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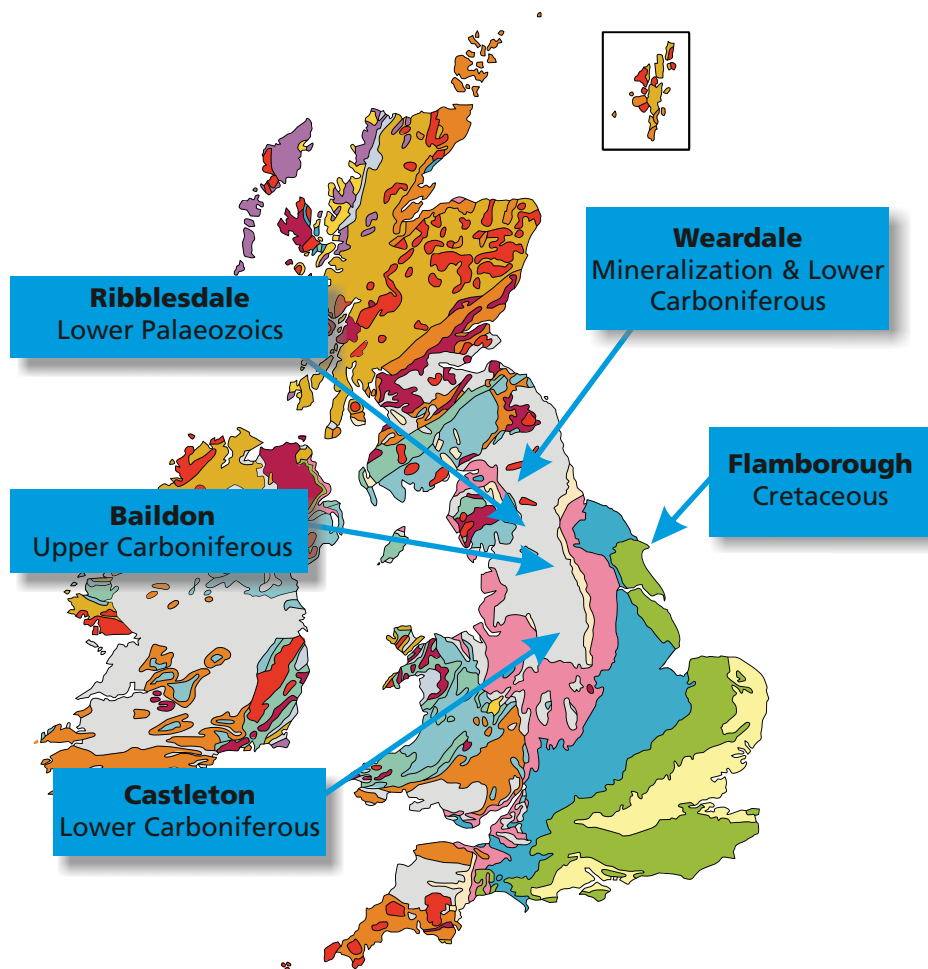
Field Visit Reports Summer 2017

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17

Where did we go?



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2017 Field Visit Locations

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Thanks are due to the Field Visits Secretary, David Holmes, for arranging the programme, to the leaders who gave up their time to take us and to the authors of the reports and photographs.

Cover Picture: Walking down into Dry Rigg Quarry - Ribblesdale.

Dry Rigg and Arcow Quarries and Newfield Crag, Ribblesdale Wednesday 7th June

Leaders: Mike Cardus and Gary Jaques (Tarmac), Bill Fraser (LGA)

Present: 17 members

After two days of nearly constant rainfall the visit to Dry Rigg and Arcow Quarries and Newfield Crag looked as though it may be a wet and soggy start to the 2017 field trip season. Fortunately, a sunny and breezy day greeted the large party at the car park in Dry Rigg Quarry where the pumps had been working hard and removed most of the water .

Bill provided superb handouts to the group before we assembled in the quarry education centre for a brief talk by our guide, Mike Cardus, which covered the past, present and future of the quarries. Both quarries are owned by Tarmac and are awe-inspiring sights. Dry Rigg is a near vertical terraced hole dug, around 100m deep, into the Silurian, Horton Formation, while Arcow Quarry is of a similar depth but wider and is dug into the older Silurian, Austwick Formation. Above each quarry the basal-Carboniferous unconformity is clearly visible. Both quarries produce excellent quality stone with a high resistance to wear but Dry Rigg prides itself as its stone is of a slightly higher quality. The extracted stone is processed on site at both quarries and is predominantly used for roadstone throughout the UK. Currently much of the processed material from Dry Rigg Quarry is transported to Arcow Quarry for onward distribution by rail. Dry Rigg Quarry and Arcow Quarry are scheduled for closure and restoration in 2021 and 2029 respectively, although these dates are dependent on future planning applications.

After the introductory talk we ventured into Dry Rigg Quarry, shod with hard hats and fetching, high visibility clothing. After a brief tour of the impressive processing plant control room we walked down the haul-road into the belly of the quarry (see front cover photo) to view the Horton Formation up close. This lithology is a Silurian mudstone which was deposited at the distal extent of a submarine turbidite whose source area lay to the south. The rocks have subsequently undergone significant deformation and low grade metamorphism during the Caledonian Orogeny, with the Horton and Austwick Formations now being part of the NW-SE trending Studrigg-Studfold syncline. The group was treated to an array of stunning sedimentological features on the almost vertical northerly dipping beds,



A bedding plane in the Horton Formation showing nodules (left), slickensides (middle) and asymmetrical current ripples (centre and right).

ranging from asymmetrical current ripples and post-depositional carbonate nodules covering entire bedding planes to delicate centimetre-scale variations in bedding. The gross structural geology was equally stunning, with spectacular huge parasitic folding clearly visible in the quarry faces. The western side of the haul road cut through the parasitic fold axis allowing the core of the fold to be seen in section. Many slickensided bedding planes were visible attesting to the high levels of slip along the bedding planes which occurred during the deformation (see photo above).

On return to the education centre Mike was given a round of applause for being an excellent guide, and, following a quick lunch break we set off on foot to Newfield Crag, around 0.5km to the south of Dry Rigg Quarry. These rocks are located within the Austwick Formation, lying below the Horton Formation but exposed on the surface as they lie on the crest of an anticline. The exposures at Newfield Crag also represent deposition in a turbidite, although these rocks are of coarser grain sizes than those of the Horton Formation suggesting a more proximal position. Precariously placed on a steep hillside, the exposure displays what must be some of the finest examples of flute clasts in the UK (see photo overleaf). There are at least eight individual turbidite sequences exposed, with one showing a full Bouma Sequence. All members left highly impressed and walked back to the cars to head to Arcow Quarry, the final destination of the day.

At the quarry, which lies on the northern limb of the Studrigg-Studfold syncline, we met up with our guide, Gary Jaques. He informed us that the quarry has been shut down for the last 18-24 months, although it will reopen shortly to begin processing the 12 years worth of material left to work. We were led around the perimeter footpath where we stopped on the railway bridge to view the new railhead for shipping processed material from both quarries, where up to two trains per day are expected when fully operational. We continued up the hill towards a viewpoint overlooking the main face of the quarry, a spectacular view clearly showing the southerly dipping beds and complex structural geology, particularly the large scale monocline and anticline parasitic folds. At the top of the quarry the irregular and undulating basal-Carboniferous unconformity which dominated the surrounding hillsides was readily apparent (see photo opposite).

We returned through the quarry itself and on our way back to the site office we took a closer look at the processing plant and the dust cleaning systems employed on the outgoing trucks from Arcow Quarry. The group offered warm thanks and appreciation to Gary and his assistant and departed after an excellent day's geology.



Flute marks at Newfield Crag.



Arcow Quarry showing complex structural geology and the basal-Carboniferous unconformity

The Chalk at Flamborough; on foot and by boat. Sunday 25th June

**Leader: Paul Hildreth (Yorkshire Geological Society)
Present: 15 members and 2 visitors**

The group assembled in the car park at North Landing, Flamborough on a warm, sunny but breezy morning. The meeting had been advertised as "The Chalk at Flamborough Head, on foot and by boat" and the intention was to first examine a section across the Welton-Burnham Chalk boundary before viewing from the sea the stratigraphy of the Chalk Group and the Staple Nook Deformation. Unfortunately, after greeting our leader, the boatman arrived to inform us that the offshore wind was too strong so the boat would not be running. This was a disappointment but, fortunately, Paul had come prepared for such an eventuality and in the afternoon we visited Bempton Cliffs to look at the Deformation from above.

As planned, we descended the slipway to the beach at North Landing. Here, Paul gave a brief history of the research into the Chalk Group. Before the 1970s, the Chalk had been considered to be a rather monotonous,



Well bedded chalk, faults, joints and glacial till at North Landing.

homogenous, pelagic sediment of no real interest and its lithology and stratigraphy had been largely ignored. Work that had been done had been on the much softer chalk in the south of England - on the basis of macro-fossils which are rare in the north. Then in the 1970s, work was done which separated the Chalk into three distinct Provinces: the Northern - as far south as north Norfolk, the Southern and the intervening Transitional Province. Furthermore, it was realised that certain marl and flint bands could be correlated across all three provinces. At the same time four formations were recognised in the Northern Province: at its base the flintless Ferriby Chalk Formation, then the Welton Chalk Formation, the Burnham Chalk Formation and, at the top, the flintless Flamborough Chalk Formation. Subsequently, an overlying fifth formation (the Rowe) was identified but only in cores from the North Sea.

Paul explained that during the Late Cretaceous carbon dioxide levels were four times those at present and temperatures were high - perhaps 36°C. Ocean currents flowed in directions different from present and oxygen levels in the oceans were low. Very few animals could survive in such conditions, the only ones which really flourished being minute, planktonic, calcareous algae: the coccolithophorids - the hard parts of which form most of the chalk.

Looking seawards (see photo opposite), the cliffs consisted of numerous beds of chalk dipping gently inland (to the south), thinly bedded except towards the base and across which cut several fractures (some conjugate) and small faults. A number of caves had developed above a prominent ledge which marked the horizon of a soft marl band, the North Ormsby Marl. A thick layer of glacial till was draped over the cliffs and in places smeared the face.

As the strata dipped gently inland we began by walking as far out as possible across the wave-cut platform to look at the oldest strata visible in the bay: the uppermost beds of the Welton Chalk Formation. This formation is characterised by its nodular and burrow structure flints and an absence of any tabular flints. Standing on the wave-cut platform we could identify several flint-filled burrow structures on its surface.

Looking upwards we saw the first tabular flint band, The Ravendale Flint. This is at the base of the Burnham Chalk Formation which is less thinly bedded than the Welton and has several tabular flint bands but only occasional nodular flints. We tried to identify the different flint bands but apart from the curious Vale House Flint Member (the subject of a recent paper by Paul in the PYGS), it was virtually impossible to identify the others without a detailed log: all look very similar. A short discussion took place on the theories of the formation of flint, the origin of the silica and why some formations have flint



Paramoudra in the Burnham Chalk Formation with a tabular flint band above.



The Ulceby Marl Horizon in the Burnham Chalk Formation.

and others do not. Paul said that there appeared to be twice as much iron in the flintless formations and he regarded the "rotted" Vale House Flint as being an incompletely formed tabular flint.

Wandering back towards the slipway and moving up the succession we examined the Burnham Chalk Formation and its tabular flints. We ventured into a blowhole which appeared to have developed along the line of a fault (fault breccia visible). Here lay two large, well-rounded, dark coloured erratics, probably of the Whin Sill or the Cleveland Dyke - evidence that the ice had moved south along the coast during glacial times. Nearby, we found the outline of a sponge and examined iron-coloured splashes on a bed in the cliff face, which Paul said were its soft parts.

Near to the slipway Paul drew to our attention a large, spherical mass of flint (see photo opposite top) which cut through and displaced the surrounding beds. Such flints (paramoudra) surround a narrow vertical shaft (1 or 2 mm wide) filled with chalk and are believed to be caused by flint building up around a vertical burrow. At a slightly higher horizon was a deep groove caused by the soft Ulceby Marl eroding out (see photo opposite bottom). The 5-8cm thick marl was somewhat gritty and Paul said this was because it included crinoid debris and one of our members was fortunate to find part of a crinoid stem. Several flint-filled burrow structures were visible in the cliff face. Finally, before climbing the slipway, we had a look at the Ulceby Oyster Bed with its occasional echinoid shells.

Returning to the car park, Paul shot off to arrange our visit with the RSPB at Bempton whilst we sat and had lunch.

From the cliff-top at Bempton we could look both northwest down the succession toward the Jurassic of Filey Brigg and beyond, and southeast up the succession to Flamborough. Paul drew to our attention the contrast between the near vertical cliffs at Bempton and those at Flamborough. He explained that the glacial till was much thinner here, allowing the chalk to be exposed to eroding forces much more readily, which, combined with the joints and faulting in the chalk and the force of gravity, had led to the very dramatic cliff faces. Much of the activity took place immediately following the last ice age and towards the top of one of the faces we could see a patch of rubbly chalk (periglacial cryoturbation).

Walking east we saw an arch (The Staple) looking very much like an elephant with its trunk dipping into the sea. Continuing along the cliff-top to a small headland, we had been given permission to venture gingerly beyond the safety fence to look back across the small bay of Staple Nook to the other side



The Staple Nook Deformation from the top of Bempton Cliffs

of The Staple (see photo above). The beds to our left (inland) were near horizontal but suddenly became highly contorted before again returning (seawards) to near horizontal at The Staple. Paul explained that the folding and faulting was the result of reactivation of the Howardian Hills - Flamborough Head Fault (Jurassic in age) either during or after the Late Cretaceous. No photo from the cliff top can do justice to such an impressive sight and it was regrettable that the boat could not operate that day.

Paul pointed out that we had seen many different nesting seabirds including gannets, kittiwakes, puffins, guillemots and razorbills and that the variety of birds on these cliffs is much higher than those on the south side of the headland. He thought this was not just because the cliffs at Bempton face the birds' feeding grounds but also that their height, near vertical faces, hard flint bands and beds dipping gently inland, all give greater security to the birds. Inland dipping beds, in particular, mean that any eggs which are dislodged roll inland and not over the cliff edge.

At this point David Holmes thanked Paul on behalf of the group. Although disappointed by the lack of the boat trip, Paul had retrieved the situation and the day had proved to be both enjoyable and interesting - and had provided the bird watchers amongst us with an additional spectacle.

Geology and landscape of Baildon Moor

Saturday 29th July

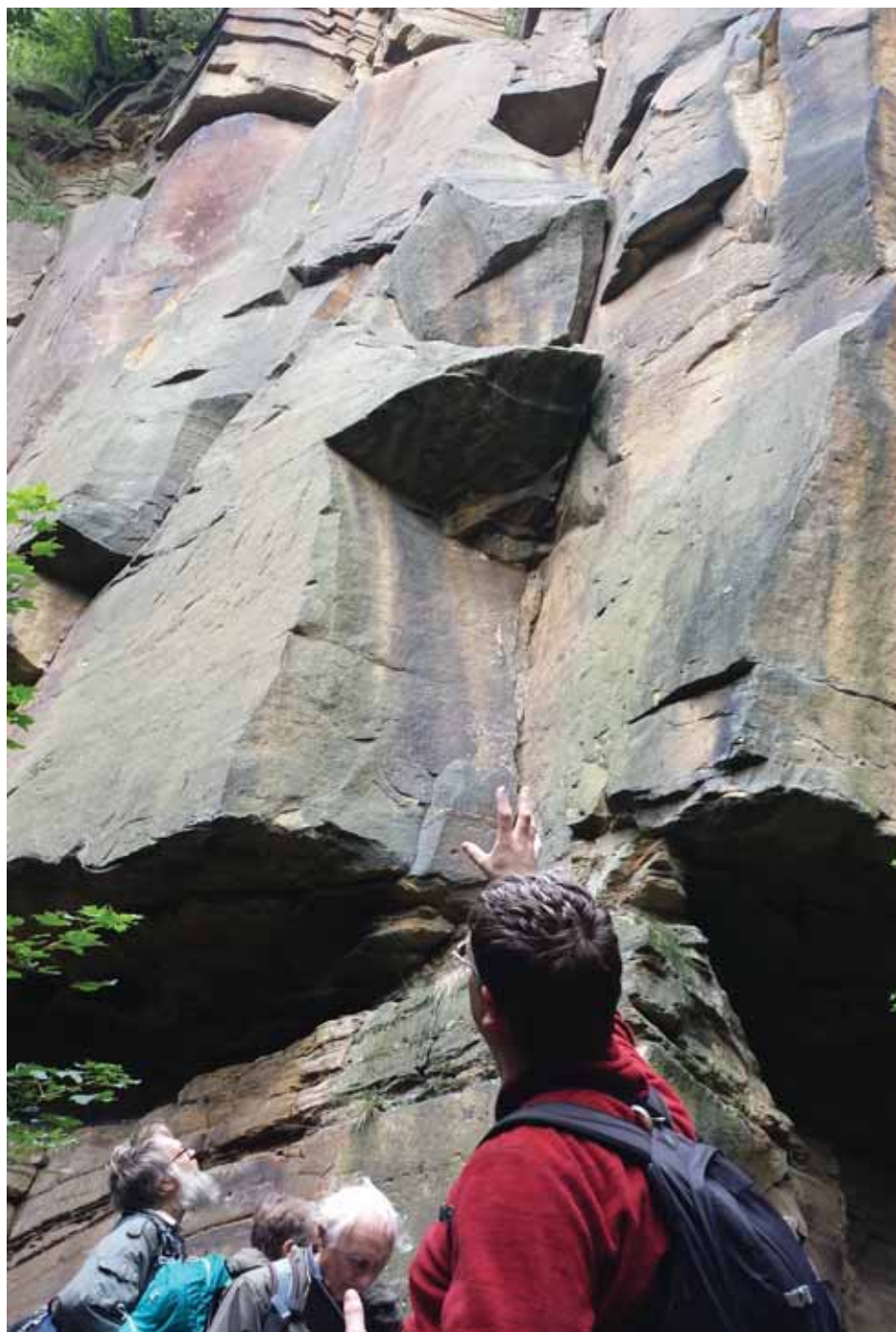
Leader: Dr Gareth Martin. Geomorphologist (Leeds Geological Association & West Yorkshire Geology Trust)

Present: 16 members and 1 visitor

We met in glorious sunshine below Baildon Hill, near the top end of the Shipley Glen Railway, for a walk to observe the Rough Rock and an outlier of Carboniferous Lower Coal Measures which make up the hill. At our meeting point we started by looking at the well exposed surface of the Rough Rock, here consisting of 80% coarse, angular quartz particles and 20% feldspars (mainly microcline) with cross and tabular bedding showing a current flow to the south. It is thought that the sediments which make up the rock are derived from high grade meta-sediments and granites eroded from Archaean aged mountains 4.0-2.5 billion years old.

Moving around the hill to the east to Baildon Green Quarry we saw the junction of the Rough Rock with the underlying Rough Rock Flags, separated by a thin, grey, laminated siltstone bed thinning to the east (see photo overleaf). The Rough Rock Flags show flaggy bedding and are thought to be deposited at the delta front as mouthbar deposits. Further round we arrived at Baildon Bank Quarry which displays a large face of the Rough Rock with metre scale cross-bedding and areas of massive sandstones. The variety in features is attributed to deposition within a huge braided river system similar to the modern Brahmaputra river which contains many very different flow regimes and repeatedly switching channels. In the lower parts of the face large fossil logs of *Calamites* were common. Far below us we could see the River Aire flowing east along the valley bottom following the line of the two parallel faults that divide Baildon Hill from the faulted block to the south. Gareth also pointed out the remains of extensive working of seatearths that were used in the local production of earthenware.

We made our way upward onto a distinct plateau on the top of the Rough Rock, crossing the boundary between the Namurian (Millstone Grit Group), and the Westphalian (Lower Coal Measures). While the direction of sediment supply (from the north) remained essentially unchanged, the lack of marine transgressions in the Westphalian and more stable environment allowed large coal swamps and coals to develop. A break of slope on the footpath up Baildon Hill is likely an expression of the Middle Band Rock which the BGS Bradford map shows here. Above this break of slope we found a small coal exposure above a grey seatearth. Further west along the hill and above this



The Rough Rock overlying the Rough Rock Flags in Baildon Green Quarry

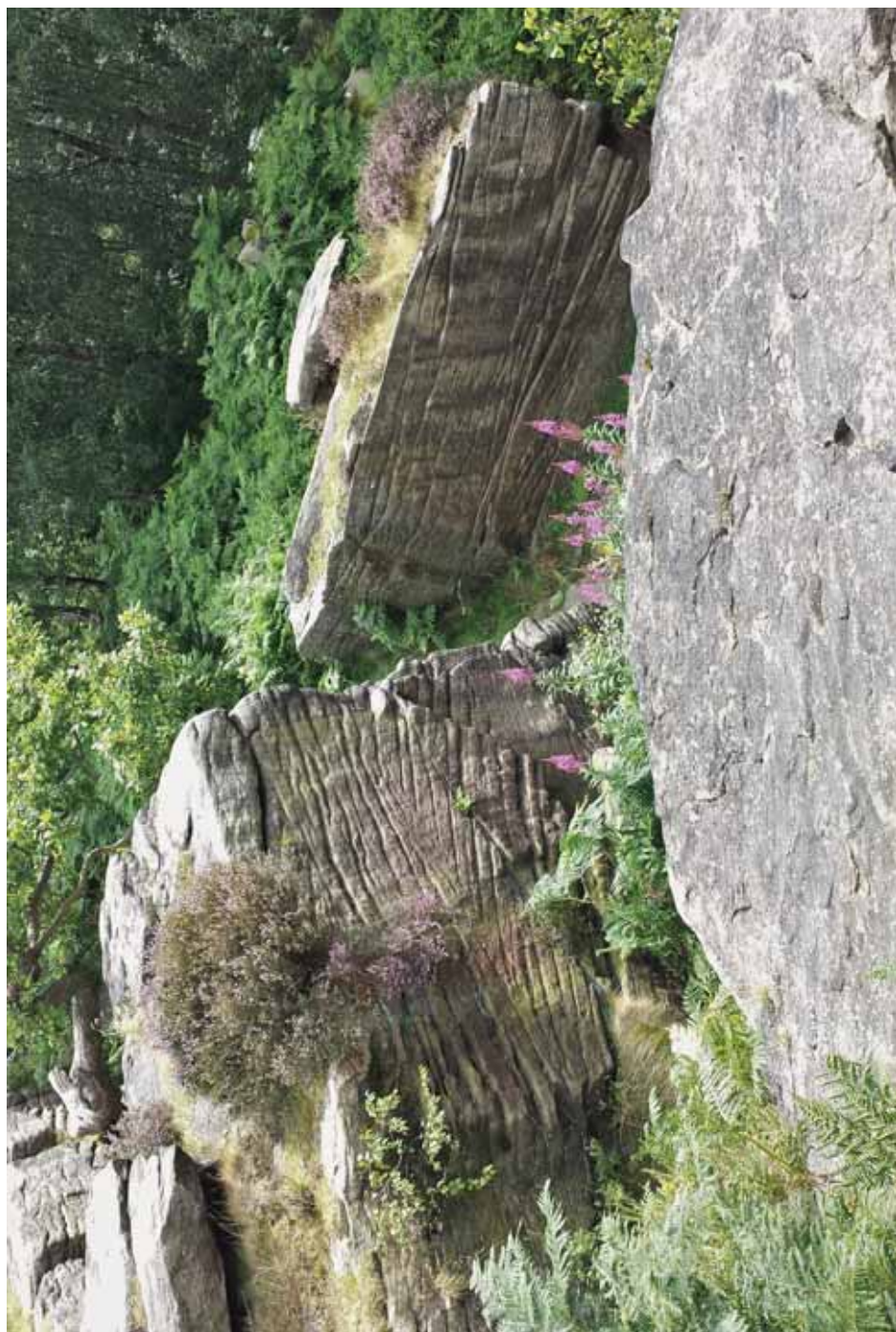


***Gastrioceras listeri* in the *Listeri* Marine Band on Baildon Hill**

coal, located in dense, high bracken, with a lot of help from Gareth, we found a nice exposure of the *Listeri* Marine Band containing good examples of the bivalves *Dunbarella* (similar to a modern-day scallop), *Posidonia* and the important goniatite *Gastrioceras listeri* (see photo above) with which the sea level rise is recognised. Immediately to the west of the marine band was an exposure of the 48 Yard Rock, a fine-grained, cross-bedded and cross-laminated, micaceous sandstone which weathered to a buff orange and yellow colour, its features suggestive of deposition in a low energy, lower delta plain environment. At this exposure it has likely been exploited as a building stone.

On top of the 48 Yard Rock is a large plateau where we were able to find, buried in the high bracken, evidence of vertical bell pit shafts with spoil around them. A look at Google Maps satellite view shows there were a great number of pits dug over the plateau, mostly for coal but some to extract ironstone nodules in mediaeval times for a local bloomery. In the distance we were able to see the 80 Yard Rock which forms the protective cap to the peak of Baildon Hill.

We now made our way down slope towards our start point and were able to look into Shipley Glen and see the beautifully weathered out tabular cross-bedding of the Rough Rock (see photo overleaf). Here we were able to thank Gareth for a very interesting and varied day out.



Tabular cross-bedding in the Rough Rock at Shipley Glen

Yoredale cyclothem and mineralisation in the Northern Pennines. Middlehope Burn, Weardale. Saturday 12th August

**Leader: Brian Young. Honorary Research Fellow, Department of Earth Sciences, University of Durham (formerly of BGS)
Present: 11 members and 1 visitor**

While the main purpose of the visit was to study cyclothem within the Alston Formation of the Carboniferous Yoredale Group as well as features of structural and mineralogical interest of the once great Northern Pennine Ore field, we knew that, with Brian as a leader, we would get a lot more besides and this proved to be no exception. In addition to Brian's wealth of knowledge of the area we were also fortunate that longstanding LGA member (ex-president), John Varker, was in attendance. Not only is John local to the area but this was one of the localities where he had sampled and analyzed limestones as part of his PhD, 50 years previously. While the forecast had been for a day of sunshine, shower clouds were making their presence felt as we left Westgate and walked up through the curiously named hamlet of Weeds. Pausing in the shelter of trees at the first outcrop of solid rock, Brian outlined the geology of the area.

Weardale is located on the Alston Block which, like the Askrigg Block of Yorkshire, has a basement of folded Lower Palaeozoic rocks intruded by granite and overlain by a relatively thin cover of rocks of Lower and Upper Carboniferous age. The Carboniferous rocks, like those of Yorkshire, consist mainly of a number of cyclothem and belong to the Yoredale Group. In the lower, Alston Formation, the cyclothem are of limestone, shale and sandstone but in the overlying Stainmore Formation they are mainly of shale and sandstone. While many of the Alston Block limestones can be correlated with their equivalents on the Askrigg Block their names differ, which is not surprising as many of these were originally given by miners using the local characteristics of the rocks. Other similarities to the Askrigg Block are that all beds generally dip very slightly to the east and that it has a rich lead/zinc orefield but a difference is that the rocks of the Alston Block were invaded by the Whin Sill.

The first solid outcrop seen in the Burn where it formed a series of waterfalls was the Scar Limestone; a dark grey, muddy rock with a strong bituminous smell when broken, which is typical of all the North Pennine limestones. Above this the burn occupies a deep gorge which exposed a considerable thickness of shale overlain by flaggy sandstones with a thicker one at the top forming a prominent waterfall. The sandstone is known locally as the 'Slaty



Erosive contact between sandstone and shale

Hazle' - hazle being a North Pennine miners' term for sandstone. These rocks and a unit of shale which lies above the sandstone, belong to the Scar Limestone cyclothem. The base of the next cyclothem was marked by another series of waterfalls but this time formed of limestone; the Five Yard Limestone. In a cliff section further upstream the shale and sandstone (The Six Fathom Hazle) of the Five Yard Limestone cyclothem were clearly exposed. The contact between the sandstone and shale is clearly erosive as the sandstone cuts down into the shale (see photo above). At this point John Varker outlined some of the work his earlier studies of these limestones had revealed. This had involved sampling all the Yoredale limestones and dissolving them to extract conodonts for use in stratigraphy. This had revealed a constancy in their pattern of distribution through each limestone unit with their abundance being low at the base, rising to a maximum in the upper 1/3 of the unit before decreasing towards the top. While a number of factors may contribute towards this, John identified the main reason as being related to the rate of deposition of the carbonate material; the greater the abundance of conodonts, the slower the rate of deposition. The frequency curve within a limestone then makes it possible to tell if the layer suffered any post depositional erosion which, in the case of the Three Yard Limestone that occurs above the Five Yard (but which is not exposed at this location in Middlehope Burn), is the case.

Approaching the site of the Slitt Mine the shale and sandstones (the Natrass Gill Hazle) of the Three Yard Limestone cyclothem were noted with again the sandstone having an erosive contact with the underlying shale marking the position of a channel. A short distance further on the previously horizontal beds now had a steep dip indicating the approach to a significant fault line. Prior to lunch amongst the conserved ruins of the Low Slitt Mine Brian pointed out and explained the significance of 'metallophytes', plants that are tolerant of high levels of heavy metals in the soil.

With lunch over for us we became lunch for the midges as Brian outlined the stages in the understanding of the origin of the North Pennine Orefield and its history of mining. The fact that large amounts of galena, sphalerite and iron ores and gangues of fluorite, quartz, baryte and witherite occurred in veins within the competent rocks of the area had been established by the long history of mining, well before geologists began to consider their origins. Miners had also recognised the fact that the veins ran in three principal directions. Most numerous and productive of galena were those that run ENE-WSW, less numerous and often barren were those that run NNW-SSE, and finally, a few which run E-W known as the Quarter Point veins which have a strong sinistral displacement and while generally low in sulphide minerals, are rich in fluorspar. In addition to ores occurring in veins, 'flat' deposits are also widespread. These are where beds of limestone adjacent to faults have been replaced by introduced minerals. Also recognised was the marked concentric zoning of the minerals with a central zone rich in fluorspar and an outer one of baryte and witherite. These zones are temperature controlled with the central zone minerals indicating temperatures of 110-220°C and the outer one 50-60°C. Initially it was believed that the source of the minerals were hydrothermal fluids emanating from a granite intrusion, perhaps of Variscan age (as in Cornwall). Gravity studies supported the presence of such a body and outlined its likely shape (which closely coincides with the mineral zones) and depth. When money was obtained to drill a borehole at Rookhope the expected granite was proved (see photo overleaf top) but its top surface was eroded and deeply weathered, indicating that the granite predated the Carboniferous rocks and therefore could not have been direct source of the minerals. What is now believed to have happened is that, in early Permian times, the high-heat Weardale Granite drove a convective circulation of brines derived from dewatering of adjoining sedimentary basins. These hot brines passed through the upper portions of the granite body and its surrounding Lower Palaeozoic rocks, the Carboniferous sedimentary rocks and the Whin Sill, scavenging metals from them on their way. Minerals were deposited by crystallisation from solution as the fluids cooled on their journey upwards and outwards along the faults and fissures and as the fluids reacted with limestone beds.



Specimen of the Weardale Granite from the Rookhope Borehole.



Fluorite and Quartz crystals on the wall of the Slitt Vein

The Slitt Vein on which the mine stands is one of the 'Quarter Point' veins and, at over 20km, is the longest single vein in the North Pennines. These veins typically have a sinistral component and signs of this could be seen by the faint slickensides on an exposed wall of the fault which here cuts through sandstone (Nattrass Gill Hazle). On adjacent surfaces well formed crystals of purple fluorite, (see photo opposite bottom) clear quartz and galena were also visible. The vein was worked here in an open cut, (see photo below) by a level, and also from a shaft which was sunk to a depth of 177 metres to reach the Tynebottom Limestone and the Whin Sill, here intruded immediately beneath it. Whereas most Quarter Point veins were generally richer in fluorspar than sulphides, at Slitt Mine the Slitt Vein was rather unusual in carrying significant amounts of galena - sufficient to yield over 100,000 tons over its productive life which ended in 1878.



Open cut working along the Slitt Vein



West Rigg Opencut Mine

Moving further up the valley the next limestone in the sequence was encountered; the Four Fathom Limestone (equivalent to the Underset Limestone of the Askrigg Block) which here is medium to dark grey with conspicuous crinoid and shell debris and with a strong bituminous smell when freshly broken. At this point it was decided to take a short cut to the final location so we returned to the Low Slitt Mine and took a direct line out of the burn, passing through the extensive spoil heaps of the Slitt Pasture Mine, an opencast working on the valley side on the Slitt Vein, to reach the West Rigg Opencut Mine on the valley top.

The LGA visited this site in 2012 but for many on today's visit this was new. It is a remarkable site consisting of a large open quarry with a prominent 10-15 m wide rib of rock running through it, which itself is cut through the middle by a narrow slit (see photo opposite). The central rib is the Slitt Vein and the rock making up the quarry walls is the Great Limestone, the Yorkshire equivalent being the Main Limestone. The mine was worked for ironstone which formed as a 'flat' deposit of siderite (iron carbonate) as hydrothermal fluids flowing up and along the Slitt Vein reacted with, and replaced, the thick limestone where it was overlain by impervious shale. The flats were subsequently weathered by supergene processes to goethite (iron hydroxide), a soft, brown mineral, which occurs in abundance around the site. The central rib is the mineral vein itself and is largely composed of quartz with patches of brecciated limestone. On its outer surfaces good examples of sub-horizontal slickensides were seen (photo overleaf), matching those at the Low Slitt Mine in the burn below. The cavity through the middle is the 'stope' cut by miners working the galena rich band through the centre of the vein. These were the earliest workings on the site and it was only the later opencast working for iron ore that exposed the remains of the vein. The high proportion of iron in the hydrothermal fluids that created these deposits is believed to have been formed by fluids which passed through the Whin Sill. To the west, across Middlehope Burn, further workings marked the line of the vein running up the hillside. After discussion of the other minerals found along this vein and in the area, and the potential for future exploitation, Brian was thanked for such an interesting and entertaining day.



Slickensides on the wall of the Slitt Vein

A walk around Castleton to look at carbonate platform margins

Sunday 3rd September

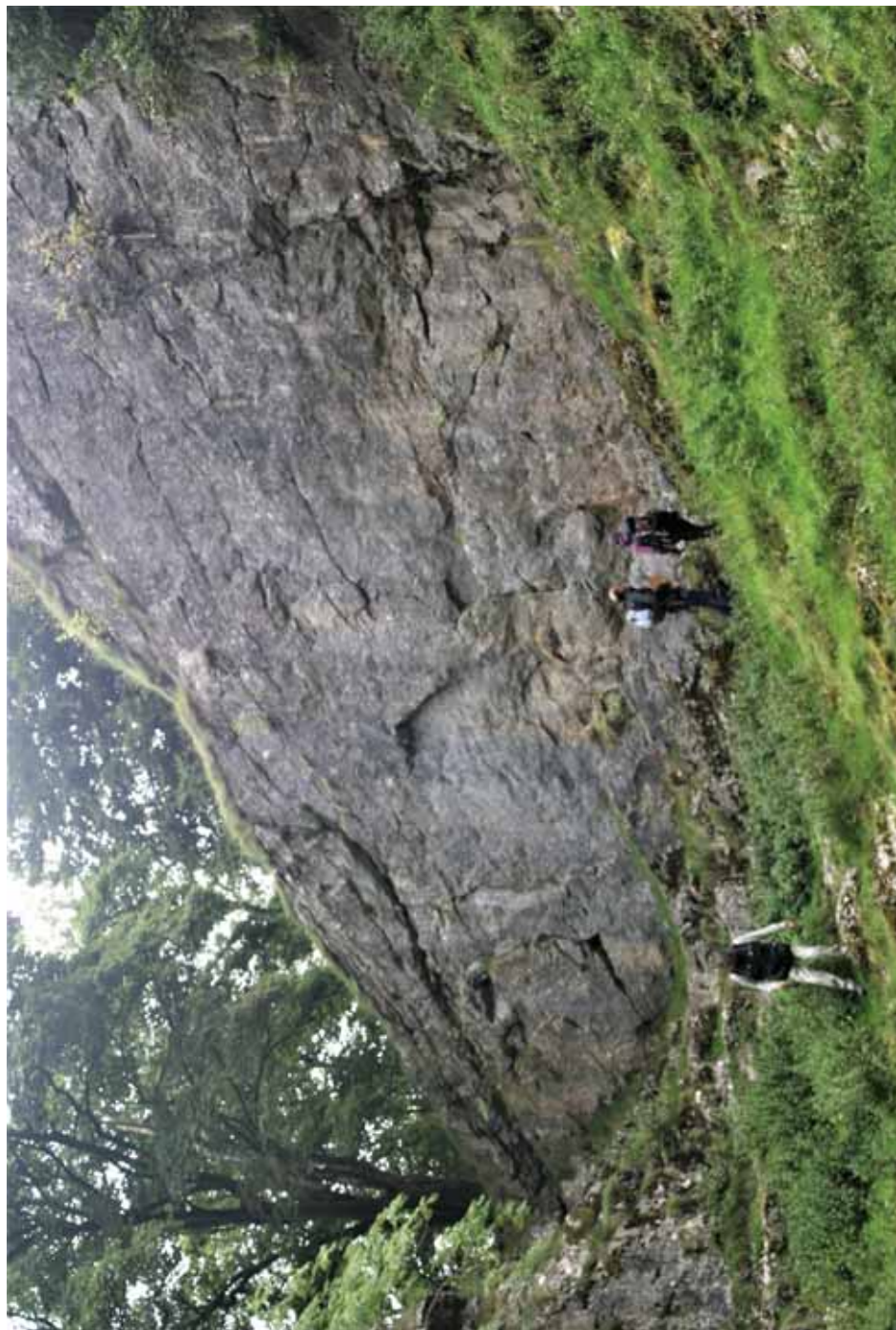
Leaders: Dr Cathy Hollis and Lucy Manifold (Manchester University)

Present: 5 LGA and 11 Manchester Geological Association members.

On a rather grey day, members of Leeds and Manchester Geological Associations met Cathy and Lucy in the car park in the middle of Castleton where, after introductions, Cathy outlined the regional setting of the area.

In Lower Carboniferous times the crust in the area that was to become the North of England consisted of eroded Lower Palaeozoic rocks intruded in places by granites. Back arc extension (linked to the closure of the Rheic Ocean to the south) resulted in the crust fracturing along lines of weakness developed during the preceding Caledonian Orogeny. Between the Southern Uplands Massif to the north and the Wales – Brabant Massif to the south a series of fault-bounded 'blocks' with intervening grabens and half-grabens ('basins') developed. A pattern of differential subsidence became established as the blocks remained buoyant while the basins subsided. The basins began receiving sediment from surrounding blocks early and, as they continued to subside throughout Lower Carboniferous times, limestone and clastic mudstone accumulated, in mainly deep water, to form considerable thicknesses. A combination of tectonics and fluctuating sea levels due to periodic melting of ice-caps covering southern Gondwanaland saw the blocks submerged under shallow seas but without any supply of terrigenous sediment. Carbonate platforms developed across their tops with some of the material being shed down their flanks. Unlike the Askrigg and Alston Blocks to the north where geophysical evidence was used to site boreholes that proved granite intrusions in deformed Lower Palaeozoic rocks, no such signs exist for the Derbyshire Platform and no boreholes have penetrated the complete carbonate cover. Current thinking is that the basement for this platform therefore consists only of Lower Palaeozoic rocks. The day's itinerary was to take us from the margin of the Edale Gulf (a basin) onto the Derbyshire Platform (a block), viewing the nature of the carbonates deposited on the way as well as mineralisation.

From the village we began to climb Cave Dale, a steep, narrow, dry valley cut in thick limestone of Asbian age. The first locality, an old quarry above the village, revealed tall faces of massive limestones with a northerly dip of 15 – 25° (see photo overleaf). Lichens covered most of the accessible rock faces



Massive limestones deposited on platform slope.



Massive Reef limestone surrounded by bedded limestone.

and, as it is a National Park and hammering was not allowed, details of textures and structures were difficult to see. It was, however, possible to find fossil debris, mostly crinoidal but some brachiopods, and some distinctly 'rubbly' layers. The broken nature of the fossils, the rubbly layers and the dip of beds indicated that this site was located on the platform slope and that the material had been transported down this before coming to rest on an inclined surface. Geopetal structures have been found at this site which confirms that the dip of the beds is original but we were unable to locate any on this occasion.

At the next locality, in a prominent crag, the limestone occurred as a massive body made of fine-grained carbonate and contained abundant brachiopod and crinoids remains. This was a 'reef' although it would not have looked much like modern ones, being more a mound made of shell material bound together by algal growths. The existence of reefs, and the fact that bedding to the south was now horizontal, (see photo previous page) indicated that it had formed at the edge of the platform top and it was from this type of location that material was being shed down the platform slope. Looking across the narrow valley another massive limestone surrounded by bedded rock indicated that the width of this reef belt was in the order of 100m. Discussion took place on the origins of carbonate mud and the difficulty in using modern carbonate environments as analogues due to the variations in composition of seawater over time. A short distance on, an E-W fault was exposed on the walls of both sides of the valley (see photo on back cover). While the major faults that control the platform margin have been detected by seismic surveys they do not appear at the surface and this was an associated one. The fault plane, which was approximately 2 m wide, was filled with coarsely crystalline calcite. This was arranged in distinctive layers showing that the fault had widened in stages. Vertical displacement was minimal showing this was a strike-slip fault which is common in faults on the platform.

Continuing up the steep narrow path the next outcrop encountered was of basalt lavas. The flow was approx 4-5 m thick and, in places, showed good columnar structure (see photo opposite). There are a number of similar outcrops around the platform as well as others known from boreholes and all originate from volcanic centres at Buxton, Bakewell and Matlock and are related to the extension tectonics that occurred throughout Lower Carboniferous times. Discussion took place as to whether this outcrop was the result of submarine or subaerial activity. Shortly after this the moor top was reached and we followed a track taking care to avoid the masses of mountain bikers descending at high speed. A brief stop was made to observe the faces of opencast workings for fluorspar in Dirtlow Rake, a mineral vein of the Derbyshire Orefield

After a lunch taken above some abandoned workings in Dirlow Rake (see Photo on inside back cover) these were examined more closely from below. This vein has been worked for galena for a long period of time but between the early 1970's and late 1990's operations were renewed for fluorspar. The vein is approximately 10 m wide and here had been worked to a depth of around 15-20 m leaving a deep narrow chasm in the surrounding land surface, clearly exposing the sides of the fracture. These displayed some excellent examples of slickensides which showed that movement along this NE-SW trending fault was largely horizontal and, in places, were coated in deposits of baryte showing fan-shaped patterns. Plenty of samples of barites containing galena and traces of fluorite were seen on the quarry floor. There is no known granite mass within the basement rocks of the Derbyshire Platform so the origin of the hydrothermal fluids that created these deposits is different from that we had seen in the Alston Block on our previous field trip to Weardale. These are believed to have originated from deep burial of shale in the adjacent Edale Gulf causing dewatering, with the hot fluids rising through the shale, scavenging metals as they rose up dip and into and along the faults in the limestones of the platform.



Columnar basalts



Solitary rugose coral surrounded by crinoid and brachiopod debris.

From Dirlow Rake a steep descent was made into Pin Dale Quarry, an abandoned working of the Hope Limestone Works. This long, narrow quarry has faces up to 30 m high and exposes beds of Brigantian age which are better bedded than the Asbian limestones seen in Cave Dale. Several of the bedding planes are identified by narrow, grass covered benches which correspond to erosion levels, formed at times of sea level fall which exposed the carbonate sediments to weathering and erosion and development of soils. Examination of outcrops at the base of the cliffs showed that, in places, the rock consisted of extremely coarse grainstones made up of coarse brachiopod and crinoids debris in which large solitary and rugose corals lay in random positions (see photo above). These are further examples of material deposited as shoals (sandbars) by strong wave and current action in shallow waters on the platform top. At the mouth of the quarry a large carbonate mound was almost completely obscured by vegetation but its existence marks that, once again, we had reached the margin of the platform.

At this point Cathy and Lucy were thanked for such an interesting day and the party made its way back to Castleton. On the way, in a roadside exposure, a fine example of platform top carbonates consisting almost completely of stacked brachiopods was observed.



Dirtlow Rake



E-W strike-slip fault associated with platform margin.