Farnham Geological Society

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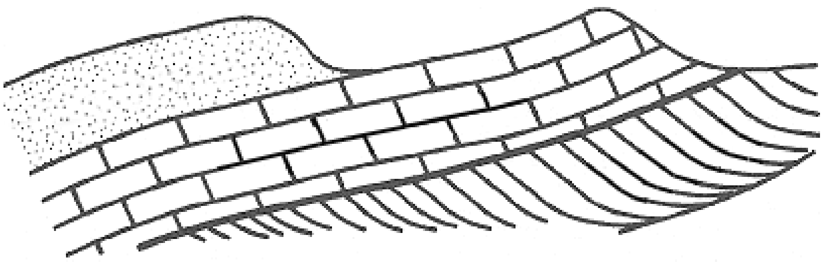

A local group within the GA

Vol. 17 No.3

Newsletter

October 2014

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Editorial

I have been on many different field trips and made many geological visits to varied countries, establishments, geological centres etc. But, one of the best which I personally have ever made, and a place which I am sure some members of Farnham Geological Society have also visited, was to the private fossil collection of Steve Etches. Now we all have rock and fossil collections, but Steve's is without doubt an extraordinary collection and one which I personally found incredible, the care and attention to detail are truly amazing.

Steve lives close to the Jurassic Coast and, over the years, has made a world-class collection of fossils, including many impressive fish and dinosaur finds. He had long aimed to create a secure and permanent home for his collection in the form of a museum at Kimmeridge. It is pleasing to know that this project is now under way and that planning permission has been given for the museum. But further, that Steve has been recognised for his unending patience, skill and endeavours to create this amazing collection and has been awarded a M.B.E. Many congratulations. For further information go to: *http://www.kimmeridgeproject.org.*

Liz Aston, Editor

FGS Field Trip to N Yorks & Durham, May 30 - June 4, 2014

Led by David Walmsley & Graham Williams. Summary compiled by Liz Aston with contributions from Kate Jemmett, Susan Martin, Margaret Richards, and Peter Norcross.

Overview

The fieldtrip examined coastal sections of Permian rocks (marine Zechstein sequences near South Shields), the famous Jurassic sequences of the North Yorkshire coast and the Chalk sequence at Flamborough Head. Triassic and Lower Cretaceous beds were not visited. The area concerned is shown in Figure 1 and a summary of the succession in Figure 2. This newsletter concentrates on the Jurassic sequences visited as there is much to report regarding those outcrops. The Permian and Cretaceous sections will be reported in the January newsletter.

The Jurassic Sequences of the North Yorkshire Coast

The Jurassic was examined at various outcrops along the N. Yorks Coast, particularly Staithes Bay, Cayton Bay, Scarborough and Whitby and included visits to the Ironstone Museum at Skinningrove, the Peak Alum Works at Ravenscar and the Rotunda Museum in Scarborough.

The oldest Jurassic strata were the Lower Jurassic Lias sediments seen at Staithes, the famous ironstones of the Cleveland area and the Alum Shales of Ravenscar. The overlying Middle Jurassic sediments were mainly examined at Whitby and Cayton Bay and the trip included viewing the famous slip of Holbeck Hall, Scarborough. Upper Jurassic deposits were seen at Cayton Bay.

Sadly many potential outcrops and coastal exposures are covered by *in situ* and slumped Quaternary sediments, mainly boulder clay, head, etc., as shown in several coastal views in the figures below.

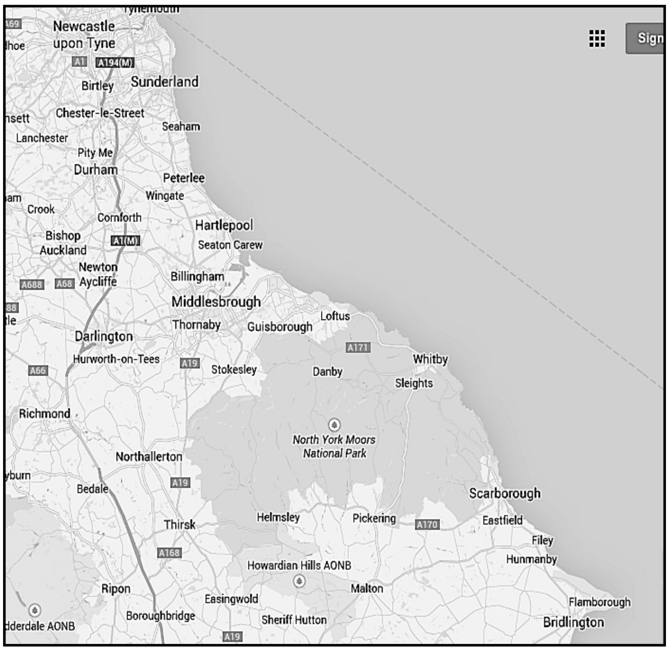


Fig. 1: Coast from South Shields to Flamborough Head

Period	Formation/Group/Member/Deposit	Locations
Quaternary	Glacial deposits (till, sands and gravels)	At most places along coast
Tertiary	Cleveland Dyke (dolerite intrusion)	Not visited
Upper Cretaceous	Flamborough Chalk Burnham Chalk Welton Chalk Ferriby Chalk	Flamborough Head
Lower Cretaceous	Red Chalk Speeton Clay	Not visited
Upper Jurassic	Lower Calcareous Grit Oxford Clay Hackness Rock Member Red Cliff Rock Member	Cayton Bay
Middle Jurassic	Cornbrash Fm Scalby Fm Scarborough Fm Cloughton Fm Ellerbeck Fm Saltwick Fm Dogger	Cayton Bay Scarborough Ravenscar Whitby (compare west and east side of harbour)
Lower Jurassic (Lias)	Blea Wyke Beds Striatulus Shales Peak Shales Cement Shales Main Alum Shales Hard Shales Bituminous Shales Jet Rock Grey Shales Cleveland Ironstone Staithes Sandstone Ironstone Shales Pyritous Shales Siliceous Shales Calcareous Shales	Staithes Ravenscar
Triassic	Penarth Group (Rhaetic) Mercia Mudstone Sherwood Sandstone	Not visited
Upper Permian (Zechstein)	Evaporites Magnesian Limestones	Durham Coast

Fig. 2: Succession of the Durham & Yorkshire Coast

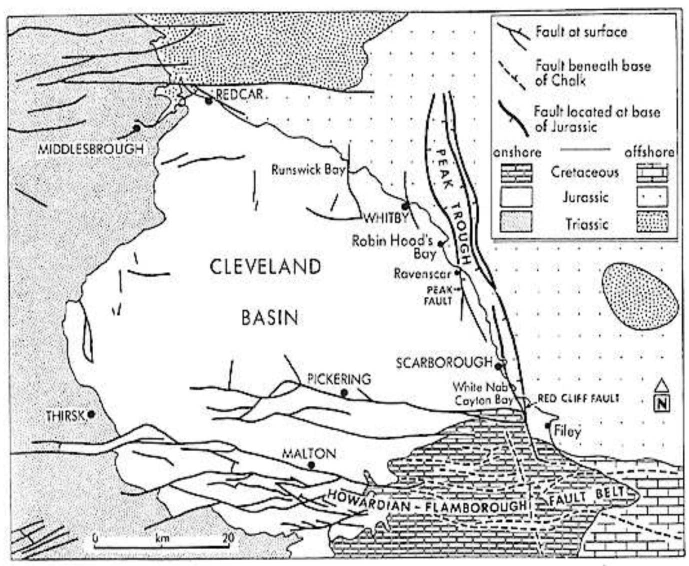


Figure 2. The structural framework. (After Kirby & Swallow, 1987; Milsom & Rawson, 1989; BGS 1:50,000 Sheet 54 Scarborough, 1998).

Fig. 3: Structural Elements of The North Yorkshire Area

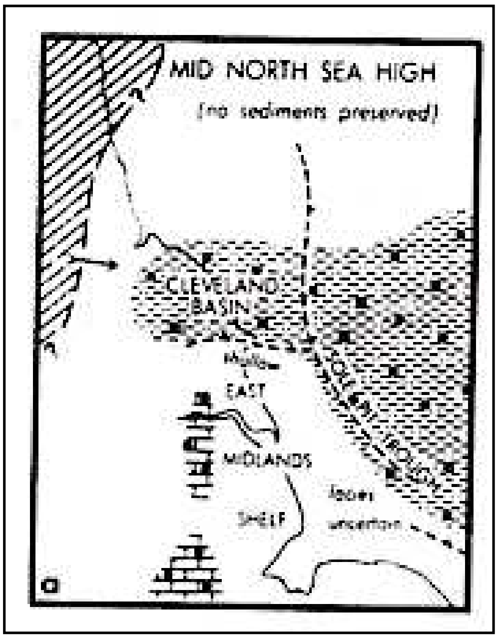


Fig. 4: Paleogeography of Lower Jurassic.

At the start of Jurassic times, the Cleveland Basin and East Midlands Shelf were developing due to differential subsidence. The structural elements of the area are shown in Figure 3 and a paleogeographic map forms Figure 4, both figures are reprinted from The Yorkshire Coast GA Guide[1]. This differential subsidence continued through the Jurassic into the Cretaceous. The N-S trending Peak Trough which lies within the basin, was probably active during the entire Jurassic and the E-W trending Howardian-Flamborough fault belt bound the Cleveland Basin to the south. There were probably minor faults, within the basin, locally controlling sedimentation.

The sea level rises at the start of the Jurassic gave rise to a marine environment in the Cleveland Basin which is regarded as marginal to, but contiguous with, the Southern North Sea Basin. The nomenclature of the Lower Jurassic Lias Group has been recently revised, giving five main groups, although the older local names, defined by ammonite zones, have been retained (Figure 2 above).

The earliest Lias beds (the Redcar Mudstone Formation) are marine shales which pass up into near shore, shallow water sandstones and siltstones and ferruginous oolites. The latter giving rise to iron ore deposits. The shoreline moved according to the location and speed of any subsidence and accordingly the shallow water sediments are very varied. Iron rich sediments are common throughout the Lower Jurassic suggesting input from rivers draining tropical swamps and forests to the north and west.

The topmost sequences of the Lias reflect the rapid global increase in sea level with deep anoxic bottom water conditions and a restricted fauna (represented by the Mulgrove Shale and Jet Rock), but well oxygenated conditions in higher levels of the ocean, with a full presence of marine animals (ammonites, fish etc.). The later sequence of Lias beds were deposited in normal marine conditions and of particular interest on this trip were the Alum Shales,

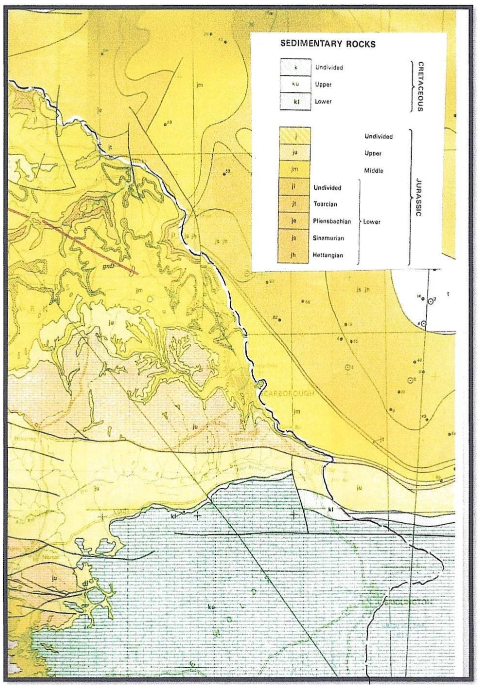


Fig. 6 (left): Quaternary deposits which accumulated or slid over the Lower Jurassic at Runswick Bay.
Examples of local rocks were examined from boulders on the beach.

Fig. 5: The Jurassic and Cretaceous outcrops of Staithes to Flamborough & offshore extensions.

Fig. 7: Runswick Bay: calcareous sandstone with angular clasts of grey shale.

Fig. 8: Runswick Bay: calc., ferrug. silty f.gr. bioturbated sst. with abundant shell clasts.

The Middle Jurassic sequences are also of interest because the North Yorkshire sediments were deposited in conditions varying from alluvial to intertidal but with short lived marine incursions. This coastal environment is very different to the well known shallow, clear water, marine conditions and oolite deposits of the Cotswolds etc. to the south west and also to the major fluvio-deltaic sequences seen offshore in the Central North Sea oil fields.

The Upper Jurassic deposits show a gradual change from nearshore to deep offshore waters.

Lower Jurassic – Lias Group (ca. 200-178Ma)

We met and resided at Runswick Bay, which lies in the heart of the Jurassic coast of N Yorkshire (Figure 5). Eager to start and it being a lovely day, the group immediately paid a quick visit to the bay, where significant deposits of the Quaternary boulder clay obliterated much of the *in situ* geology (Figure 6). However interesting examples were found of the shallow water Jurassic sandstones common in the area (Figures 7 and 8).

Staithes Sandstone Formation (ca. 29m thick): Our first visit was to the pretty and interesting village of Staithes built on a precipitous slope. Both sides of the harbour are dominated by the Staithes Sandstone Formation. The steep valley (like others along the coast, Figure 9) has been cut through the Jurassic sequences by the beck (stream) and glacial ice. The sandstones and siltstones (Figures 10, 11, 12) were laid down in a shallow water marine environment and varied from high to lower energy conditions, displaying cross bedding, storm related structures, bioturbation, concretions and soft sediment deformation. Fossils were common, particularly bivalves, belemnites, shell debris and *thalassinoides* burrows. The Staithes Sandstone Formation passes up into the Cleveland Ironstone Formation which contains frequent beds of ferruginous oolites; these are more resistant to erosion and at Penny Nab form an ironstone pavement.

The Staithes Sandstone Formation and Cleveland Ironstone Formation at Staithes Bay were the oldest beds seen on the trip. The lower boundary of the Staithes Sandstone Formation grades down into iron rich mudstones of the Redcar Mudstone Formation (over 250m thick).

Grey shale boulders with a good marine fauna were found on the beach at Staithes harbour, E side, and are presumably from the associated shale sequences (Figure 13) but it was uncertain from which part of the sequence / cliff they have come.

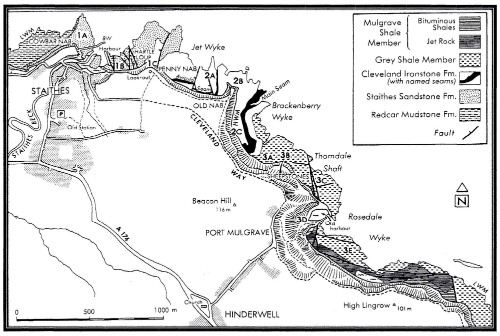


Fig. 9: Lower Jurassic outcrops at Staithes Bay and southwards toward Runswick Bay.


Fig. 10: Staithes Sst. Fm'n in cliffs at Cowbar Nab, W side of Staithes harbour.


Fig. 11: Staithes Sandstone Fm'n in Staithes road section, E of Staithes harbour

The Cleveland Ironstone Formation (ca. 25m thick): The formation was viewed at Staithes (top of Figure 12) and at Kilton Beach (Figure 14). The ironstone bands vary in thickness, up to ca. 0.6m and the iron minerals present vary from siderite[2] (often concretionary) to chamosite[3] (as ooliths). The ironstones are interbedded with highly fossiliferous marine shales and with shallow water sandstones, which include storm surge deposits with large erosional gutters.

The visit to the Cleveland Ironstone Museum at Skinningrove introduced us to the history, atmosphere, techniques and sounds of ironstone mining and a glimpse of the lives of the miners (the mine employed most of the local population). The ironstone ore, being chamosite oolites, was low grade, but nonetheless was economically very important between 1860 and 1880. The main works were centred on Skinningrove where it was mined from drift and shaft mines (there were 83 in the locality). The productive life of a mine was generally ca. two years only and, since the ore produced iron at just 28% by weight, the industry was eventually overtaken by other mining operations with iron ore deposits of significantly higher grade.

The ore was put through a sinter process at Skinningrove to remove the sulphur and then shipped out through Kilton Beach at the foot of the valley. The mining and associated works had a great influence on the everyday life of the surrounding villages and helped Teesside's industrial landscape develop. There were many dangers and problems associated with the underground mining which had to be overcome by the Victorian engineers.


Fig. 12: E side of Staithes harbour: f.gr. bedded sst (up. part of Staithes Fm'n) at base of cliff pass up into irreg. bedded & deformed calc. sst. & concr'ns, then into mudstones of the Cleveland Ironstone Formation.


Fig. 13: Staithes: Grey marine shale with various fossils from either the Staithes Sandstone or Cleveland Ironstone Formations (refer to Fig. 9)


Fig. 14: Cleveland Ironstone Formation exposed in the cliffs at Kilton Beach. Note the colour of the rocks - the 'raw' material from which the iron was extracted.

Alum Shale Formation: Alum Shales were visible in the cliffs along much of the coast. The Alum Shales, show pulsed deposition and were laid down in a low energy offshore environment.

The history of alum production is interesting - most people are aware of Henry VIII's tiff with the Pope and the destruction of the monasteries. Fewer people are aware that it resulted in the growth of the alum industry in

North Yorkshire, which thrived from early in the 17th century until about 1862. In the Middle Ages the Pope had a monopoly on alum supply, charging ~£52 per ton, and post Henry's affairs, supplies to the UK were terminated.

This mattered for two main reasons, alum was used as a mordant in the dying industry to fix fugative dyes in the colourful textiles so admired in wealthy circles, and, it was used in leather tanning to render leather supple and more durable. It also had, and still has, medicinal uses such as a cure for some skin disorders, for water purification, as a contraceptive, as an antiperspirant and to stop bleeding by coagulating blood. Old shaving kits often included an alum stick (styptic pencil) to stop bleeding from minor cuts suffered when shaving. Alum can also be used to fireproof fabrics, to harden candles etc.

Alum is generally thought of as the double sulphate of aluminium and potassium ($KAl(SO_4)^2.12H_20$) which is colourless. The alums include several other salts in which the potassium ion is replaced by other single valent ions e.g. sodium, ammonium and the aluminium ion is replaced by other 3 valent ions e.g. ferric iron or chromium. Alum forms regular octahedral crystals, and many people will have seen in their chemistry lessons, a purple chrome alum crystal inside a cloudy ammonium alum crystal (Figure 15).

Fig. 15: Alum crystal

The Yorkshire alum industry is said to have begun after Thomas Chaloner of Guisborough, visited Italy and noted the vegetation in alum producing areas was similar to that at home. He returned with a few alum savvy Italians and having established his local shales were indeed alum bearing, he opened the first alum works in 1604 near Guisborough. The Ravenscar works opened in 1650. A key factor in their success was that the shales were rich in pyrite and low in lime, and, the fact that, in the Ravenscar area, there was little overburden to be removed to expose the shales (Figure 16, 17, 18). As many as 30 alum works flourished along the Yorkshire coast. Coastal sites were ideal since they allowed materials - coal, potash, seaweed, urine to be brought in and the alum to be exported. The need for boats established Whitby as an important ship building centre. The coastal sites also enabled the treated shale waste to be dumped. There are the remains of quarries in the cliff at Saltwick Nab and Black Nab. An associated industry to the alum quarrying was cement production, which started in 1811 using hard calcareous nodules which were broken up, roasted in kilns and then ground into cement.

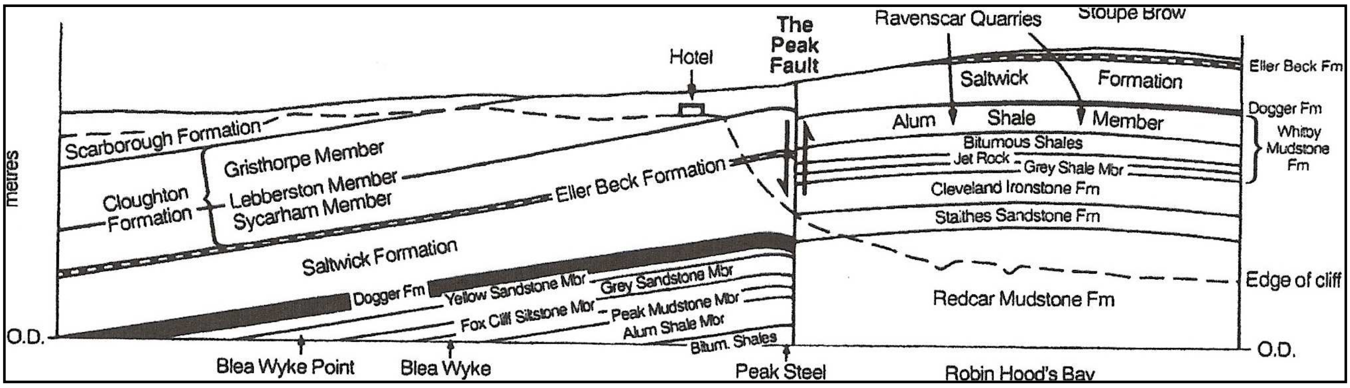


Fig. 16: Diagrammatic Section across the Peak Fault at Ravenscar (as seen from the shore). Section ca. 3km ESE (left) to WNW (right) and maximum height above OD of ca. 240m

The production of alum was a highly labour intensive industry - 100 tons of shale provided less than one ton of alum. Several millions of tons of shale were removed from the quarries, reshaping the coastline. The rock was quarried and stacked with alternate layers of brushwood or gorse and, when local supplies of these were exhausted, with coal in huge 30m heaps, and then fired. The pile would burn for up to a year. During calcination, sulphuric acid formed from the pyrite reaction with the alumina-silicates in the shale to produce aluminium sulphate. Excess lime in the shale would have neutralised the acid. The brick red calcined material was transferred to soaking pits to dissolve the aluminium sulphate. Urine, collected locally in jars, which people left on their doorstep, or in bulk from Hull and even London, was added to the concentrated aluminium sulphate solution to produce ammonium alum. Sea weed ash or potash, mined at Whitby, was added to the solution to produce potassium alum. About 20 tons of seaweed was needed to provide one ton of potash ash. The final solution was further concentrated by prolonged boiling until the alum crystals began to precipitate and the hot solution transferred to large barrels in a Tun House. When crystallisation was complete the barrels were smashed open and the alum ground to produce alum flour - the final product.

The alum industry was a Crown monopoly for its first 70 yrs and the price varied from £7-£26/ton. With increasing production, owners of alum works formed a cartel to keep prices high. Alum's value was such that pirates would attempt to intercept boats carrying it and a large cannon was installed on the cliff at Peak, near Ravenscar, to deter them. The cannon may be the one now lying under a dust sheet in a nearby outbuilding? The Peak Alum Works, situated at Ravenscar on the south end of Robin Hood's Bay (Figure 17, 18) above the cliffs, are now an industrial museum, maintained by the National Trust, which has an excellent information centre.

The alum industry lasted until 1871 when the last works closed. More efficient means of producing alum from colliery waste killed it.

Fig. 17: Cliffs with alum shales and outcrops of Lower to Middle Jurassic in Robin Hood's Bay, famous for its dome-like anticline as seen above.

Fig. 18: Spoil heaps from the alum works at Ravenscar above Robin Hood's Bay.

Middle Jurassic (ca.178-157Ma)

Whitby: Whitby harbour lies in a deeply faulted channel (Figure 19), drained by the River Esk. Mapping of the Dogger Formation shows that the downthrow on this fault is no more than 12m to the west (Figure 20). Atop the east cliff, 57m high, are the ruins of Whitby Abbey founded in 654 AD, whose abbess was Hildergard of Bingham - she wrote music still in vogue today and had an ammonite named after her (*Hildoceras*).

The west beach is approached by the "Khyber Pass", a narrow defile at the harbour entrance formed by the cliff composed predominantly of channel sandstones, stacked one above the other. These are thus non-marine sandstones of the Saltwick Formation. Research into the fault and the adjacent beds by Alexander (1986) suggests that the fault was active during the Middle Jurassic and downthrew consistently to the west, allowing the progressive deposition of multiple channel sequences (Figures 21a, b). One particular channel sequence (Figure 22) showed the top of the cross bedding of the lower channel sandstone was deformed relatively shortly after deposition by movement of the overlying (erosional) beds. The whole of the upper channel appears to have moved as a 'block' - possibly caused by an earthquake and possibly related to the suggested movements of the Whitby Fault during Middle Jurassic times.

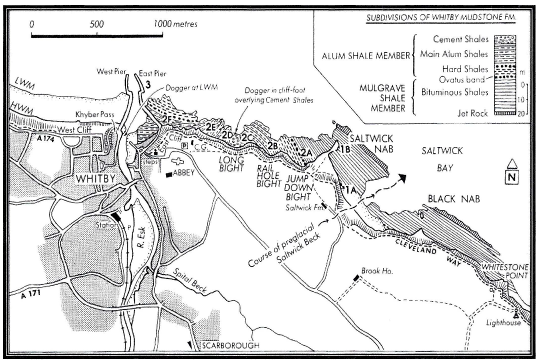


Fig. 19: Outcrop map, Saltwick to Whitby

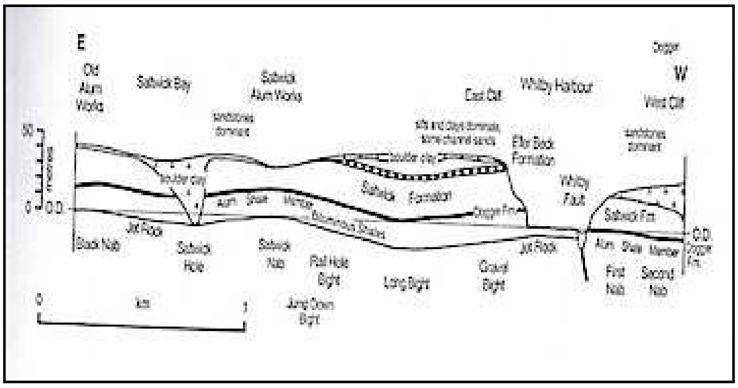


Fig. 20: Cross Section, Saltwick to Whitby (from GA guide The Yorkshire Coast)


Fig. 21 a, b : Channel-fill sandstones of the Saltwick Formation in the Cliffs of Whitby Bay – West of the Harbour

Fig. 22: Detail of syndepositional deformation – see text for description.

The massive sandstones of the Saltwick Formation are underlain by the Dogger Formation, highly visible on the beach to the east of Whitby Harbour.

The E beach (Figure 23) provides a striking contrast consisting with marine Alum Shales at the base followed by the Dogger Formation and Saltwick Formation, topped by the Ellerbeck Formation and boulder clays. Further E the cliffs and beach are composed of the Mulgrove shales, with a narrow band of the Jet Rock further out to sea; this was mined and provided a thriving jewellery industry in Victorian times but is now in decline. Examples of these sediments form Figures 24-27.

Fig. 23: Cliffs at Whitby E – see text.

Fig. 24: Grey shales of deep water marine origin with ammonite impression.

Fig. 25: Jet (drifted wood) within sandstone, Whitby E.

Fig. 26: Rock (upside down) with a thin shallow water rippled bed which was originally under the more massive sandstone.

Fig. 27: Carbonaceous plant remains within a non-marine silty sandstone.

The strata of the E Whitby cliffs were deposited within a mix of energy environments, as shown by the variation of rocks in Figures 24-27 - rippled sandstones of shallow water origin to deep water grey shales of marine origin and non-marine silty sandstones with carbonaceous plant remains. In places, the soft sediments were deformed by the weight of overlying blocks and there is slumping in the upper bands. All this took place in a tropical environment.

Upper Jurassic (157-145Ma)

Cayton Bay: Cayton Bay lies just south of Scarborough. On descending to the beach, to our left towards the north end, we could see the Water Works. This site had been very well engineered, as it lies on a beach liable to cliff crumbling. In April 2008 the bay had been subjected to a major landslip resulting in the destruction of two properties. Walking south we passed an area of significant fallen rocks and glacial till with destroyed WW2 pill boxes. Behind this debris would have been the Osgoody sandstones.

The southern end of the bay was approached via the coastguard station and the cliff section here presented a dramatic view of the Upper Jurassic rocks (Figures 28, 29). The three sequences of this imposing Red Cliff are clearly seen with the Osgoody Formation sandstones at the base. Above is the sloping Oxford Clay Formation and on top the vertical Lower Calcareous Grit. There were many fallen rocks on the beach at the base of Red Cliff, mostly Lower Calcareous Grit with abundant *thalassinoides* burrows. Concretions were also seen (Figure 30). Our renowned fossil finder, Barry, spotted what to him looked like a dinosaur footprint. This was confirmed when a very similar footprint was seen at the Rotunda Museum later in the day.

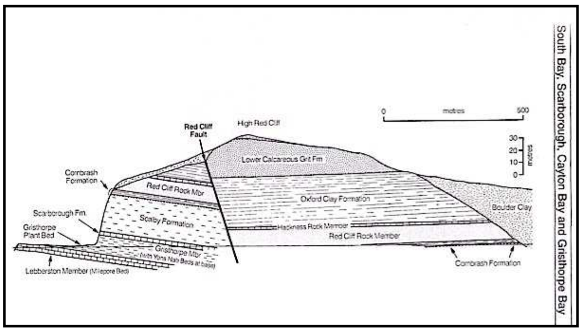


Fig. 28: Cliffs of Upper Jurassic rocks at southern end of Cayton Bay

Fig. 29: Cliffs at Cayton Bay - Lower Calcaraeous Grit Formation overlying Oxford Clay Formation

At the south east end of the bay the Red Cliff Fault could be seen where the rocks to the east have been thrust upwards putting the top of the Red Cliff Rocks of the Osgoody Formation, near the junction of the Oxford Clay and Lower Calcareous Grits.

Lunch was taken at Holbeck Hall car park, just to the south of Scarborough. This site now shows no sign of the catastrophic and well-publicised landslide which destroyed much of the Holbeck Hall Hotel and grounds on 5th June 1993. Heavy rain caused a devastating rotational landslip of the glacial till and sent the hotel and its grounds over the cliff and down on to the beach. We were told about the financial and legal battles that went on between the owners, Scarborough Council and the Insurance Companies after the event. Today the whole site is landscaped.

Then the Rotunda Museum in Scarborough was visited, one of the oldest purpose built museums in the country - a geological museum built to a design suggested by William Smith (the father of English geology) in 1829. It was his brainchild. The Museum contains one of the finest collections of the Jurassic in Yorkshire, arranged in chronological order, and also an impressive collection of fossils and minerals. As well as the collections and story of William Smith and the Scarborough of his time, we saw the unique skeleton of 'Gristhorpe Man'. The 4,000 year old skeleton was found at Gristhorpe in 1834 and has remained behind closed doors until the recent refurbishment of the museum gave him centre stage.

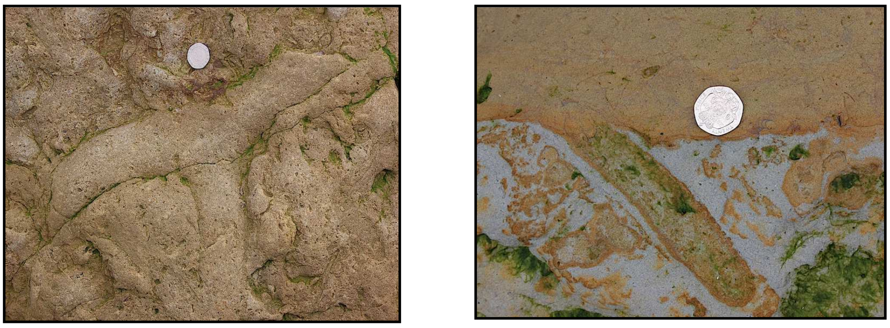


Fig. 30: Thalassinoides burrows in fallen rocks – frequently made by crabs burrowing into shoreline/near shore bedding surfaces. Note secondary iron staining associated with the sample on the right.

Fig. 31: Fallen slab of Lo. Calc. Grits, now vertical – note concretion in one of the beds

Fig. 32: Holbeck Hall slip of 1993, now landscaped.

References

1 Geologist Association Guide to The Yorkshire Coast

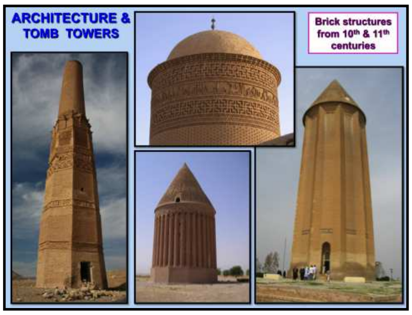
2 Siderite is a hexagonal carbonate mineral with composition $Fe^{2+}CO_3$, can be crystallised or fibrous, stalactitic, spherulitic, cleavable, fine-grained massive.

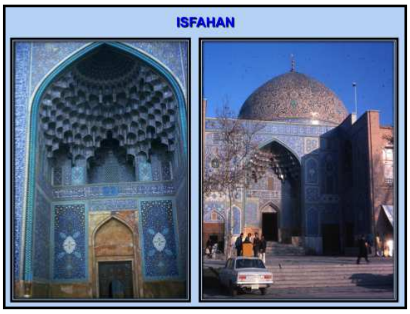
3 Chamosite is a monoclinic mineral with composition: $(Fe^{2+};Mg;Fe^{3+})5Al(Si_3Al)O_{10}(OH;O)_8$. It occurs in scaly aggregates, foliated or granular; if oolitic, it is made up of very minute radiating crystals; also can be massive.

(2 & 3 From Dana's System of Mineralogy and Deer, Howie & Zussman's Rock Forming Minerals)

A Geologist in Iran/Persia

Summary of January 2014 lecture given by Dr Graham Williams, Member FGS





Graham's talk on his experiences in Iran/Persia in the 1970's was very informative and, for me, fascinating. I found the beautiful buildings a delight and the information and pictures of rug making by nomadic people was as surprising as it was interesting. How did they manage to produce such lovely, intricate, rugs with hand-made, seemingly crude, looms?

Graham went on to put Persia's oil production into a world context (huge!) interspersed with lovely views of the landscape in different areas of the country. His explanations of oil seepage and salt seeping were another surprise plus the best pictures I have ever seen of an anticline. It was a great talk; not one you could doze through!

Margaret Richards - photos by Graham Williams

Rare baby dinosaur skeleton unearthed in Canada

Summary of article in Live Science by Philip J. Currie, Robert Holmes, Michael Ryan Clive Coy, Eva B. Koppelhus, University of Alberta, Canada.

A team from the University of Alberta were in Dinosaur Provincial Park, Alberta, in 2010, when they saw a fossil sticking out from a hillside – this turned out to be the bony decorative frill that surrounds the back of the head in ceratopsids. After full excavation, they were able to unearth the smallest intact skeleton ever found of a baby rhinoceros-like dinosaur (ceratopsid). It was estimated to be just 3 years old; it was 1.5m long and showed no bite marks, so it had probably drowned in a river ca. 70Ma ago and was identified as a tiny *Chasmosaurus belli*, a species commonly found in the area. These dinosaurs take ca. 20 yrs to reach maturity and are then 2m long with skulls weighing 3 - 4 tons. The preservation was so good that some of its skin left impressions in the rock.

Baby chasmosaur found by Philip Currie.

Finding intact baby dinosaurs is extremely rare: *'The big ones just preserve better: They don't get eaten, they don't get destroyed by animals'* said Philip Currie, a paleobiologist. *'You always hope you're going to find something small and that it will turn out to be a dinosaur.'*

This new fossil helps paleontologists understand how plant-eating dinosaurs grew, e.g. it shows that Chasmosaur juvenile frills look different from those on adults, and that limb proportions don't change much as they grow. Predatory theropods such as Tyrannosaurus rex have disproportionately long limbs as juveniles, presumably to keep up with the adults in the pack. By contrast, *'In Chasmosaurians, the proportions are essentially the same, which probably means the adults were probably never moving that fast'* Currie said. *'There was never priority for these animals to run to keep up with the adults.'*

FGS field trip to Berkshire, Sunday 11 May 2014

Led by Lesley Dunlop, reported by Dr Alan Witts, Member FGS

On Sunday 11th May 2014, Lesley Dunlop led some 20 of us on a field trip to three geological sites in Berkshire. Lesley is a leading member of the Berkshire Geoconservation Group, a volunteer group which works with local authorities, landowners and the general public to safeguard the Berkshire landscape for future generations and to promote understanding of its geology and geodiversity. The group undertakes work to preserve geological sites, provides education for schools, universities and local groups, helps train geologists and geographers, and supports research and the local leisure industry - see http://berksgeoconservation.org.uk/index.php

We met at a parking area near our first destination, Fognam Quarry (SU 298800), NW of Upper Lambourn. Lesley explained that this chalk quarry provides one of the best Chalk Rock exposures in S. England. The Chalk Rock, deposited about 90 Ma ago, marks the junction between the Middle and Upper Chalk. The formation can be traced from Hertfordshire to Dorset, but the chalk of Berkshire is only around half the thickness seen in the other S. English localities because it is conjectured that it was deposited over an area of relatively higher ground (the Berkshire-Chiltern Shelf, part of the London Platform) and therefore in shallower seas. This condensation makes correlation with other formations difficult and controversial, due to the absence of certain marker beds, although dating from fossils in the quarry, particularly Middle and Upper Turonian ammonites associated with inoceramid bivalve assemblages has been attempted.

We were able to examine two substantial faces set at right angles to each other. A number of potential horizons were apparent as shown in Figure 1. From the top, the most prominent were as follows:

1. A brownish soil/overburden containing chalk fragments,
2. A distinct hardband ca. 30cm thick which stood out a little from the horizons above and below,
3. A thicker, distinctly nodular or jumbled horizon,
4. A second hardband, thicker and slightly less distinct than the higher one,
5. A second nodular band,
6. A thin marl band, only a few cm thick, a greyish-green colour and powdery consistence, which appeared very distinct when observed from a distance as in Figure 1, but, close up as in Figure 2, was seen to merge into the units above and below which appeared to have similar appearance near the margin.
7. A thicker horizon containing more massive formations which appeared less nodular than the third horizon above.
8. Lower bands were obscured by scree from what was obviously a rapidly eroding and highly fractured exposure.

In discussion it was suggested that the nodular appearance was due more to the disturbed environment during deposition than the development of true 'nodules' and that the hard bands resulted from slower deposition in a quieter environment.

Fig. 1: General View, Fognam Quarry

Fig. 2: Close-up of Marl Band, Fognam Qy

Flints and fossils were not easy to find either in-situ or on exposed surfaces, but rust coloured pyritic nodules and echinoid fossils were observed and some ammonite fragments were found among the scree, see Figure 3. The ammonite fragments are possibly from *Collignoniceras woollgari* or *Lewesiceras mantelli*, both reportedly[1] found in the quarry.

Generally, the Berkshire Downs, which are well known for the appearance of temporary bournes in the valley bottoms in winter months and/or after extensive periods of wet weather, were still showing the after-effects of the exceptionally wet winter (up to 2.5 times normal amounts of rain in December to February over much of the South). The whole of the River Lambourn catchment is still subject (as of 21^{st} May) to an Environment Agency Flood Alert. The drive to our second location through the Lambourn and Winterbourne valleys showed the Rivers Winterbourne and Lambourn to be flowing strongly, the latter still observed to be out of its normal course in one place.

Our second location of the day was Snelsmore Common, some 15km East of Lambourn. This is an SSSI consisting of a variety of woodland and heathland habitats comprising dry heath, wet heath, valley mire (bog), birch woodland and ancient semi-natural woodland, all relating to the nature of the underlying geology. The common is one of a number of relatively flat areas in this part Berkshire lying around 115-140m above sea level formed of Paleogene and Quaternary deposits sitting unconformably on top of the Chalk bedrock. It was explained that such flat areas may be the remains of an eroded plateau formed before development of the present valley system which now cuts down into the underlying Chalk. At Snelsmore Common the top of the plateau consists of a thin layer of gravel of uncertain age which is underlain unconformably by London Clay and the sands and clays of the Lambeth Group (Reading Formation) which in turn also sits unconformably on the Chalk basement.

Fig. 3: Ammonite Fragments

Fig. 4: Snelsmore Sink-hole

We walked from the visitor entrance along several straight, good tracks which were a relic of Army occupation during the 2^{nd} World War, and headed towards the western flanks of the common. In places, the predominantly heathland vegetation (heather and birch) gave way to boggy areas with pools of standing water (there had been recent heavy rain), believed to be areas where the London Clay lies close to the surface. On descending the western flank, a notable change underfoot was noticed as wet and boggy ground gave way to firmer standing with areas of grass and bracken indicating that we were now on the Lambeth Formation. We then descended to the edge of the common and observed green fields presumed to be on the Chalk of the valley. The intersection of the Chalk and Lambeth Formation has given rise to a line of sink-holes caused by acid water run-off from the Lambeth Formation and the overlying gravels percolating down through fissures and dissolving the chalk. This process of dissolution and formation of sink-holes is believed to be still active, as evidenced by bends in tree trunks. Figure 4 shows a sink-hole containing a small pool of water, probably as a result of the wet winter, coupled with recent heavy rain and, potentially, an alluvial clay plug preventing efficient drainage.

Fig. 5: Unconformity at Rushall Qy

Fig. 6: Close-up of Unconformity

Fig. 7: Final Examination

Possible mechanisms for the production of acidic water were discussed. Lesley reported that pHs of 2 had been measured, which is probably more acid than can be obtained merely from dissolution of CO_2 in rainwater (a well-known mechanism for dissolution of calcium carbonate to form pot-holes etc). Peat deposits and decaying vegetation can also produce acidic run-off, but pH as low as 2 may indicate additional mechanisms, perhaps involving chemical breakdown, in the presence of decaying vegetation and associated bacteria, of iron pyrite (FeS) from pyritic inclusions in the gravels and sands of the Lambeth Formation to produce ferrous sulphate which can subsequently oxidise on exposure to air to hydrated iron (Fe III) oxide and sulphuric acid. Similar mechanisms have been suggested for the rust-coloured streams south of Wokingham[2] - clearly a case waiting for a proper chemical analysis to support or disprove such theories!

Our final destination of the day was Rushall Farm (SU588726), some 13km west of Reading. This is an important site that normally provides excellent views of the unconformity between the Upper Cretaceous Chalk and the overlying Palaeogene beds. However much of the quarry face had been obscured by a recent slip of the Palaeogene beds no doubt caused by the exceptionally wet winter. The farmer/owner spoke to us in person to report that work was due to commence shortly to clear the rock face. However, a sufficient section of the unconformity was left unobscured to enable us to view both the Chalk and the over-lying sediments.

A general view of the section taken during our visit is at Figure 5. Close inspection of the topmost level of Chalk showed evidence of erosion in the form of an uneven/irregular surface in contact with the overlying sediments, and a number of fissures in-filled with overlying material. It was suggested that the unconformity represents a gap in deposition of around 30Ma until the area was again covered by water about 55Ma resulting in deposition of sands and clays. The layer (2-5cm) of sandy clay immediately above the unconformity was observed (see Figure 6) to be of a greenish brown colour in contrast to the reddish brown of the higher levels. It was suggested that this was due to the presence of glauconite which would indicate deposition in seawater while the upper levels would likely have been deposited in an estuarine environment. Investigation of samples of the greenish brown layer under a hand lens showed the presence of dark coloured crystalline particles mixed in with the soft sandy clay.

This being a Local Geological Site, an explanation board has been provided by the Berkshire local authority. The description on this board suggested that iridium had been found from the area of the unconformity. Could this be a record of the K/T boundary asteroid collision? In discussion, this was thought unlikely since an uncertain thickness of chalk had been lost to erosion before the Palaeogene sediments were deposited.

Before leaving the site, FGS Members were quizzed (Figure 7) by two local residents who appeared to appreciate our presence in their field!

Earlier, we had been joined at the Rushall Farm exposure by a member of Reading Geological Society who had made a detour from a rambling group to view the exposure. He invited our party to join the ramblers for tea and cakes at our parking place at Rushall Manor Farm, where a vote of thanks was given to Lesley for providing us with a stimulating and interesting insight into some notable geological sites in Berkshire.

Acknowledgement: I should like to thank Lesley Dunlop for supplying us with informative hand-outs, in addition to her live descriptions of the sites, to enhance our understanding of the areas visited. Extensive use of this material has been made in compiling this account of the field trip.

References:

1. Fognam Quarry, Extract from the Geological Conservation Review, Vol 23: British Upper Cretaceous Stratigraphy Chapter 4.

2. Booklet: Geological Sites to Visit in Berkshire, Published by Berkshire Conservation Group.