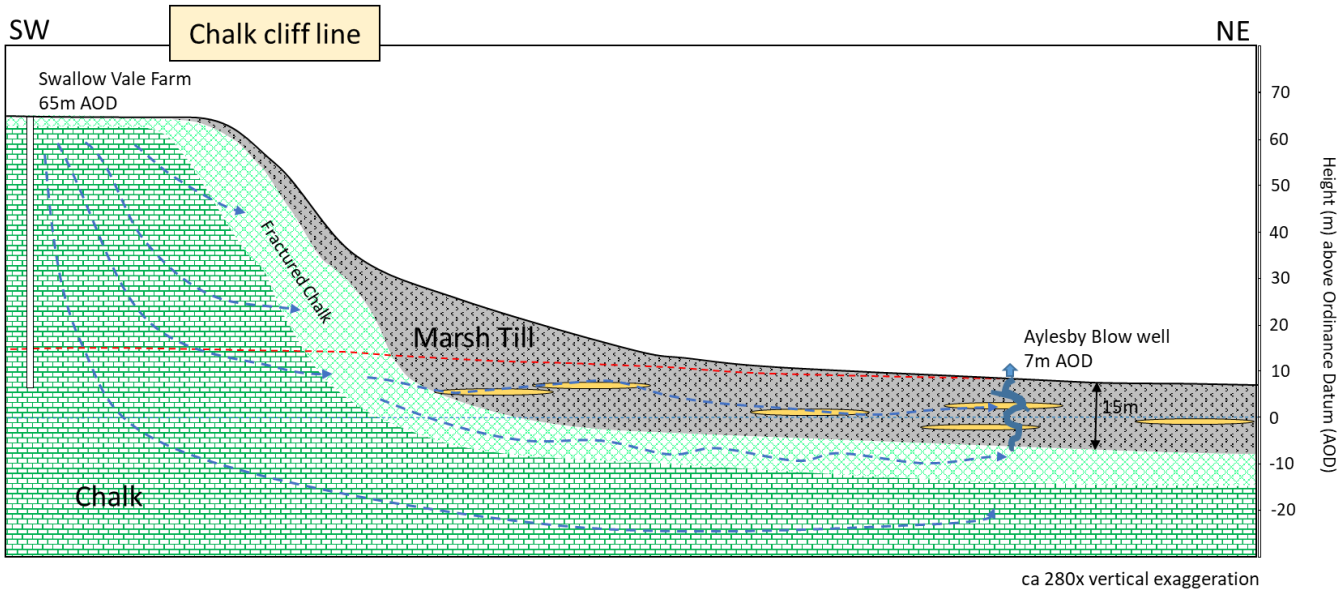

Figure 26 *Schematic illustration of the recharge of the Aylseby blow well from the Lincolnshire Wolds.*

Swallow Vale –Devensian Outwash Channel Fill

Grid Reference: TA 1738 0425; Postcode: LN7 6DW; What3Words: *///*occupiers.dodging.quality

From the Aylesby blow well, we drove up over the former cliff line into the Wolds and to Swallow Vale Farm. At the farm there is a small quarry in the Welton Chalk Formation (**TA 1749 0430; LN7**

6DW; ///takeovers.foods.stuns). The chalk was massively bedded without obvious flints horizons (Figure 27). The top of the quarry showed the weathered and fractured chalk, but no till.

Peter pointed out that this area was beyond the extent of the last Devensian glaciation which deposited the Marsh (Skipsea) Till against the former cliff line to the east.

Figure 27 *Bedded Welton Chalk Formation without obvious flint at Swallow Vale Farm.*

After seeing the chalk, we walked down into the vale to view the N-S dry valley cut into the chalk. Peter explained that this was an outwash channel from a glacial lake generated in front of the ice sheet to the east. In a small sand pit (20 x 50m) at the base of the valley, the valley fill could be seen to be flat bedded sandstones with lenses of sand with small angular flint and chalk pebbles (pebbles typically angular and less than 20 mm in length). The sandstones are planar laminated on mm to cm scale and fine grained (Lower - 125-177 μm), well sorted with frosted grain surfaces (Figure 28). In the lower part of the exposure, pebbles occur as discontinuous lags parallel to bedding but pebbles become more abundant towards the top of the pit. Gravel beds are preserved with scours, dm-scale planar cross sets with imbrication of the clasts.

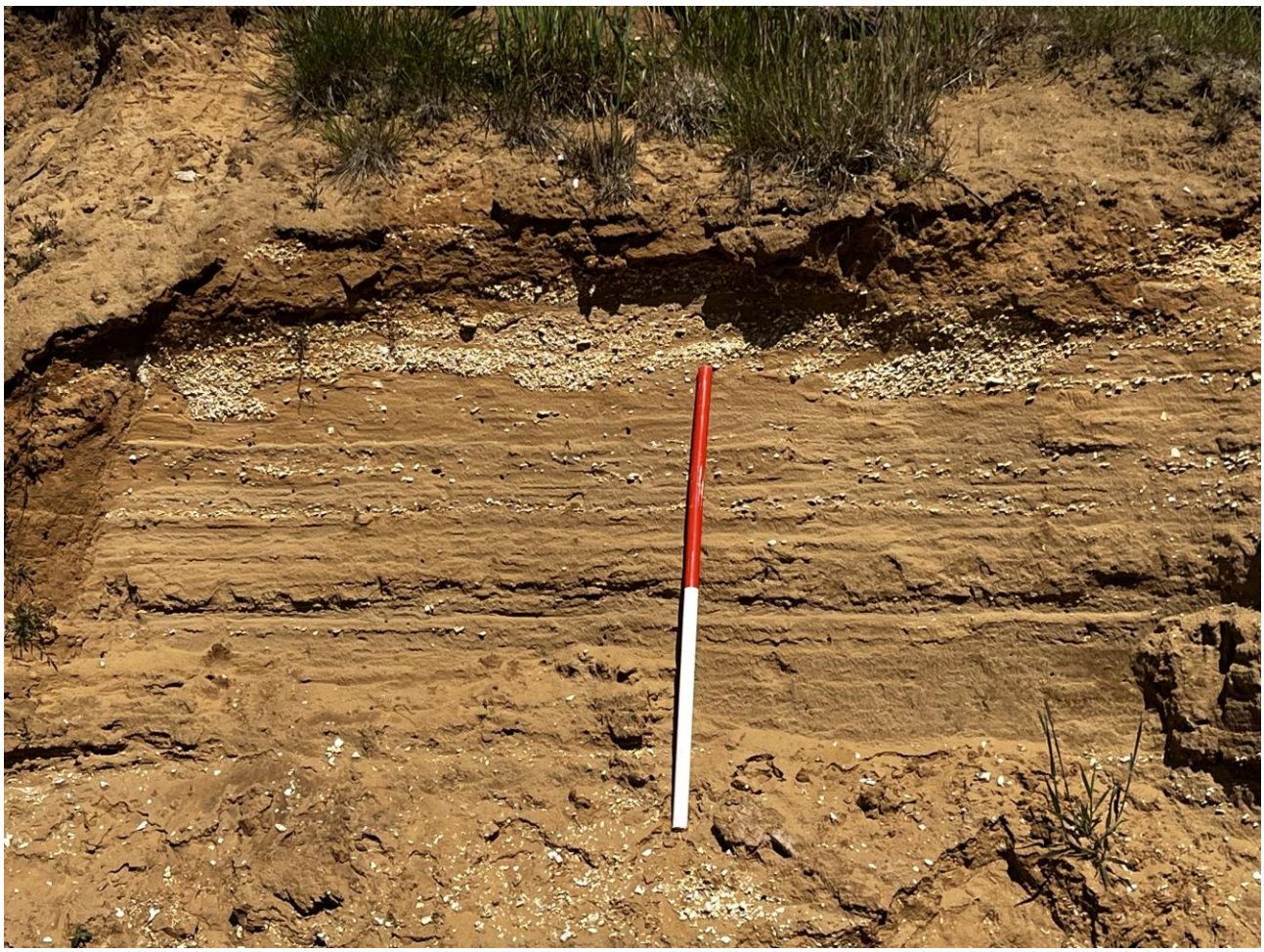

Figure 28 *Parallel laminated sands wit flint and chalk gravel lags and scoured beds at Swallow Vale*

The group discussed the depositional setting. The gravels indicate that deposition is in part fluvial, but the uniform grain size and parallel laminated sands may in part be aeolian in origin. Note that the BGS mapped wind-blow sand on the hill top to the NE of the location (Figure 29). Peter explained that the Swallow Vale is interpreted to have been cut by outwash from waters ponded in lakes to the west of the Devensian ice-sheet that deposited the Marsh (Skipsea) Till. As the ice retreated, the lakes would have expanded until water was able to flow out at low points on the interfluves cutting incised valleys through the chalk which was presumably still frozen (permafrost). The sediments in the base of Swallow Vale infer that the valley was back-filled with sand and locally derived gravels from the local hill-sides rather than during the cutting of the valley.

At Swallow Vale, we had an interesting discussion with a local farmer who had drilled water wells in the area. He informed us that the Swallow Vale was filled with sand along its length. In a well at Swallow Vale Farm (60 m AOD), water is encountered at 7m above sea level at a similar height to the Aylesby Blow Well.

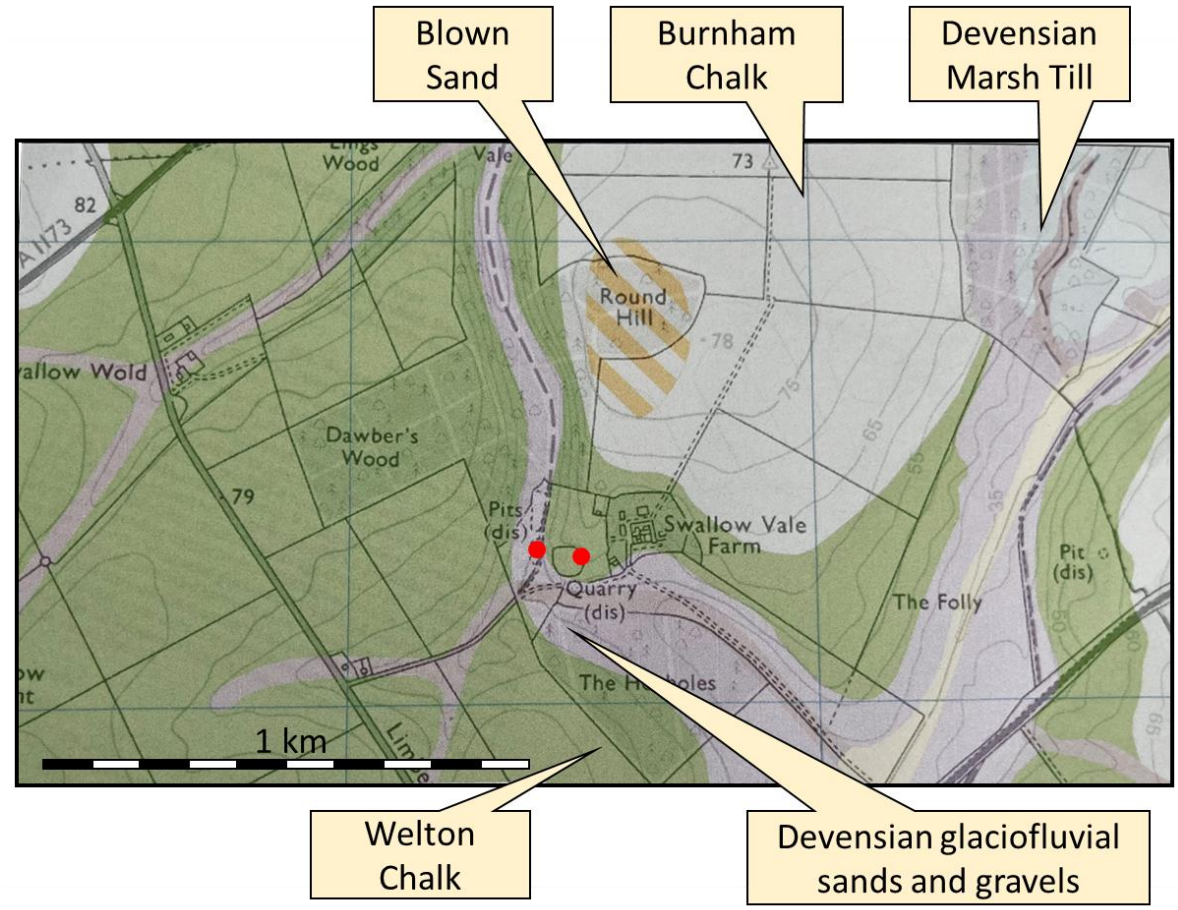

Figure 29 *Geological map of Swallow Vale showing the N-S orientated outwash channel at Swallow Vale. Note the plugging of the larger valley to the NE by the Marsh (Skipsea) Till. The red dots are the locations of the chalk quarry (right) and sand pits (left).*

Nettleton Church

Grid reference: TA 1110 0019; Postcode: LN7 6NP; What3Words: *///*runways.wand.teaspoons

From Swallow Farm we drove westwards across the Wolds to the village of Nettleton. Here we examined the church which is made largely of freestone from the local ferruginous and arenaceous limestone (Figure 30). While on the trip we believed that the stone was the Claxby Ironstone, however, following discussion between Peter and Pete Rawson they that it might be the younger Tealby Limestone.

The Claxby Ironstone is of Lower Cretaceous age (Valanginian to Hauterivian) and overlies the Upper Jurassic to Lower Cretaceous Spilsby Sandstone Formation and passes upwards into the clays of the Tealby Formation. To the south the Cretaceous succession thickens and the Claxby Ironstone passes laterally into the Hundleby Clay. To the north, the Cretaceous units thin and pinch out onto the Market Weighton High and the Claxby Ironstone is not present in the Middlegate Quarry visited on the previous day.

The church at Nettleton dates back to the 11th and 15th centuries but was restored and rebuilt in 1805 and 1874. The church is made of very weathered limestone of large irregularly shaped ashlar blocks with quoins and window arches of pale limestone and a slate roof. The Tealby Limestone is a sandy, oolitic limestone with geothite ooids and common shelly fragments (Figure 31). Excellent examples of large bivalves, belemnites and ammonites are visible in the walls of the church. The limestone weathers and the block work is in general in poor state.

Figure 30 *Ashlar of Tealby Limestone in the church at Nettleton. Note the large bivalve (Camptonectes cinctus) visible in one of the blocks. The quoin stones are of Lincolnshire Limestone.*

Figure 31 *Oolitic shelly ironstone with a calcareous matrix and common shell fragments and scattered lydite pebbles.*

Ironstone was mined and quarried in the local area until 1968/69. The ironstone was taken by rail to Scunthorpe where it was blended with the Frodingham Ironstone and Cleveland Ironstone.

Nettleton Top and Acre Nook mines

Grid reference: TF 1184 9827; Postcode: LN7 6SY; What3Words: ///motivates.gadget.respond

We proceeded back into the Wolds to Nettleton Top where we could get an overview of the area and see the locations of the Nettleton Top and Acre Nook mines (Figure 32). The ironstone was quarried with open cast mining in the valleys until the 1960's. A new mine was sunk beneath the main chalk escarpment lying to the east was developed but the pay was largely worked out and by 1968. The mines are pillar and stall designs.

From the hill tops little is now visible other than small outcrops of the ironstone, but mine entrances are still visible. The base of the valley is in the Spilsby Sandstone with the hill tops above the Claxby Ironstone of thin Tealby, Roach and Carstone formations and capped by the Hunstanton (Red Chalk) Formation and grey Ferriby Chalk.

Figure 32 *Location of the Nettleton Top mine with a mine entrance visible in the valley bottom.*

Report and pictures by Ross Garden

Welton le Wold, West and East Quarries (Old Gravel Pits SSSI)

West Quarry - Grid reference: TF 2819 8840; Postcode: LN11 0QS; What3Words: ///strict.including.boards
East Quarry - Grid reference: TF 2860 8816; Postcode: LN11 0QS; What3Words: ///motivator.darts.resist

From Nettleton Top, we drove back south-eastwards across the Wolds towards Louth and Welton-le-Wold. In this area, there is evidence of glacial deposits from before the most recent, Devensian glaciation (approx. 20 Ka. BCE, MOIS 2). These produced tills with different characteristics, as evidenced by their differing colours and erratics, indicating that the glaciers that deposited the tills travelled from different directions over differing bedrock.

At Welton-le-Wold, below the tills were gravels from an earlier, cold stage (approx. 375 Ka. BCE, MOIS 10). The interpreted stratigraphical sequence is shown in Figure 33 and the lateral variation is shown in Figure 34.

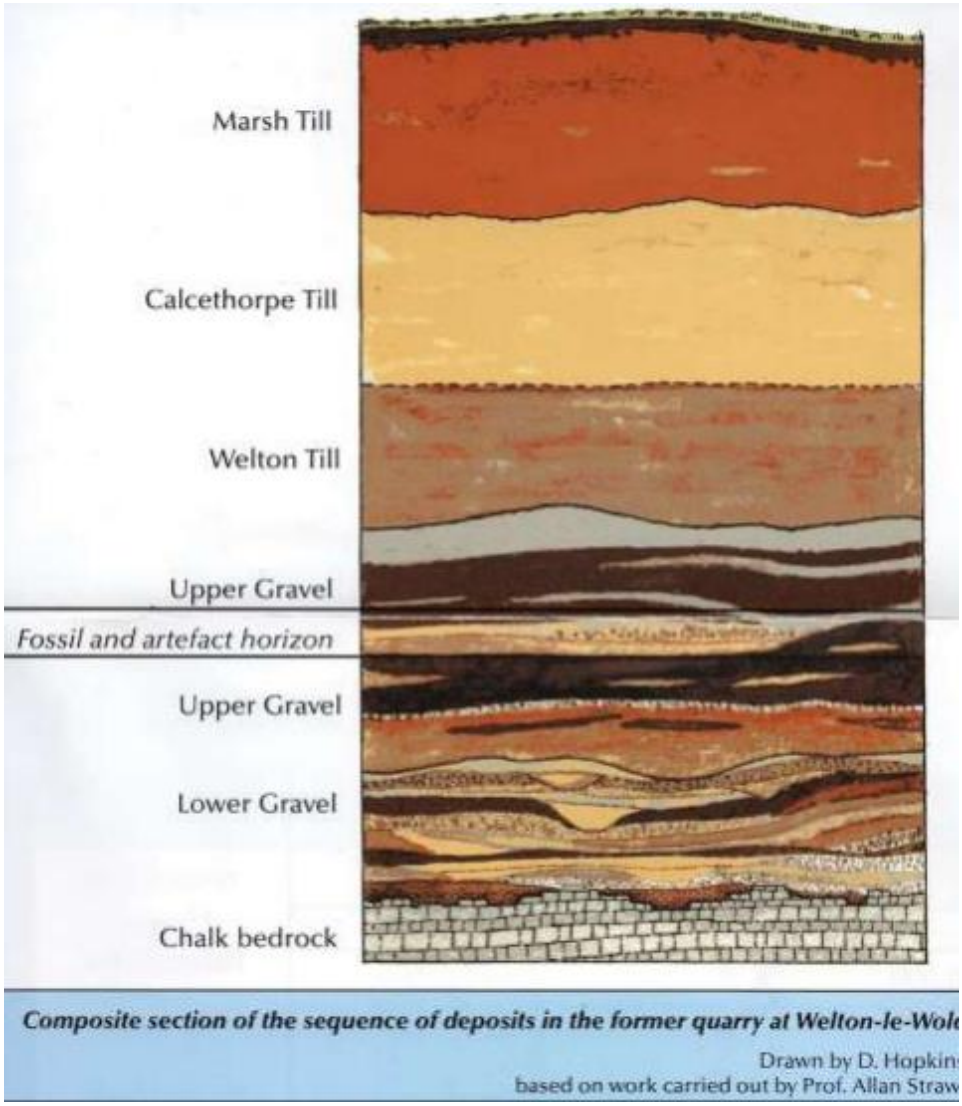

Figure 33 *A composite cross section of the glacial deposits from the Welton-le-Wold area. There are no interglacial deposits recognised – the fauna and human artefacts are associated with a cold / cool environments.*

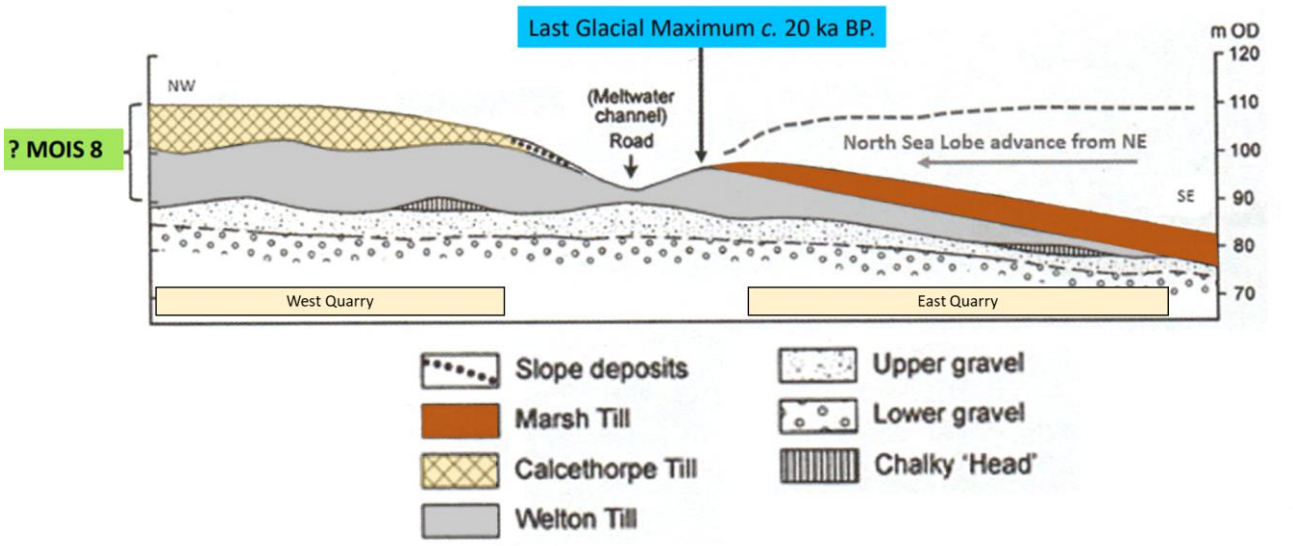

Figure 34 *Lateral spatial variation in the stratigraphy at Welton-le-Wold modified from Straw (2015).*

The quarries that we visited are designated as an SSSI for their geologically significant glacial deposits, recorded by Natural England as the Welton-le-Wold Old Gravel Pits SSSI.

We visited the West Quarry first, where we had permission from the landowner, driving a long distance over a rough track to get to the outcrop. The yellowish coloured Calcethorpe Till was well exposed (Figure 35) with the underlying, greyer Welton Till visible but poorly exposed.

Erratics seen from the pre-Devensian tills (Welton & Calcethorpe) ranged from a 1 x 1 x 0.25 m block of Middle Jurassic sandstone from North Yorkshire to small boulders and cobbles of Cheviot granite, other granite, dolerite inferred to be from the Whin Sill, possibly Dalradian psammite, flint and chalk. The underlying dark grey Welton Till had flint pebbles in it and was deposited from a glacier that had travelled over Jurassic mudstones, thus gaining grey rock flour to colour it. The gravels below the tills, the target of the quarry, were not exposed, but in the past the Upper Gravels yielded three Lower Palaeolithic artefacts (pre-Devensian) as well as the remains of elephant, deer, horse and bison.

Figure 35 *A 4 m high section through the highly calcareous Calcethorpe Till showing weathered out erratics standing proud of the finer grained matrix.*

At the East Quarry, which is managed by the Lincolnshire Wildlife Trust, we had requested and received permission to visit the site with a local warden accompanying us. This quarry showed a different sequence of tills with the Marsh (Skipsea) Till overlying the Welton Till, but with the Calcethorpe Till missing. A search for erratics in a broad bean field on the Marsh Till found a large variety of lithologies similar in composition to those from the Calcethorpe Till. Some of the more exotic erratics found included granite from Shap in the Lake District and rhombic porphyry rhyolite from Scandinavia. It was suggested that these well-travelled rocks were probably moved to their current location by more than one glacial event, however this may also be the case for the Calcethorpe Till which contains erratics from a wide range of geographical locations. The exposure

in East Quarry itself was very poor, although there are plans by the Wildlife Trust to clean a section of the quarry face with the help of local students.

Both the west and east quarries were developed during World War II to exploit the gravels below the tills to construct aeroplane runways. The clasts in the lowermost gravels are very angular and are composed predominantly of flints (Figure 36). The overlying till was considered valueless and was not exploited.

Figure 36 *Angular flint gravels, part of the Lower Gravel sequence from the West Quarry.*

Report and pictures by Sarah Cook

Thursday 15th June

Report on morning session (Kirmington, Twigmoor Woods and Black Walk

Aim: to explore the age and the composition of the deposits present at; the raised beach at Kirmington, the Big Dune at Twigmoor Woods and of cover sands at Black Nook Walk (NB the latter two were obscured by vegetation and described from former research – see references).

Kirmington Interglacial site and raised beach

Grid reference: TA 1034 1161; Postcode: DN39 6YX; What3Words: //personal.monday.clearcut

The age of the deposits:

Peter described the investigations undertaken at the former clay pit (now infilled and used as a football field) to identify the age of the deposits. Both the 1904 British Association borehole and the

subsequent 2006 Trent Valley Palaeolithic Project (TVPP) borehole (published in Bridgland et al., 2014) gave evidence consistent with the Hoxnian interglacial within a total sequence thickness of 10 m. In 1955 a botanist (Watts, 1959) had assigned macro Phragmites fossils and pollen spectra as being of probable Hoxnian age (his samples had been extracted from a trench dug down to the thin peat layer at the base of the bank). The first borehole had drilled down to the chalk and had identified 10 metres of interglacial deposits. The TVPP borehole only proved 3 m of till as it did not reach the chalk.

Debate followed about why Allan Shaw had claimed in 2018 (Mercian Geologist) that the deposits were from a raft of uplifted material (similar to a huge erratic), as this would have required the deposits to have been transported 30 m above current sea level. The current consensus is that the raised beach is Hoxnian i.e., from MOIS 11. As the raised beach gravels contain artefacts (seen in the North Lincolnshire Museum at Scunthorpe) a further problem in assigning the gravels to the Ipswichian (last interglacial) is that currently there is no evidence of human occupation anywhere in Britain during this time.

The composition of the deposits

Clay has been excavated from the first pit (now converted to a sports field) and gravels from the second pit. The clay was of estuarine origin similar to that found in the Humber estuary today, and contained marine fossils. The house opposite the sports field was made from bricks that used the local clay. These estuarine Hoxnian deposits were capped by 3 m of interglacial gravels which have also been excavated.

At the far end of the football field, we walked up the steep bank at the edge of the former clay quarry. Peter noted that the base of this bank marked the peat layer at the junction between the clay and the gravels above.

Figure 37 *Raised beach exposure at Kirmington.*

We then walked round to the gravel quarry now a shooting range and examined the only visible exposure of the contact between the Marsh Till (Skipsea Till) above the gravels which comprise the raised beach deposits (Figure 37). ‘Chatter marks’ on the surfaces of the flint cobbles and pebbles are good evidence that the gravels are beach sediments (Figure 38).

Figure 38 *Chatter marks on a broken, but rounded flint cobble.*

Inland dune at Twigmoor

Grid reference: SE 94143 05551; Postcode: DN20 9NF; What3Words ///shuttling.cities.worksheet

We visited the ‘Big Dune’ at Twigmoor Wood (now obscured by rhododendrons and a pine forest). A sample from a shallow excavation in the dune crest was undertaken in 1999 had yielded an Optically Stimulated Luminescence (OSL) age estimate of 10.3 Ka suggesting that the dune stabilised at the end of the Loch Lomand Stadial (Younger Dryas).

The Quaternary deposits have been dated (Bateman et al., 1999) using marine oxygen isotope stage ratios and show the following ranges indicated in Figure 39, however, Peter questions their validity.

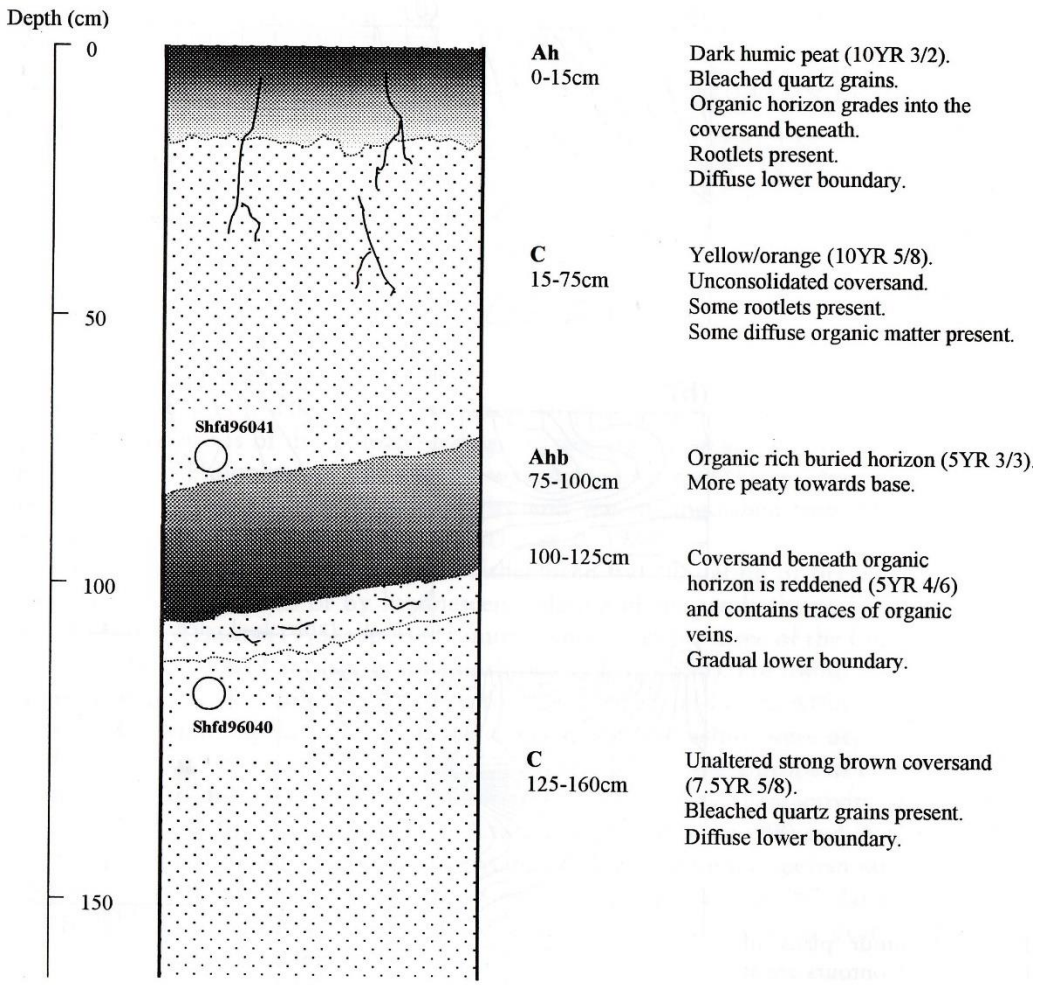

Figure 39 *Profile of coversands in a previous excavation at Twigmoor.*

Peter noted that the top metre of podsol was derived from sediments that were probably reactivated during the Little Ice Age 200-300 years ago.

Coversands at Black Walk Nook

Grid reference: SE 911 020; Postcode: DN21 4BB; What3Words: ///harp.limitless.raven

After the last glacial, aeolian sands were blown from west to east from the Trent valley across large parts of North Lincolnshire and banked up against the Lincolnshire Limestone escarpment and the Wolds. These are all categorised by the bucket term ‘coversands’ and are about 2-3 m thick. They represent the latest Quaternary deposits. The coversands were formed mainly by sheet not dune movement in a cold climate with little vegetation.

It was hoped that this site, in a ditch at the parish boundary, would have shown the contact between the Windermere interstadial peat bed and the base of the coversands. Most of the ditch was obscured however and the bridge missing so Peter described the contact. The peat was from the Windermere interstadial about 12,000 years ago and Mesolithic artefacts had been found here.

Although some of the sand has been used for building, the majority of the sand here had been excavated and used in glass manufacture and for foundry sand.

Debate

- The extent of and period of glaciation to which the various tills belonged;

- The importance of human artefacts to help refine MOIS and pollen dates;
- The extent of the aeolian transport from the angularity of the pebbles;
- How inland dunes formed as compared to coastal dunes;
- The horizontal stratigraphy of the sands and clasts; and
- How the coversands were stabilised.

Report and pictures by Angela Snowling

Welton Oil Field

Discovery well location: Grid reference: TF 0357 7678; Postcode: LN2 2XB; What3Words: ///iron.imply.pace
Gathering Station: Grid reference: TF 0451 7481; Postcode: LN2 2QX; What3Words:///fevered.sparrows.crystal

In the afternoon the group drove south down Ermine Street along the Middle Jurassic Lincolnshire Limestone escarpment towards Lincoln with the Trent valley lowlands to the west. We stopped at the site of the Welton oil field discovery well between the villages of Scothern and Sudbrooke. The well pad now had up to nine production wells with four active and one inactive beam pump (nodding donkeys; Figure 40) at the time of viewing. Considering the close spacing of the well heads it is apparent that the wells are high angle or inclined. Directional drilling from a limited number of well pads would have reduced the environmental impact of the development and reduced the number of flow lines (local pipelines) needed to collect the produced fluids.

The principal reservoir in the Welton field is the early Westphalian Crawshaw Sandstone (Figure 41). Oil is also found in other Westphalian sandstones and additional shows are present in the Lower Carboniferous (Visean and Tournasian) and the Namurian. The Westphalian consists of interbedded sandstones, mudstones and coals (Coal Measures), which were deposited in swampy delta plain environments.

In the late Carboniferous, a major basin, the Pennine Basin, existed between landmasses situated in the area of the Scottish Southern Uplands Massif to the north, and the English Midlands to the south. The Pennine basin is segmented into a series of relatively small, linked sub-basins with their corresponding fault-bound blocks. The sub-basins have an asymmetric profile with thickening of Westphalian sediments into the hanging wall, typical of tilt-block half-grabens. The sub-basins accumulated thick pro-deltaic sequences of organic rich mudstones, particularly in the Dinantian and early Namurian. These mudstones formed the source rocks for the Welton field oils.

In Namurian and early Westphalian times, clastics were transported from East Greenland and the Scottish Highlands and deposited across the Pennine basin by major fluvio-deltaic systems. The basal Westphalian Crawshaw Sandstone and its lateral equivalents at outcrops comprise coarse-grained, pebbly sandstones and fine to medium-grained, micaceous sandstones. At Birchen Edge in Derbyshire, the Crawshaw Sandstone is interpreted as the deposits of braided low-sinuosity fluvial systems that crossed a delta plain and fed fluvial-dominated deltas (Guion et al., 1995).

In the East Midlands the elongate basins, include the Gainsborough Trough, Edale Gulf, and Widmerpool Gulf basins (Figure 41). The Welton field lies in the Gainsborough Trough and is one of a number of fields where oil is trapped in rotated fault blocks with seals provided by the interbedded Westphalian mudstones.

Figure 40 *Nodding donkeys (beam pumps) active at the Welton discovery location.*

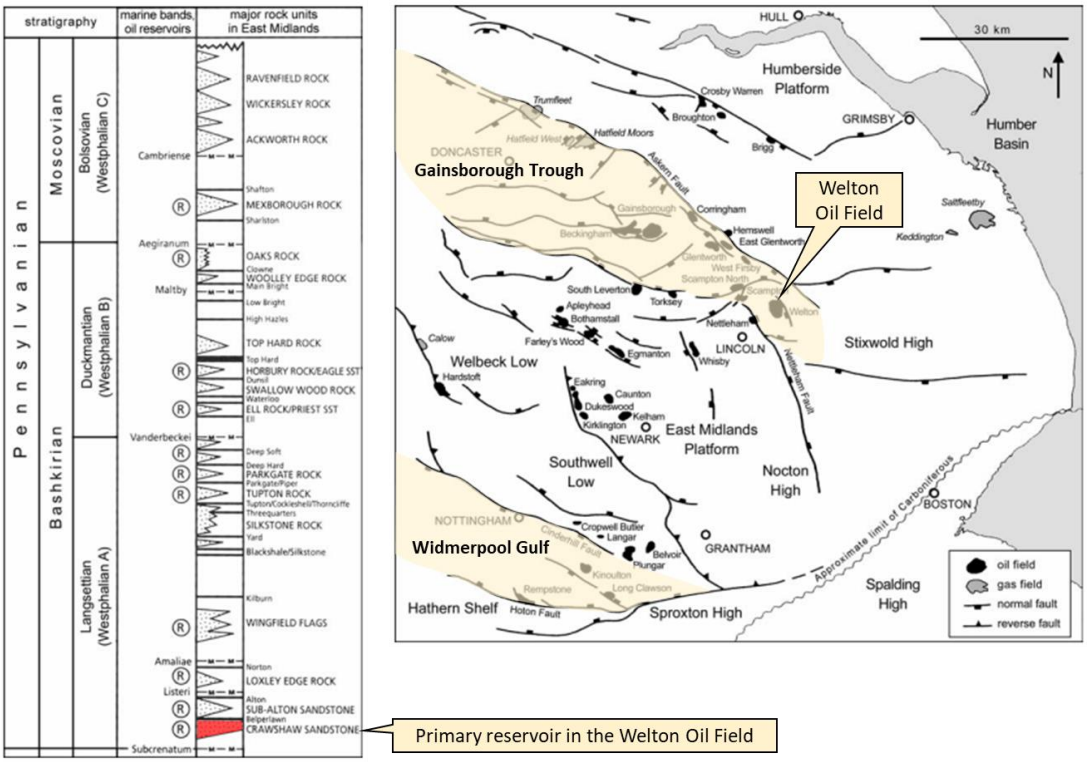

Figure 41 *Stratigraphy of the Westphalian A-C of the East Midlands (after Guion et al., 1995) and the main accumulations of oil and gas, and the major faults, in the East Midlands hydrocarbon province (after Fraser & Gawthorpe, 2003).*

The Welton field was discovered in 1981 by BP with production starting in 1984. The field is the second largest oil field found onshore in the UK to date (the largest is Wytch Farm in Dorset). Ward & Folorunso (2020) indicate that the field was developed by 65 development wells and 12 water injection wells and had peak oil production rate of 3,297 barrels of oil per day. The field has

a predicted total production of 16.7 million barrels (2.6 million m^3). Initial production was collected from the development wells at the gathering station to the south of Sudbrooke and transported by rail to the refinery at Immingham in north Lincolnshire. In late field life, production has declined and oil is now transported to Immingham by road tanker. The field is now being produced by Star Energy (iGas) Limited.

The Sudbrooke Erratic

Grid reference: TF 0340 7558; Postcode: LN2 2SF; What3Words:///piled.ulterior.rebounder

Between the Welton field locations we stopped to examine the Subbrooke erratic (Figure 42). The erratic was a large stone used for a monument in the village (Millennium Stone). The boulder is of fossiliferous Jurassic sandstone. The original bedding can be determined from the layers of bivalves and small scale, cross-stratification. The westward facing surface (shown in Figure 42) is relative flat and smooth with gouge marks whereas the eastern face is more rounded.

Figure 42 *The Sudbrooke erratic, a bolder of fossiliferous Jurassic sandstone from Yorkshire transported southwards across Lincolnshire during a post Anglian glaciation.*

The Sudbrooke erratic is interpreted to have been transported southwards during a cold stage in the Wolstonian Glacial Complex (MOIS 6-10) after the Anglian glaciation (MOIS 12). The Devensian glaciations did not extend into this part of Lincolnshire being limited to the east of the Wolds.

Lincoln Gap

Grid reference: SK 98197 69579; Postcode: LN4 2RP; What3Words:///twin.stump.miss

The final stop of the RGS trip to Lincolnshire was on the edge of the South Common at the International Bomber Command Centre to the south of Lincoln. The location provided an overview of the Lincoln Gap; the valley of the River Witham (Figure 43). The overview of the city of Lincoln showed the former industrial centre west of the city on the floodplain of the River Witham which is now the site of University of Lincoln. The city rises above the river valley on its northern side with the base of the slope in the Charmouth Mudstone formation and the hill capped by the cathedral and castle on the Lincolnshire Limestone formation. In the distance, 20 km to the north-west, the 2 megawatt, West Burton coal fired power station is located on the river Trent.

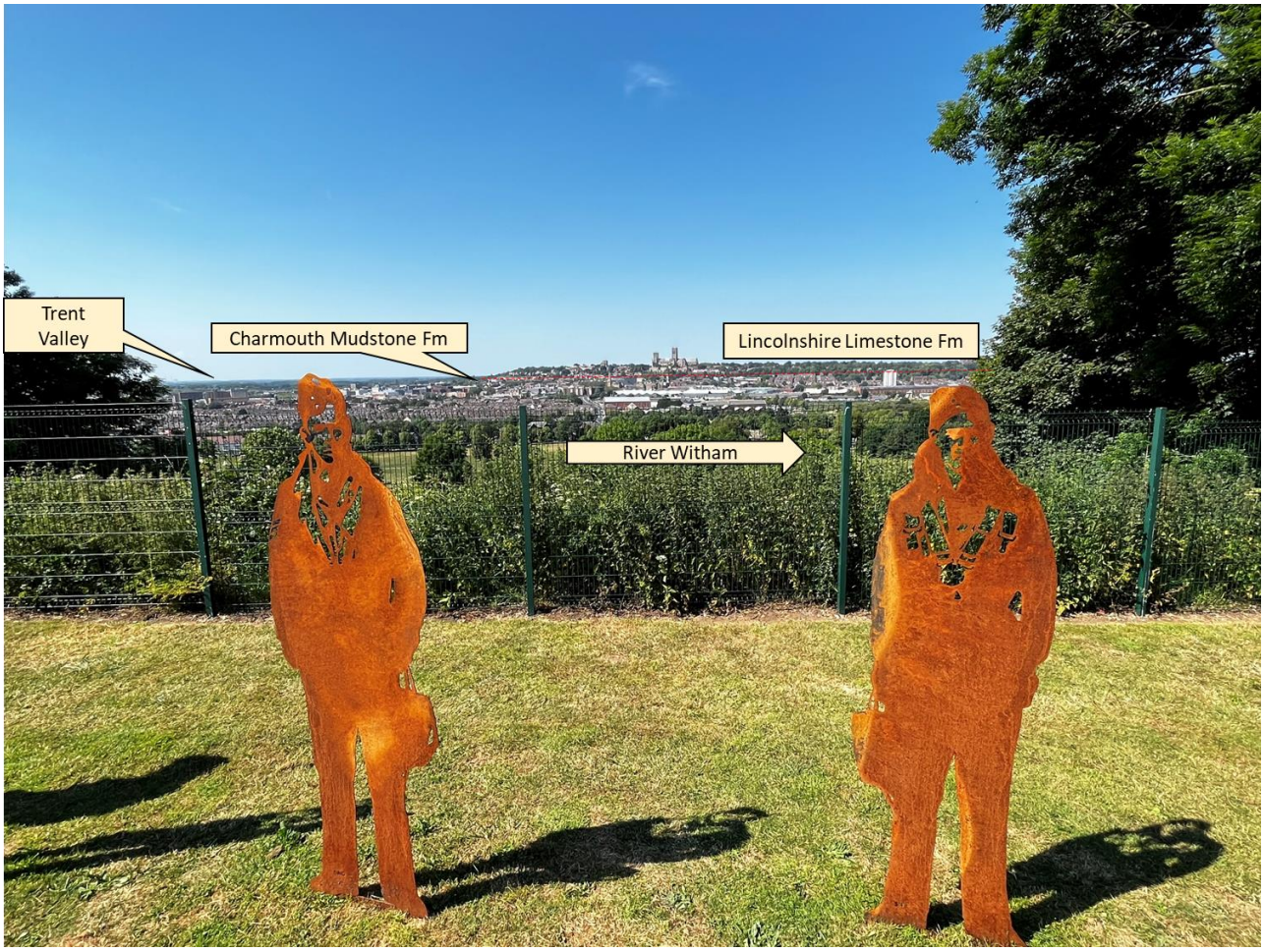

Figure 43 *The Lincoln Gap from International Bomber Command Centre, South Common.*

The Trent, which a much more significant river than the Witham, flows north parallel to the Jurassic scarp line to enter the Humber west of Alkborough (Figure 20, Figure 44). In contrast, the undersized Witham flows south-eastwards to Boston and beyond into the Wash. Peter described how in the past, glaciations had prevented northern drainage and the proto-Trent river systems cut through the Lincolnshire limestone escarpment at Lincoln and Ancaster near Grantham. With the retreat of the last ice sheets at the end of the Devensian (ca 15 ka) the Humber had a lower threshold than the Wash and the Trent flowed northwards leaving the valley for the Witham. The reason for the gap at Lincoln was discussed but without resolution, but interestingly on the BGS maps the area show a relay zone in the fault system (Figure 45).

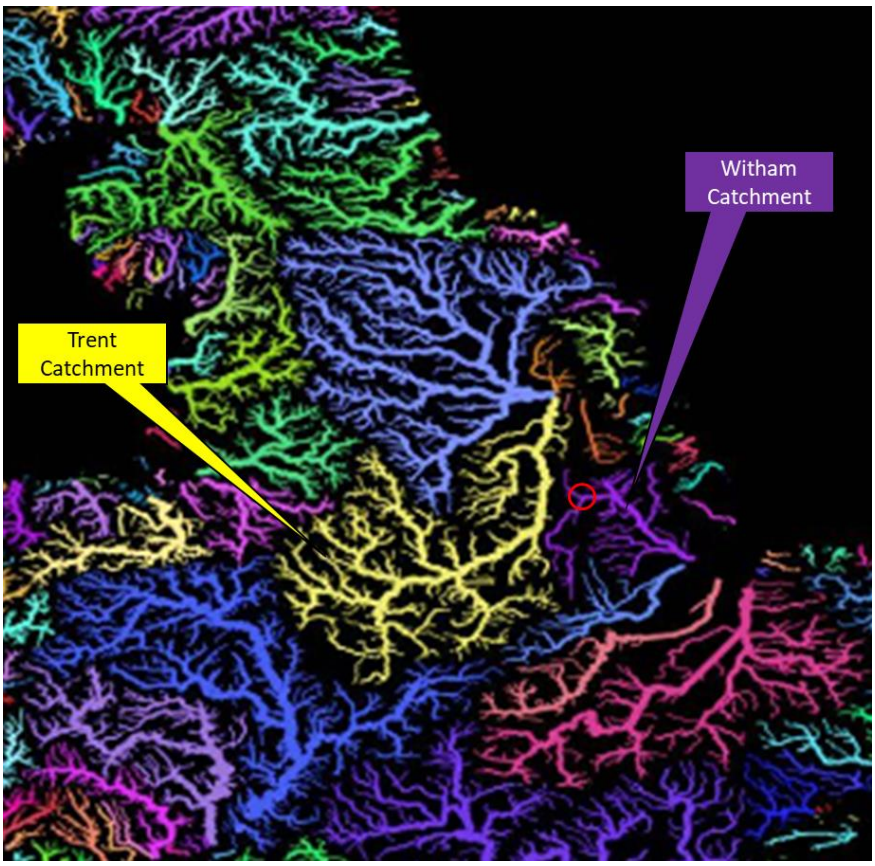

Figure 44 *River catchment basins of the northern and central English. Lincoln located at the red circle.*

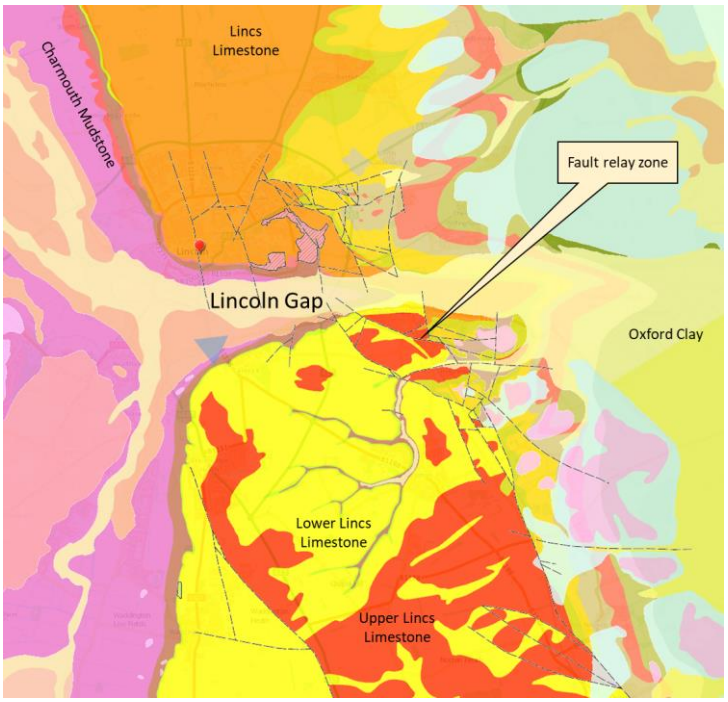

Figure 45 *Geological map of the Lincoln area from BGS GeoIndex Onshore showing the fault distribution in the Lincoln area and the relay zone. The red dot is the location of Lincoln Cathedral and the blue triangle gives the view from the IBCC.*

The field trip was concluded with thanks to Peter for a stimulating and enjoyable trip. The weather had been tremendous and Peter's energy, experience and knowledge were greatly appreciated by us all (Figure 46).

Figure 46 *RGS Members at Blossom Pit, Uffington, Lincolnshire.*

Report and pictures by Ross Garden

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