Leeds Geological Association

Founded 1874 - Registered Charity No. 1016696

Field Visit Reports

Summer 2004

130th Anniversary Year

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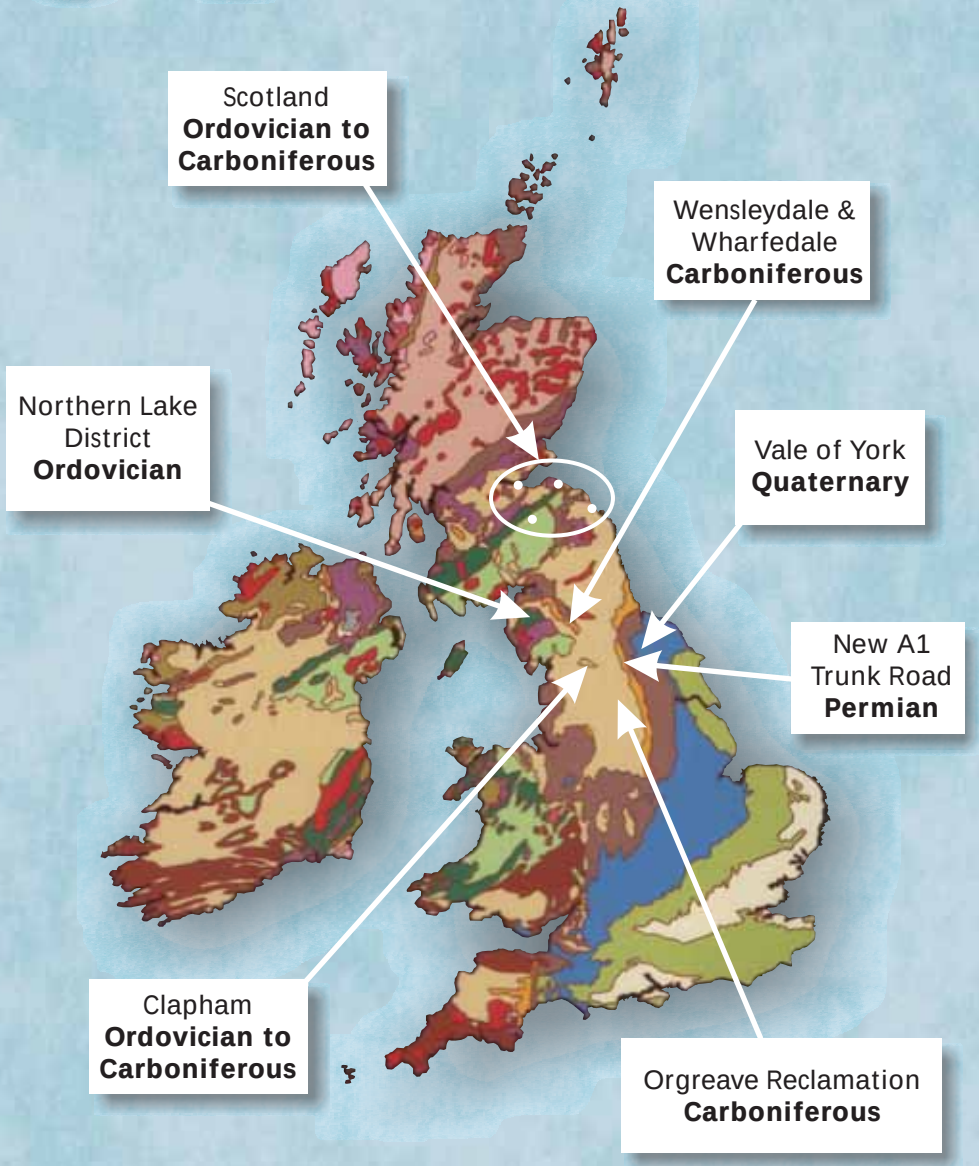
130th Anniversary Year

Where did we go?



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Cover picture: David Stephenson describes to the group Hutton's Section on Salisbury Craig, Arthur's Seat, Edinburgh.

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Glacial Features in the Vale of York
Saturday 15th May

Leaders : Tony Cooper, Jon Ford and Holger Kessler (BGS Keyworth)
15 Members present

Introduction : The British Geological Survey (BGS) are currently producing a new edition of the Selby Sheet. The area of this sheet was first mapped in the 1880s, though the drift deposits received very little attention. Further work during the 1970s resulted in an updated version being published in 1973. The latest mapping has investigated the drift deposits in detail, establishing their stratigraphy and relating it to events during the glaciation of the Vale of York. Some of the conclusions reached, in particular those regarding the maximum limit of the ice front, are at odds with the established story and may require the text books to be rewritten. This field meeting provided an opportunity to assess the evidence at first hand.

Geological Background : The drift deposits of the Selby Sheet record the advance of the Vale of York ice sheet to its maximum extent (at around 18ka) and its subsequent wastage during the closing stages of the last (Devensian) glaciation. Post-glacial sediments are also present. A new stratigraphy for the drift deposits, based on lithological differences, has been established and distinguishes the following members :

Hemingbrough Glaciolacustrine Formation. This is a laterally and vertically persistent body comprising up to 20m of laminated clays and silts interspersed with sand beds. It was deposited in a vast lake that formed ahead of the southwards advancing Vale of York ice when drainage through the Humber Gap was blocked. Three subdivisions are recognised:

- *Thorganby Clay Member :* laminated silt and clay
- *Lawn House Member :* silty sands, commonly water-saturated, forming "running sands"
- *Park Farm Member :* a consistent unit of silt and clay

Vale of York Till Formation . This is present as a basal till to the north of the Escrick Moraine and as melt-out till on the moraine itself. It is inferred from borehole and other evidence that it does not extend further south than Escrick. Clasts are predominantly Carboniferous limestone and sandstone of local origin.

Poppleton Glaciofluvial Formation. This unit, which includes the Crockey Hill Esker Member, commonly overlies the Vale of York Till or rests directly on bedrock. It comprises bedded sand and gravel with rare clay horizons and was probably deposited by fluvial systems under, within and on top of the southward advancing ice.

Breighton Sand Formation. These sandy sediments blanket the underlying

formations and are known as "Cover Sands", although in places they have been removed by later erosion. They probably originated in fluvial systems and were later modified by aeolian processes.

Description.
Six localities were visited to examine the evidence. These are briefly described below, but for a more detailed, illustrated description see a copy of the field visit hand-out or the reference at the conclusion of these notes.

Locality1
Our start point for the day was a lay-by on the A19 close to North Deighton (SE 627 447). Here, with the aid of several large maps and the side of their minibus, the leaders introduced the day with a summary of the drift deposits found in the Selby area. Their work has used digital datasets and computer visualisation together with borehole data and field observations to revise the stratigraphy of the drift. In the course of their work no evidence for the presence of the ice sheet beyond the Escrick Moraine has been found. This contradicts previous work which has suggested a short lived advance down to the Isle of Axholme.
Driving south along the A19 we followed the line of the Crockey Hill Esker, a long ridge of sand and gravel assigned to the Poppleton Glaciofluvial Formation. On reaching Escrick we noted the rise of the Escrick Moraine.

Locality 2
East of Stillingfleet the Biffa Clay Pit (SE 621 403) exposes silts and clays of the Hemingbrough Formation. These were deposited in front of the ice sheet on the bed of a lake. Later erosion has reduced their thickness to around 5m here. Close examination revealed silty ripple marks on some surfaces. Tectonism has also been seen here, attributed to the ice advance.

Locality 3
Near to the Stillingfleet Radio Mast (SE 605 418) field mapping has revealed patchy till attributed to small push moraines.
Moving from this site we crossed over sandy lake deposits behind the Escrick Moraine which have proved to be good soil for cultivating turf, carrots and potatoes! Holger Kessler has found peats in this area.

Locality 4
At Little Skipwith (SE 648 388) there is a low hollow in the surrounding cover sands cut by post-glacial drainage. Here there is more complete sequence of the Hemingbrough Formation than at Locality 2. A little digging brought up a sample of the sandy Lawn House Member. The high silt content of this unit makes it a potential geohazard. It is a mini-aquifer and very unstable as a foundation - hence the term applied to it of "running sand". It is almost never seen at outcrop because it erodes so easily. Though it is thin the distinct engineering property of this member can be used to map it.

Locality 5
The "cover sands" are generally higher than the surrounding deposits.
On Skipwith Common (SE 669 378) Holger demonstrated the use of the auger.
Cores here have shown the upper clay of the Hemingbrough Formation is missing.
Peats imply a warming climate and waterlogged conditions. The sharp cooling associated with the Younger Dryas was accompanied by the deposition of the "cover sands."

Holger Kessler demonstrates use of the auger.

Locality 6
Having left the cover sands of Locality 5 we moved on to look at the post-glacial alluvial deposits on the floodplain of the River Derwent, and considered the issue of flooding.
The BGS has been working with the Environment Agency to help predict areas liable to flooding and have been engaged in mapping the flood embankments. A lack of upstream relief tends to push flooding downstream and drainage is inhibited by the underlying clay. Mining in the Selby area has also lowered the ground level and with it the level of the flood embankments.

Further Reading
Hand-out for the field visit

Ford J F, Kessler H K, Price S J, Hall M & Cooper A H. 2004 . Field Guide to the Glacial Evolution of the Vale of York. British Geological Survey Internal Report IR/04/106

BGS 1 : 50000 Selby Sheet 71 (Drift)

UK Coal / Orgreave Reclamation Site, Sheffield Thursday 20th May

Leaders : Mr Derek Harrison and Mr Simon Wood, UK Coal. 14 members present

After introduction of our two leaders from UK Coal, Derek Harrison, Site Manager and Simon Wood, Site Engineer, the group toured the very large (260 hectare) working area in 4 x 4 vehicles, stopping for an on foot inspection of the (current) pit from the top, the working floor and to inspect the fault which runs through the site.

Orgreave was the site for many years of a conventional deep mine and a coking plant; it became notorious as an emotional focal point during the miner's strike in the mid 1980's, with fierce clashes as strikers attempted to prevent coal supplies reaching the coking plant. The plant and the mine finally closed in the early 1990's.

Today, UK Coal is reaching the end of a 12 year contract to "clear up the environmental mess" from the coking plant, extract 5 million tonnes of coal by open cast mining on the site, and to restore the site for industrial, residential, recreational and amenity use. The contract was awarded in 1995 and is due for completion in 2007, with coal extraction completed in autumn 2005. The site has 76 UK Coal employees, but the real stars of course are the huge excavators, dozers, shovels and dump trucks which consume 36000 litres of fuel every day to extract up to 2000 tonnes of coal. To date 3.7 (of 4.2) million tonnes of coal has been mined, and a further 0.6 (of 0.7) million extracted from the old inefficient mine tips by barrel washers. The product is transported by lorry to a local blending plant and then direct by rail to local power stations. During the whole Project to remove and contain contaminated material and to remove overburden for coal extraction, a total of almost 100 million cubic metres of material will have been moved.

Our visit to the workings first had to cross the site, and we realised the enormous scale of the operation. At the time of our visit the pit (see photo) had a depth of about 90 metres, but it had previously reached 130 metres. It is a very large hole of about 9 million cubic metres! Coal extraction is hampered by a fault running approximately NW / SE, with a downthrow of about 14m to the SW. Removal by

General view of Orgreave open cast pit

erosion of upper seams to the NE of the fault has resulted in 7 seams being worked on the downthrow side and only 3 on the north side of the fault. The fault is very clear, and a large sandstone member can be followed across the site, showing the displacement. Thickness of the seams varies from 0.1 to 1.5 metres, the main seams being Meltonfield and High Hazel; the seams here are, of course, much higher in the sequence than those we are familiar with closer to Leeds.

The orderliness of such a large operation is very impressive, as well as the use of heavy equipment to remove final cover from and then extract thin seams of coal.(see photo) A lot of water drains into the low point of the pit and is pumped away. The "most polluted river in Europe" - the infamous Rother - ran across the site and an early task was to divert 800 metres of river course to beyond the site perimeter. We were proudly shown the "new" river by its creator Simon Wood, who swore that the herons on view alongside this charming landscaped fishing river were not UK Coal employees!

View inside main coaling area

In discussion afterwards, a visitor with our party, John Price of ROC-Oil UK, had kindly brought a seismograph section across this location which he explained, and we viewed and discussed UK Coal's plans for reclamation of the area.
Some 2 million tonnes of contaminated material fron the coking plant has been removed and placed in specially designed and engineered containment cells. These cannot be built on or even have trees planted as roots would pierce the sealing membrane, and will be play/picnic areas. Half of the site will be compacted and made available for light industrial and residential development, and the remainder landscaped for recreation and amenity use. Once the old tips are removed, parts of the outer environs of Sheffield will be able to see each other for the first time in over half a century!

Against this success story the future of coal-fired power generation is under serious threat with pressure to reduce harmful emissions. Coal extraction by deep or surface mining is only likely to continue if a decision is taken by Government to purchase and deploy expensive new washing technology in the near future.

We had enjoyed a most interesting and informative tour under very pleasant conditions and our thanks went to our hosts, UK Coal. As we headed north up the A1 through a severe thunderstorm we reflected that it might have been a very different experience.

RMS (A1) Construction, Darrington to Hook Moor
Thursday 5th August

Leaders : Mr Ian Dunn / Mr Alan Willoner (RMS Construction)
13 Members present

This visit, originally planned for 30th June, had been postponed because of very wet and muddy conditions. Our hosts at the RMS (Road Management Services) site depot just off the A63, 1km east of the Selby Fork junction with the present A1, were Messrs. Ian Dunn and Alan Willoner (Site Geologist) of RMS.

Mr Dunn explained that the work was part of the ultimate plan to upgrade the A1 road to motorway standard from Darrington to Dishforth. He was concerned with two sections which RMS, (a consortium of the contractors AMEC, Alfred McAlpine, Dragados and Kellog,Brown and Root) , were to design, finance, build and subsequently maintain for a period of 33 years under the Government's Private Finance Initiative. The project will create a total of 53km of motorway; the main southern section from Darrington to Hook Moor will cost an estimated £189M, and the northern section from Wetherby to Walshford an estimated £51M. Both sections are completely new roads away from the existing A1, parts of which will remain as single carriageway sections for local transport. Together these works form the largest civil engineering project in the north of England at the present time.

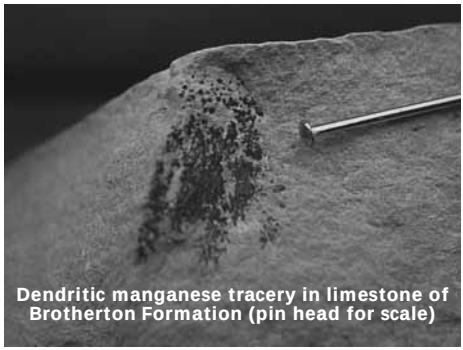
Mr Willoner outlined the surface geology of the works around the Ferrybridge area, and Mr John Price of ROC-Oil UK Ltd (who was attending as an LGA visitor) presented and analysed a very informative seismic diagram of the structure of the Permian strata of East Lincolnshire. This had been produced in connection with a proposed borehole near Louth which is expected to tap an important gas/oil field of a size comparable with some of the smaller offshore gas fields of the southern North Sea.

The group visited locations on the southern section, which, in places, is already complete and surfaced (in order to open part of the route early). We included points of special interest close to the M62, where a major new motorway intersection is being constructed, and a new bridge over the River Aire, west of Ferrybridge Power Station. It was in this area, as widely reported in the press, that an Iron Age chariot was exposed during site excavations - good evidence of pre-Roman occupation in South Yorkshire. The exact location is being kept secret!

Project excavations in the Ferrybridge area had been mainly in the dolomitic limestones of the Cadeby Formation, close to the base of the Permian, a formation whose thickness here was estimated to be about 40m. There had been a report of the orange coloured Basal Permian Sands being seen in one of the pits for foundations of a motorway sign gantry. In the underlying Carboniferous strata there are NE/SW faults which were reactivated in Permian times, leading to fissures up to 10cm wide in some parts of the Cadeby Formation. In the limited number of sites we had time to visit, both the strata and the topography are generally horizontal. Although very large amounts of Permian material are being excavated and reworked for filling (see photo - over leaf), there is a deficiency of fill material within the project area and some 800,000 cu.m. of additional fill material is being transported from opencast colliery tips in the Castleford/Pontefract area. This darker coloured Carboniferous material, rich in carbonaceous fossils, now contrasts strongly with the light yellow dolomitic limestone when used for bankings. These will eventually be landscaped.

Permian material being re-worked

During our rapid tour in a convoy of three 4x4 vehicles, it was impossible to know the exact geological position in the sequence of each location visited. We did examine two temporary quarries which had been opened up to provide local materials for the civil engineers to use. One was in the lower part of the Cadeby Limestone, a thick yellowish-coloured rock, with well defined bedding, the lighter coloured part of which had been found to have a moderately weak compressive strength, rendering it suitable only for ground fill purposes. There were blocks in this area faulted up by reactivation of Carboniferous disturbances. The second quarry, in the Brotherton Formation limestone, was less vuggy than the Cadeby, and was of moderate strength, suitable for use in the concrete aggregates required on site. A glacial till on top of the Brotherton had originally been classified as a marl, possibly because the Edlington Formation marl itself (with its white band of badly weathered gypsum) was exposed above the Brotherton to the south of this site. An interesting feature of this second quarry was the attractive thin dendritic manganese tracery seen when some of the smaller hand specimens of the Brotherton limestones were broken. (see photo)



Dendritic manganese tracery in limestone of Brotherton Formation (pin head for scale)

A major engineering complication of the Project is construction of a full motorway underpass beneath the M62 without interrupting E-W traffic. This is being constructed in 3 phases. The first bridge was built alongside the existing road, and when complete carried all eastbound traffic. A second phase is now being constructed, with major problems as overhead equipment cannot be used. This will carry all westbound traffic during construction of the final phase, so that normal M62 traffic flow can continue throughout the operation. We saw the second phase in construction, showing large exposures of yellow dolomitic limestone with very vuggy horizons. Some of the cavities produced by volume changes during dolomitisation were several litres in volume and contained typical calcitic encrustation. Fortunately the main vuggy band is well below the surface of the M62 and poses no engineering problems.

An attempt to examine a deep excavation for the foundation of an overhead sign, which might have exposed the Basal Permian Sands, failed due to poor light and a rapidly approaching thunderstorm, which caused the field trip to be terminated prematurely at about 8.30pm, with thanks to RMS and our leaders and drivers for a most interesting field visit.

Celebratory Outing to Wharfedale and Wensleydale Saturday 12th June (See photographs page 15)

Leaders : Tony Benfield and Dr John Varker

A central feature in our celebration of the 130th year of the Association was for some past members and officers together with longstanding members and current officers to share a relaxing day in the field based on a coach outing with a commentary over familiar ground. The chosen route was a circuit from Leeds into and up Wharfedale, visiting Swinden limestone quarry near Grassington in the morning and Aysgarth in the afternoon with a picnic lunch at Buckden and a final stop for tea and ice-cream at Jervaulx.

Good weather was important and whilst it was not a 'scorcher' we certainly had a fine day. A party of 25 were collected early from Wetherby, Leeds and Otley; from the 'off' in Leeds we had a thoroughly informative and entertaining commentary from John, based on the splendid hand-out which he and Tony had prepared for the day. This covered not only geology and geomorphology but also some very interesting social and environmental background as we passed through the Leeds suburbs and continued up Wharfedale.

At Swinden Quarry, now run by Tarmac, (part of Anglo American plc), we saw interesting displays of the development of the site, product samples and end-uses, fossils and minerals found over the years, and were shown an informative video on the history of the site and its transformation from famous industrial 'blot on the landscape' to the well-screened, rail-linked and much bigger enterprise that it is today. After a walk to the viewpoint for an overview of the modern operation, with mobile primary crusher at the rockface, served by a very long conveyor belt system, we had the privilege of a circuit of the workings in the coach to see the workface close up and to experience the scale of the operation.

The geocommentary continued, looking at glacial features and the limestone sequence up the dale and over Bishopdale to Aysgarth, 'interrupted' by a most enjoyable picnic lunch and opportunity for reminiscences at Buckden. Into Bishopdale Tony Benfield took over as party leader, and at Aysgarth we walked up the river bank where Tony reminded us of the environment in which the classic Yoredale cyclothems were deposited and we examined local glacial features; waterfalls were unfortunately water trickles on the day, detracting from a photo-opportunity. The party then progressed to the famous Brymor establishment for tea and the inevitable ice-cream en route to a gentle drive home over Triassic and Permian strata down the A1.

Participants agreed that a thoroughly relaxing and informative day had been enjoyed by all, and our thanks go to the leaders for their enormous contribution to a memorable day.

Anniversary outing to repeat the first LGA field Visit Sunday 11th July (See photographs pages 16-18)

Leader : Dr Neil Aitkenhead, BGS (retired)

On Sunday July 11th, on the anniversary to the day of the first field visit by the Association to Clapham, a full coach of 33 (plus one or two by car), repeated that visit in celebration of the Association's long history.

Our general plan was to progress up through the stratigraphy from the village to the summit of Ingleborough with key geological and topographical features en route described by our leader for the day. Before setting out, a group photograph caught the mood of a party ready for action.

We progressed up Clapdale through the Ingleborough Estate Nature Trail, a route popular with walkers as well as geologists, and believed to be the way used by the original party.

The first feature to catch the group's attention was a waterfall associated with the South Craven Fault. This important fault, though not exposed here, is said to underlie a dam just a little way upstream. The dam impounds a lake flanked by tree-covered Carboniferous Gordale Limestone which crops out between the South and North Craven Faults.

Further on, a rise in the track beside the head of the lake marks a minor scarp of the North Craven Fault, throwing the Ordovician Norber Formation against the Gordale Limestone. Nearby, a botanical indication of the less calcareous soils of the Norber Formation is provided by the presence of unusually tall rhododendron bushes. Slaty mudstones, siltstones and sandstones with steeply dipping bedding and cleavage are well displayed on the bed of a stream that passes beneath the track at this point.

About 100 metres up this stream at Cat Holes, we examined a fine exposure of the basal Carboniferous unconformity marked by a bed of limestone resting directly on beds of the Norber Formation, similar to those described above. No conglomerate was seen at the contact, in contrast to the corresponding unconformity near Ingleton. It was pointed out that the concept of an unconformity is one of the most profound in earth science and had been long-established by 1874, so that members on the first LGA outing would have been able to recognise this one. It is now known to represent a time gap of about 100 million years - including the Arcadian Orogeny of early Devonian times.

Continuing upwards, the party entered the towering gorge of Trow Gill, which becomes narrower and steeper towards its head. This has been eroded in the Cove and Gordale Limestone members of the Great Scar Limestone Group and strong joint control is apparent. Here, **Iain Burgess** (BGS, retired) explained that bedding plane evidence indicates emergence in the form of a prominent undulating palaeokarstic surface and there is evidence of disconformity between limestones of Holkerian and Asbian age. Trow Gill was probably cut by a very powerful glacial

meltwater stream flowing at a time when the underground drainage systems were shut down under deep permafrost conditions at the end of the last (Devensian) glaciation. Whether the stream was subglacial or proglacial is a matter of conjecture and debate.

The path beyond the gorge crossed dark limestones (Upper Hawes Limestone of Brigantian age) containing rather indistinct oncolitic coatings on fossil fragments marking the presence of the Girvanella Nodular Band. This is one of the most persistent marker bands in the limestone succession.

After a brief stop at the awesome pothole of Gaping Gill, with a vertical drop of 110 metres (nearly twice that of Niagara Falls), the party divided itself into two. Ten members descended to visit Ingleborough Cave at the foot of a 20m cliff in the Great Scar Limestone, whilst the others climbed Ingleborough.

The stratigraphy of the upper part of Ingleborough seems unusual, if not unique, with the Main Limestone indicated by a line of sinkholes and conspicuous white chert fragments containing numerous crinoid remains, sandwiched between two coarse-grained cross-bedded sandstone units assigned to the Millstone Grit Group. The higher sandstone, the Lower Howgate Edge Grit, forms crags flanking the summit plateau and contains conspicuous rounded white quartz pebbles in places.

Like our predecessors, we ended the day with a well earned repast at the local inn, where thirsts were slaked, the day's findings discussed, and a good time had by all before the journey home.

Residential Weekend in Edinburgh
23 - 25th July - 15 members

The journey north / Dob's Linn in the Southern Uplands

Commentary on Journey : Tony Benfield
Leader at Dob's Linn : Dr Jim Floyd, BGS Edinburgh

On a bright sunny July morning 15 members and partners gathered at Goldsborough to park cars (under Howard Dunnill's expert guidance) and board Peter Dawson's minicoach for the journey to the Southern Uplands of Scotland.

After we had joined the A1(M), Tony Benfield began his coach commentary on the geology we could see from the coach. Our route north took us along the strike of the drift-covered Triassic rocks, and we noted such glacial features as eskers and lake deposits, and around Boroughbridge saw how recent road-side excavations had exposed the bright-red Sherwood Sandstone below thin till. North of Leeming we crossed on to drift-covered Permian and south of Scotch Corner descended on to the sub-drift Carboniferous.

The A66 took us north-westwards past the Middleton Tyas Anticline and along the axis of the Lower Carboniferous Stainmoor Trough. Up to the summit of Stainmoor, good glacial features, particularly eskers, were seen.

Dropping down to the north-west, Tony pointed out how the Lower Carboniferous rocks were actually overturned immediately adjacent to the Dent Fault. Crossing the Fault took us into the Vale of Eden with its down-faulted Permo-Triassic rocks and its spectacularly large drumlins, whilst the Lower Palaeozoics of the Lakeland Hills formed the skyline to the west, and the Carboniferous of the High Pennines that to the east.

We joined the M6 at Penrith and followed the basal Permian unconformity northwards. Past Carlisle, our attention was drawn to the recent work by the British Geological Survey (BGS) on the long history of the Carlisle Basin, and to the fact that we had passed over the Iapetus Suture deeply buried beneath the Carboniferous of the Northumberland Trough.

After a short stop at Allandale, we entered the Southern Uplands through the Permian outlier which leads to Moffat, and then drove through the typical rounded hills of the Lower Palaeozoic up Moffatdale.

Our lunch stop was at the Scottish National Trust's Visitor Centre at the Grey Mare's Tail, where we met the organiser of the week-end, Dr David Stephenson, and our leader for the afternoon, Dr Jim Floyd, both of the BGS Edinburgh Office. After lunch and a short walk to see the eponymous waterfall and the intense folding of the exposures adjacent to it, Dr Floyd briefly outlined the geology of Moffatdale.

The Celebratory outing party

Members on the riverbank at Aysgarth

Anniversary group photograph in Clapham before setting out.

Examining the unconformity at Cat Holes

Iain Burgess describes formation of the Girvanella Band

Reviewing the formation of Trow Gill

The 'A' party on the summit of Ingleborough

The area around the Grey Mare's Tail, which includes the famous Dob's Linn locality, lies within the fault-bounded belt of the Southern Upland Terrane in which the rocks range in age from mid-Ordovician to Silurian. The sequence comprises black graptolitic shales of the Moffat Shale Group overlain by the greywackes and shales of the Gala Group. The former are a very condensed sequence, some 100 meters of strata representing approximately 40 million years of deposition in a deep marine environment, into which submarine fans eventually prograded to deposit the Gala Group. Charles Lapworth's classic 1878 studies of the zonal biostratigraphy of the graptolite faunas within the Moffat black shales led in 1899 to the Geological Survey's isoclinally folded structural model of the Southern Uplands. Mid to late 20th century use of way-up criteria for the turbidites suggested a structural complex of thrust slices, which has been linked to an accretionary prism model. The latest ideas on these rocks involve back-arc to foreland basin thrusting, following continent-oceanic arc collision. Finally Dr Floyd pointed out a Late Glacial lateral moraine high on the valley side before we drove about 1 km to park above Dob's Linn.

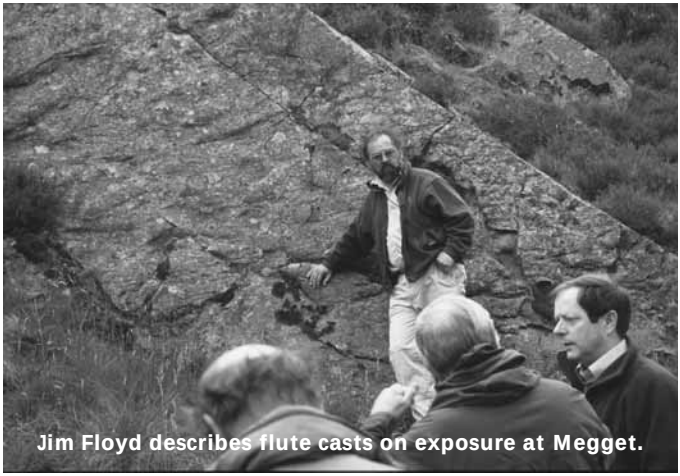
Here, after a steep descent, we followed the stream section in the Hartfell and Birkhill shales of the Moffat Shale Group northwards. At first graptolites were rare, but then appeared in great abundance with enthusiastic collection taking place in the footsteps (or perhaps hammer-prints!) of Charles Lapworth. Dr Floyd showed us some lighter coloured layers of bentonitic volcanic ash which had periodically accumulated on the early Silurian sea floor.

Dob's Linn - soft sediment structures in the bentonite

Finally, following a western tributary, which showed evidence of faulting, our way was blocked by a great face of steeply dipping greywacke turbidites at the base of the Gala Group down which a waterfall plunged. Much discussion of the spectacular groove-casts visible on the base of this bed ensued.

Dob's Linn waterfall - showing groove-casts

Returning to our minicoach, we continued past the house in which Lapworth had stayed whilst working at Dob's Linn. We then went via St Mary's Loch to our second and final exposure of the afternoon, a road cutting at Megget, south of Innerleithen, where we were able to examine greywacke turbidites in the Gala Group, which exhibited rip-up clasts and really excellent flute-casts.



Jim Floyd describes flute casts on exposure at Megget.

Our route into Edinburgh took us through Peebles to cross the Southern Uplands Fault and enter the Midland Valley of Scotland near Leadburn. We traversed the folded Carboniferous rocks of the Mid-Lothian syncline before reaching our accommodation in the University of Edinburgh's Pollock Halls of Residence at the foot of the Lower Carboniferous Arthur's Seat volcano.

Arthur's Seat, Holyrood Park, Edinburgh
Saturday 24th July

Leader : Dr. David Stephenson, BGS, Edinburgh

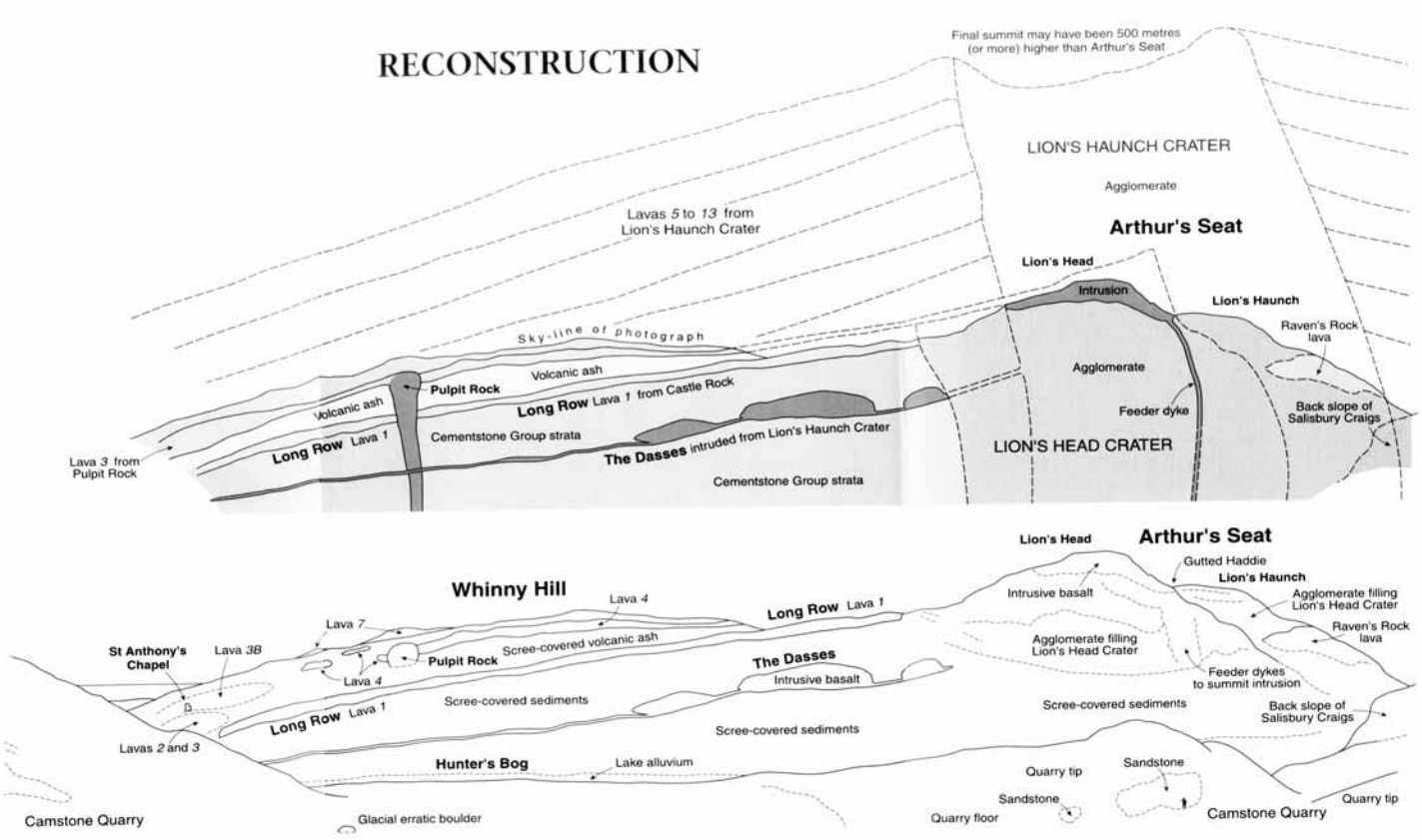
Leaving our base on the Edinburgh University Campus we were immediately oriented to the southern aspect of the hills. St Leonard's Sill with the very prominent Salisbury Craigs - two of the main basaltic sill intrusions - were almost directly above us. Then to our right, below the twin eroded vents of the Lion's Head (251m) and the Lion's Haunch (237m) of Arthur's Seat, we could see the curving columns of Samson's Ribs - a vertical alkaline dolerite intrusion along the edge of the crater fill of the Lion's Haunch. See the cross-section and reconstruction diagrams overleaf.

As part of Laurentia, this area of southern Scotland was involved in a subduction zone some 20 degrees south of the equator as the Iapetus Ocean closed some 400-350Ma ago. The Pentland Hills to the west formed some 50 million years before the active volcanoes of Arthur's Seat arose from a flat plain fringing a tropical lagoon in early Carboniferous times. Following extinction, the volcanoes were eroded and covered with thousands of metres of sediment. Later uplift and erosion to the base of the Lower Oil-shale Group has revealed the volcanic vent plugs and a number of lava flows which we see today.

St Leonard's Sill - about 5m thick, is brownish red and intruded in early Visean times. It consists of a first intrusion of (outer) Hawaiite with a later (inner) Basalt.

Salisbury Craigs - a 30m basaltic sill of alkali dolerite (teschenite) which thins towards the centre of the volcano, was intruded after the volcano became extinct. There is a 25 degree dip to the east - very obvious when we later entered the Hunter's Bog area. At the base of the sill we saw the red and white strata of siltstones of the Ballagan Formation (formerly Cementstone Group) which forms an irregular bowed up and brecciated base for the intrusion into consolidated rock (the St Leonard's Sill was into unconsolidated strata). The sill has dark rock top and bottom with a paler centre, probably resulting from different pulses of magma. It shows columnar jointing and spheroidal weathering. This area is famous as the site of Hutton's Section in his Theory of the Earth (1788) providing telling evidence of magmatic intrusion in contradiction to Werner's 18th century Neptunism. James Hall, a contemporary of Hutton in the Edinburgh Enlightenment (1750-90) was an experimental petrologist who provided proof of Hutton's theory of the igneous origins of rocks by his experiments in melting samples of different rocks and allowing them to crystallise. The Craigs were quarried between the late 18th century until 1831 providing roadstones for London. "Hutton's Rock" is a knob of basalt adjacent to the quarry cut by a vein of iron ore; it was reputedly left unquarried at Hutton's request and is therefore an early example of environmental conservation.

Next we walked on the dip slope of Salisbury sill to **Camstone Quarry** where the Ballagan Formation was quarried in the 16th century to provide raw material for Holyrood Palace. The quarry rocks consist of grey, red and green sandstones and mudstones with thin cementstones (chemically precipitated dolomites) and showed symmetrical waveform ripples, desiccation cracks, mudstone clasts fining upwards - cross bedding with lime concretions (this was 10 degrees south of the equator when formed) - indicating cyclic shallow water, fluvial and lagoon sedimentation.



Cross section and reconstruction of Arthur's Seat

From Camstone Quarry we looked east across Hunter's Bog to the three distinct blobs of **The Dasses**, another basalt sill. Above this we saw the long sloping shelf of **Long Row** (lava Flow 1) and above this again Whinny Hill with its lava flows and Pulpit Rock - a side vent. Over to the right towered the main feature of Arthur's Seat, the "Lion's Head", and beyond and below this the "Lion's Haunch" with the hidden Gutted Haddie between, down which we were to descend later.

On close inspection the Dasses Sill is about 1 metre thick, with a chilled top surface, fine and glassy with grooves in more than one direction and early phenocryst feldspar crystals. North-west directed ridges suggest casts of drag folds. Other lines perpendicular to these were suggested to be a slickenside effect (see photo).

Surface of the Dasses Sill

Going towards Haggis Knowe we could see Calton Hill, a displaced fragment of the Arthur's Seat volcano, and yet further north-west, Castle Rock in the centre of Edinburgh, the eroded remains of an earlier eruption. This also produced the lava flow forming the Long Row with a separate extension to the north of St Anthony's Fault. This produces the spring at St Anthony's Well. Here, above the lava, chemically precipitated limestone containing small sand grains crops out indicating shallow lagoonal conditions.

The hermitage of St Anthony's Chapel was built around 1450 of basalt quarried on site with carved freestone, probably from Camstone Quarry. The chapel stands on the lower columnar part of lava flow 3, (origin the Pulpit Rock vent) which makes the cliff east of the chapel. The columnar tops are at different angles suggesting water cooling. The topmost layer of lava is brecciated and contains bits of fossil wood suggesting that this had been a forested area.

We walked up the Dry Dam towards the Lion's Head with the north facing glaciated corrie to our left. There was insufficient time to explore Whinny Hill and its easterly dipping lava flows with eroded scarps facing west.

The summit of Arthur's Seat - the Lion's Head - is a glacially moulded basaltic plug. The basalt fed lava flow 4 and, on consolidation, blocked the Lion's Head vent. The summit views were superb, including the yellow crane derricks around the (stimulating?) new Scottish Parliament Building near Holyrood Palace and the white mass of Bass Rock off-shore to the north-east. From here we scrambled down to the top of Gutted Haddie, a gully eroded along the contact between the infilled craters of the Lion's Head and Haunch, exposing their respective agglomerate with the columnar basalt intrusion forming the Lion's Head summit.

We descended the well made zig-zag path towards our lunch, having had (as one member put it) a morning's field trip worthy of an international conference!

References : Lothian Geology : an excursion guide. McAdam and Clarkson.1986 edition (republished 1996); Discovering Edinburgh's Volcano : a geological guide to Holyrood Park. Edinburgh Geological Society. 2000

North Berwick Coast
Saturday July 24th

Leader : Professor Brian Upton

Continuing the volcanic theme of the morning, Saturday afternoon found the group with Brian Upton, retired Professor from the Earth Sciences School at Edinburgh University, who led our party along the foreshore west of North Berwick. To each side of the town is the North Berwick Coast Geological Conservation Review Site, which extends for 17km from Fidra to Dunbar. The coastline has a succession of exposures, younging westwards, of sedimentary rocks of the Ballagan Formation through the dominantly volcanic Garleton Hills Volcanic Formation to the unconformity with the overlying sedimentary Gullane Formation. Volcanism was mainly of latest Tournasian to early Visean age but with a probable recurrence in Permian times some 50 million years later.

The volcanic rocks form part of the East Lothian volcanic field and consist of a basal sequence of bedded tuffs and volcaniclastic sedimentary rocks, overlaid by predominantly basic lavas, which are in turn overlaid by felsic (trachytic) tuffs and lavas, all dipping in general to the west. Most of the basaltic tuffs were erupted through a large number of small volcanoes whose eroded relics are now seen as vents; larger volcanoes, from which the lavas and trachytic tuffs were erupted, developed at a later stage. Fourteen vents have been recognised along this coast and there are probably many more offshore, and buried onshore under drift deposits.

Examining Cliff Section at Weaklaw Vent

We joined the coast at a nature park at Longskelly Point, formed by lavas from the nearby Yellow Craig Plantation Vent, poorly stratified tuffites with associated basanite intrusions. Off the coast at this point is Fidra island, consisting of a thick columnar jointed basanite sill A further small vent, the Weaklaw Vent, cuts through the trachytic tuffs; plant fossils are well preserved, and it is considered that the plants grew on the flanks of an active volcano and were killed by ash flows.

Basanites in the Weaklaw Vent contain not only fragments of volcanic and sedimentary rock, but also xenoliths representing rock types from deep levels in the crust and upper mantle. Garnet, kyanite, rutile and also peridotite inclusions up to 15cm in diameter are found in xenoliths at Weaklaw (and we did find several; good samples for our collections!) The intrusions and volcanic rocks of this section are renowned for the abundance and wide variety of exotic rock fragments that have been brought up from great depths by the magmas. These constitute a unique method of sampling the deeper levels of the earth's crust and provide information of international value on the nature of the lower crust and the underlying upper mantle.

Our thanks went to Brian Upton for what in the time available could only be an introduction to the complex geology of a fascinating coastal section; the hand-out for our visit is a recent paper on this coastal review site, and is recommended reading to obtain a clearer picture of the complex volcanic origins of these exposures.

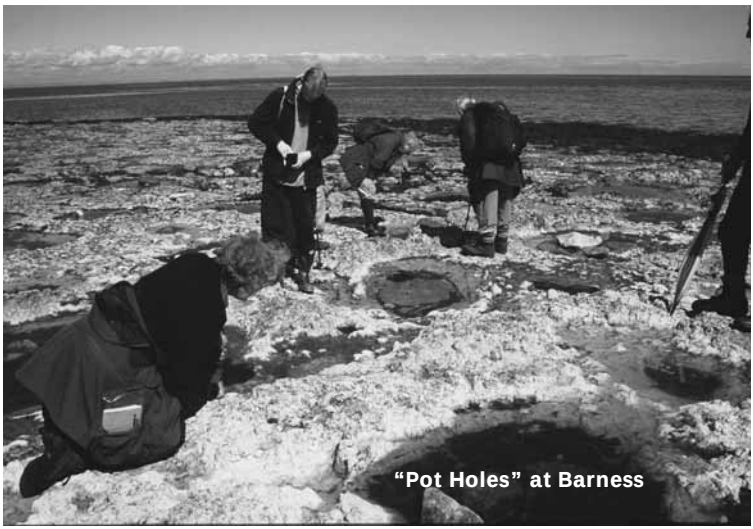
Hand-out reference :
North Berwick Coast, East Lothian. Paper by Upton B.G.J.
Contribution to : **Carboniferous and Permian Igneous rocks of Great Britain north of the Variscan Front** (Geological Conservation Review Series: Joint Nature Conservation Committee and British Geolgical Survey.)
Edited by Stephenson D, Loughlin S.C., Waters C.N. and Williamson I.T.

Dunbar Coast / Siccar Point
Sunday July 25th

Leader : Mike Browne, BGS Edinburgh

Heavy drizzle from lowering clouds greeted us at breakfast, but by the time we reached the coast brightness had emerged and we enjoyed wall-to-wall sunshine thereafter. We were to spend the day with Mike Browne at three coastal locations south of Dunbar, and south of the Southern Upland Fault, looking at a variety of exposures which would demonstrate (though not in chronological order) some of the environments and events shaping the succession from the Silurian [Llandovery] to the top of the Lower Carboniferous [Brigantian] in this area.

We began at **Barnsness** beach, where limestones are exposed from the late Asbian stage, when glacioeustatic oscillations in sea level created a cyclical, Yoredale-type succession widely across south-east Scotland. Our first view of these strata, (now dipping gently to the east), was of the sandstone facies of the Middle Longcraig Limestone with the swirling concentric 'cockstails' of the trace fossil *Zoophycos*, and the U-shaped burrows of *Diplocraterion*. Familiar corals *Lithostrotion junceum* and *Siphonodendron* were abundant in the overlying limestone, but the most striking feature here was the karstic upper surface of this limestone which is "pocked" with evenly-spaced basin-shaped hollows about 1 metre across. (see photo) These "pot-holes" are also of Carboniferous age since they are partially filled by overlying seatearth. The "rhizocraterion-look-alike" knobbles round the sides of the hollows are actually the fossilised remains of the roots of now-vanished trees; and as further evidence of this swamp / subaerial environment there is a thin coal seam in the cross-section seen in the low cliff nearby, with *Stigmaria* and rootlets visible in the seatearth.



“Pot Holes” at Barness

Further along the beach, facies from younger cycles showed other points of interest:

- a 25cm thick storm-deposit of the solitary coral Koninckophyllum, (looking like heaps of dishevelled grey sausages), about 1m below the top of the 6m thick Upper Longcraig Limestone;

- abundant crinoid ossicles and some Gigantoproductus in the overlying Lower Skateraw Limestone which is topped by a poorly exposed mudstone, seatearth and coal sequence;

- and, in the 4m thick Middle Skateraw Limestone, (the youngest [Brigantian stage] of the cyclical horizons which we saw), were colonies of the flat and discoidal sponge Chaetetes, and also many specimens of the foraminiferid Saccaminopsis (found as minute apricot or fawn-coloured spheres) - evidence of very clear water.

After lunch, enlivened by ice-cream in the **Pease Bay** Caravan Park, we proceeded to the bay itself. The Pease Bay-to-Cove sequence presents a conformable succession from the Upper Old Red Sandstone to the Asbian marine bands; but we had time to sample only a few exposures which well demonstrated the typical Upper Devonian aeolian / fluvial environments with some lacustrine development.

- For example, we examined the base of a bedding plane near a block in which crowded specimens of the fossil fish Bothriolepis had been found previously; we could just see part of a head-plate, and understood that, (like the celebrated Dura Den find), this block may have preserved a pool which dried up when a sand dune migrated over it, trapping all the fish. Fossils are said to be generally rather rare in the Upper O.R.S but we also observed *Beaconites* burrows; traces of the activity of one of the many Devonian arthropods.

- Other evidence, both of flood plain pools and of their "drying-out" were the thinly layered grey/green lake-margin deposits, with wave-ripples, and desiccation cracks.

Cross-stratification in Devonian at Pease Bay

- The northern end of Pease Bay is a high cliff, composed of just such alternating grey-green laminated deposits and cross-bedded red sandstones, all dipping at about 20 degrees north. At the base there are classic fluvial sedimentary features : fine trough cross-stratification and pebble lag; (see photo) The troughs trend southwards and can be seen in section as well as in plan from above.

- Elsewhere we observed "climbing ripples", evidence of rapid deposition of voluminous sediment in a fast flowing current, as after a flash flood.

- We also saw exposures showing wind-blown deposition, reflecting a truly desert environment..

Finally we drove to the quarry from which to access Siccar Point, and, climbing down the very steep slopes to the cliff base through waist-high midsummer grass, we were glad that the grass was now dry, relieved when we reached flatter ground, but then stunned and excited by what we saw.

With the green wall of grass behind us and still high above the brilliantly blue sea, we were standing on a sloping dissected platform of rough red conglomerate, through which there seemed to protrude teeth and ridges of an almost vertical smooth grey rock, shining as it caught the light. We were looking, of course, at Hutton's most famous unconformity (though not his first): a basement of vertical Silurian greywackes and shales covered unconformably (and unevenly) by gently dipping reddened sandstones and breccia of Upper Devonian /Lower Dinantian age. The breccia is formed of greywacke fragments deposited under flood conditions; the strong imbricate structure of the clasts in the breccia showing that the material was derived not from the cliffs above, but from the NNE. Even the prosaic James Hutton described it in 1788 as "a beautiful picture of this junction washed bare by the sea" (see photo - back cover)

But it was John Playfair, (Hutton's Boswell) who brought out both the drama of the scene and its true significance, as the "testimony of the senses" authenticated "theoretical speculations". Playfair recognised that the unconformity was much more than an interesting structure; it was mind-bending (and perhaps soul-damning) evidence of the antiquity of the Earth and the continuity of its formation. We are used to seeing earth-processes reckoned in hundreds or thousands of **millions** of years, (do we really grasp this?); the eighteenth century still held belief in one act of Creation some **thousands** of years before. When Playfair stood at Siccar Point, he looked down the "extraordinary perspective" presented…when the "most ancient of rocks…lay in horizontal planes at the bottom of the sea", when "that immeasurable force which has burst asunder the pavements of the globe" forced those rocks upright, when the "sandstone before us was only beginning to be deposited in the shape of sand or mud from the waters of the superincumbent ocean", and his "mind seemed to grow giddy by looking so far into the abyss of time".

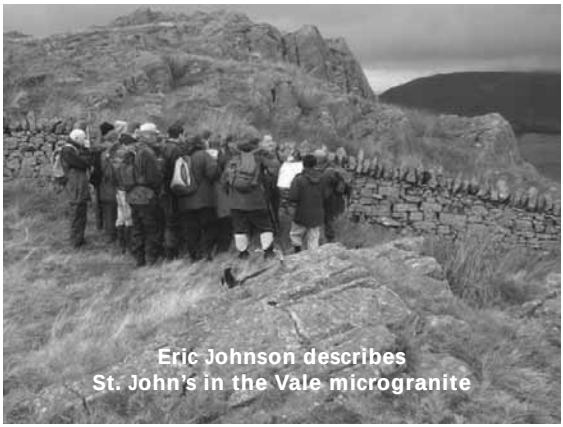
As we sat where Hutton and Playfair had sat, Mike read out Playfair's words and we too fell silent.

Volcanic and Quaternary features in the Northern Lake District : St John's in the Vale
Sunday 26th September

Leader : Dr Eric Johnson
19 members present

Our aim on this visit to the northern Lake District was to look at some features and relationships of the Ordovician Skiddaw and Borrowdale Volcanic Groups in the light of recent research by the British Geological Survey with whom our leader worked for many years in this area. The new evidence and interpretations were reviewed looking at outcrops on Low and High Rigg.

On a fresh, clear autumn day we climbed first to the summit of Low Rigg, an outcrop of the St John's in the Vale microgranite; often just included as a part of the Threlkeld microgranite, it was formed during regional uplift preceding subduction (epeirogenesis). The pinkish sub-volcanic intrusive rock at outcrop showed a blocky appearance caused by surface cooling joints. Analysis had shown it to be an acidic rock (a fact hinted at by the distinctive bright green lichen growing on its surface) with a 70% silica content. Dating had given an age for its intrusion of 452 million years, 3 million years after the first deposition of the lower Borrowdale Volcanic Group (BVG) in the late Llanvirn.(see photo)



Eric Johnson describes St. John's in the Vale microgranite

Down slope to the south we came to a bench running along the hillside marking the present edge of the exposure and found the contact with the underlying Buttermere Formation of the Skiddaw Group, about 460 million years old, which we had previously seen in the distance forming most of the smoothly rounded hills and valleys to the north of Low Rigg. These turbidites of silty mudstone and sandstones had later experienced regional scale folding, thrusting and slaty cleavage by the Acadian Orogeny. The cleavage had also less strongly affected the edges of the microgranite. We were able to see flow foliations in the base of the microgranite at 90 degrees to the contact surface, created as it flowed over the surface of the Skiddaw Group rock.

Passing over a faulted area down-thrown to the south, (this weakness having more recently formed a route for a glacial meltwater channel), Eric described briefly the varying flow directions of the glaciers as ice from the direction of Scotland overwhelmed ice flowing from the central Lake District and then retreated; how this had affected the local landscape, in some places causing erratics to be spread in two opposite directions.

Heading south up High Rigg we soon reached the base of the BVG; this was the Birker Fell Formation, a dark grey massive Andesite lava dipping at about 30 degrees to the south. It contains phenocrysts and in places had a basal conglomerate (some sub-rounded and others angular) of the underlying eroded Skiddaw Group.

This subaerial lava was overlaid by a pyroclastic flow deposit, a reddish unit with weathered out fiamme, and many more fragments of the Skiddaw Group picked up as it erupted through the succession. This is typical of the tuffs in the basal 500 metres of the BVG. Crude bedding could be seen in the upper fall-out deposits which became finer as the succession reached its full 20-25 metres. The tuffs, and to a much lesser extent the lava flows, had a cleavage superimposed by the Acadian Orogeny. We were told by Eric that the assemblage of volcanic rocks we were looking at showed that this had been the site of an island arc subduction zone.

As we walked up High Rigg this whole sequence was repeated twice more; in the second of these lava-flow banding parallel to the bedding could be seen where different layers of lava had progressively cooled. A more clearly defined bedding was seen in the ash-fall deposits and on the top surface of the last lava autobrecciation was very clearly visible with an infill of ash between the blocks.

We moved to an exposure (see photo) which earlier geologists had interpreted as a volcanic vent. We were told that it is now thought to be a good example of autobrecciation with dust filling the gaps between the blocks, and a spectacular wall of blocky lava running up the slope is now recognised as the infill of a tension-created tear fault in the lava flow.

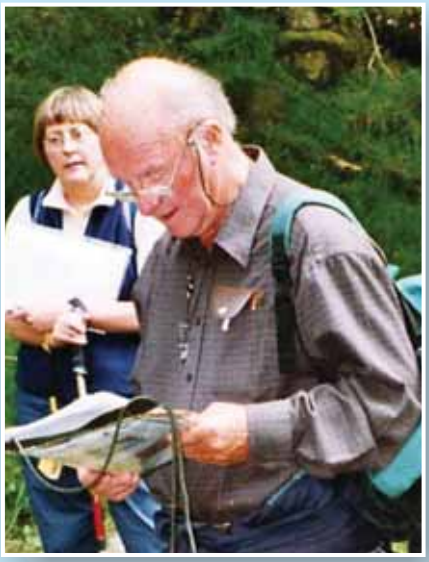
Andesite Lava in tear created fault

Finally we walked up to the summit of High Rigg with the intention of having an overview of the area, but circling ravens and gathering dark rain clouds meant an early and very atmospheric end to the day. Our thanks were offered to Eric for his guidance through a very complicated and otherwise confusing piece of geology and we all retired to Rheged for a well earned drink (of tea)!

New for 2005

Thanks to our past president & welcome to our new president.

Pauline Sweet
(past President)



Neil Aitkenhead
(new President)

Our thanks to contributors of field visit reports and images to this compilation:
Tony Benfield, Howard Dunnill, Bob Gibson, David Holmes, Brian Holroyd, Stuart Spencer and Pauline Sweet.

For more information visit us at:
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Sub-horizontal ORS conglomerates lying unconformably on near vertical Silurian greywackes
"100 million years between my hands" - Siccar Point