LGA

Leeds Geological Association
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Field Visit Reports
Summer 2009

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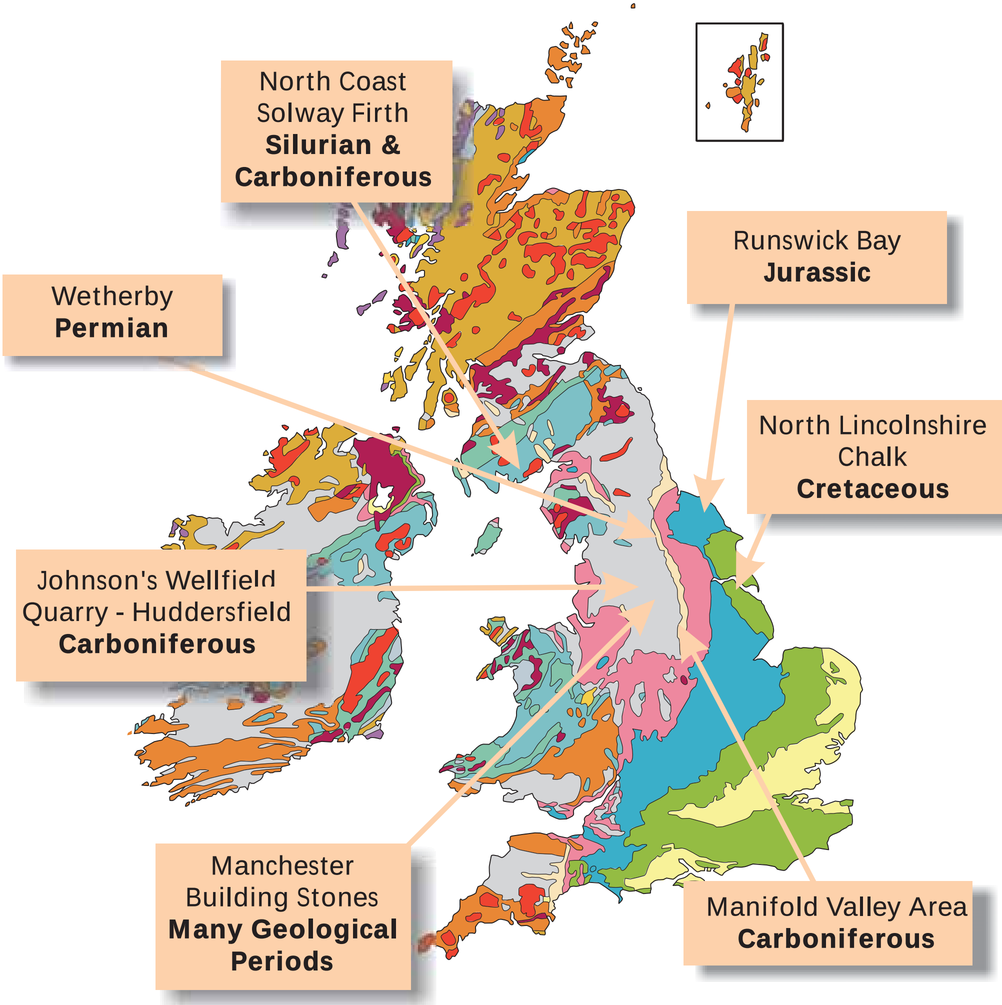
09 Where did we go?



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2009 Field Visit Locations

After 8 years of planning and organising the very successful and enjoyable field visits, Howard Dunnill is stepping down from arranging the day visits. The LGA acknowledges with gratitude all his hard work in producing such a varied set of visits each year. We are very pleased that Judith Dawson has agreed to take on the job, and look forward to more excellent programmes in the future.

Thanks to the authors of the field visit reports who also produced the images: Judith Dawson, Howard Dunnill, Jeremy Freeman, Brian Holroyd, Shirley Leach, David Leather, Alan Rayner, Phil Robinson and Judith Whalley. Additional image produced by Ian Wallace.

Cover Picture: The group examined the Carboniferous rocks on the Southerness beach. (See report on page 30)

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Permian Rocks at Wetherby and Boston Spa
Thursday evening 21st May

Leaders: Alison Tymon and Alan Rayner
15 Members and 3 Visitors present

Purpose: To examine exposures of the Permian in the riverside cliffs at Wetherby and Boston Spa.

Our group met in the Wetherby Riverside Car Park on a beautiful spring evening. Our leaders explained that Local Geological Sites (formerly RIGS) in West Yorkshire have very few Permian locations. Alan (who lives locally) started examining the nearby exposures with a view to getting them listed and it is expected that West Yorkshire Geology Trust will agree to this in the near future. There is now a good understanding of the Permian sequence here, both through his field work with Alison and colleagues, and reference to earlier published papers by Denys Smith and others, but work has not finished. Boston Spa Parish Council has bought its narrow strip of riverside woods and plans to open it up to visitors with interpretation boards which will include the relevant geology. The LGA have a representative in the team working on this.

Wetherby Riverside Cliffs. Hampole Beds in the Cadeby Formation showing two bands of greenish clay (indicated).

Location 1 - Wetherby Riverside Cliffs

A short walk from the end of the car park along the riverside path brought us to the foot of the cliffs. Glacial melt water carved the gorge through the Magnesian Limestone through which the River Wharfe now flows. Alison explained that the rock face in front of us was the Cadeby Formation (Upper Permian EZ1) sitting unconformably on Pennine Carboniferous rocks, which had been uplifted by the Variscan Orogeny and then eroded. The shallow Zechstein Sea which flooded a broad basin (then at latitude 15-20° north), varied in both depth and salinity. The Cadeby Formation was the first carbonate deposit to form in this sea, and it has an upper Sprotborough Member and a lower Wetherby Member divided by the Hampole Beds. These latter are about 1m thick in total, and consist of three thin (1cm thick) soft green clay bands identifiable from Nottingham to Ripon. It is thought that they are estuarine beds, formed when sea level dropped slightly. The difficulty our local geologists had was in identifying the bands in these Wetherby cliffs! They are now confident that they have found the upper two bands and we set to work to find them. Both the Sprotborough and Wetherby Members are ooidal dolomite but they have distinguishing features. The Sprotborough has cross bedding, indicating that it formed as sand dunes in shallow water, whereas the Wetherby contains bryozoal patch reefs, which developed in quiet water. At the junction of these two we found the upper two clay bands, (see page 4). The lowest, known as the Hampole Discontinuity, (a sub aerial erosion surface), is thought to be below ground level here and has not been investigated.

We then drove to Thorp Arch and walked down towards the river. There are three quarries and two cliff faces along this stretch of the river, each showing a different depositional environment in the Wetherby Member. They were not all visible with leaves on the trees.

Location 2 - Thorp Arch Old Mill Quarry

The Wetherby Member here in the quarry face showed a typical bryozoan - algal patch reef, (a reef core of bryozoan dolomite and a domed algal mantle). There were voids visible where gypsum has been dissolved out. Next to it was horizontal bedded oolitic dolomite. A few metres further on, the rock face had small scale cross bedding in opposite directions, indicating quiet shallow water tidal effect, possibly in a lagoon or behind an offshore bar. Above it was another reef.

We proceeded down to a pleasant permissive path by the river walking in a NW direction and looked across to rock exposures on the Boston Spa side.

Jackdaw Crag. Domed stromatolite reef near base with bedded dolomite draped over. Voids visible from dissolved gypsum.

Location 3 - Promontory Quarry
This is a 250 year old quarry about 5m x 3m at the top of the cliff which appears to overhang the river. The rock has been examined and is coarsely oolitic. From across the river we noticed a stromatolitic reef at the base and a land slip at one side.

Location 4 - Jackdaw Crag
We looked across the river and the lower rock face revealed two domed stromatolite reefs, a bigger left and smaller right one, with voids from dissolved gypsum. There was bedded dolomite draped over them (see page 6). To the right of the crag there is a glacial outflow channel.

Location 5 - Erosional Terrace
Our final area of interest was a flat terrace at the top of a grassy bank away from the river. Alan and Alison suspect that this marks the original bed of the River Wharfe prior to the last Ice Age. The till that was dumped here by the melting valley glacier coming down Wharfedale, was eroded by glacial meltwater. This cut the valley gorge, and changed the course of the river. On the lower slope of the terrace, bedrock could be seen in places. Higher up, but below the top of the terrace, patches of bare soil revealed pebbles and breccia of all sizes which were thought to be of Carboniferous Limestone, many with fossils.
We returned to our cars, and the evening finished with a vote of thanks to our leaders for a fascinating insight into the 'work in progress' to understand these Permian rocks.

A Visit to Johnson Wellfield Quarry, Crosland Hill, Huddersfield Saturday 6th June

Tour Leaders: Graham Mallinson and Nicola Bullas, from Johnson Wellfield Quarry
10 Members present

A warm welcome was given by Graham Mallinson and Nicola Bullas from Johnson Wellfield Quarry on a very wet morning. Johnson Wellfield is a big quarrying operation with several separate quarries on the same plot providing a range of products, including sand, flags and high quality sandstone blocks for major construction projects.

The quarry perimeter has been landscaped with a footpath, and at the first viewing level Graham told us that stone had originally been removed by manually mining sideways into a hill where the stone was exposed. Nowadays the stone is located by taking core samples and plotting the target rock. This avoids expensive machine digging.

We moved on to the Waterstones quarry (where the water pours through from a natural stream in the far corner). Digging is done layer by layer and starts by removing the top soil which is kept for restoration work. The next layer is irregularly bedded rock which is used for dry stone walling, followed by more fractured rock for road aggregates, sand and gravel. Another layer with smaller blocks is sold to small businesses, then come the huge sandstone blocks which are removed and dried out over the summer period. Finally there is a layer of flagrock which is split and used as York paving. Under the flagrock is a siltstone which is as far down as the quarry digs.

The value of the higher-quality construction material depends upon how the rock is bedded and jointed. The price of the sandstone blocks and flagrock is subsidised by the other products removed on the way down. The main costs incurred in the quarrying process are associated with labour and machinery. Less obvious costs come form the requirement of the operation to meet visual impact criteria imposed by the local council.

The next location showed good evidence of fluvial deposition (see page 9). The quarry is known to be in the Rough Rock of the Yeadonian sub-stage of the Carboniferous, currently dated at around 314Ma. The rock is generally medium-grained sandstone. Walking through the quarry we could see over a short distance detailed changes in the generally flat deposition. This was probably a fairly wide ancient river which travelled slowly. Only plant fossils have been found on the site. Further on, there was further evidence of change in deposition, with very thin beds deposited on top of flat material, maybe indicating a lot of small rivers changing direction, volume and width (see page 10). Nearby there was fluvial sandstone, part of a big river system. There is a gentle regional dip towards the east in these rocks, with a fold in the strata that could have been formed during the formation of the Pennines. The Rough Rock was studied intensively by Charlie Boston who did his PhD at Leeds University on braided river systems. He concluded that the rocks at this location were part of a massive braided river system which deposited fluvial sand in a sheet-like deposit.

The next quarry has recently been expanded to reach very good quality sandstone for which there is a good demand in the market. Although only about 15 minutes walk from the previous quarry, changes in deposition could be seen, within the overall fluvial setting. The large deposit being removed was suggested to be a sandbar.

Reinstatement of the overburden is carried out to fill the space made by quarrying. Topsoil is replaced and grassed to ensure an acceptable visual impact.

Approaching the quarry where the horizontal sandstone bedding was clearly visible.

Thin beds of sandstone and shale on top of more massive blocks.

All quarrying is done by zoning the deposits. Each area is plotted as a grid reference so that Johnson Wellfield know exactly where each block of stone comes from and on what day it is quarried. All stone is extracted from a face rather than forcing it off the natural bed, which can cause damage.

Notable examples of rock from this site are to be found at Harlow Carr in Harrogate, where the so-called Dinosaur Egg Stone can be seen, and at Bradford Law Courts.

We ended the morning with tea and cakes provided by a very hospitable Nicola, and a vote of thanks to our leaders for a very interesting tour.

Runswick Bay
Sunday 14th June

Leader: Professor Paul Wignall
18 Members present

At 11 o'clock on a bright and warm summer Sunday morning, eighteen LGA members met at Runswick Bay to examine the Jurassic geology round the bay from the attractive hamlet of Runswick to the point of Kettle Ness, a distance of about 4.5km.

Paul Wignall (with help from assistant Jon Poulter) set the scene and we found we were standing on the top of the Cleveland Iron Formation – on the Sulphur Band – where important changes were to take place between these beds and those above. The Sulphur Band is made up of organic-rich, laminated shales deposited in a shallow water environment. We soon discovered it was surrounded by beds full of fossils: bivalves, belemnites, ammonites and trace fossils. We were looking at ammonites such as the strongly ribbed *Pleuroceras* which became extinct at this point, and were replaced in the beds above by *Dactylioceras* and *Harpoceras*, which apparently migrated from warmer waters further south to take up residence in the space vacated by *Pleuroceras*. Trace fossils in the Sulphur Band included the U-shaped burrows of *Diplocraterion* which left pairs of 1cm 'holes'. Another trace fossil, *Chondrites*, looked like a branching root. Many of the fossils were in pyrite and the weathering of the sulphide gives the bed its 'Sulphur' name.

Beautiful impressions of the ammonite *Harpoceras* with sharply defined sickle shaped ribs were common in the shale.

One tap of the hammer and small nodules opened up to show a handsome specimen of *Dactylioceras* from the Bituminous Shales.

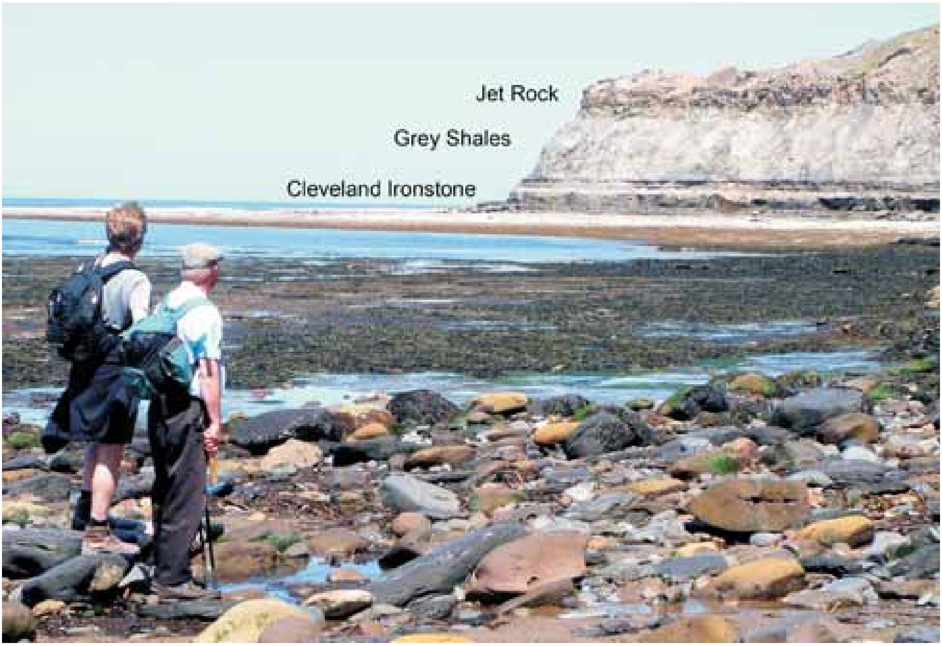
Above the Sulphur Band we moved into the Whitby Mudstone Formation, moving from late Pliensbachian into the early Toarcian (Middle Lias to Upper Lias). First the Grey Shales made up the bottom 10m of the cliff where several lines of small nodules could be seen, and above that was the Jet Rock which included the much bigger whalestone and curling stone concretion horizons. In the shales were beautiful imprints of *Harpoceras*, up to 15cm across, with their closely spaced sickle shaped ribs (see page 11). But most common of all was *Pseudomytiloides dubius*, an oval shaped bivalve with distinct growth lines. Many of them were preserved in pyrite and shone like gold in the sunshine, but care had to be taken in collecting the rather friable shale, to prevent it from falling to pieces.

We moved on round the Bay and took lunch sitting among the concretions of the Jet Rock. Again there was a big environmental change and a mass extinction. The anoxic Jet Rock muds accumulated very slowly in deep water, after a major marine transgression, with water depths to about 200m, the deepest water in the Jurassic. The concretions had a complex history, de-watering producing septarian nodules with growth of calcite crystals in the centre, and well preserved fossils often embedded in them. In the 'oil' shales were more pyritised 'dubius' bivalves, many belemnites and fossil wood of the tree *Araucaria* – the present day monkey puzzle. Some of the fossil wood was black and shiny in the form of Whitby Jet. A paler band 3m up the cliff, the Top Jet Dogger, was a limestone made up of coccoliths, as in The Chalk. This is the oldest bed made of these planktonic fossils in the world.

It was a wonderful day for fossil collecting and several members picked up small nodules that had fallen from the Bituminous Shales higher up in the cliff. They contained the ammonite *Dactylioceras* and a light tap with the hammer revealed an almost perfect specimen (see page 12). Also along the shore were tell-tale banks of red burnt shale from the Kettleness Alum workings, as well as some interesting erratics such as pebbles of jasper and rhomb porphyry washed out from the glacial till.

We walked along towards the point of Kettle Ness, and having crossed a fault, the beds were repeated, and at sea level we found we were now below the top of the Cleveland Ironstone for the first time where more trace fossils, some large specimens of *Pecten* and many fine belemnites were on display in the shallow marine siltstones. The nodular ironstone, of siderite (iron carbonate) here makes up an almost continuous nodular bed and has provided low grade iron ore.

The outline of the headland reflected the three main successions we had been studying: the jutting Ironstone formation at the bottom of the cliff, then 12m of Grey Shales followed by the rough outline of the Jet Rock at the top (see below). We'd had a most enjoyable and memorable day and many were weighed down with samples. Low tide was at about 3pm as we walked over the ancient wreck of an iron ship and out onto the wave-cut platform beyond the Ness (see inside back cover), where Howard Dunhill gave Paul a well-earned vote of thanks.



Paul Wignall and Neil Aitkenhead view the strata at Kettle Ness Point.

The Chalk of North Lincolnshire
Saturday 27th June

Leader: Paul Hildreth
10 members present

Members met the leader Paul Hildreth, at a well concealed Little Chef near Elsham, N.Lincs on a dry but hazy day. He explained the purposes of the excursion: to show that chalk was "not all the same and boring"; that Lincolnshire was not all flat; and to demonstrate the correlation of poorly fossiliferous Chalk exposures using flint bands, marl bands and rare shell beds. Flints were found at a limited range of horizons, occurring only in the Burnham and Welton Formations. We set off in convoy to visit three chalk pits, covering nearly all the Cretaceous succession in North Lincolnshire, working down from high in the Burnham Chalk Formation, then Welton and Ferriby Chalk Formations, to below the Red Chalk.

The first stop was at the derelict Ulceby Vale Quarry, on the south side of the A180, where the Turonian Burnham Chalk had been worked for hardcore, its high flint content making it useless for most other purposes. At the NE corner of the quarry the face was 8-10m high with scree below. The bedding was roughly horizontal with numerous flint bands. An important marker band, the Ulceby Oyster Bed (type locality) was soon found about 2m above the scree, a bed some 20cm thick and "very fossiliferous *for the chalk*" (see page 15). There were varying concentrations of small bivalves (*Pycnodonte sp.*) with terebratulid and rhynchonellid brachiopods. Another marker, the Ulceby Marl (type locality), said to contain microscopic shards of volcanic glass, was found at the top of the scree. Descending to the quarry floor, the party was confronted by a face some 20m high, with numerous tabular flint bands. These, the Vale House Flints, included 15 significant bands, some extremely prominent, others thinner and less persistent. The leader explained that these continuous bands of flint were characteristic of the Burnham Chalk, whereas flint bands in the underlying Welton Chalk were typically nodular, i.e. not continuous. Flint development seemed to have reached a maximum in the Burnham environment, possibly linked in some as yet unknown manner to a volcanic maximum and/or to climatic change. Nearby, next to a deeper excavation, attention was drawn to a very prominent light grey flint band further down the succession, the Ludborough Flint. This was also seen on the far side of the quarry where it showed some tendency to split into two bands. About a metre below this was the North Ormsby Marl Band, sticky and not laminated, the lowest marker band clearly visible in the quarry.

Leader indicating position of Ulceby Oyster Band, Ulceby Vale Quarry; Marl Band at foot level.

The next stop was at the much smaller and partly overgrown West Ravendale Quarry, some 18km to the south east, on the north side of a dry valley. The succession here overlapped that at Ulceby and the quarry had been worked from the Burnham Chalk down into the Welton Chalk. The face at the NW end contained a small cave and was also cut by a deep cleft, possibly a fault. The leader nobly scrambled through undergrowth and over recently tipped builders' rubble to the cave and pointed out various features, notably the pale grey Ludborough Flint, some 30cm thick. A little lower, a deeply weathered notch was presumed to mark the North Ormsby Marl and still lower could be seen the three flint bands of the Triple Tabular Flints. Higher up the face, the leader pointed out two paramoudras, roughly cylindrical flint concretions formed round vertical burrows now filled with hard chalk.

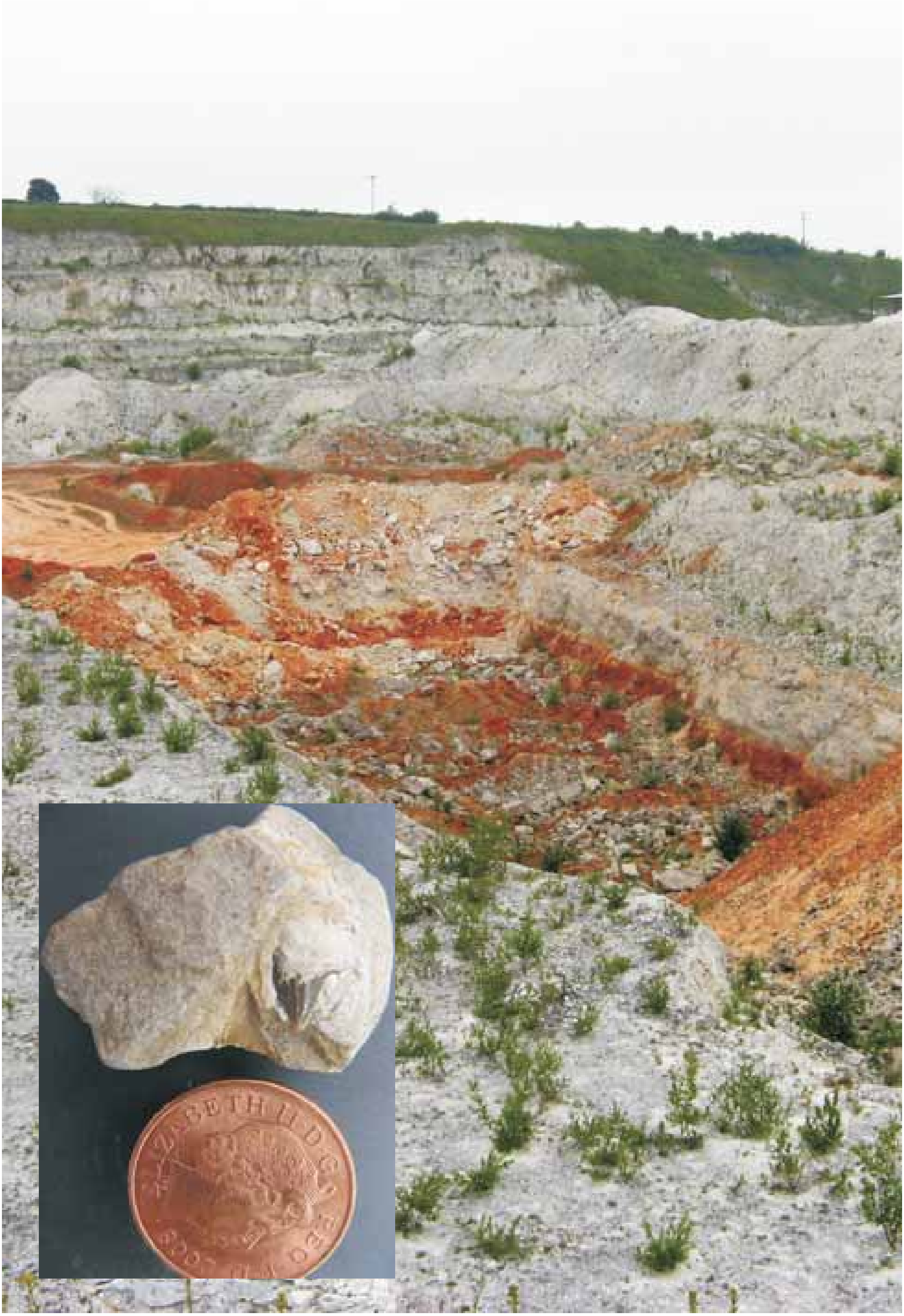
The party moved to the main face, where the junction between the Burnham Chalk above and the Welton Chalk below was concealed by scree. The nature of the flint bands underwent a transition; first, some very thin (~ 1cm) bands of "wafer flints", then a progressive change in the flint bands from tabular to nodular (i.e. discrete), characteristic of the Welton Chalk. Scrambling up through undergrowth, a section of face clear of scree was found. Below the Triple Tabular Flints, another prominent band, the Ravendale Flint (type locality) was seen. Some 50cm lower, a very thin (1-2 mm) marl band taken as the Burnham-Welton boundary was located with some difficulty.

After some discussion, the party drove about 19km westward past Caistor to Nettleton, where lunch was taken at picnic benches, probably Neolithic from their state of decay, in the paddock of the Salutation Inn. The village was situated on Lower Cretaceous rocks, but its proximity to the Upper Jurassic could be seen from the orange-brown building stone used for the church and many houses.

Mansgate Quarry, just outside the village, had been substituted for the advertised location at Bigby, where recent landscaping had destroyed most exposures. It was reached by a short drive up the chalk escarpment which on a clear day should have given an impressive view. The large quarry was now worked intermittently in a series of benches from the Welton chalk down into the Red Chalk (see page 17). Our leader explained that the boundary between the Welton Chalk (flint-free in its lowest 4m) and underlying flint-free Ferriby Chalk is considered to be an erosion surface just below a conspicuous bed, the Black Band. This is a variable sequence of no more than a metre (but here, about 50cm) of thin clays and silty chalk beds, some containing small brachiopods and including the Black Band (sensu stricto), said to contain fish scales. It represents an anoxic interval and an extinction event (as shown by microfossils). The band could be seen in the irregular quarry faces and a spot was eventually found where at least the more active members could scramble up. Specimens recovered included fish scale fragments, a tooth, (see page 17 - inset), and also some small gypsum crystals.

The party walked down to a lower bench on the outcrop of the Red Chalk. Intervening beds were concealed by spoil, which included several large blocks of Totternhoe Stone, with a green glauconitic base. Examining the Red Chalk face would have involved another scramble so members contented themselves with looking at the spoil, soon finding abundant small belemnites *(Neohibolites)*, as well as small brachiopods and fragments of *Inoceramus.* Also found were numerous small blackened phosphatic pebbles.

At this point Howard Dunnill thanked Paul Hildreth on behalf of the party for this interesting and comprehensive survey of what we used to call the Middle and Lower Chalk. The group then returned to their cars and dispersed.



Mansgate Quarry from North-East
(Inset - Fish tooth, Black Band, Mansgate Quarry)

The Manifold Valley, North Staffordshire Peak District, and Ecton Hill Copper Mine
Sunday 26th July

Leader: Dr Neil Aitkenhead, LGA
16 Members present including the leader

Purpose: To examine the lithology and structure of Carboniferous limestones of basin facies to the west of the Peak District carbonate platform at the eastern margin of the North Staffordshire Basin.
Also: To visit Salt's Level of the old Ecton Hill Copper Mine

The group met at the old Hartington Station and then moved on to the car park at Hulme End, nearby, which is at the northern end of the Manifold and Hamps Geotrail, where Neil briefly outlined the geology of the area.

He explained that during the Early Carboniferous, the area was a warm, tropical, shallow sea but we were now in a deeper basin that subsided immediately to the west of the carbonate platform. From time to time, debris was carried off the platform into the deeper basin by turbidity currents. Along and near the edge of the platform apron-reefs and knoll-reefs formed. During the later Hercynian Orogeny a series of, approximately, north-south trending anticlines and synclines developed obliquely to the direction of thrust - probably being controlled by the underlying basement structures. We would visit four locations on the Trail to examine the basin facies, reefs and fold structures.

Apes Tor [SK 098 587]
At this roadside section several tight asymmetric folds were clearly visible in the well-bedded basin facies Ecton Limestone. One anticline had a clearly exposed bedding plane plunging to the north; the hinge of the adjoining syncline was intensely fractured (see page 21). Neil explained that these were minor folds in the Ecton Anticline.

The limestone was dark grey, fine-grained, mainly thinly bedded with a few thicker beds, and with shale partings. Iron-staining and chert nodules were visible in places. One bed displayed a fining up sequence with conglomerate at its base, consistent with turbiditic deposition.

We then walked eastwards about 50m to look at the Apes Tor Mine Adit before ascending a private road to the rear of an unusual copper-roofed house jokingly referred to as 'Count Dracula's Castle'.

Salts Level - Ecton Hill Copper Mine [SK097 583]
We were welcomed by Tim Colman who was to be our underground guide, and had our sandwiches in the mine office which was very welcome, given the deteriorating weather. Here, Tim explained the history of the mine and its geology.

The copper is thought to have been in the form of chalcopyrite, possibly with calcite, but as the ore has been entirely removed its exact form is not known. The deposits were in pipes, probably filling cavities in the near-vertical bedding. Copper is rare in the Peak District, lead veining being the 'norm' but here there were two large pipes, the Ecton Pipe Vein and the adjoining Clayton Pipe Vein. It is believed that hot salty brines carried the metallic sulphides eastwards from basinal shales during Westphalian/Early Permian times i.e. after the major folding and fracturing took place. The metallic ores were deposited when these fluids penetrated and reacted with the limestone.

There is evidence that the mine was worked during the Bronze Age and again in the 1600's but the first major development took place in 1719 when the Apes Tor Adit was excavated. However, it was not until the landowner, the Duke of Devonshire, took over responsibility for working the mines in 1739 that they became profitable. He exploited them until 1760 before leasing them to others who picked over what remained. Mining ceased in 1890.

The mines are now largely flooded apart from Salt's Level, the highest level, excavated in 1804. Salt's Level is 50m below the surface of the hill top but the main shaft is about 400m deep.

Walking along the Level we were in the well-bedded Ecton Limestone, with a few partings of sticky clay – probably degraded volcanic tuff. Fault planes showing slickensides were seen and variably dipping beds indicated fold structures. We then moved into the older, more thinly bedded, Milldale Limestone. Near vertical beds at the shaft showed tension gashes in-filled with calcite (see page 20). The excavated pipe vein, itself, was merely a deep water-filled vertical hole with calcite veining and malachite staining on its walls. It was 2m wide at this level but is reported to attain 180m at its widest point.

Having thanked Tim for an interesting tour we moved on to:

Wetton Mill [SK095 561]
On the left-hand side of the entrance to the car park is a small exposure. This is part of a knoll-reef in the core of the Ecton Anticline and is of Chadian age i.e. older than the Ecton Limestone. On the other side of the bridge, adjoining the public car park, are further exposures.

The knoll-reef had no obvious bedding and although there were fossils, they were impossible to identify in hand specimen. Neil said that the knolls were originally mounds of lime mud which hosted numerous brachiopods, crinoids and bryozoa but no framework corals: they were comparable with the Waulsortian mud mounds of Belgium. Small cavities were visible. Neil explained that, in thin section, these cavities could be seen to be infilled with a mixture of micrite and fibrous calcite. The cavities had probably been created by rotting organic matter, before the enclosing lime mud became indurated.

In view of the weather and time, we then drove up to Wetton to view **Thors Cave [SK097 549]** from the road side. This is a natural cave formed by underground streams. Subsequently the river cut down through the underlying reef limestone to create the present gorge.

The meeting concluded with afternoon tea at Wetton Mill. Despite the weather, everyone felt that the area had much to offer, both geologically and scenically. A vote of thanks was given to Neil for introducing so many of us to an area which certainly requires further exploration.

Calcite filled tension gashes in Salts Level (pen for scale).

Folding in the Ecton Limestone at Apes Tor.

Residential weekend to the north Solway coast
Friday 11th to Sunday 13th September

Leader: Dr Doug Holliday
23 members and spouses present

The weekend's activities centred around exposures close to Langholm on Friday afternoon, exposures close to the North Solway Fault between Rockcliffe and Gutcher's Isle on Saturday and foreshore exposures at Southerness and Arbigland Bay on Sunday.

Friday 11th September

Whita Hill, Skipper's Bridge and Tarras Water

After meeting in Langholm and enjoying lunch on the bank of the River Esk, the party proceeded to the top of Whita Hill above Langholm for an overview of the geological structure and its origins, some detailed aspects of which we would examine over the weekend.

Our leader, Doug Holliday, described the formation of the low lying land between high ground of the Lake District to the south, and the Southern Uplands to the north. Beneath this area is the subduction zone locally from closure of the Iapetus Ocean - subduction of the Avalonian Plate beneath the Laurentian Plate . At the beginning of the Carboniferous, as a result of structural tension, downfaulting, and accompanied by some igneous activity, the ENE-trending Northumberland – Solway Basin was formed in which Carboniferous strata rest unconformably on the underlying folded Lower Palaeozoic rocks. The earliest Carboniferous deposits (which we did not see) formed in arid environments, but later a shallow tropical sea invaded the area. Large rivers brought sediment into the area from the east and north-east and local deltas fed from high ground to the north. Over time, the dominance of fluvial and marine influences repeatedly fluctuated to form the wide range of deposits we were to see over the next two days. The presence of younger Carboniferous strata within the basin and the overlying rocks of the Permo-Triassic Carlisle Basin was also indicated but we did not visit these during the excursion.

Around Langholm there are exposures of early Carboniferous rocks of the Tournaisian Stage, which are not exposed further east, and we would see the Birrenswark Volcanic Formation and overlying Ballagan Formation, both in the Inverclyde Group.

Whita Hill is on the northern margin of the basin, marked by the major North Solway Fault which is exposed further west, and which we would encounter later. The hill is part of a 300m+ thick Whita Sandstone Member of the Ballagan Formation, mainly gently dipping medium-grained, white freestones of fluvial origin from a northerly source, likely to be in the

Southern Uplands. The buildings of Langholm and the immediate area are largely of this stone.

Beneath Skipper's Bridge, 2km SE of Langholm, we examined a section of the Birrenswark Volcanic Formation, formed when crustal tension and thinning at the initiation of the basin caused an outpouring of basaltic magma. At this location the deposit is about 50m thick. The main lithology is olivine rich microporphyritic basalt with olivines and pyroxenes up to 2mm in size. We saw examples of the pyroxenes weathered out and replaced by iron oxide, of cracks in the lavas which had been intruded by fast cooled, and therefore finer-grained basalt, and of sedimentary carbonate deposits interbedded with the lavas (see below). The carbonates contained xenoliths of earlier vesicular basalt.

Overlying the Birrenswark Volcanics is the Ballagan Formation, a section of which we examined in the bank of Tarras Water, a tributary of the Esk, at a location about 5km SE of Langholm. This section comprises thinly bedded grey siltstones interbedded with hard, pale grey ferroan dolomite 'cementstones', (see back cover). Some of the dolomite layers contain bivalves, ostracods and conodonts. Similar beds are found in the Lower Carboniferous of central Scotland and in Ireland, sometimes containing anhydrite; the depositional environment is envisaged to be estuarial.

Carbonate deposits interbedded in the larvas of the Birrenswark Volcanic Formation beneath Skipper's Bridge.

Saturday morning 12th September

Rockcliffe, Castlehill Point and Gutcher's Isle

As we left Castle Douglas Arms Hotel the sun shone but there was low cloud near the coast. From the car park at Rockcliffe we followed a coastal track in single file through the bushes, above the beach to our first location east of Castlehill Point. The intention of using this view point for orientation was left to our return in the afternoon, but even so the Lakeland hills to the south were still hazy.

We descended steeply to the beach, reached on a receding tide, to inspect a large spectacular exposure of the fault scarp of the North Solway Fault (see page 25). At this point it is cut by a cross fault separating the headland. The fault is taken in this area as the northern boundary of the Upper Palaeozoic Solway Basin. The cliff comprises rocks of the Ross Formation (Hawick Group,Silurian) and intruded porphyritic andesites. The down thrown rocks on the shore are of the Rascarrel Member (Fell Sandstone Formation) of Visean Lower Carboniferous age. These strata are exposed along the shore for more than a kilometre eastwards. Their dip decreasing from 50º near the fault to 15º over some 30m seaward.

Carbonated-cemented fault breccia was observed and some reddened porphyritic andesite, greywacke and mudstone.

Walking further east along the shore the line of the North Solway Fault ran within the hill covered by gorse and there was sighting of a raised beach with scree on the cliff above. Going towards Gutcher's Isle, the Rascarrel Member consisted of conglomerates with angular clasts of greywacke, porphyritic andesite and granite/granodiorite (see page 25). These pass upwards and laterally into arkosic sandstones, siltstones and mudstones and have been interpreted as shallow marine sediments and associated basin margin alluvial fans.

Several boulders (probably glacial erratics) of coarse-grained Criffell-Dalbeatie Granodiorite were found on the beach with numerous xenoliths of partially assimilated hornfelsed greywackes and more basic igneous rocks. The Criffell Granodiorite pluton was formed c.400 Ma and is associated with a suite of porphyritic andesitic dykes of similar age.

As we approached Gutcher's Isle, our lunch stop, we were able to view the fifty - odd wind turbines undergoing completion in the Firth to the south.

The dramatic cliff is the fault scarp of the North Solway Fault.

Rascarrel Member Conglomerate with angular clasts of greywacke, porphyritic andesite and granite/granodiorite.

Saturday afternoon, excursion continued

At Gutcher's Isle we met two geologists known to one of the professional geologists in our party. Inevitably an animated discussion took place, more rock formations were examined, and a deeper knowledge was gained!

During lunch some of us discussed the work involved in extracting millstones from specific sandstone layers, having seen a partially hewn one on the beach. A circular groove was chiselled into the rock deep enough for the thickness of the millstone, and dry wooden wedges forced into it. Once the seawater covered the area the wedges expanded and forced the 'blank' from the bedrock ready for the millwright to produce a finished millstone.

Continuing our perambulation after lunch we clambered up the low cliff near Gutcher's Isle and walked westwards along the coastal cliff top footpath to Castlehill Point. The path was underlain by Ross Formation turbidites and associated porphyrite dykes immediately north of the slickensided, near vertical cliff face of th ENE-WSW trending North Solway Fault. We were able to look down on to the Carboniferous Rascarrel Member on the shore, (examined in the morning), and on to the Castlehill promontory over the NE-SW trending secondary fault within the porphyritic andesite.

At the Castlehill viewpoint the panorama across the Solway Firth was extensive. It extended from the Triassic sandstone cliffs at St Bees Head in the

Dyke intrusion in the greywacke.

Foliated porphyritic andesite dyke.

west, past the full range of the northern Ordovician Lakeland Fells, to the Vale of Eden and Namurian rocks of Cold Fell in the east.

We then continued due north towards Rockliffe along the rugged and stony beach which exposed the Silurian (Wenlock) Ross Formation, a sequence of medium to thickly bedded well sorted fining upwards greywackes and thinly bedded silty mudstones. They generally dip to the east from below 13 to above 80 degrees. Here the Ross Formation, intruded (see page 26) and partly hornfelsed by a suite of foliated porphyritic andesite dykes (see above), has been under strong compressive tectonic pressures with folding and small faults visible on the shoreline. The NE-SW trending dykes, with thicknesses ranging from 50mm to 5m, were probably related to the intrusion of the Criffel-Dalbeattie Granodiorite.

We proceeded round the bay to Port Donnel at the northern end of the Rockcliffe beach. Here the sharp contact between the dominantly pink, coarse-grained Criffel-Dalbeattie Granodiorite, containing white plagioclase feldspar with dark biotite and amphibole and the heated margin of the Ross Greywackes is well exposed (see page 28).

After studying these rocks we returned along the Rockcliffe beach road to enjoy a well earned afternoon tea, at the Rockcliffe Tearoom before returning to the Douglas Arms Hotel for another excellent dinner and plenty of discussion of the day's events.

Sharp contact between the pinkish granodiorite and the heated margin of the graywackes.

Sunday 13th September

Southerness and Arbigland Bay

The morning was spent on the beach at Southerness.

Between the lighthouse and Borron Point to the north-east, the low tide had exposed extensive deposits of early Carboniferous rocks with depositional environments ranging from open marine to fluvial. Fossiliferous rocks within the sequence suggest the rocks are in the Chadian to Asbian age range. They had been deposited within the Solway Basin but further away from the North Solway Fault than the rocks seen on Saturday.

The first location, furthest from the lighthouse, is part of the Lyne Formation (Southerness Limestone Formation) comprising very fossiliferous muddy limestone with interbedded shales, and containing minor faults, gentle folds and quartz veins, part of a large anticlinal area. The orientation of the faults and folding suggests a transtensional regime with east-west compression, possibly related to strike-slip movement on the North Solway Fault. The folds are not syn-sedimentary, and are thus likely to have been formed as part of the end-Variscan inversion.

The group traversed slowly across the rocks towards the lighthouse (see front cover).

Algal domes in the Southerness Limestone Member

The limestones have extensive trace fossils in the form of elongated burrows, with some clusters showing a north-south orientation. Several beds, 16.7m thick, of argillaceous limestone and calcareous mudstone are known as the '*Syringothyris* limestone' and contain a varied Chadian marine fauna, including the brachiopods, in particular *Syringothyris* cuspidata, bivalves, polyzoa and crinoid ossicles. Other beds contain numerous bivalves. East-west orientated slickensides could be seen on a minor strike-slip fault.

In other limestone beds, large numbers of randomly-distributed limestone concretions were seen which are thought to be algal in origin. These, together with algal domes in the limestone beds, (see page 29) suggest that they formed in low intertidal to shallow subtidal environments. Other limestone beds revealed packed shell beds of well preserved *Syringothyris*, again suggesting a low energy shallow marine depositional environment.

In contrast to the limestones on the foreshore, a series of cross-stratified quartzitic sandstone beds with varying strikes and dips indicate a meandering channel sandstone within the limestone deposits. This could possibly have been a river associated with and influenced by the North Solway Fault.

The contact between the Lyne Formation and the overlying Fell Sandstone is probably conformable, but is faulted in this foreshore location. The lower strata of the Fell Sandstone are generally red in colour and comprise purple flaggy sandstones, conglomerates and red siltstones and mudstones, with some conglomerates.

In the foreshore the pebbly sandstone represents the Gillfoot Member. It has a fine grained matrix, and is possibly derived from weathered granite. The lithologies of the Fell Sandstone suggest a basin-marginal depositional environment associated with alluvial fan or braided rivers' deposits spreading over supratidal flats.

At the Lighthouse, which is built on a dome, red shales indicate an arid terrestrial environment. Intercalated limestone beds contain planolites.

After lunch at Powillimount, north-east of Southerness, the group continued with its study of the Fell Sandstone by walking along the beach north-eastwards from the car park. The Fell Sandstone here, the Powillimount Sandstone Member, is much higher in the succession than that seen previously.

To the north-east of the car park is fluvial Fell Sandstone with large scale cross-stratification throughout, and good examples of overfolding of cross-bedded strata, possibly suggesting seismicity (see above). The exposures contain extensive dewatering structures and loss of primary sedimentation. Several stages of dewatering suggest several movements of the fault. Palaeocurrent directions vary from south to north. The uppermost beds of the Fell

Powillimount Sandstone Member showing overfolding of cross-bedded strata.

Sandstone contain the Thirlstane Natural Arch.

Further east, the Tyne Limestone Formation is juxtaposed with the Fell Sandstone at a reverse fault. Elsewhere the two formations are conformable. The Tyne Limestone extends to the north-east, and contains sandstones, and sandy limestones which are locally oolitic or algal. The limestones were observed and found to be rich in different types of coral and gigantoproductid brachiopods.

At this point the party returned to the car park where Howard thanked Doug Holliday, our leader, for an excellent weekend with varied and interesting geology which often stimulated considerable discussion! We also thanked Howard for his usual superb organisation.

For comprehensive information on the locations visited, and many more geological excursions in south west Scotland, the following BGS guide is recommended, available from BGS, from Edinburgh Geological Society or from bookshops.

Geology in south-west Scotland. An Excursion guide.
Edited by P. Stone ISBN 0 – 85272 – 261 - 3

Building stones of Manchester
Sunday 4th October

Leader: Howard Dunnill
10 Members present

Our planned leader, Fred Broadhurst, who has updated his excellent guide to the Building Stones of Central Manchester (see below) had to withdraw from this event through ill health, and very sadly had passed away just days before we met, making the walk very poignant for those who knew him.

We convened in St Anne's Square at the church, with its literally chequered history of repairs, using sandstones from different quarries to the original having produced a patchwork effect on subsequent cleaning. After agreeing to embark on walks 1 and 2 of the four detailed in the guide, we crossed Albert Square to the Central Library and the Cenotaph to encounter the barricades and serried ranks of the law defending the latest political conference. These proved to be not too much of an inconvenience, and we were able to follow the route, missing only two locations at the G-Mex Centre, which were totally 'off-limits'.

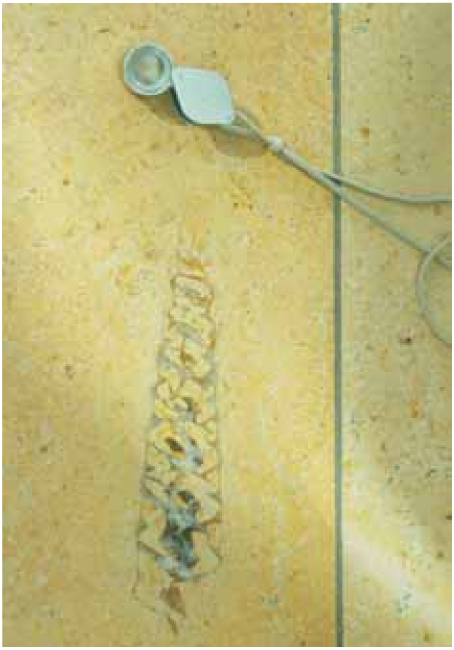
We visited nearly 40 locations which exhibited the usual range of igneous rocks, limestones, sandstones and metamorphic examples; the highlights (although it is very subjective) were :-

Location 4 : Fitness First, Lower Mosley Street.
A Multicolor Gneiss facing stone from India, a banded rock deformed and folded at high pressure and temperature to form a stunning metamorphic rock with folds and fractures (See page 33). Not shown to its best advantage in this location.

Location 11: Great Northern Leisure Complex.
The flooring of the cinema entrance concourse on the first floor level is a yellow limestone paving of Cretaceous age from a quarry near Lyons. It is highly fossiliferous, including corals and, most notably, large fossil snails (see page 33).

Location 12 : 201 Deansgate.
Cross-bedded Hall Dale Sandstone, a Carboniferous sandstone from Derbyshire, set above Rapakivi Granite from Finland. Structures in the sandstones, cut into facing blocks, provoked much discussion as to which blocks are upside down from their in-situ origin – and several are (see page 34).

Fitness First, lower Mosley Street. Multicolor Gneiss from India.



Great Northern Leisure Complex. Large fossil snail in limestone of Cretaceous age from a quarry near Lyons.

Location 29 : 55 King Street.
Used to be a bank, now shops. The building is of Emerald Pearl, a variety of larvikite from Finland, mostly left rough with machined grooves, but polished panels at pavement level show, in marked contrast, the well known reflective change in colour and brightness of the feldspar grains when viewed from different directions (known as the 'schiller effect').

Location 37: Cardinal House, St Mary's Parsonage.
External walls and internal floors are faced with Jura Grey, a late Jurassic limestone from the Solnhofen region of southern Germany, rich in fossils, among which are ammonites, belemnites and sponges (see page 34).

Location 39 : Blackfriars House, St Mary's Parsonage.
A Portland Stone building, but with a very unusual granite from south-west England at pavement level.

In the middle of the day we visited the John Rylands Library, a very impressive edifice, not only for its red sandstone construction, (Penrith Sandstone outside, St Bees Sandstone inside), but for its labyrinthine design, a building and displays which in themselves could have taken the whole day.
The cafe in the new entrance wing was also a very good lunch stop.

201 Deansgate. Cross-bedded Carboniferous Hall Dale Sandstone from Derbyshire.

Cardinal House, St Mary's Parsonage. Jurassic Jura Grey Limestone with sections of sponges.

The real highlight of our day was Fred's book, which is so easy to use and follow the route of each walk, with very concise descriptions of locations, the stone and their origins. This is useful for either an individual or a group, and several members of our party resolved to use any opportunity of a future visit to the City to spend time looking at the locations we had not seen. A future visit on a weekday (to include missed opportunities on this weekend visit, to enter buildings such as the Town Hall) would be well worthwhile to complete our circuit of all 4 trails in this superb guide.

'A Building Stone Guide to Central Manchester' Morven Simpson and Fred Broadhurst.
Second Edition ; Manchester Geological Association 2008.
Available from the secretary at secretary@mangeolassoc.org.uk £5.00

The day's excursion ended at low tide on the wave-cut platform beyond the point of Kettle Ness.

For more information visit us at:
www.leedsga.org.uk

The group examine a section of the Ballagan Formation in the bank of Tarras Water