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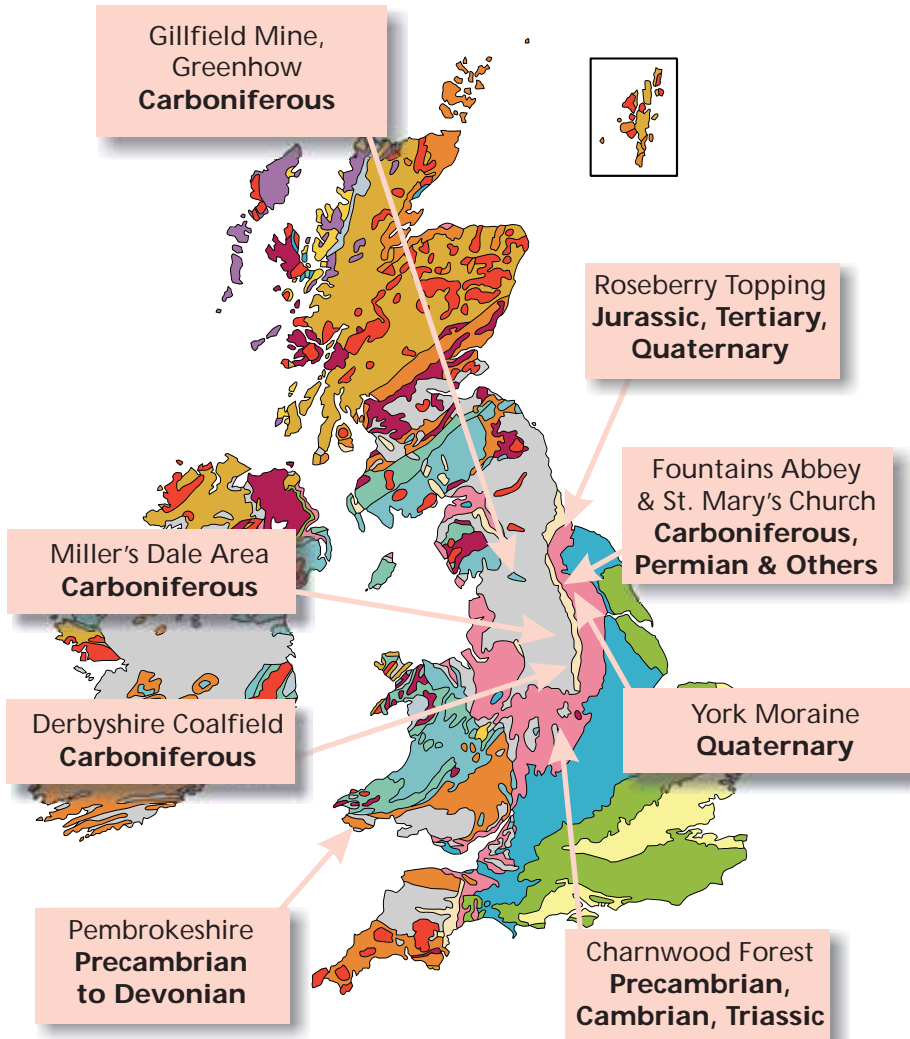
## Field Visit Reports Summer 2010

A group of about ten people, mostly men, are gathered on a rocky shore. They are wearing outdoor gear, including jackets and backpacks. They appear to be engaged in a field visit or a geological study. In the background, there is a large, dark rock formation with distinct horizontal layers and some curved structures, possibly a cave entrance or a natural rock arch. The scene is outdoors, and the ground is covered with rocks and some sparse vegetation.

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## Where did we go?



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## 2010 Field Visit Locations

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Thanks to the authors of the field visit reports who also produced the images: Neil Aitkenhead, Tony Benfield, Judith Dawson, Howard Dunnill, Jeremy Freeman, David Holmes, Brian Holroyd, David Leather, Phil Robinson, Judith Whalley. Extra images provided by David Peatfield and Kevin Read.

Cover Picture: Recumbent fold with vertical limb displaced by low-angle thrust fault at Broad Haven.

## **Gillfield Mine, Greenhow, Upper Nidderdale**

### **Two evening visits on 29th April and 13th May**

**Leader: Shirley Everett, Coldstones Quarry Manager, (Hansons Aggregates)**  
**23 Members visited the mine**

On a blustery rainy evening in April, twelve of us gathered in the offices of Coldstones Quarry with our leader and members of the Mine Preservation Society. We took the opportunity to view their mineral and fossil collection, maps of the mineral veins and detailed 19th century survey drawings of the local mine workings.

After an overview of the geological setting of the Greenhow area from Tony Benfield, we drove down the rough track to the bottom of the steep sided Brandstone Beck valley to the north of the quarry. We then collected our miner's lamps and entered the stone vaulted arch of the adit which was draining the mine workings in the northward slope of the Greenhow Anticline. We paddled down the adit that had been cut with hand-tools and noticed that it was very straight as it followed the course of a fault. This could be seen in the roof and was probably apparent to the miners on the surface. The adit exposed the succession down from the Red Scar Grits through the Nidderdale Shales, the Grassington Grits, and the Toft Gate Limestone to the oldest unit, the Greenhow Limestone in the centre of the anticline. Seepages of iron, calcium and manganese-bearing fluids through faults in the roof gradually increased as we went through the impervious shales. Here we observed a low grade sulphur-rich coal seam and thin cross-cutting faults filled with calcite at the junction of the shales and underlying sandstone. The crinoidal Toft Gate Limestone was largely covered with calcite but a few crinoids were seen as were some thin shale beds.

Eventually, in the Greenhow Limestone, we reached the cross cutting fault that hosted the Waterholes Vein. There, hand-cut workings, still with candle soot marks on the roof, had been enlarged in the 1930s by larger workings for fluorite, forming a long high void with stemples (wooden props), wedged from side to side to support the miners as they worked upwards following the ores. This method was known as stoping and there were platforms visible still carrying large quantities of spoil that the miners had left to gradually lift them up to the new ores higher up. A climb up a vertical ladder (see photo opposite) took us to a level with an abandoned ore wagon about a metre long that the restoration team had set back on rails. An area of slickenside was smeared with calcite and galena and we were able to get good views of the lead vein running along the roof within the calcite fill of the fault.



**Members making their way up an iron ladder between the stemples to higher level; the footwall is on the left.**

Returning via the ladder we made our way along a further adit cut using the same methods as before, that led us to the Sun Vein. Here we saw gulfs, areas where old swallow-holes had been filled by a variety of materials including huge boulders, fine sands and clays of probable glacial origin. These were dangerous and unproductive areas for the miners and many have now been made safe by the preservation group. This part of the mine is just above the present day water table and we gingerly walked the plank over old flooded workings. A scramble up a small waterfall led some of us up into an old void that had beautiful square fluorite crystals up to 8cms long encrusted on its roof (see photo top of page 6). They must have been missed by the miners. We passed a well preserved wooden ore shoot used for filling the wagons with galena, fluorite or spoil each of which was distributed at a turntable that existed just outside the mine entrance. We then retraced our route and stumbled out into the now total darkness of the isolated valley.



**Square crystals of fluorite up to 8cms across in the roof above a void.**



**Massively bedded channel sandstones of the Saltwick Formation.**

# **Ayton Banks, Cleveland Dyke and Roseberry Topping**

## **Saturday 1st May**

**Leader: David Taylor**

**17 members and 5 visitors present**

*Purpose: To examine the Lower Jurassic succession, the Tertiary Cleveland Dyke and Quaternary Devensian Deposits. Also remains of ironstone, jet, alum, whinstone, sand/gravel mining and quarrying.*

Having left Leeds in glorious sunshine, we met on a cold, dismal morning below Gribdale Gate. Not deterred, we crossed a stile on to Ayton Banks, where we admired the view and David outlined the geological succession seen on the escarpment and the line of the Cleveland Dyke. This can be traced through Cliff Rigg Wood and Slacks Wood before disappearing to re-emerge as the prominent ridge beneath Dikes Lane. It continues at depth beneath Gribdale Gate, creating a weakness in the country rock. During the Devensian, meltwater at the base of ice in the Vale of York exploited this, flowing up and eastwards over the col.

### **Ayton Banks**

We climbed an old track to Cockshaw Quarry, also known as Ayton Banks Quarry. Here, building stone was quarried by hand until the 20th Century from massive beds (about 3m) with lenses of thinner bedded material of the Mid-Jurassic Saltwick Formation (see photo bottom of page 6). At the base of the quarry face is a pond, indicating that here the formation lies directly upon the Whitby Mudstone Formation, the intervening Dogger Formation at the base of the Middle Jurassic being missing.

From the edge of the quarry bench we could see disturbed ground below. The Alum Shales are the topmost 30m of the Whitby Mudstone Formation and had been worked here for alum between 1767 and 1774. The short period of exploitation means that the site is archaeologically important, providing evidence of the manner of working alum at the time. David pointed out a heather topped hillock. This is a clamp of unburnt alum shales covered in clay which, according to historical records, awaits an improvement in the market. The production of alum, used as a fixative for dyes and in tanning processes, was very capital intensive; coal had to be brought from County Durham, kelp from the coast or urine from the cities. The shales burnt for several months, and the operation here proved to be uneconomic. We walked down the slope through the shales to examine the steeping pits (which actually stand proud, the containing stone walls having been removed at some stage), the gravity

channel and nearby spoil heaps.

Further downhill we came to the site of jet workings. Towards the base of the Whitby Mudstone Formation is the Jet Rock, a 10m thick mudrock. The jet occurs as lenses towards its base and is the fossilised wood of the Araucaria tree (similar to the modern day Monkey Puzzle). During Victorian times the jet was worked by drifts driven at 50ft intervals with tunnels running between, and later by stripping off the overburden. The ground is very pock-marked with deep and often hidden subsidence hollows.

We passed through the spoil heaps and, beyond, the reddened spoil heaps from ironstone mining. The Cleveland Ironstone Formation has 5 ironstone seams and is 29m thick here. We examined an entrance to an adit which some thought may have been used for ventilation. The Main Seam is about a man's height and was worked between 1910 and 1926 using the bord and pillar method with solid rock forming the roof. About 40% to 45% of the available seam was removed but sometimes the pillars were then removed to give 'complete' (90%) mining. The iron content was about 30%; one-half that sought today.



**Cliff Rigg - Whinstone quarry showing thin retaining “wall” of dyke and to the right the thin Pecten Seam below the Main Seam of Cleveland Ironstone Formation.**

## **Cleveland Dyke**

After lunch we approached Cliff Rigg Quarry from Aireyholme Lane and David said that the field to its west had been a landfill site following the extraction of glacial sands.

We climbed a slope to the north of the Quarry from where we looked down into it. Apparently there is hardly any variation in the dyke's mineralogy or direction in its 420km length from Mull to near the Yorkshire coast and it is believed to be continuous at depth. Here the dyke is 25m wide and the dark fine-grained basaltic-andesite was extracted first by quarrying and then by tunnelling into the quarry sides. Eventually the galleries collapsed and Grey Shale of the Whitby Mudstone Formation slipped down the sides leaving only an occasional bed of ironstone visible within the scree. The City of Leeds leased the quarry in the late 1860s, using the best stone as setts to pave the city's streets and the chippings as roadstone.

Turning back we walked round the south side of the quarry to reach a col between this and another quarry to its west. The latter has a thin 'wall' of dyke left by miners to hold back the country rock (see photo opposite). We crossed the col and climbed the steep scree/shale slope to see opposite us seams within the Cleveland Ironstone Formation.

## **Roseberry Topping**

Walking towards Roseberry Topping, we crossed a tramway and visited the shooting hut/folly. Unusually, the walls are most weathered on the inside - are these re-used sandstones from the alum steeping pits? David pointed out the geological succession visible on Roseberry Topping, which is an outlier and capped by the Saltwick Formation. Apparently the Topping had been conical before a rotational landslip in 1912, the extent of which is very clear. During the 1880's ironstone was extracted from beneath the Topping. Then in 1908 the mine was re-opened and the pillars removed to give 'complete' extraction, probably causing the landslip.

We climbed the Topping where, looking down, we could see that the extent of the mine workings agreed with David's mine-plan. We admired the view and examined the channel sandstones before returning to the cars where David was thanked for a most interesting day. Unbelievably, within an area of about 1 sq. mile, we had seen evidence for the extraction of six different minerals: building stone, alum, jet, ironstone, sand and roadstone.

## **Duckmanton Cutting and Lodge House Opencast Site, Derbyshire Wednesday 26th May**

**Leaders: Paul Guion (University of Derby)  
Brian Worsley and Alan Ashburn (UK Coal)**  
**8 Members present**

Members gathered at 10.15 in Deepsick Lane, Duckmanton (some 5km W of Bolsover) for this field trip to the East Pennine Coalfield, unusually held midweek. Our leader, Paul Guion, explained that we would view coal seams and associated strata in the late Langsettian (formerly Westphalian A) Pennine Lower Coal Measures and early Duckmantian (formerly Westphalian B) Pennine Middle Coal Measures. The Vanderbeckei (formerly Clay Cross) Marine Band, marks the base of the Duckmantian for which the stratotype crops out in Duckmanton Cutting. This short section of railway cutting, running roughly E-W and preserved as an SSSI, lies on the eastern limb of the Brimington-Calow Anticline and the beds there dip roughly east at about 16°.

We crossed the stile and went down the steps into the western part of the cutting, which provides a roughly 300m horizontal section through the two highest Langsettian coal seams, the Vanderbeckei marine band and several metres of early Duckmantian mudstones above it. Much of the geology was obscured by soil or vegetation, notably stinging nettles. The marine bed had



**Duckmanton Cutting with close up of Chavery Coal under shelter on N side;  
ironstone nodules can be seen in the mudstones above the coal.**



'Cone-in-cone' structure.

formerly been well exposed next to the northern parapet of the road bridge, now infilled with concrete. Several metres west of the bridge, a gap in the vegetation revealed grey shaley mudstones dipping eastward, overlying a thin (c 30cm) sandstone, of which the top 10cm included wave ripple marked beds. The slightly darker mudstones immediately above were taken to be the marine band. Surprisingly, the type fossil *Anthracoceratites vanderbeckei* had not been recorded here, a situation unchanged after examination by our members.

Some 120 m to the west, the Chavery coal was exposed in both sides of the cutting. Shortage of time and rather wet conditions underfoot prevented a search for the Sitwell seam some 8m lower in the succession. Elsewhere in the coalfield, these two merge to form one seam, the Clay Cross Soft Coal, indicating local variations in subsidence while they were being laid down. On the N side, a short section of the Chavery coal and overlying beds had been protected by a shelter made of mine roadway roof arches (see photo opposite). On the opposite side, a continuous exposure perhaps 30m long, comprising coal and about a metre of overlying beds, ran diagonally up the S side of the cutting. The coal, some 60cm thick, consisted of two leaves separated by a thin shaley band, about 5cm thick to the S and only 1-2cm to the N. The coal itself, particularly the upper leaf, showed two sets of small scale vertical jointing known as cleat. This is peculiar to bright coals and needs

to be taken into account when designing underground workings. In the overlying mudstones could be seen nodules and impersistent bands of ironstone, formerly worked as the Pinder Park Rake. Fallen blocks were found containing freshwater bivalves, provisionally identified as *Anthracosia regularis*. The leader showed us a specimen from a thicker ironstone band, about 1.7 m above the coal but no longer exposed, which displayed the little understood "cone-in-cone" structure (see photo on page 11).

We then visited the former site of Arkwright Town nearby. Methane escaping from underground coal workings had made this former pit village unsafe and a new town, completed in 1995, had been constructed a few hundred metres north, on the site of former ironstone workings. This had been paid for out of the profits from opencasting the site of the demolished old town and reworking old spoil heaps for coal. The site is now landscaped but with vent pipes to prevent accumulation of methane.

Lunch was taken in Smalley, some 25 km further south, then at 14.00 members reassembled by the office at Lodge House Opencast Site, operated by UK Coal. After a welcome and introduction by the Site Manager, Brian Worsley, we divided into two groups who alternately toured the site with Brian and were given a presentation by Alan Ashburn, Company Geologist. Around 1990, British Coal had drilled the 122 ha site extensively, showing that the geology was straightforward, with near horizontal undisturbed beds and no sandstones substantial enough to require blasting. It was expected to yield nearly a million tons of coal over 4.5 years, working to a depth of 41m and extracting five Duckmantian coal seams. The lowest Duckmantian coals were not extracted, being of lower quality and having been previously exploited by deep mining. In the northwest of the site, the three highest seams had been opencast mined during 1944-7 and the land restored to a poor standard. About a third of the site to the south was cut off by Bell Lane, an old track with mature trees which was being preserved, foregoing some 3000 tons of coal; similarly for a small mature wood to the west of the site.

The method of working was to strip and grade separately the topsoil and upper and lower subsoils, stored in heaps on the perimeter. The site was then excavated in strips about 40m wide, the overburden being used directly to infill the previous strip. The clean coal was removed, crushed to below 2" (5cm) and sent for blending if needed, otherwise direct to power stations, e.g. Ratcliffe-on-Soar. Landscaping was to have taken place continuously as strips were backfilled but approval was awaited for an amended landscaping plan to accommodate the larger than expected volume of overburden. The area previously opencast had now been worked through, leaving about a half of the total coal output to come from the remaining quarter of the site.

The tour by Landrover passed the weighbridge, crusher and heaps of coal stocks, then took us to the southern edge of the current workings. To our right (east) the complete 41m deep section was exposed, from mudstones

above the Bottom 1st Waterloo down to the 3rd Waterloo coal, with benches working the Lower 1st Waterloo and the Waterloo Marker seams. Overburden was taken by truck and tipped directly where the exhausted strip, to our left (west) was being backfilled (see photo below). Occasional small sandstone lenses seen between the 3rd and Bottom 2nd Waterloo coals were considered to be the deposits of a lacustrine delta. A well-defined persistent sandstone bed, about 1m thick and 3m below the 2nd Waterloo coal was interpreted as a crevasse splay deposit. We were driven to the Waterloo Marker bench where the leader had seen ripple-marked beds and after a search, a fallen block with vestiges of wave ripples was found.

The two groups were reunited in the site office at about 17.15 and all three leaders were thanked for their contributions to an excellent field trip. Thanks are also due to the Derbyshire Wildlife Trust for permitting access to Duckmanton Cutting and to UK Coal for the visit to Lodge House Opencast Site.



**Lodge House Opencast Site showing coal of the Waterloo group of seams being worked; back filling to left.**

# **Fountains Abbey and St Marys Church, Studley Royal Saturday 19th June**

**Leaders: Neil Aitkenhead and Murray Mitchell**

**The double bill, led by two of our most respected and popular leaders, attracted 16 members for the morning walk and 21 for the less energetic church visit in the afternoon.**

**Fountains Abbey and the River Skell** (led by Neil Aitkenhead).

We met at the Lakeside car park, overlooking a drained and muddy lake bed which was in the process of being restored to its nineteenth century water garden appearance. Taking the track along the meandering valley of the River Skell, we examined Lower Magnesian Limestone at three or four fine localities. There was little sign of disturbance in the thinly bedded dolomites, and ripple marks indicated a shallow water environment. At one outcrop we stood on the dry river bed where the water had disappeared underground to examine a rubbly horizon which was interpreted as collapsed breccia. The river itself seemed hardly capable of excavating the deep gorge, even when it was seen running above ground, and it was considered that glacial meltwaters were the eroding agent.

The Lower Magnesian Limestone lies unconformably on the Millstone Grit (here the Lower Plompton Grit) which we first saw near Half Moon Pond and again more dramatically in the quarried crags nearer to the Abbey where there were striking examples of cross bedding (see photo on back cover). Finally we examined the crinoidal limestone in the now rather weathered narrow columns or shafts that adjoin the larger pillars among the abbey ruins.

**St Mary's Church Studley Royal** (led by Murray Mitchell).

By 2pm we gathered outside the church and were provided with a print out of Murray's short paper '*Building and Decorative Stones of St Mary's Church Studley Royal*'. We were led on a close examination of stone from local sources and other more exotic stone from across Europe which architect William Burges had used to build and decorate the church, when it was constructed in the 1870s.

The church exterior was built of cut gritstone from the Upper Follifoot Grit, quarried at Catraig Quarry, with well matching Magnesian Limestone used for delicate mouldings. The two very different stones still blend very well after 130 years of weathering, and the green slates from the Lake District volcanics that make up the roof are now subdued in colour.

We were not prepared for the richly adorned interior where the splendour, colour and polish of the decorative stone made a huge contrast.

The nave had piers of Magnesian Limestone adorned with amazing columns of dark grey polished limestone with fine crinoid debris. It is believed this was Kilkenny Marble from Ireland which William Burges had used in Cork Cathedral.



**Some of the colourful polished stone with travertine panels and coloured columns.**

We soon moved along to the remarkable Marquis of Ripon's Chapel where high quality white Carrara Marble from Italy had been used for the carved figures, the same material Michelangelo used for his statues. Alabaster from the Derby-Nottingham area formed carvings round the chest. In contrast, dark green serpentinite breccias from Greece with white calcite matrix formed the chest top slab. The walls were of white Greek marble with green veins, and on the chapel floor, a famous creamy white marble from Greece that had been used on the Parthenon in Athens.

We spent some time in the choir area where the steps to it were of black marble from Belgium with white calcite tension gashes, while the steps to the sanctuary were of three different polished stones: Red Egyptian Porphyry from the eastern desert of Egypt and used in earlier times by Roman emperors, black crinoidal limestone possibly from Belgium, and Carrara Marble from north-west Italy. The brownish yellow chancel walls were of polished travertine from Italy. But the magnificent colourful polished stone columns were made up of alternating Connemara Marble, Cork Red Marble and an unknown orange marble.

The travertine walls were richly decorated with coloured inset panels which included among others, green porphyry from Greece, red serpentine possibly from the Lizard, green serpentine, red Egyptian porphyry and pale green Iona Marble. (See photo above).

We came out of the church and walked round to the east end to take in the wonderful view directly to Ripon Cathedral with the White Horse of Kilburn in the Hambleton Hills just showing in the distance. We thanked our leaders for a rewarding day. Thanks also to Kevin Read who supplied all the photographs for this report.

# **Calton Hill and Miller's Dale, to study igneous rocks in Derbyshire**

## **Saturday 26th June**

**Leader: Dr. Chris Arkwright, Open University**  
**14 Members and 2 visitors present**

Throughout Derbyshire, Carboniferous age igneous rocks are intercalated with Carboniferous limestone. Igneous activity in the Lower Carboniferous was sporadic and localised, with intrusive and extrusive rocks found at different horizons which are identified separately depending on the outcrop. The igneous rocks are thought to have formed as a result of back arc extension which caused limited igneous activity during the formation of Pangea. Evidence of ash and tuff layers suggests explosive eruptions while intrusive dolerite sills cross-cut limestone and lavas. Four volcanic centres have been proposed in Derbyshire based on borehole data.

Members met at Miller's Dale railway station, now an information office, and walked along an abandoned rail track to the first location in Miller's Dale Quarry, a large limestone quarry with lime kilns. Limestone beds exposed in the quarry range from Miller's Dale Beds (Asbian) at the bottom of the quarry to Station Quarry Beds (Brigantian) at the top. The limestones are not very fossiliferous, but brachiopods, crinoids and corals were seen.

Two lavas are found which bracket the rocks of the quarry, though they are not exposed in the quarry. The contact between the basaltic Lower Miller's Dale Lava (LMDL) and the overlying limestone was found in the river bank below the quarry. The basaltic Upper Miller's Dale Lava (UMDL) was seen at higher level in the surrounding hills.

The next exposure was at Litton Mill. UMDL is exposed on the south side of an abandoned rail track where altered brecciated basalt shows spheroidal weathering (see photo opposite). The cause of the brecciation is not clear but studies have suggested that there was either contact between lava and seawater, or auto brecciation of a moving lava front. Another interesting feature of this outcrop was seen further along the rail line where there was an abrupt change in dip in the overlying limestone beds at the nose of the lava front. This was suggested as having occurred in shallow water. The limestone mantled the lava nose and was very weathered and contained varying clast sizes.

As time was running out we did not visit Tideswell Dale dolerite sill, an igneous body intruded between the LMDL and the underlying Chee Tor



**UMDL showing altered brecciated basalt with spheroidal weathering.**

Limestone. The dolerite has been dated at 287Ma. However, we went back to the Miller's Dale car park to examine hand specimens of dolerite provided by Chris Arkwright.

The final location was at Calton Hill quarry, where late Westphalian dolerite was intruded into an earlier (Visean) complex of lavas, tuffs and agglomerates. The large quarry was worked until the 1990s and parts are preserved as an SSSI. Three main types of igneous rocks can be seen - tuff, vesicular basalt lava and columnar olivine basalt. The group spent some time examining the columnar jointing, (see overleaf), with its coarse angular crystals of weathered olivine, referred to as mantle nodules. (See inset - overleaf).

The location represents a vent agglomerate with lavas and tuffs which was subsequently buried by limestone. Magma was emplaced through a volcanic centre, ponded and solidified with columns orientated in many directions. Associated minerals, for example chlorite, were seen, as well as amygdalae. At a high level in the outcrop, there was a good example of a lava containing calcite crystals and amygdalae with haematite and chlorite.

In summary, there are not many outcrops of igneous rocks in Derbyshire. What is visible is a mixture of lavas from explosive volcanism, possibly phreatic, and intrusive dolerite. Geological studies have been carried out and for further reference the following papers are recommended:

McDonald et al., 1984, Geochemistry and petrogenesis of the Derbyshire Carboniferous basalts, *Journal of the Geological Society of London*, vol. 141, pp147-159.

Wolverson Cope, 1997, An igneous dyke complex in the Carboniferous Limestone of North Derbyshire and its significance, *Proceedings of the Yorkshire Geological Society* vol. 51(3), pp 245-249.



**Columnar basalt at Calton Hill Quarry  
(Inset - Olivine inclusions (mantle nodules) in columnar basalt).**

# **Bradgate Park, Charnwood Forest**

## **Sunday 25th July**

**Leader: John Carney, BGS**  
**12 Members and 1 visitor present**

Our group convened at the Hunt's Hill entrance of Bradgate Park to examine Precambrian and Cambrian exposures on a circular walk through the park, a unique and historic parkland to the SE of Charnwood Forest and on the NW outskirts of Leicester. Bradgate House and the park were the childhood home of Lady Jane Grey, briefly and tragically queen of England in 1553.

The Precambrian rocks of Charnwood Forest were formed about 575 Ma from a period of intense vulcanism to the NW with the Charnian volcanoes as an island arc emitting ash and lava as pyroclastic flows which cascaded down into the surrounding seas. Montserrat in the Caribbean island arc is a modern day example. The deposits resulting from this activity are the Charnian Supergroup. Subsequent folding produced a NW/SE trending anticline, and erosion has exposed Precambrian rocks, and in particular the Beacon Hill and Bradgate Formations of the Maplewell Group in Bradgate Park.

Our walk took us up the sequence, and we ascended the hill towards Old John

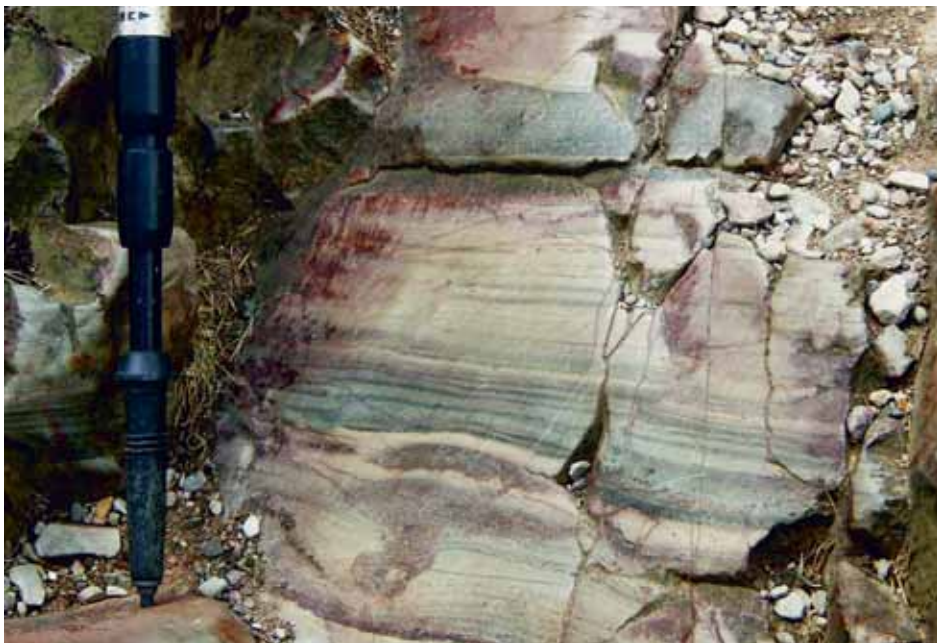


**Leader describes beds in the Old John Member / Beacon Hill Formation.**

Tower, reaching the oldest Charnian unit, the Beacon Hill Formation, and the crags of the Old John Member which crown the hill. These are volcanoclastic laminated sediments of mudstone, siltstone and sandstone containing microscopic sized shards of volcanic ash (see photo bottom of page 19). The most prevalent structures are graded bedding and examples of soft sediment deformation, with sand grade material penetrating into underlying mudstone or siltstone beds, very well shown on the smooth, worn surfaces of footpaths (see photo below). As a result of subsequent compression (dated at 420Ma in the Late Silurian), the rocks display intense cleavage, typical of all Charnian rocks, which shows refraction through the coarser and finer grade sediment layers. Grading of the bedding indicates that most deposition was from turbidity currents, with a contribution from volcanic ash which fell on the sea surface and settled through the water column. Absence of significant cross-bedding or ripple marking indicates that deposition was below the storm wave base of about 50m.

From the top of the hill the party viewed Bardon Hill to the NW, one of the volcanic centres which fed into the Bradgate deposits, and Castle Hill, 4km to the NE, formed from Ordovician rocks belonging to the Mountsorrel diorite, extracted until recently at Mountsorrel Quarry.

The party then headed east along a series of outcrops which follow the strike



**Soft sediment deformation shown on worn surface.**

of the Sliding Stone Slump Breccia, eventually reaching a prominent outcrop which is the type locality. The rock is a coarse-grained volcanoclastic sandstone containing rafts of dark grey mudstone, often contorted (see photo below). The breccia is considered to have been formed by tectonic activity causing slumping and downslope movement of turbidite beds consisting of muddy layers intercalated with coarse sands; the sandy beds would have been loosely consolidated and easily liquified, but the muddy layers with less retained water content were deformed plastically and then broken up within the mass flow of the liquified sand. Hourglass shapes in pieces of the mudstone are evidence of early plastic deformation at the start of the slump.

Moving to the SE and up the sequence we saw a small quarry of volcanoclastic mudstones and siltstones still within the Bradgate Formation but with thin beds separated by prominent laminated intervals. Microscopic examination shows that these beds formed at a time when volcanic activity was beginning to decline. Close by, we saw an exposure of conglomerate beds containing well rounded volcanic pebbles. This is the Hanging Rocks Formation, overlying the Bradgate Formation. The pebbles were probably formed in rivers or along a shoreline fringing a volcanic terrain, finally having been carried into and deposited in a submarine fan and delta environment. The evidence of terrestrial origins suggest that the source was a volcanic land mass that was undergoing uplift and erosion in the final stages of the



**Classic example of Sliding Stone Slump Breccia at the type locality.**

Charnian magmatism, and that the Hanging Rocks Formation should be included at the top of the Charnian Supergroup and not in the overlying Brand Group.

The party made a detour to the NE to Swithland Wood to see an exposure of the Swithland Formation, highly cleaved siltstones and mudstones which had accumulated on the sea floor which covered the Charnwood Formation in Cambrian times. Mountain building pressure in the Late Silurian developed a close spaced cleavage, which enabled the beds to be split for slates. The now flooded Great Pit quarry in Swithland wood (55m deep) was one of the major sources, and produced slates over a long period until the late 18th century; the product was thicker, heavier and rougher than Welsh slates, and the latter then rapidly replaced them as a preferred roofing material. There is ample evidence of Swithland slates in local villages, both as slates and headstones, and still a demand for slates 'reclaimed' from old buildings as sources for roof repairs, extensions etc. Swithland headstones have been found to contain the fossil *Teichichnus* which would indicate a Cambrian age for this Formation.

Close to Bradgate House we saw exposures of the South Charnwood Diorites, medium to coarse-grained diorites with a distinctive mottled pink-grey texture, seen clearly in a polished sample produced by our leader. Although fractured and slickensided, these rocks do not show the cleavage seen in the Bradgate formation. These rocks represent the final episode of Precambrian magmatism in the Charnwood Formation.

To the south of Bradgate House across a small bridge is Stable Pit quarry where the Stable Pit Member is exposed. These are medium-grained quartz-rich sandstones deposited in a coastal environment after vulcanism had ceased. The exposure is split by a diorite dyke, about 1 metre in width, trending E-W, parallel to the local cleavage. Originally thought to be Precambrian, this member is now reclassified into the Brand Group of the Lower Cambrian.

In dramatic contrast to all the above exposures, nearby, and at the lowest point in the park, is an exposure of red mudstones belonging to the Mercia Mudstone Group and deposited in a desert environment in Triassic times. This area was subsiding during the Triassic Period and red beds buried the older landscape. Preferential erosion of the Mercia Mudstone has now reexcavated the original valleys to expose the Precambrian/Cambrian landscape.

On our return walk 'down' the sequence, we were privileged to be shown the famous fossil locality, on a bedding plane of graded volcaniclastic sand stones and well laminated mudstones and siltstones above the Sliding Stones Slump



**Precambrian fossil *Bradgatia Linfordensis*, seen in the famous bed.**

Breccia. Over an area of about 25 square metres of the bedding plane as many as 50 fossil impressions have been found (see photo above). These are impressions on upper bedding surfaces when soft bodied animals have come to rest on the silt and been buried rapidly, pressing them down into the sediment. These are the only examples of Precambrian fossils in western Europe and are extremely important. Since their discovery in Charnwood, similar fossils have been identified in Australia, Newfoundland, Russia and China.

Our day concluded on this high note, and Judith thanked our learned leader John for his lucid description of all we had seen through a full day, and also for his comprehensive handout, which I have learned subsequently will become a BGS report :-

Carney, J N, 2010 "Guide to the geology of Bradgate Park and Swithland Wood, Charnwood Forest." *British Geological Survey Occasional Report, OR/10/041*

Also, background to the geology of Charnwood and description of 11 walks covering the area are in the BGS publication :-

'Exploring the Landscape of Charnwood Forest and Mountsorrel' Ambrose, Carney et al 2007

Available from BGS or via ISBN 978-085272570-2

# The York Moraine

## Saturday morning 21st August

**Leader: Mr Bill Fairburn**  
**14 members and 3 visitors present**

On a bright sunny morning our party met the leader, Mr Bill Fairburn at Fulford Allotments, York. Mr Fairburn, a geology graduate of Durham University, introduced himself and at the outset said that his conclusions were at odds with other Quaternary researchers, including members of the British Geological Survey (BGS). He, therefore, emphasised his professional experience as a geologist, initially with the former Colonial Surveys in Africa, moving to Australia to work first as a mineral geologist and then in oil exploration. Following retirement he became an expert on the geology of the famous Barossa Valley vineyards in South Australia.

Returning to Britain, he had settled in York and became interested in the geomorphology of the York and Eskrick Moraines and adjacent areas. He explained that these features dated from the Late Pleistocene Dimlington Stadial (c. 23-15 Ka) when ice originating in the Lake District and the Pennines flowed partly down the Vale of York and partly down what is now the Yorkshire Coast, thereby blocking eastward drainage through the Humber Gap and creating the large pro-glacial Lake Humber. It should be noted that the established view of most researchers is that initially a high level Lake Humber with shore lines at c.33m above Ordnance Datum (aOD) was developed. One member pointed out that a recent publication suggested that the Lake drained from an initial high level of c. 27m aOD down to 4m below OD before rising to 8m aOD. In the Vale of York, an ice front advanced southwards to produce a terminal moraine at Eskrick. Subsequent recession and then stabilisation of the ice front at York produced the York Moraine.

Mr Fairburn explained that, in contrast, he had been able to recognise terraces and related erosional surfaces on and around the York Moraine at elevations up to 33m aOD. He had mapped them over some 800sq km and considered that they represented horizontal strandlines. The principal inference from his observations was that the high level Lake Humber post-dated the formation of the York Moraine (and, therefore, that of the earlier Eskrick Moraine) rather than predating these features as held by previous workers. Mr Fairburn concluded by saying that his aim was to convince us of the existence of the terraces and of their origin as strandlines.

The party then walked through the allotments to reach the path heading northwards across the flat ground of Walmgate Stray. Mr Fairburn said that this surface was at an elevation of 15m aOD and that he had recognised strandlines at the same level on both sides of the Eskrick Moraine further



**Members standing on the 20m terrace on the south face of the York Moraine above Walmgate Stray.**

south. Looking northwards up the steep face of the York Moraine to the east of the Retreat, he pointed out a terrace feature located at 20m aOD which represented a higher strandline. On walking up to the back of this feature, Mr Fairburn indicated a hollow which he believed had been eroded by water movements.

Continuing up the Moraine, we were shown another break in slope at 25m aOD which Mr Fairburn identified as a higher littoral zone. However, some members were concerned that certain of these features may have resulted from sand and gravel workings and it was difficult to identify the terrace features looking across to an adjacent but inaccessible field.

Mr Fairburn then led the party across University Road to open ground to the north east which he explained was at around 31m aOD and represented a planar surface caused by lacustrine erosion across the top of the Moraine. Passing the Water Tower, we reached Mill Mound (the site of the ancient windmill) at 35m aOD which the leader suggested would have emerged above the highest lake level. However, in view of tree cover and the historical record, it was difficult to assess how much of this ground was undisturbed. Walking towards the North Car Park, small exposures of pebbly sandy silts were observed at the roadside which the leader said might be reworked littoral deposits. However, some members of the party felt that they could be Head.

Dropping down to University Road, the party followed at a westerly and then a north westerly direction to cross the crest of the Moraine before turning right into the housing developments along Thief Lane and Newland Park. Mr Fairburn identified breaks in slope in the roads and gardens as the 30m Surface and the lower 25m Surface. However, it was not clear how extensive any land stripping prior to building had been. The party returned over the crest of the Moraine to the path to the west of the Retreat leading down to Walmgate Stray, pausing only for a photograph with members of the party standing on Mr Fairburn's 20m terrace (see photo overleaf), before returning to our starting point. Here some of the party commented that the proposed shore-lines might have been perhaps more clearly demonstrated in an area well beyond the city limits, within which much of the ground had been subject to considerable modification over the centuries, maybe even dating back to Roman times. Mr Fairburn agreed, but explained that the York Moraine was a small, easily accessible, area for a morning's excursion. Judith Dawson then proposed a warm vote of thanks to Mr Fairburn on behalf of the Association.

## **Residential Weekend to Pembrokeshire Friday 24th to Sunday 26th September**

**Leader: Dr. Charlie Bendall of the Geography and Earth Science  
Department at the University of Aberystwyth  
18 members and spouses present**

During the weekend we studied the geology of eight magnificent coastal locations in the most western part of Pembrokeshire, from St Anne's Head in the south to Strumble Head in the north. The rocks varied in age from Precambrian to the Upper Carboniferous Coal Measures.

On Saturday we visited places in the south where Silurian rocks, Old Red Sandstones and Coal Measures sediments had been deposited, and had undergone deformation during the Variscan Orogeny. On Sunday our area of study was further north, where we discussed the older rocks of Precambrian age in the St David's area, and examined Cambrian and Ordovician rocks which had been subjected to the Caledonian Orogeny.

On Friday afternoon a number of the party carried out an informal examination of some of the Carboniferous rocks in the Saundersfoot area.

### **Friday afternoon 24th September**

#### **Saundersfoot**

Our weekend activities commenced in Saundersfoot as we gathered after a long journey from Yorkshire, to examine cliff features between the harbour and Monkstone Point, and in particular Variscan Thrust features in this Westphalian sequence. This short excursion was a suggestion by Sid Howells, noted Pembrokeshire geologist based nearby, who also kindly provided a general sketch of the sequence for party members to mark in thrusts, faults etc. What an interesting introduction it was to the orogenic evidence we were to see over the next two days; and what a fascinating feature the Ladies Cave Anticline (see photo top of page 28) proved to be for the majority of the party who had never seen it 'in the flesh' before. Our thanks go to Sid for his suggestion and providing the information.



**Ladies Cave Anticline exposed to the south of Saundersfoot harbour.**



**Antiform/synform folds at Cobbler's Hole (St. Anne's Head).**

## **Saturday 25th September**

### **Cobbler's Hole, St Anne's Head [SM 806 028]**

Here Dr Bendall reminded us that this was the bay where the oil tanker Sea Empress had struck rocks in 1996 creating extensive oil pollution of which there is now, fortunately, no sign. The main geological interest is an antiform/synform pair of folds in the interbedded red sandstones and siltstones (see photo bottom of page 28) in which a distinct cleavage is present. This is approximately parallel to the axial plane of the folding. Tension gashes marked by short en echelon quartz veins are commonly present. The predominant red colour, due to the presence of hematite-coated grains, with some green partings, reflects the oxidation and permeability of these beds when they were at or near the ground surface. Gullies in the cliffs marked the presence of faults. There is no evidence of the age of these beds but they are assumed to be Devonian.

### **Marloes Bay [SM 774 076]**

Exposed here are red sandstones, presumably non-marine, overlain by green sandstones said to contain marine fossils, all steeply dipping to the south. The red sandstones contain numerous quartz-filled tension gashes (see photo overleaf). A 'pressure solution cleavage' is also present. Cross bedding indicating fluvial sandbanks alternated with sharp-based beds with rip-up clasts composed of red mudstone, suggesting flash floods. The sandstones also contain some clasts of basalt.

### **Broad Haven [SM 859 144]**

A little further along the coast at Broad Haven, we came across a fine example of a recumbent fold whose vertical limb was displaced by a low-angle thrust fault (see front cover). We were told that students had found mussels in these strata indicating a Lower Coal Measures age. The complexities of the recumbent folding provoked much discussion.

### **St Brides Haven [SM 803 112]**

Here we saw red sandstone beds up to 1 metre thick interbedded with red siltstones heavily pockmarked by the solution of presumed former gypsum or carbonate inclusions. These beds were disrupted by low-angle thrusting. One very unusual coarsening-upwards quartz granule conglomerate bed was also seen. Equally unusual was a 1cm wide dyke of conglomerate offset about 3 metres laterally by a bedding-parallel thrust plane.



Quartz-filled tension gashes showing cleavage lines, Marloes Bay.

## Sunday morning 26th September

### Whitesands Bay to St David's Head

Saturday had been devoted to Variscan structures to the south, so we were to start the day to the north with Caledonian structures, Lower Palaeozoic sediments and igneous intrusions.

We arrived at Whitesands Bay on a beautiful day with the promise of some sun. Ramsey Island to the S.W. and the Islets of Bishops and Clerks further west became easily visible as we climbed the coastal path going north towards St. David's Head.

We looked down on the Trwynhwrddyn headland (ram's nose) consisting of quartz rich sandstone, micaceous siltstones and flaggy mudstones of the Lingula Flags (Late Upper Cambrian), with strata dipping to the north west. The Cambrian Ordovician unconformity outcrops here on this headland. Although we were not able to examine the details there is hummocky and swaley cross stratification, indicating deposition in storm dominated near-shore shelf environment.

At the next bay, Porth Lleuog, a tall pale stack of acid tuff gave way to black mudstones of the Penmaen Dewi Shale Formation containing *Tetragraptus* and dendroid graptolites of the Ordovician. (see photo below).

We ascended to the ridge crest of the headland, Penlledwen, promontory of Carn Llidi, a gabbro intrusion which is repeated on the northern limb (at St. David's Head) of the north-east trending syncline. The composition varies in



View of Porth Lleuog from coastal path with stack of acid tuff jutting into the sea, and black Ordovician mudstones in the cliff. (Trwynhwrddyn headland in the distance).

zones parallel to its margins: lower and upper margins are composed of quartz dolerite and quartz gabbro of undifferentiated magma, the rest being 'in situ' differentiation. The upper contact with overlying siltstones and mudstones revealed contact metamorphism with round spot hornfels. The lower contact was examined in the cliff below. The gabbro showed dark and light mineral layering emphasised by weathering. The rock has been tilted vertically (see photo below): originally the dark bands containing mafic minerals (and more easily eroded) were below the lighter plagioclase feldspar (more resistant to weathering). The brown weathering is typical of gabbro. The banding was due to magmatic differentiation in the magma chamber by crystal fractionation and gravity settling.

We continued northwards and dipped down into Porthmelgan. The cliffs were of weathered, faulted and cleaved silty mudstones of the Aber Mawr Shale formation (mid Ordovician Arenig). It was so compacted that it was difficult to make out the angle of bedding. Bedding and cleavage relationships were explained but difficult to demonstrate on either side of the bay to confirm that it was intersected by the axial plane of the north-east trending syncline.

In places there were films of slaty-purple manganese deposits, and in the rocks around the cave iron pyrites. There were several quite large nodules, some of which had ochre staining, consistent with anoxic deep water deposition of these rocks.



**Gabbro intrusion, tilted vertically, and showing layers of dark and light minerals.**

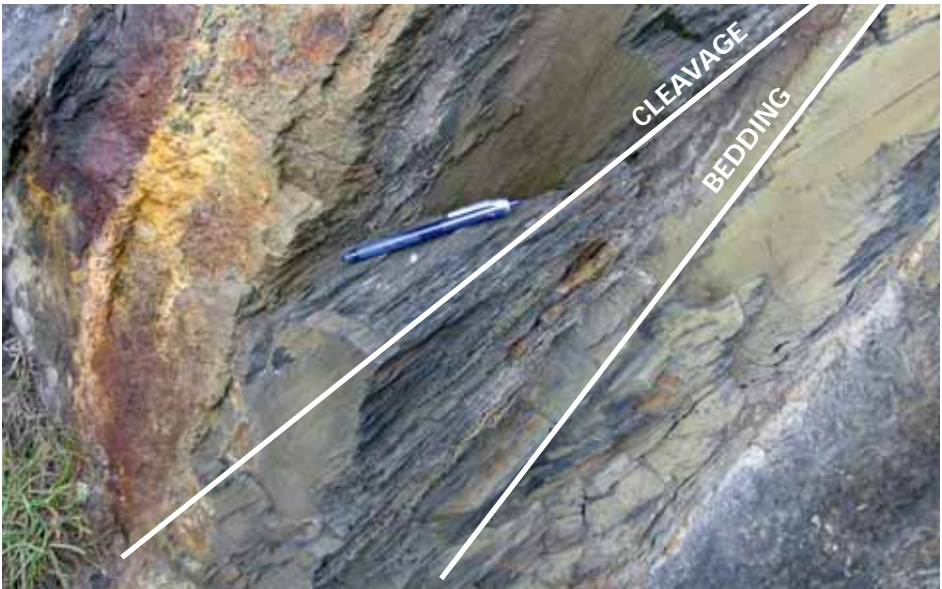
## Sunday afternoon, excursion continued

### Porthgain [SM 815 326]

After lunch in the attractive village of Porthgain with its sheltered harbour and evidence of its industrial past, Charlie explained that until the nineteenth century the only activities were fishing and 'burning' limestone. This all changed when two quarries opened nearby in the late nineteenth century.

The first was a slate quarry. At this time there was a big demand for slate, both for roofs, and for floors that were strong enough for the machinery used in mines. Unfortunately this mid Ordovician slate soon rotted and it could not compete with the much better quality Cambrian slate from North Wales. Through local ingenuity the slate was now used to make bricks and a brick works was built which is still on the quayside. The slate was crushed (though not very finely) and heated to soften it before being shaped into bricks and baked in a Hoffman Kiln. This industry soon declined and finished in about 1900.

In 1889 quarrying of the hard dolerite intrusion near Porthgain started. (Our leader had recently examined thin sections of this rock and found that it is actually tonalite, which is similar to diorite, but with an appreciable amount of quartz). The quarry mainly produced road setts and aggregate for roads. Hoppers and crushers were built on the harbour to process the rock and the remains of these buildings, including those used for the slate, dominate the harbour. The processed stone was transported away by sea. This industry finally came to an end in 1931, because of poor transport links in such a remote location.



**Abreiddi Slate Quarry - showing cleavage and bedding plane on the overturned limb of an inclined syncline.**

### **Abereiddi Bay [SM 797 304]**

A short walk from the car park at Abereiddi Bay (with a syncline axial plane passing through it) brought us to the Blue Lagoon and the remains of the Ordovician (late Llanvirn) slate quarry. The fine grained mudstones, deposited in the Welsh Basin were transformed into slate during the Caledonian Orogeny at the end of the Silurian to early Devonian. We stopped to examine an excellent exposure, on the edge of the quarry, with autobrecchiated limestone interbedded with the slates, where it was possible to make out both the bedding and the slaty cleavage. From the angle between the two we were able to deduce that we were looking at the overturned limb of an inclined syncline (see photo page 33).

There was very obvious iron staining of the slates. Charlie explained that they are very carbonaceous and produce a reducing environment so that pyrite (iron sulphide) forms sulphuric acid and iron in solution. This is unstable and results in precipitation of iron oxide on the surface of the slates. In turn, this causes the slate to rot and accounts for their poor quality.

We then examined the slate spoilheaps for fossils and and it wasn't very long before good examples of *Didymograptus bifidus* were found.



**Strumble Head. Probable spherulites in rhyolite outcrop.**

## **Strumble Head [SM 895 412]**

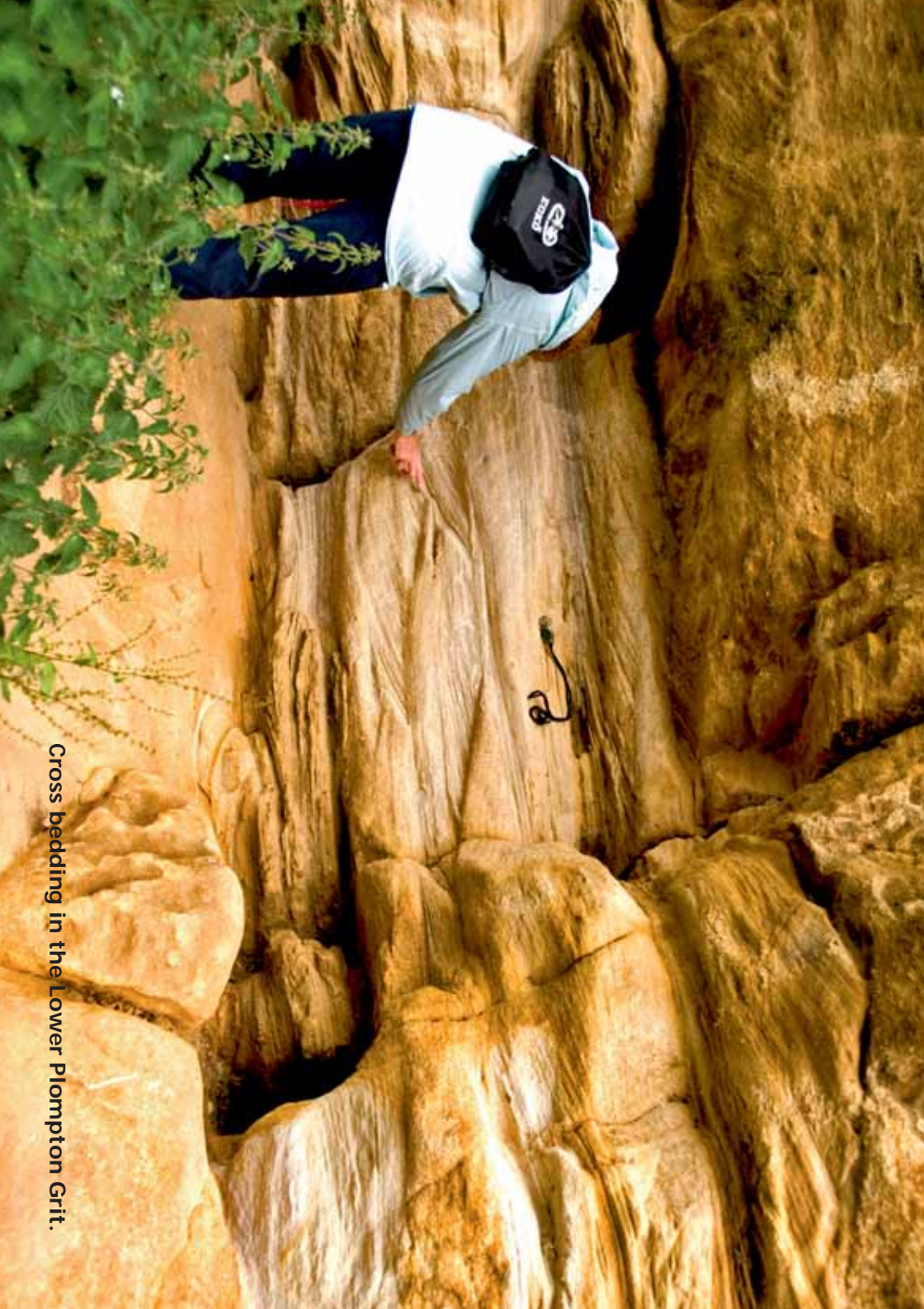
Our last location was at Strumble Head, a wild dramatic cliff top with a lighthouse. We walked a short distance down the cliff to some rocky outcrops which were pale coloured, fine grained, glassy, and contained white inclusions. This was mid Ordovician rhyolite, produced as a lava flow from a nearby volcano. There was a discussion about the nature of the inclusions, which could possibly be phenocrysts or amygdales, but our leader is of the opinion that the rhyolite had undergone devitrification to form spherulites (see photo opposite). Some had weathered out. A nearby rock was brecciated to produce an aggregate of glassy fragments produced by rapid chilling of rhyolitic lava flowing into water - a hyaloclastite.

We descended further on to a 'geologists' paradise' of rocks! Here with a view down to the crashing waves were masses of pillow lavas of all sizes containing vesicles, (see photo below), Llanvirn Ordovician shale bands with graptolites, and sheets of basalts which had been rapidly extruded. A few of us scrambled down the pillow lavas and found deposits of dark fine grained chert amongst them. This occurs because hot lava heats the surrounding water and silica which had been in solution is precipitated round the pillows.

We then ascended the cliff back to our cars where Howard thanked Charlie for an excellent weekend with wonderful geology and scenery. His enthusiasm and clear explanations helped us understand this complex landscape.



**Pillow lavas of all sizes at Strumble Head.**



Cross bedding in the Lower Plompton Grit.