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Field Visit Reports Summer 2014

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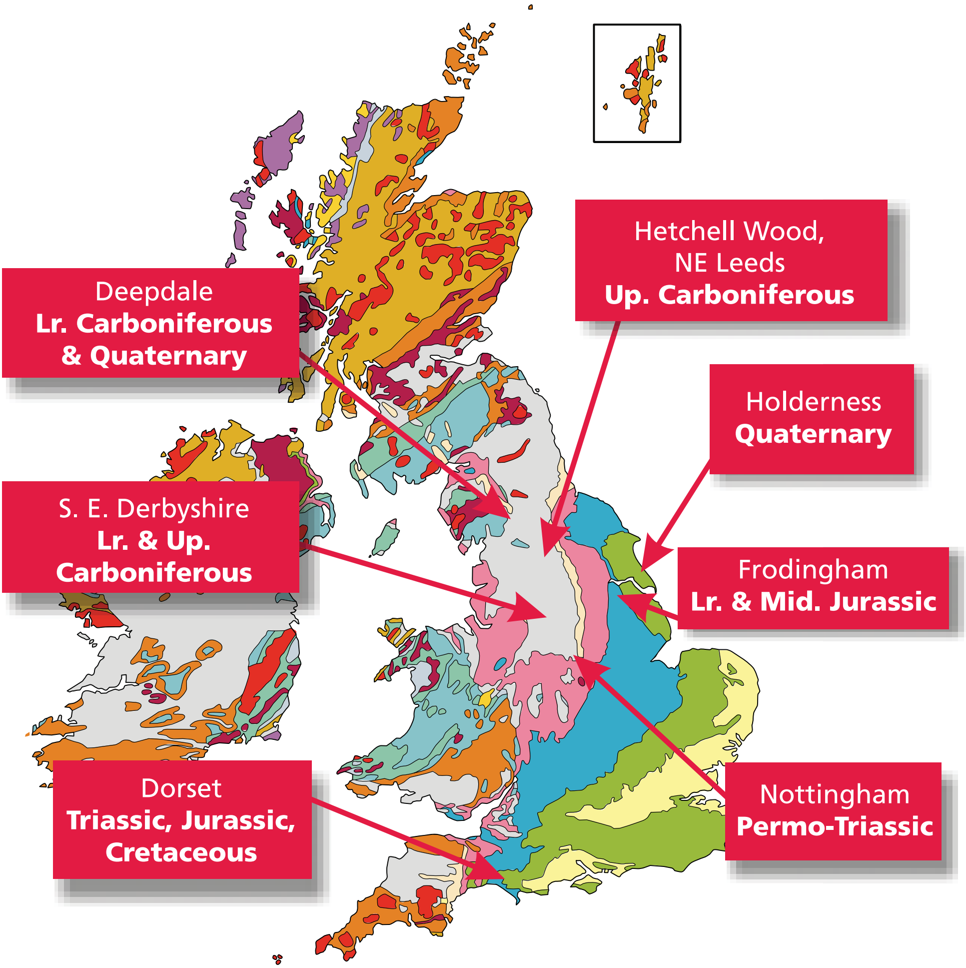
14 Where did we go?



Contents

2014 Field Visit Locations

Thanks are due to the Field Visits Secretary, Judith Dawson, for arranging the 2014 programme and also to the authors of the field visit reports and those who provided images:

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Cover Picture:
The Lulworth Crumple at Stair Hole with Lulworth Cove beyond.

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A geological walk around Hetchell Wood, Scarcroft & Thorner, NE Leeds

Sunday 11th May 2014

Leader: Bill Fraser (Leeds Geological Association)

Present: 8 members, 7 visitors

This was a Yorkshire Geology Month event intended for members of the public and it was pleasing to have visitors from the local area together with members. From the parking area Bill drew to our attention the contrasting landscapes of the arable plateau on which we stood and the undulating wooded country below us, explaining this was a consequence of the differing underlying rocks and soils.

We descended the hill and walked along the abandoned railway line to Scarcroft Cutting (a Local Geological Site- LGS), where a complete coarsening upwards cycle in the upper part of the Millstone Grit Group is exposed - from dark grey shales through siltstones to a buff-coloured, medium-grained sandstone. Tectonic forces have tilted the beds gently northwards so that they could be easily examined. Bill described the characteristics of each rock type and the environment in which it had been deposited. He explained that about 325 ma years ago during Upper Carboniferous (Namurian) time Britain had been on the equator and that in this area there had been a huge prograding tropical river delta system fed from mountains of Himalayan proportions to the north. He pointed out bivalve impressions in the shales which had been deposited in deeper water in front of the delta and, in the sandstones, symmetrical ripple marks and worm tubes - features of a shallow sea, exposed to the tides indicating the delta had advanced.

Returning along the railway line to Hetchell Woods (a SSSI for its fauna) we climbed part way up the hill to the base of Hetchell Crags, another LGS. Here was evidence of the succeeding river deposits with massive cross-stratified beds, interrupted by planar erosional surfaces. Most beds were graded with textures varying between poorly sorted, sub-angular and coarse-grained gritstone to fine sandstone, indicating variable rates of flow. The cross-stratified sets varied enormously in both dip and direction, (see photo opposite) indicating that we were now on the delta top with sediment being deposited on point bars in braided river channels.

Cross-bedded gritstone at Hetchell Crag

Behind the flat topped Crag is a break in slope indicating a change in the underlying geology with flowering cowslips indicating the soil was now alkaline. Nearby is the disused Hetchell Wood Quarry, another LGS, where rock faces display well-bedded, well-cemented, creamy coloured, fine-grained dolomite with occasional cavities lined with crystals. These are the Cadeby Formation of Permian age. Bill explained that, at the time of deposition, Britain was in desert latitudes and a shallow, clear, intra-continental sea was evaporating in the arid conditions causing carbonates to crystallise out from the super-saline waters before being altered to dolomite. Between the Millstone Grit seen at Hetchell Crags and the Permian limestone seen here, there had been a period of about 40 ma, during which the intervening Coal Measures had been deposited and then, after uplift as part of the Variscan Orogeny at the end of the Carboniferous , completely eroded away.

We walked downhill, passing an old quarry in the Millstone Grit, and crossed the line of a Roman road to have a brief look at Pompocali with its strange crescent-shaped, dune-like, heather-topped features. Several theories have been put forward for its existence but the most probable is that they are spoil from the nearby Millstone Grit Quarry. Here Bill was thanked for his illuminating talk before 10 of the party went on to the final location in Thorner.

We parked on a steep hill to look over a wall at an old quarry face and, further up the road, rocks in situ at the wall's base where Bill said that he expected the junction of the Basal Permian Sands (Yellow Sands Formation) with the underlying Millstone Grit to lie. Certainly the quarry face appeared to show massively bedded Yellow Sands with cross-stratified buff-coloured grits below (see photo below). However, examining the rocks at the base of the wall, the texture was not always as expected. In some places it was fine, well-sorted, well-rounded and poorly cemented (characteristic of windblown desert sands) but in others it was coarse and more angular with occasional mica. Also the small scale cross-stratification is somewhat unusual for aeolian deposits. After some discussion, the consensus of the party was that the Basal Sands had been deposited on an undulating surface and that, subsequently, there had been a reworking and mixing of these and the underlying grit at times of heavy rain, with the hollows being infilled.

With further thanks to Bill for an interesting afternoon the meeting ended.

Part of the problematic exposure in Thorner

Permo-Trias Exposures around, in and below Nottingham Sunday 15th June 2014

Leaders: Drs Andy Howard and Keith Ambrose, BGS
Present: 10 members

Our group met with leaders Andy and Keith at Clifton, on the river Trent SSW of Nottingham where the outline of the day, to visit a number of Permo-Trias outcrops, was explained.

Descending the path from Clifton towards the River Trent we first saw an exposure of the Cotgrave Sandstone Member (Sidmouth Mudstone Formation, Mercia Mudstone Group), a greenish-grey fine sandstone which contains some cross-bedding, cross-lamination and parallel lamination. Recent work has shown that this Member extends northwards across Yorkshire, but is not well developed southwards. It represents a developing river system but little is known about the source. Further along the cliff were excellent exposures of the Gunthorpe Member (Mercia Mudstone Group). In general this member comprises blocky, structureless red mudstones deposited as windblown dust in the Triassic desert, but at this location a bed of blocky mudstone is overlain by laminated mudstones with two beds of green siltstone in which ripple marks and salt pseudomorphs were seen. These beds are the result of heavy rain and flash floods in a desert environment producing temporary 'playa' lakes; dust blowing into the lakes then produced the thin laminated beds. When the lake dried, mud cracks and halite crystals developed. Subsequent wet episodes dissolved the halite and further sediment filled the halite crystal space to form a salt pseudomorph. Also present are gypsum deposits that would have been deposited originally as small primary nodules, but which were dissolved and re-precipitated as thin veins (see photo overleaf).

A short drive took us to the University campus where, adjacent to the boating lake, we examined a small exposure of the Radcliffe Formation (Sidmouth Mudstone Formation), distinguishable within the Mercia Mudstone Group by its very thin laminations and distinctive colours. These range from reddish brown to purplish to pinkish reds and were formed by alternation of red mudstone with pale grey laminae of siltstone and sandstone, the latter usually only a few millimetres thick, and often showing ripple marks. There are many desiccation cracks. This structure indicates a shallow lake environment, with the coarser laminae resulting from storm events leading to dust and fine sand being swept into the lake and desiccation cracks forming when it periodically dried out. This Formation occurs with a very similar form across the East Midlands suggesting that the shallow lake covered an area of hundreds of square kilometres.

Also adjacent to the boating lake, at the same level as the previous outcrop due to local faulting, we examined an old quarry face in the Chester Formation, a brownish grey, medium to coarse grained sandstone containing

Gypsum beds at Clifton

well rounded quartz and quartzite pebbles eroded from rocks of a Variscan mountain range in northern France. The major braided river system carrying these erosion products across most of England continuously branched and rejoined around low sandbars, with sand being moved and deposited downstream, producing complex cross-bedding but with foresets mostly inclined towards the north-east.

Below the foundations of one of the campus buildings we were able to examine a small in situ exposure of the Lenton Sandstone Formation, a fine to medium grained, poorly cemented sandstone with well-rounded grains indicating its origins as aeolian dunes (see photo below). A high clay content and iron as haematite give it a deep red colour. In other locations this member is known to have steep cross-bedding/cross-lamination and their absence here is because the exposure is aligned along the strike of the beds. The composition, rounded grains, clay and iron oxide content, made this material ideal as a moulding sand, and it was in great demand until replaced by synthetic substitutes.

Lunch was taken in the University Park Rock Garden which, topped by a Chinese summer house, had long been heavily overgrown and was not rediscovered until 2006 during renovation work. The Rock Garden lies next to a disused quarry in the Chester Formation exposing up to 10m of pebbly, planar and trough cross-bedded sandstone. The garden is built around the flanks of the quarry, with large architectural blocks of dolostone from the

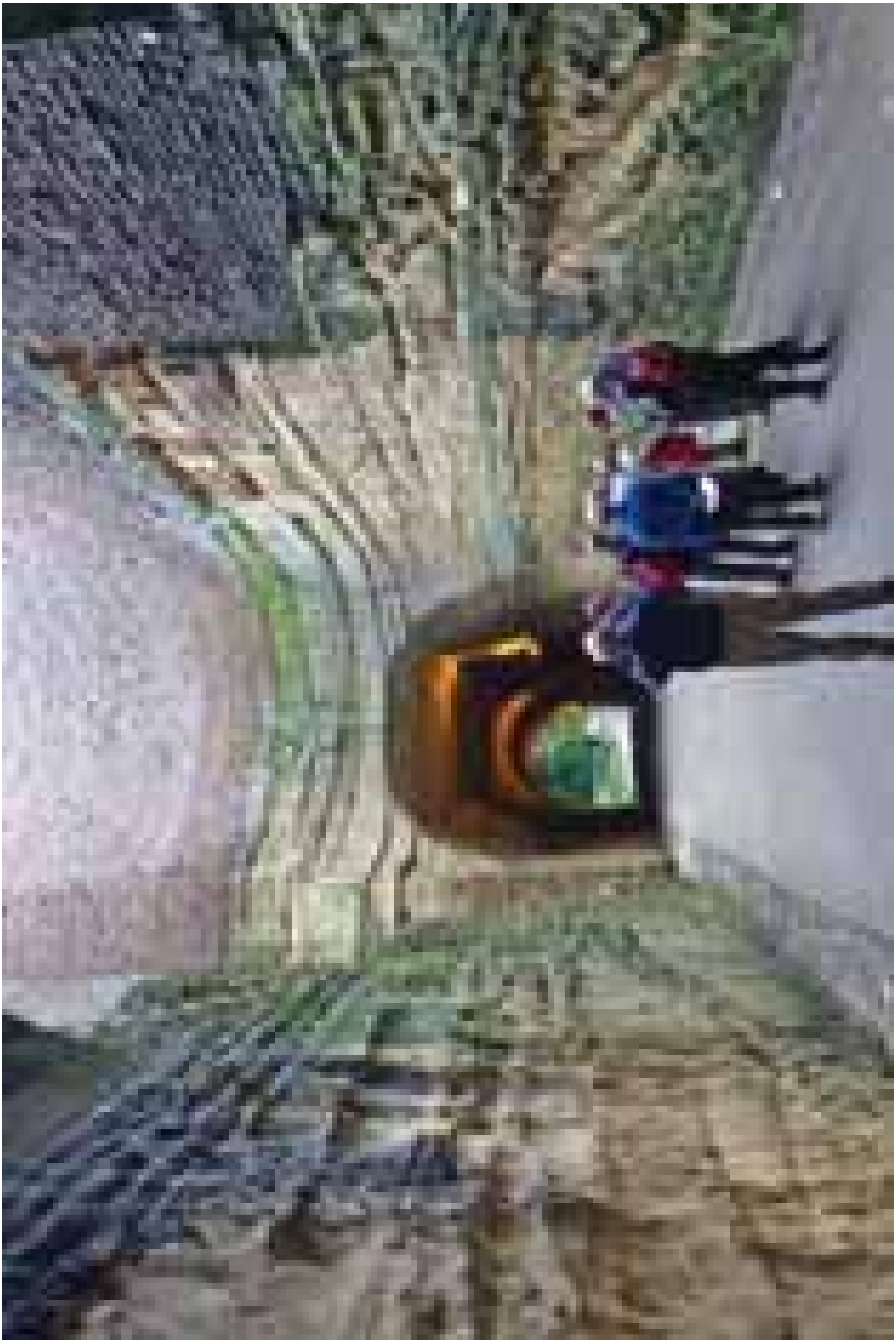
An outcrop of the Lenton Sandstone Formation beneath a lecture theatre

Late Permian Cadeby Formation (formerly called Lower Magnesian Limestone) intermingling with steps and terraces of in situ Chester Formation sandstones and traversed by paths of Carboniferous sandstone flags with current rippled surfaces. The Cadeby Formation blocks are formed of granular, yellow brown dolostone, superficially resembling a sandstone but with grains of rhomboidal dolomite instead of silica. This rock, known locally as Bulwell Stone, was originally deposited as an ooidal carbonate on the south west margin of the Late Permian Zechstein Sea, and was then re - crystallised to a dolostone soon after deposition. Bulwell Stone is almost ubiquitous in Nottingham, and used for walling and ornamental stone in all parts of the city. It was formerly quarried from the outcrop in the north west of the Nottingham but the last quarries closed in the 1980s.

Leaving cars in the Broadmarsh Shopping Centre car park near the City centre we next visited the 'City of Caves' which lies beneath the Centre within the weak and friable sandstones of the Chester Formation. This makes them a poor building stone, but, as they are easily extracted, they have been extensively worked in the area as a source of sand and aggregates for the building industry. The deposits beneath the city of Nottingham were excavated over centuries to create cellars, vaults, habitations and workplaces; the lack of close spaced joints making for stable excavated structures. During the last war, small caves in the two intensively 'burrowed' areas were linked to form two large cave systems which served as air raid shelters for many thousands of citizens. The visit was a good opportunity to get a flavour of this environment, with a guide giving an excellent social and commercial (but not geological) explanation of the features seen. The Sherwood Sandstone is highly permeable and a major source of potable ground water. In recent years, however, extraction has decreased, especially for the brewing industry, and the water table has risen which could become a problem to structures in the city.

After a steady walk from the city centre up Derby Road we turned into a side road with stone walls as the only geology on view. A small gateway gave access to a large staircase into a pit containing the Park Tunnel. This was excavated in the mid nineteenth century to enable the reclusive Duke of Newcastle to enter and leave his adjacent estate onto the Derby road in private, and it was built high enough to allow horse drawn carriages to pass through. A very impressive structure! (see Photo opposite) It was soon made redundant by improvements to local roads, but has left a valuable geological legacy as it permits a three dimensional study of the formative processes by which the river dune system developed. Brickwork at the northern end of the tunnel showed us more examples of the Bulwell Stone.

Our day ended with a pass of Castle Rock, a 30m high river bluff of Chester Formation Sandstone with its many cave openings, topped by the remains of Nottingham Castle. At this point our leaders were thanked for a most informative day and members returned to the University to collect cars for the journey home.



3D dunes in Park Tunnel

Glacial Features in Holderness.
Saturday 28 June 2014.

Leaders: Prof Mark Bateman [Sheffield], Dr Paul Buckland [retired] and [at Kelsey Hill] Mr Stephen Whitaker.
Present: 10 members.

At 10.30 am on a dry, still morning our party assembled a little north of Easington gas terminal, descended to the beach and walked north for about a mile, passing irregular slumped cliffs of glacial diamict. Assorted erratics seen on the sandy beach included various granites, flints and fossiliferous Carboniferous and Jurassic limestones. Eventually we reached Dimlington cliffs (see photo below), adopted in 1985 as the type site for the last glacial maximum because it had good access, good cliff sections and was the best dated such site. Erosion at more than 1 m per year had destroyed previously mapped sections. Mark described the supposed maximum extent of the last glaciation, which had occurred in different places at different times. Three tills were now recognised, successively the Basement, Skipsea and Withernsea tills. A supposed fourth till was now considered to be a deep post-Flandrian weathering profile.

The Basement Till was greyish, relatively low in clastics and its undulating erosion surface was exposed only at the base of the cliff. Its age is disputed, either being Wolstonian, around 160 000 BP; or perhaps only 20 000 BP, immediately preceding the overlying Skipsea Till. In the 1960s, Penny and

Dimlington Cliffs

Catt had found pockets of sticky brown laminated silts, the Dimlington Silts, apparently laid down in small lakes, which contained sphagnum moss. This showed that the lakes had been subaerial and it contained enough carbon for dating at about 21 000 BP.

The overlying Skipsea Till contained more Devonian erratics from Scotland and Norwegian erratics [now thought to have been scraped from the North Sea bed] than the Withernsea Till above, which was sandier and contained more Lake District erratics carried through the Stainmore Trough. Both had been deposited successively by the same ice sheet as the main ice source had changed from Scotland to the Lake District.

A body of sand had been discovered in the cliff, between the Skipsea and Withernsea Tills., with laminated clayey silts grading into sands with ripples, which seemed to have been laid down in small lakes. These were shown to have been subaerial when Paul Buckland found well preserved trails on bedding planes in the clays and later discovered various subarctic insects. Dating indicated an ice withdrawal of unknown extent and duration at around 16 000 BP, preceding deposition of the Withernsea Till.

Members spent a while examining a 1.5 m thick lens of DImlington Silt and the tills. The laminated sands higher up the cliff were inaccessible. We then walked slowly south, looking at exposures in the slumped cliffs and erratics on the beach. One large angular erratic block [from Scotland?] about 1.50 m wide, consisted of a fairly fine grained reddish feldspathic sandstone ,with clay clasts up to 10 cm across.

Lunch was taken near the cars, then we drove to Mr Whitaker's quarries in the Kelsey Hill Gravels [a series of pockets of sand and gravel in a narrow NNE-SSW trending belt], just beyond Keyingham, close to the western limit of the Withernsea Till. In the northern quarry, now worked out, Mr Whitaker showed us his collection of bone fragments from the quarry, mostly representing cold-loving steppe vertebrates such as bison and mammoth; (see photo overleaf) also his collection of shells, mainly bivalves, some of temperate marine species, others from warm fresh water. All are thought to be derived from earlier beds by glacial meltwater. Near the mainly flooded old workings, Mr Whitaker described how, between the Skipsea and Withernsea tills, a band of sands and gravels of lenticular section ran very roughly N-S. A much narrower band of sands and gravels, cut into the top of the Basement Till, ran roughly E-W. This he likened to a meandering river bed, with cobbles at the bottom. Presumably these two bands must have been very roughly contemporary with the laminated sand and Dimlington Silts seen in the morning. In the working quarry south of the road we saw a 3m high ridge, with a worked face of brown sand running roughly E-W for about 200 m. The bedding seemed predominantly horizontal. It was not clear how this deposit related to those in the northern quarry. Mr Whitaker had collected a similar range of bivalves here and members had little difficulty finding more in the gravelly sand underfoot.

Stephen Whitaker with a prize specimen

After Mr Whitaker was thanked for taking us round his quarries and showing us his collection we drove under the Humber Bridge and parked in a narrow lane in North Ferriby, crossed the end of a field resplendent with borage and poppy blossom, down onto the Humber foreshore and walked east. The low cliff rose steadily from 1.5 to about 5 m at a point, Red Cliff, mapped by W.S.Bisat in 1932. Despite vegetation, rainwash and some slumping, we could see the section through a ridge of Skipsea Till about 3 m high, overlain with well bedded sands and gravels disturbed by occasional ice wedges. (see photo opposite). This terminal moraine was deposited by ice which had pushed up the Humber channel and impounded the first [32 m] Lake Humber. After the ice had been breached, the moraine itself impounded the second lake. When this failed, escaping water cut a 30 m deep channel, missed during exploratory borings for the Humber Bridge, resulting in engineering problems when constructing the south pylon.

Finally, Paul pointed downstream to where estuarine silts overlie peat resting on till and where, in 1939, three sewn plank boats of late Bronze Age had been discovered.

The Field Visits Secretary then thanked Mark and Paul for leading such an interesting excursion and the party dispersed at about 5pm.

Moraine at Red Cliff

Deepdale - The Dent Marble Quarries
Saturday, 19th July 2014

Leader: Bill Fraser. Leeds Geological Association
Present: 8 members plus 2 visitors

This Field Visit was a follow-up to Bill's LGA lecture on the Dent Marble industry in January. The purpose of the day was to visit three disused quarry sites around Deepdale, looking at the raw materials used in the Dent Marble industry, where these materials fit into the stratigraphical characteristics of the Yoredale (Wensleydale) Group, and the working practices involved in their extraction. There was also the opportunity to take a brief look at some Quaternary features from the Devensian Stage.

The group set off in persistent rain to the first site, a quarry on White Shaw Moss near the head of Deepdale. This exposure is in the Hardraw Scar Limestone, the first complete cyclothem of the Yoredale Group in this area, and is a very hard, dark, fine-grained limestone, almost black when wet. (see photo below) Although not very fossiliferous, small numbers of brachiopods (*Productids*), crinoids, colonial corals (*Lithostrotion*), and trace fossils (*Zoophycos*) were seen, mainly in the more shaley layers. Known as 'Black Marble' when polished, the stone was used for tiles, fireplaces, and other more ornamental uses. In the stream bed below the quarry blocks of limestone were seen that had been partly polished by the water, showing very clearly the smooth, black appearance of the rock.

Black Hardraw Scar Limestone showing drill holes, White Shaw Moss Quarry

Crinoidal Undersett Limestone, Binks Quarry

The limestone in the quarry is only about 10 m thick, and with the difficulty in transporting the large blocks down to the mill at Stonehouse in Dentdale for cutting and polishing, production would have been on quite a small scale.

The second locality was on the western slope of Deepdale, at Binks Quarry. On the way to the quarry we saw very clear examples of sedimentary structures in some unweathered sandstone blocks in a dry stone wall and in the track, particularly slump bedding, truncated beds, and flute casts.
Binks Quarry exposes the Undersett Limestone, which is in the uppermost cyclothem of the Yoredale Group and reaches its maximum thickness of 20 m here (perhaps a reef or a hollow in the sea floor?). The limestone was much paler than the Hardraw Scar Limestone due to a lower content of mud and carbonaceous material, but was highly fossiliferous, predominantly crinoid debris. The crinoids were patchy, being found mainly in the upper beds, but were impressive in quantity and size, with individual ossicles up to 2 cm in diameter and stem lengths up to 15 cm. (see photo above). This limestone was also cut and polished for ornamental use and, as in the quarry on White Shaw Moss, numerous large blocks were lying around, presumably ready for transporting to the mill, but abandoned when the quarry closed. Working practice was to pile the waste material behind the working faces, and large retaining walls that maintained access through the spoil heaps were still clearly visible.

As well as providing welcome refuge from the elements for a lunch stop, the

Binks Quarry in foreground with corrie and terminal moraine below Great Coum beyond

quarry also allowed a good view across Great Combe, which is a NE facing corrie on the slopes of Great Coum. This is one of 5 small corries in the Western Pennines formed during the Loch Lomond Stadial of the Devensian Stage between 13,000 - 11,500 yrs ago. Both terminal and lateral moraines were clearly visible, and the marshy area at the bottom of the quarry was probably the site of a small lake. (see photo above)

The third and final locality was reached after a short detour across the moor to a quarry on High Pike, where the sun finally made a welcome appearance. This quarry exposes the top of the cyclothem below the Undersett Limestone, and was worked to extract the sandstone, not the limestone. The sandstone was seen to be fine to medium grained, well cemented, and very variable in bed depth, up to 20-25 cm, and was quarried during the 18th and 19th centuries as flags for roofing, paving and walling. The beds were discontinuous, grading horizontally into shale, (typical of braided channel sedimentation), and in places were very thinly bedded, micaceous with carbonaceous material, and quite crumbly. There were also thin bands of limestone containing *Spiriferid* brachiopod fossils. The Undersett Limestone outcropped above the sandstone in the quarry but had a very different character here compared to Binks Quarry just 1 km away across the valley. Fallen blocks showed that it was more thinly bedded, fine grained, and less fossiliferous, and the crinoids present were very much smaller, possibly evidence of it being a lower energy environment and consequently less need for a robust construction.

All in all Bill gave us a very enjoyable, interesting and informative visit, the take-home message being how much the appearance and properties of limestone can vary, both laterally and vertically, over a relatively short distance.

Frodingham Ironstone
Saturday 16th August 2014

Leader: Paul Hildreth
Present: 13 members

Our group met Paul at the North Lincolnshire Museum in Frodingham, on a generally overcast but dry day. We had come to examine the Jurassic rocks at two quarries and after a short introductory talk by Paul and taking refreshments kindly provided by the museum staff, we took the opportunity to look around the museum. We found the geological and archaeological exhibits especially well displayed and informative.

Lincolnshire's bedrocks form a simple pattern of north-south stripes at the surface, with the older Triassic rocks in the west, overlain progressively by marine Jurassic rocks and the younger Cretaceous rocks in the east. Originally deposited nearly horizontally they all became uplifted above sea-level and then tilted down to the east by a few degrees around 60 Ma. At the end of the Triassic period a major series of marine incursions flooded much of England. During the Jurassic, Lincolnshire, part of the East Midlands Shelf that forms the western margin of the North Sea Basin, remained beneath the sea, or just emerged along coastlines as reefs, lagoons and marshes. During the Early Jurassic, the Lias Group mudstones, limestones and ironstones are dominant, occurring along the western side of the county from the Humber as far south as Grantham. The fossil record of the mudstones of the Charmouth and Scunthorpe Mudstone Formations, formed in deeper waters, are dominated by free-swimming ammonites and belemnites, whereas the Frodingham Ironstone Member, formed in shallow, oxygenated waters, with its higher proportion of bottom-dwelling life, is dominated by Gryphea and other bivalves. By the Mid Jurassic, more extensive areas of shallow, sub-tropical seas across the county supported a rich variety of life. Rocks of the Inferior Oolite Group, including the Lincolnshire Limestone Formation, form the scarp extending south from the Humber as far as Lincoln. Quaternary wind-blown sand draped the escarpment and extended into adjacent low-lying areas.

Leaving Frodingham, which lies on the present outcrop of the Frodingham Ironstone Member, our first stop was at the Conesby Quarry. We parked the cars near the entrance to the quarry and walked in about 2 km before descending about 50 m into the quarry (see photo overleaf) where we were able to examine the only remaining in situ exposure of the Frodingham Ironstone Member safe for group visits. These rocks are packed with fossils with more than 40 species having been recorded, including bivalves,

Rocks of the Lower Lias Group at Conesby Quarry

Berthierine/chamosite coated fossil bivalve, *Gryphaea arcuata*, Conesby Quarry

pectinids, brachiopods, echinoderms, belemnites, ammonites and burrows. However, by far the most common fossil we found, even among the rubble on the roadway, was the bivalve *Gryphaea* (see photo above), frequently with both valves intact, so it is not surprising that two *Gryphaea* are incorporated in Scunthorpe's coat of arms.

Ironstone has been quarried around Scunthorpe for more than 130 years and was the basis for the town's former prosperity in steel-making. There is evidence of Roman and Saxon iron workings in the area, but abstraction had ceased until the 1850s when Rowland Winn became aware of the commercial potential of the ironstone deposits and opened a quarry. The first blast furnace opened in 1864 and eventually five companies smelted iron on the spot. Commercial abstraction from quarries situated along the outcrop from Thealby south to Ashby continued until 1987. Ironstone was also once an important vernacular building stone, which when freshly exposed is greenish-grey in colour, but after prolonged exposure becomes more variegated, ranging from yellow-brown to red-brown.

Sedimentary rocks with more than 15% iron are known as ironstones. Phanerozoic ironstones are usually local accumulations of fossiliferous oolitic deposits and are called ooid- ironstones. In the Frodingham ironstone the ooids mainly consist of iron-rich sheet silicates (berthierine/chamosite). The matrix cementing the ooids variously consists of berthierine, chamosite, iron carbonate (siderite), quartz and calcite. Aspects of the origin of oolitic ironstones have been controversial topics for decades and, currently, chemical sedimentologists and ore-deposit geologists are sharply divided on the issue of whether the iron could be a product of superficial weathering of soils or marine sediments, or of an exhalative origin including tecto-magmatic regimes, deep magmatic sources, pure volcanic origin, or precipitation of hydrothermal solutions.

After returning to the cars we drove to Manton, which is situated on the edge of the escarpment about 10 km south east of Scunthorpe. Here we picnicked for lunch at the entrance to the Manton Stone Quarry. The quarry is now worked partly for aggregate and partly for landfill but was formerly the site for the extraction of "cementstone" for the nearby Kirton Cement works. At the quarry, the Kirton Cementstone Beds (muddy limestones) overlie the oolitic sandy limestones (Santon Oolite). These rocks are of Mid Jurassic Bajocian age and were formed in warm shallow seas with carbonate deposited on platform, shelf and slope areas, about 170 Ma, and contrast sharply with similarly aged beds in North Yorkshire which were deposited, in the main, by an oscillating delta complex. The basal beds of the section, the Raventhorpe Beds Member, comprise siltstones and muddy sandstones which represent the last vestiges of arenaceous sediment from the North Yorkshire delta into the clearing East Midlands shelf sea.

The quarry occupies a total area of about 180 ha on both sides of the B1398. We visited the north-west section (see photo on back cover) nearest to the village of Manton. The active, southern face of this quarry section was not accessible to our party but viewing the fresh face from a distance we were able to distinguish the darker Kirton Beds from the other paler limestones. This distinction was not as evident in the exposure we were able to inspect due to weathering. Although not as fossiliferous as the rocks at our first location, members were able to identify burrows, corals, belemnites, bryozoas and brachiopods.

We duly thanked Paul for arranging the visits to the museum and the quarries. By sharing some of his extensive local knowledge with us he greatly contributed to our understanding of the geology of the area and our enjoyment of the day.

SE Derbyshire
Saturday 6 September

Leader: Dr Cathy Hollis; University of Manchester
Co-leaders: Dr Jim Marshall and post graduate student Cat Breislin; Liverpool University
Present: 12 members and 4 visitors

The party met Cathy and her co-leaders in the car park at Middleton Top on a day that, while misty, was warm and remained dry. Middleton Top is close to the eastern end of the High Peak Trail, a 17 mile route for walkers, cyclists and horse riders, opened on the track bed of the former Cromford and High Peak Railway that ran from Whaley Bridge to Cromford. It was built in 1831 to carry coal, limestone, cotton and other goods between the Peak Forest Canal at Whaley Bridge and the Cromford Canal at High Peak Junction before finally closing in 1967.

The Trail runs past abandoned quarries and natural outcrops as well as providing exposures in cuttings, and it was along this that the group spent the day walking (and dodging cyclists). The localities to be visited all lay on the southern margin of the Derbyshire Platform which was created in early Carboniferous times when N - S tension reactivated E - W trending faults in the Caledonian basement rocks. Differential subsidence created a platform upon which shallow water carbonates of Lower Carboniferous (Dinantian) age were deposited, and fault bounded basins in which a mixture of remobilised carbonates from the platform and fine grained sediment from the Wales - Brabant land in the south and the Caledonides to the north, accumulated. Subsidence slowed in the later part of the Carboniferous and the whole area became buried by southward prograding delta systems. Late Carboniferous, early Permian times saw the faults reactivated and basin inversion occur when tensional forces turned into compression as Laurasia, Gondwana and Avalonia collided to form Pangea. As well as different facies we were also able to see the effects of mineralisation and diagenesis and ponder the mechanisms by which these occurred.

The morning localities required us to first descend the impressive Middleton Incline, a 1 in 8 gradient, up and down which loaded wagons were wound (attached to a continuous steel cable by leather straps relying on friction!). At the bottom lies Black Rock (see photo overleaf), an outcrop of the Ashover Grit of Namurian age, surrounded by the spoil of Cromford Moor Mine, a former lead mine sunk into the Gang Vein. The Ashover Grit is here a coarse grained, immature sandstone displaying large scale cross bedding which had a southerly orientation suggesting a northerly source and an indication that Wales - Brabant land may have extended northwards to link with the Caledonides. The spoil adjacent to Black Rock is largely made of limestone

Black Rock, Ashover Grit with spoil from Cromford Moor Mine in foreground

and, having come from below the Grit, shows that this locality lies off the platform edge in an adjoining basin. While limestone was the most common material in the spoil a search soon uncovered fragments of galena, sphalerite (ore minerals), barite and calcite (gangues) and a few specimens containing bitumen. This lead to discussions of the possible sources of these which here is believed to be related to the Variscan Orogeny when shale in the Widmerpool basin was compressed, heated and dewatered, leaching out the metallic ions which then moved into the limestone where they collected sulphates to form the sulphide minerals.

Heading back up the incline towards Middleton Top we paused to look down on the National Stone Centre. This is sited in an old quarry that exploited limestone formed as a reef knolls in the Hoptonwood (Asbian) Limestone which reinforces the platform-basin margin situation of the locality.

Halfway up the incline we entered a cutting and tunnel driven through horizontal, thick bedded Monsal Dale (Asbian) Limestone which showed we had crossed back onto the platform top. Emerging from the tunnel, two layers of red stained, rubbly limestone, approx. 50cm thick and 1.5m apart were seen in the cutting sides between thick beds of pure limestone. These are palaeokarsts (see photo overleaf) and formed during times of emergence of the sea floor when the carbonates previously deposited were exposed to weathering and erosion allowing karstic features to develop along with thin soils, now preserved as palaeosols. The clay component of these contains a proportion of clay minerals derived from volcanic ash which can be related to the Lower Carboniferous age volcanics seen elsewhere on the platform. Immediately above the 'clay wayboards' the limestones were brachiopod (*Productid*) rich showing a rapid return to shallow marine environment. The causes of such rapid cyclic changes of sea level that created these features was discussed with eustatic changes related to growth and decay of polar ice caps being the most likely.

Lunch was taken at the car park before we set off to walk west along the High Peak Trail to a natural limestone outcrop at Harborough Rocks. This is composed of the Hoptonwood (Asbian) Limestone and the Matlock (Brigantian) Limestone, both of which have been dolomitised and weathered to a very irregular nature, being heavily pitted. The total thickness of limestone exposed is almost 50 m but we restricted our observations to the lower half. Working up the outcrop the lowest beds showed thin, well bedded layers, gently dipping in a southerly direction but, in places, quite deformed. Brachiopods could be recognised and some burrows. What appeared to be some quite large clasts could also be seen. These beds were interpreted as having been involved in slumping suggesting they had been deposited on a slope on the platform margin leading down into the adjacent basin. Moving upwards the bedding became progressively thicker with some southerly dipping cross bedding but with patches that were quite heavily

A palaeokarst in the Monsal Dale Limestone

burrowed. Brachiopods, crinoids and coral were more obvious and the weathering less intense. These were interpreted as being more typical of the platform top adjacent to the margin. Towards the top of the massive layers, a rubbly layer similar to the ones seen earlier on the incline was seen. As before, this is a palaeokarst surface showing sea level has fallen and the platform experienced emergence and weathering. This boundary is believed to correspond to the Asbian - Brigantian boundary. Above this the rock immediately returned to massive beds showing cross-bedding and containing brachiopods and corals indicating that sea level rose rapidly to re-establish shallow, high energy, shelf conditions.

The whole thickness of limestone here has been dolomitised and Cathy outlined the theories (and their problems) of how this may have come about. One process may have occurred at shallow depths quite soon after burial as sea water, concentrated by evaporation, sank through the deposited carbonates. Another may have involved much deeper burial and heating of fluids contained in the basin sediments before they passed up faults into the limestone. The E - W fault that lies to the south of the dolomitised zone and forms part of the southern boundary of the platform, lends weight to this origin.

At this point Cathy was thanked for providing such an well planned day and for her enthusiasm and the party made their way back to the car park.

Residential Field Visit: Dorset
26 -28 September 2014.

Leader: Alan Holiday, Chairman of Dorset Geologists' Association Group and Dorset's Important Geological Sites Group.
Present 13 members

Friday
Arriving on Portland at various times on Friday afternoon members of the group visited the nearby Portland Museum which is devoted to the people and industries of Portland and contains an eclectic mix of exhibits including fossil cycads and stromatolites. It was founded by Dr Marie Stopes in 1930 and is run by enthusiastic volunteers. The group assembled before dinner at the hotel to meet the leader Alan Holiday who had kindly come to give us an introduction to the Dorset and East Devon Coast World Heritage Site we were to visit and the reasons for its 95 miles being so designated in 2001. His talk was amply illustrated with photographs, including some of places we would visit over the next two days.

Saturday
Starting out from our scenic hotel on Portland on Saturday we travelled west into Devonshire to Seaton Hole, where the Triassic Branscombe Formation can be seen. We walked down the Beer Fault to the pebble beach, our path diverted and marked with our first warnings about unstable cliffs. To the west of the fault we noted the Cretaceous with the grey-green sands of the Foxmould Member and the Whitecliff Chert Member (calcareous sandstone with flint). Above lies the Beer Head limestone used as a building stone in Exeter Cathedral for its carving properties. To the east we admired the beautiful red beds of the Branscombe Mudstone Formation, here 220 metres thick, and up-faulted against the Chalk and Upper Greensand. The Branscombe Mudstone Formation is a red mudstone with thin green sandstone bands; the red due to oxidised iron, the green due to its reduction. They were formed 210-220 ma, when this was a hot dry desert within the Pangaea super-continent, 20 degrees north of the Equator. Occasional rainfall and flooding by shallow seas led to the formation of evaporite deposits in sabkhas and one of the products of these, gypsum, was found on the beach and in the rock faces. The scarcity of fossils has resulted in dating being based on magneto-stratigraphy. We noted the 1839 landslip and those of recent years which result from to the lack of cement in the mudstones which then collapse and slip when saturated. Rock armour brought in to protect the recent coastal erosion was a mixture of fossiliferous Portland limestone containing the gastropod *Aptyxiella portlandica* (the Screwstone)

Cone-in-cone structure within Shales with Beef, Monmouth Beach

and harder, grey, Carboniferous limestone containing corals, from the Mendips. Examining the beach pebbles we found flint and chert from the Greensand and ones containing solitary corals, trace fossil burrows, brachiopods and crinoids from the Carboniferous.

Moving to Lyme Regis we walked along Monmouth Beach to the "ammonite graveyard" at Devonshire Head. Here there is a gentle east-west anticline which runs against the regional pattern of gentle easterly dip. The Lower Jurassic Blue Lias beds consist of interbedded clays and limestones which are dark in colour due to the presence of pyrite. The alternating nature of the beds has been suggested as either due to Milankovitch cyclicity or diagenetic changes. The overlying Charmouth Mudstone Formation is formed of Shales with Beef (diagenetically formed bands of fibrous calcite, some with cone-in-cone structures) (see photo opposite) and the Black Venn Marl Member. The Shales with Beef are organic rich and similar to source rocks for the Wytch Farm oilfield to the east. Along the beach abundant ammonite casts with marked differences in size attributed to sexual dimorphism were found along with *Cenoceras* (nautiloid), *Gryphaea* (bivalve) as well as crinoidal debris and worm burrows, possibly of *Rotularia concava* from the Upper Greensand. We lunched looking at the landslips and the beach huts attacked both by sea and land last winter.

Our next stop was at Hive Beach, Burton Bradstock. Here we were standing on Pea Grit at the far end of Chesil Beach. We walked cautiously past the orange coloured Burton Cliff, formed of Bridport Sand with Inferior Oolite capping and Fullers Earth or Frome Clay above. Marked undercutting and major vertical joint lines showed where the next movement will occur. The brilliant colour is due to oxidation of their iron salts. (see photo overleaf) The beds alternate due to differences in the calcite cements in the sands. In the Inferior Oolite there are well preserved fossils of ammonites, bivalves, brachiopods, gastropods echinoids and sponges. We found the "snuff box" concretions, algal build-ups around shell fragments marking a distinctive marker horizon within the Inferior Oolite. Bioturbation was very evident.

Further east we stopped at Abbotsbury Hill to admire an excellent view of the Weymouth Anticline and saw how the low ground of Weymouth has been protected by Chesil Beach, a fossil barrier beach which possibly originally joined up with the Portland raised beaches now 10 metres above sea level. It is migrating toward the shore gradually with the Fleet, a lagoonal lake, behind it. Down at the Fleet, at sea level behind Moonfleet, we examined the Forest Marble, with thin layers of shelly limestone formed in very shallow water of the Oolite Group in the Middle Jurassic..

Returning to Portland we walked to King Barrow Quarries to view the fossil

Burton Cliff with undercutting and joint lines in the Bridport Sand, capped by Inferior Oolite

forest horizon. Here we saw the "crow's nest" *stromatalitic* structures (see photo below) retaining the shape of the boles of the trees in the wooded areas growing in a lagoonal environment. The thin stromatolite limestone bed here lies on the Jurassic Cretaceous boundary, where the Purbeck Beds lie above Portland Limestone.

This was a full and very varied day. Despite the lowering clouds and poor light, the rocks were bright and colourful and the visibility extended at one point for 30 miles.

Sunday

A misty start soon gave way to bright sunshine as the group set off from Portland to visit coastal localities east of Weymouth. The rocks dip gently from west to east so we made our way up the stratigraphic sequence as we travelled east. We were fortunate with the weather and had clear, long-distance views of the splendid Dorset coastline throughout the day.

Our first stop was Durdle Door, an impressive coastal arch cut by wave action in near vertical Portland Limestone. We descended the cliff and examined the rock sequence above St Oswald's Bay. Alan explained that the lowest

Fossilized forest: Stromatolitic tree bole cast, Kingbarrow Quarry nature reserve

beds visible were Portland Stone overlaid by thinly-bedded Purbeck Group rocks consisting of interbedded sands and clay, which is less resistant than Portland Stone. Above these strata are the Lower Cretaceous Wealden beds, a mostly poorly cemented mixture of clay and sand, lacking in fossils (except lignite). These are the least resistant rocks and form the most indented part of the bay. Above the Wealden beds, the Upper Greensand, a calcareous, glauconitic sandstone, is exposed, and above that is the Chalk, on which we were standing. The Chalk is a relatively resistant rock and forms the back of the bay. All these layers were steeply dipping, almost vertically in places, as a result of deformation during the Alpine Orogeny.

Walking towards Durdle Cove gave an excellent view of Durdle Door and the Chalk cliffs to the west. Near vertical Chalk strata were clearly distinguishable in Bats Head Cliff. By considering the dipping strata, we could appreciate that we were on the north limb of an anticlinal fold; Portland lies on the south limb of this fold. Near the foot of Bats Head Cliff, we could see evidence of a new arch being formed (see photo opposite). This, together with the remains of several Portland Stone stacks in the sea, highlighted the dynamic nature of this coastline. Some members of the group descended to the beach to examine the folded Purbeck beds at close quarters before we then drove to our second locality, Lulworth Cove where we first visited Stair Hole to observe the impressive fold known as the Lulworth Crumple (see photo front cover).

The Purbeck Beds here increasingly steepen from an initial dip of about 40°, then overturn. These beds are less competent than Portland Stone so were more readily deformed during the Alpine Orogeny. Alan pointed out that the Lulworth Crumple is highly localised; the folds observed on the east side of the cove are not continued on the west side. The narrow cove entrance comprises massive, resistant Portland Stone. It protected the less resistant Purbeck beds behind but once the sea breached the Portland Stone, it could readily carve out the cove. We saw evidence of extensive erosion and landslips arising from movement of the weak Wealden Beds beneath the Purbeck Beds. Some members climbed a path to a high vantage point on the cliff to the west, which gave a view of Stair Hole, Lulworth Cove and the coast to the east beyond.

We made our way round to a scenic lunch spot overlooking Lulworth Cove, then walked down to the beach in the Cove. The now-familiar tilted rock sequence observed at Durdle Door was repeated as we walked clockwise round the Cove and we were able to examine each rock type closely. The Purbeck Beds here are calcareous sandstone, packed with shelly debris (mostly bivalves). This tough, carbonate-cemented rock shows veins of calcite and was deposited in a lagoon environment. The environment changed from

New arch forming below Bats Head Cliff

a lagoon to a fluvial setting when the adjacent Wealden Beds were laid down. These were deposited on a flood plain as clays, with coarser sands deposited in river channels. We found fragile pieces of fossil wood (lignite) from trees which grew and died on the flood plain and were washed down in storm events. We then crossed the Lulworth Spring, a narrow stream of clear water that enters the Cove and is fed from a chalk spring 200 metres upstream. The next layer was the Upper Greensand, distinguished by tiny dark glauconite crystals giving it a speckled appearance. Alan used HCl to demonstrate than this was a calcareous sandstone.

Further walking to the back of the Cove brought us below cliffs of the Lower Chalk which are characterised by an absence of flints and where we were delighted to find a *Micraster* fossil that had fallen onto the beach (see photo opposite). Plate movement has influenced the diagenesis process in these rocks making them denser, less porous and tougher than other Chalk strata. The strata further round Lulworth Cove dip at an increasingly steep angle eventually overturning on the far (eastern) cliff face.

As the Army firing range to the east was in use we returned west and made our final stop at Bowleaze Cove near Weymouth. From the cliff top, we had spectacular, if hazy, views of Weymouth and Portland. Grey Oxford Clay, surmounted by orange Corallian sandstone, was exposed in Furzy Cliff, just to the west of Bowleaze Cove. Alan indicated and explained the extensive sea defences that protect the cliff. Just offshore, a submerged line of Portland Stone is thought to be the remains of Victorian sea defences.

We concluded the day with a fossil hunting session on the beach at Bowleaze Cove, then returned to the cars and thanked Alan for his patient and competent guidance throughout an excellent field weekend.

Micraster in chalk, at Lulworth Cove

The Lower Lincoln Limestone Member of the Inferior Oolite Group at Manton Quarry