Reading Geological Society

Lake District and North Yorkshire
Field Meeting Report

Sunday September 24th 2023 to
Saturday 30th September 2023

Led by Dr. Bernard Skillerne de Bristowe

Introduction

Eight members of Reading Geological Society were joined by two members of Farnham Geological Society and one guest (for just the first day) for this field meeting. Our base in Penrith was chosen as we were to be visiting areas in both the Lake District and the Northern Pennines.

Bernard Skillerne de Bristowe, who had led the society previously on other field meetings, had kindly offered to lead this visit. Bernard had previously been a member of the Reading Geological Society, but had moved north some years previously, so he was already known to many of our members.

The week prior to our visit had experienced notoriously bad weather, with floods affecting much of the area. More rain was forecast so waterproofs and boots were sure to be needed.

Bernard met us on the Monday morning and gave us a short introduction before we set off for the first site.

RGS Members

Skiddaw in the background

Honister Mine - dump of Borrowdale Volcanic Group slates in carpark

Photos by Hilary Jensen

Monday 25th September - Glenderaterra Valley.

NY 30241 25645

Access from a public car park, due west of the Blencathra Centre.

We walked up the Glenderaterra Valley along a well-made footpath and on our way walked over a classic traverse across the Kirk Stile Formation of the Skiddaw Group through the contact metamorphic aureole of the Skiddaw Granite.

Close to the car park, we began by examining the Ordovician Kirk Stile Formation which has been affected by the Acadian orogeny of late Silurian to early Devonian age. Here the Kirk Stile Formation is unaffected by the metamorphic aureole and is comprised of low grade regional metamorphosed mudstones and occasional sandstones (Figure 1). The original mudstones are now described as pelites, a fine grained metamorphic rock, and are thinly bedded, very dark grey and slippery due to the presence of graphite. Bernard suggested that the graphite was the remains of organic material left after hydrocarbons had been generated in the sediments during burial and then driven off, leaving the remaining carbon as graphite. The sandstones show relics of soft sediment deformation with isoclinal slump folds seen within a single bed. The Kirk Stile Formation is considered to be a sequence of turbidites that have been affected by syn-depositional, large scale soft sediment slumping.

A second outcrop (Figure 2) showed evidence of tectonically folded rocks with bedding parallel slickensides. Bernard suggested this deformation could be due to mountain building processes such as microcontinent collisions (e.g. Avalonia colliding with Laurentia) caused by the closing of the Iapetus Ocean during the Acadian Orogeny. At this time, granite plutons such as the Skiddaw and Shap granites were intruded as part of a suite of trans-Iapetus granites.

Figure 1

Figure 2

As we walked along the path up the Glenderaterra Valley towards the Skiddaw granite, Bernard asked us to look out for the change in colour of the pelites from grey to greenish grey to blue grey. This is thought to be caused by water been driven out of the sediments during contact metamorphism which changed the clay minerals present from illite, to chlorite then biotite. We didn't spot this on our visit.

As we moved closer to the Skiddaw Granite the first signs of contact metamorphism were the presence of small, 0.5 to 1mm sized, white spots of andalusite which were associated with small patches of iron staining resulting from pyrite weathering. The pyrite was created when H_2S gas was generated by altered organic material. Further along the path we saw much more obvious, 1-2cm, needle shaped crystals of andalusite with dark grey graphite-rich cores, known as chiastolite (Figure 3).

Figure 3

Further along the path the rocks changed from grey-black to red in colour as we approached a waterfall, (Figure 4). The waterfall is associated with fractures and is probably formed along the line of a fault. Red colouration like this is common in the Lake District and iron-rich waters are thought to have moved along faults and fractures (Figure 5) from the haematite-rich Permo-Triassic such as that seen in the mining area near Barrow in Furness. The source of the iron in this deposit may be the Permo-Triassic red beds beneath the Morecombe Bay area or even the Devonian as suggested by information displayed in the Threlkeld Mining Museum we visited on Day 3.

Figure 4

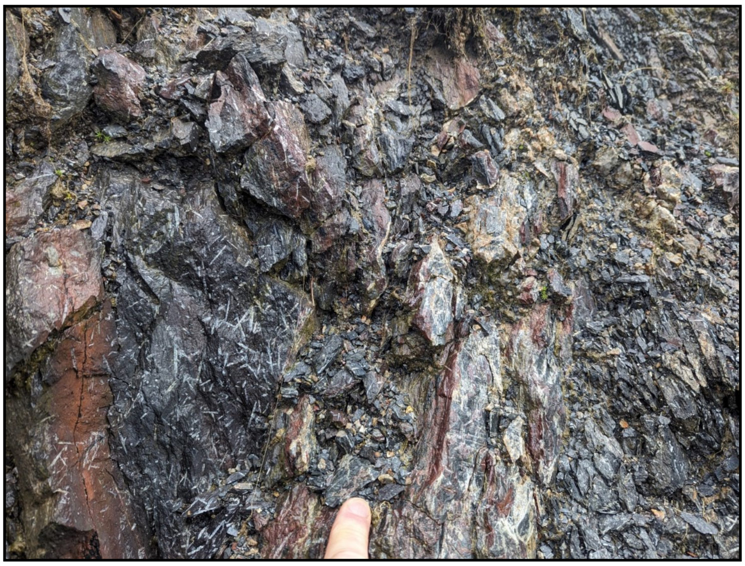


Figure 5

Further along the path away from the stream the rock returns to a grey colour with the addition of dark oval spots, 2-3mm in length, which are identified as cordierite (Figure 6). This is another mineral that occurs in contact metamorphic zones. The black colour at this locality rather than the more normal white colour of cordierite is due to the graphite present in the rock.

Figure 6

As we approached the granite body, which was only seen as boulders sparsely scattered across the landscape, the path was flooded by a stream in spate. At this location the pelite rock had been baked hard by the granite intrusion and metamorphosed to a hornfels, a hard splintery rock which makes a ringing sound when hit with a hammer, as demonstrated in the field.

A recent thin section study of samples from near the granite contact has found sillimanite present in the rocks proving a higher grade of contact metamorphism that previously thought.

The usual sequence of contact metamorphic rocks is to first see cordierite, then andalusite and then depending on the temperature and pressure conditions at the time, the andalusite might be replaced by sillimanite or kyanite. On the path we took across the contact metamorphic aureole we saw andalusite before cordierite which is probably due to the topography of the top granite surface beneath the path. Bernard suggested that as one gets closer to the granite the rocks tend to get a coarser texture as the heat from the granite allows the minerals to recrystallise into larger more stable crystal shapes. We didn't spot this on our visit.

We only saw the Skiddaw Granite as boulders at the side of the path. It had two features of note, firstly it contains a lot of biotite which is characteristic of a granite that was formed from the melting of a previous igneous body. This makes it an I-type granite rather than a S-type granite which is made from melting sedimentary rocks. Secondly it appears to have only one type of feldspar present rather than the two normally seen in granites (plagioclase and alkali feldspars). This is apparent rather than real as the feldspar seen by eye is a perthitic intergrowth of the two feldspar types caused by the way the rock crystallised as it cooled. Initially as the granite was cooling the feldspar was sanidine which had Na, Ca and K in its lattice, but as the granite cooled the crystal structure changed and sanidine was no longer stable so it changed into an intergrowth of blebs of plagioclase feldspar within a K-rich alkali feldspar.

A recurring theme throughout this day was assigning observations to events. Regarding foliation within the sediments, we saw 4 different events:

Soft sediment slumping followed by compression on burial – Ordovician age.
Cleavage due to compression/folding during the Acadian orogeny of late Silurian to early Devonian age.
Spaced cleavage around faults (fracture cleavage)
Sheared layers around the granite/country rock contact (not seen) – Early Devonian

Regarding metamorphic events, the following can be identified:

Burial metamorphism.
Regional metamorphism. Acadian Orogeny – late Silurian to early Devonian
Contact metamorphism resulting from granite emplacement – Early Devonian
Dynamic metamorphism, faulting
Retrograde metamorphism, or weathering

After our walk we retired to the Keswick Museum where they have on display one of the Musical Stones of Skiddaw, a lithophone made of bars of hornfels which is played like a xylophone (Figure 7).

Figure 7

Report by Sarah Cook, photos by Sarah Cook and Mike Jones

Tuesday 26th September - The Caldew Valley

The Caldew Valley lies to the north of the Glenderaterra Valley on the edge of the Caldbeck Fells. The lower valley has a flat base which was once the site of a glacial lake. The south side of the valley is composed of the same Skiddaw Group sediments that we saw on Day 1 and again at the head of the valley we find an outcrop of the Skiddaw Granite. What is different is that on the edge of this granite is a rock called a greisen and some of the country rock contains veins of tourmaline. This suggests that a different type of granite may have been emplaced along the northern boundary of the Skiddaw granite. The northern side of the valley has cliffs of the Carrock Fell igneous complex. This was first studied by Alfred Harker at the end of the 19th century and was the first layered mafic igneous intrusion to be described. In addition, the valley contains the Carrock tungsten mine and some very unusual tectonic structures which have caused great debate over the years.

Mungrisdale – Schoolhouse Quarry

NY 363 306

The second day saw us first drive to Mungrisdale, where we visited an old quarry - Schoolhouse Quarry in the Kirk Stile Formation. This formation was deposited as mudstone and siltstone between 477.7 and 458.4 million years ago during the Ordovician period. The now metamorphosed rock was fine-grained black slate, folded in different directions – the anticline (roughly east-west) plunges to the east and had been compressed and overturned a little to the south (Devonian, c 390 Ma). The overturned Acadian folding of a plunging anticline can be seen in Figure 8.

Figure 8

This could be seen more easily from the extreme eastern side of the quarry, by the road. The fold was also faulted at a low angle about half-way up the face with the hanging wall displaced about 20 cm to the south. Figure 9 shows the faulted limb of the recumbent anticline.

Figure 9

The surface of some planes in the rock appeared to be worn ripples. They were rough in one direction and smooth in the opposite direction. These were, in fact, the edges of axial cleavage planes of Acadian age. In the limb of the fold (Figure 10).

Some pieces of rock showed a bedding plane with groove casts – tool marks on the underside of a bed made by objects dragged along the surface of the older bed below by a current. In places near the road, S-folds could be seen marking the right limb of the plunging anticline. (Figure 11).

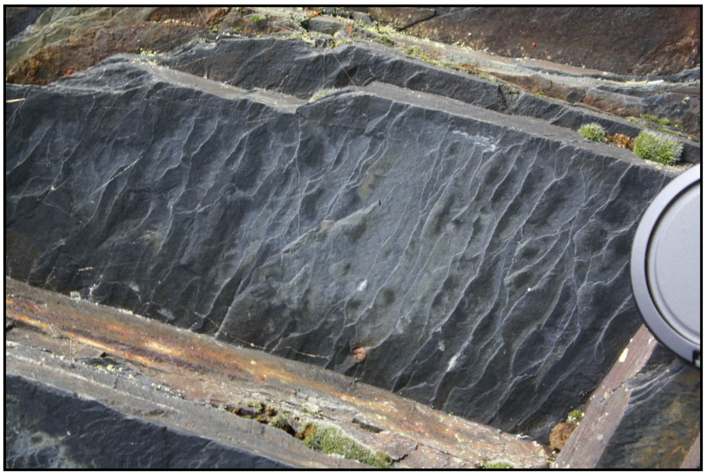


Figure 10

Figure11

Mosedale Bridge

NY 354 320

We next drove to Mosedale Bridge in search of cordierite specimens in the bed of the River Caldew but Bernard investigated and reported that the river was too high (due to the recent heavy rains).

Figure 12

Carrock Fell

The bedrock geology of Carrock Fell is the world's first described layered mafic intrusion. They are bands of rock (Carrock Gabbro-microgranite Intrusions), running east-west and listed below from north to south.

On the north side of the Fell: Microgranite formed about 416 Ma - during the Ordovician period, then a microgabbro.

On the south slope (the north side of the Caldew Valley): A dioritic rock and further down the slope are the Mosedale Gabbros formed about 468 Ma – a gabbro, a quartz-gabbro and then another gabbro.

Carrock Mine

NY 323 329

We continued to our next site which was the Carrock Mine on Carrock Fell. To reach the mine we drove up the track from Mosedale as far as we could *(NY 327 327)*. We clambered down a slope and briefly looked in the Caldew River, but again the water was too high to clearly see the rocks in the river. (Figure 12).

We then retraced our steps and walked to the mine dump and notice board near Brandy Beck. Five veins were mined all resulting from the intrusion of the Skiddaw Granite Pluton further up the valley. The mining was started for lead, copper and arsenic but later developed into a mine for the extraction of tungsten ore (wolfram and scheelite) and was the only such in the UK outside of Cornwall. The mine operation and the waste tips covered a large area but the howling wind and driving rain put off much exploration.

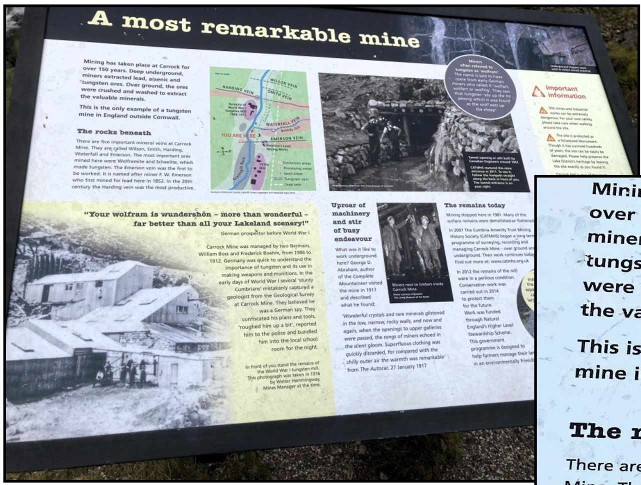
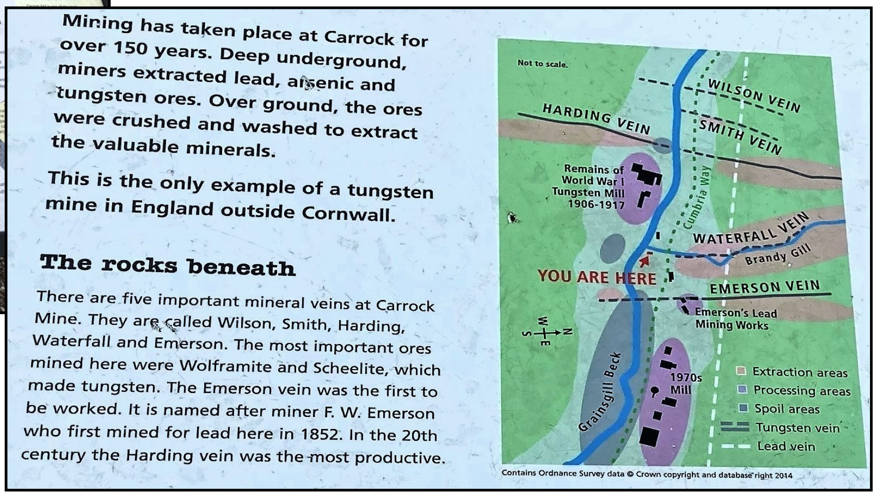


Figure 13 on the left is the notice board at Carrock Mine, below is a close up of some information of geological interest.



Eycott Hill Nature Reserve

NY390 304

The last stop of the day was at Eycott Hill Nature Reserve. We arrived at the car park where we had lunch and studied the boards for the geology, botany and wildlife SSSIs. Bernard explained that the geology was not visible from the paths through the reserve and as we were not permitted to deviate from the paths because of the SSSIs, there was no point in going further. Instead he described in detail the geological structures. (Figure 14).

Figure 14

The Kirk Stile Formation of the Skiddaw Group is overlain by the Eycott Volcanic Group. This group is made of a variety of volcanic rocks including basalt, basaltic andesite, andesite, dacite lava flows and sills and various volcanic sedimentary rocks, all aged about 460 Ma. This is unconformably overlain by Devonian and Carboniferous rocks. The lavas dip towards the east forming a series of ridges of scarp and dip slopes with wetland between the ridges, some of which could be seen from the car park.

After this we returned to the hotel where Bernard gave a seminar on the ancient tectonics of the creation of the Lake District rocks.

Report by Roger York, photos by Roger York and Hilary Jensen

Wednesday 27th September - Causey Pike Fault

Purpose: To follow the Causey Pike fault and sediments and intrusions along it, as well as volcanic/ glacial scenery and a visit to a slate quarry in the Borrowdale volcanic series.

Starting point: Penrith

Honister Slate Mine

NY 225 135

We followed the Causey Pike fault west from Penrith to Keswick and then headed south, via Derwent Water and Borrowdale to the head of Honister Pass to visit the Honister Slate Mine, which is the last working slate mine in England. We parked in the mine visitor centre carpark. We didn't enter the mine, which is underground and can be approached via the small road visible in the top left of the photograph. Figure 15 shows a narrow gauge steam engine with head of U-shaped valley in the background.

Figure 15

Figure 16

We examined the mine waste, (see picture on Page 2) placed in the car park for view by, and sale to, visitors. A few specimens were collected for further examination. The Westmorland green 'slates' are within the Eagle Crag member of the Borrowdale Volcanic Group of Arenig age (493 –476.Ma). The slate was deposited sub-aqueously and shows graded bedding. The sediments were seen to have two cleavages. A curved cleavage - called cleavage refraction and crenulation cleavage. The cleavages resulted from two separate phases of deformations with different orientations of compression. Figure 16 shows graded bedding and cleavage in the slate.

The magnificent U-shaped valley of Gatesgarthdale Beck could be seen and several hanging valleys. Bernard explained that although usually attributed to ice action, it has been suggested (Emrys Phillips) that U-shaped valleys might also start as gullies along faults and develop by lateral rock falls.

Causey Pike - Barrow Lead Mine car park

NY 233 217

We then drove down the valley to Buttermere, and turned into the Newlands Valley, heading back towards Keswick. The route passes several mine workings, in particular the very rich Goldscope mine; the Newlands valley was a major copper producing area.

We stopped at the Barrow Lead Mine car park (beware! open shafts in the undergrowth) and then ascended a path towards Causey Pike.

Nearby is the Stoneycroft lead mine and at the head of the valley a cobalt mine (a failure, due to the misunderstanding at the time of the chemistry, it proved impossible to separate the minerals).

We discussed the mantle origin and dating of the mineralisation. Some copper veins are cut by Acadian cleavage and are thought to date from the formation of the Borrowdale volcanics. Elsewhere, lead veins are thought to have been formed contemporaneously with the Northern Pennine ore field in the Permian period, at the same time as the emplacement of the Whin Sill.

Figure 17

Figure 17 shows the view along the fault towards Keswick.

Figure 18

In the distance could be seen Causey Pike itself, which gives the name to the Causey Pike Fault, a major fault possibly 700 Ma.

The whole valley through Keswick to Penrith and beyond is on the fault. Such major faults may have been active at different times; at times a normal fault, at other times a strike/slip fault, and at others a reverse compressional fault.

Below the fault is the Buttermere Formation, above the fault, the Skiddaw Formation. Unsuccessful attempts have been made to relate the two formations as the fault has an estimated slip of 80km.

An inclined darker band can be seen in the Pike, located at the fault boundary, topped by a bump made of hornfels with tourmaline veins, suggesting a granite intrusion. (Figure 18)

Closer to our standpoint in the direction of Keswick, lamprophyre intrusions with high potassium content have been found. Further away in Threlkeld (by the museum) is a garnet-bearing microgranite intrusion. All these suggest a deep origin; unlike normal and compression faults, strike/slip faults often go down into the mantle.

Threlkeld Quarry and Mining Museum

NY 3274 2436

This has an excellent display of minerals and of mining technology. In the quarry itself are a considerable number of mining machines. The climax of the visit was a trip on a narrow gauge railway, through pouring rain, to the quarry face itself. Figure 19 shows the RGS group and Bernard in the quarry.

Figure 19

On the way back to the hotel, we attempted to visit an outcrop of Mellfell conglomerate (Devonian, situated on the Causey Pike Thrust at the end of Ullswater) but this was obscured by the high water levels.

Report by Edmund Shirley, photos by Edmund Shirley and Roger York

Thursday 28th September - A traverse through the Eden Valley and the Alston Block of the North Pennines

Travelling eastwards from Penrith the aim of the day was to cross the Eden Valley, The Pennine Fault system and onto the Alston Block.

Overview of the Geology

The Vale of Eden is largely defined by the course of the River Eden, one of the major rivers in the area. The Vale extends beyond the valley of the river lying between the Cumbrian Mountains and the northern part of the Pennines. It is a half graben being faulted to the west by the Pennine Fault System.

There are four main rock types found in the vale:

Brockram conglomerate (Permian / Early Triassic)
Penrith Sandstone which is aeolian with cross sets (early Permian)
Evaporites such as those at the British Gypsum Mine at Kirby Thore (Permian)
St Bees Sandstone (Early Triassic)

The Pennine Fault System is a NW-SE trending zone of faulting that forms the southwestern boundary to the Pennines.

The northern Pennines are divided into two structural blocks separated by the Stainmore Trough. The northern block is the Alston Block which is home to the Northern Pennine Ore Field with lead, zinc, baryte and fluorite mineralisation. The southern block is the Askrigg Block; the topic of Friday's walk.
We visited numerous locations during the day, the main ones are summarized below.

Hoff

NY 675 175

At Hoff we walked over the fields but could not see the exposure we were looking for (a flash flood deposit) due to fencing and vegetation.

Walking on we saw the Permian / Carboniferous unconformity between the Brockram conglomerate and the Carb Limestone. (Figure 20)

Figure 20

Here the Brockram shows a coarsening up succession. The sequence starts with fine material deposited from low energy flows and coarsens upwards as flow strength increased. This is interpreted to result from flash flood deposits. The opposite, fining upwards, occurs as the flow decreases. The environment at this time was largely desert with periods of large rainfall; 300mya when Gondwana and Laurentia collided. The thinking is that there was a wadi on high ground flooding to the low ground of a downthrown block. The sediment fanned out with resulting playa lakes and evaporite deposits. A bajada consists of a series of such fans.

Bongate Weir

Driving on to Bongate Weir near Appleby we stopped to look at the Penrith Sandstone. (Figure 21) Deposited in the Permian this sandstone is an aeolian deposit exhibiting dune bedding and comprising well rounded (near spherical) grains, these are known as millet seed grains.

Figure 21

Within the main bedding were smaller beds of different sized grains, probably due to the strength of the wind. It was determined that the wind blew from the east.

Kirby Thore

NY 638 256

The next stop was at Kirby Thore near the gypsum works. The Eden Shale exposure was in the river swollen by recent rains so could not be seen. A desert existed within a graben structure. A marine transgression flooded the area and resulted in a sabkha environment of tidal flats and evaporites. Hence the gypsum mine!

Dufton

NY 694 247

The St Bees sandstone was the topic at Dufton. This comprises fluvial sandstones deposited in a braided river. The fluvial system extended from France and ended in the Eden valley. (Figures 22 and 23.)

Figure 22

Figure 23

Next, we drove through the Stainmore Trough, observing the broken ground of the fault zone and on to the Alston Block.

We found ourselves in County Durham as we drove across the moors stopping near the top above Selset Lake. Evidence of barytes mining was seen. The area was known for the production of barytes, silver, lead and fluorite. Lunch was taken while trying to find shelter from the wind!

Stanhope Fossil Tree

NY 996 391

Our next stop was at Stanhope to look at the fossil tree and make use of the facilities. The tree is a Sigillaria from the Carboniferous (Figure 24). It was found in a sandstone quarry at Edmundbyers Cross in 1915 and brought to Stanhope in 1960 in large pieces and reassembled in the churchyard of St Thomas' church.

Figure 24

West Rigg Opencast mine

NY 908 380 (Westgate)

From the road at Westgate we looked at the remnants of the West Rigg open cast mine. In the 19th century iron ore was mined from an exposed lead vein. There was also galena, fluorite and silver. Horizontal slickensides are evidence of a slip / strike fault. The core of the vein is quartz and is still in situ. The mineralisation took place during the Permian and is associated with the intrusion of the Whin Sill. Figure 25 shows West Rigg Central Quartz Core

Figure 25

Rookhope

NY 939 427

At Rookhope Mine fluorite was the main mineral mined. Dolomitization of the limestone reduced the volume of the country rock resulting in collapses so space for large crystal development developed. One of the items of interest is the Rookhope Arch; the only remaining one of a series of arches built to house a flue to carry fumes uphill away from the valley. (Figure 26) .

Minehead gear has been left in place at Groverake Mine. This mine closed in 1999 after mining lead in the 17th century and fluorspar in the 20th.

Disappointingly the Killhope Mining Museum was closed, possibly due to the access road being flooded.

Figure 26

Nenthead Mine site

NY 780 436

Our last visit of the day was to the Nenthead Mines site, although closed we were still able to look at some of the mining buildings and gear. This valley has remains of lead and zinc mining. Galena, sphalerite and barytes were all mined here. Figure 27 shows quartz veining from Nenthead. The site is not only famous for its geology but also for rare lichens and plants growing on the mine dumps. Figure 28 shows Nenthead Mining Gear.

Figure 27

Figure 28

Report by Ailsa Davies, photos by Ailsa Davies and Hilary Jensen

Friday 29th September - Ingleton Waterfalls Trail

SD 693 735

The group travelled to Ingleton to walk the 4.5 mile Ingleton Waterfalls trail; this is privately owned and a fee was required, but the advantage is that the paths and many steps are well maintained. Figure 29 shows the map of the walk on the display board and alongside is the geological map from Tony Waltham's book "The Yorkshire Dales".

Display board at start of trail

Geology (Tony Waltham)

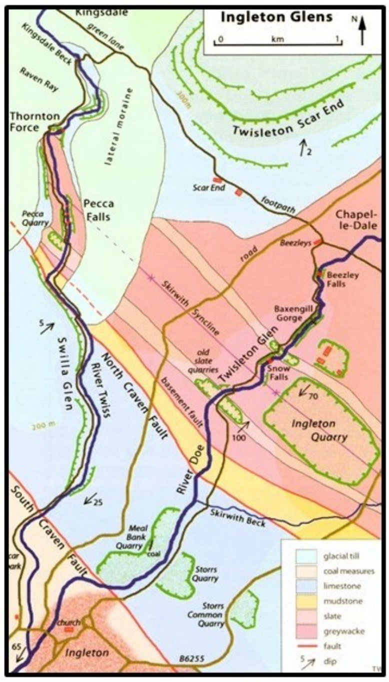


Figure 29

The trail commences in Coal Measures alongside the River Twiss in dense vegetation then heads north crossing the damage zone of the South and North Craven Faults. The throw of the South Craven fault is c. 1200m offsetting mudstones, sandstones and coals of the Coal Measures against the Lower Carboniferous limestones. The throw of the North Craven fault is c. 200m juxtaposing the Carboniferous limestone against the earlier Palaeozoic sediments. The contact between the Coal Measures and the Carboniferous could not be seen but when the trail and stream crosses the South Craven Fault and enters a limestone gorge, Swilla Glen, we were now on the Malham Formation of the Great Scar Limestone Group. It was noted that the limestone is heavily fractured and jointed and could be seen to be dipping to the southwest, but further along the path, it is dipping to the northeast, indicating the stream had cut though an anticline.

Figure 30

The trail continues up Swilla Glen and after crossing the North Craven Fault, the bedrock changes first, apparently, to Upper Ordovician mudstones, not particularly distinguishable, then onto the vertically bedded greywackes of the Ingleton Formation. Examination of the bedding in the path (Figure 30) to determine which way up showed that they are younging to the north, although this was difficult to see without Bernard's help. This is the south limb of the Skirwith syncline.

There was a discussion about the sedimentation differences between the Ingletonian Group and similar aged Skiddaw Group seen earlier in the field meeting. The Ingletonian is deemed to be from a different terrane - the Monian terrane, separated from the Lakes terrane by the Dent Faults, and the source of its sediment was from the south. These terranes are all part of the story of the closure of the Iaptus Ocean between Laurasia and Avalonia in the early Palaeozoic.

Ingletonian slates had been quarried here in the Pecca Quarry, and the Pecca Falls were a pleasant sight in full flood cascading down vertically bedded slates. (Figure 31).

Figure 31

The view from path opened out as we approached Thornton Force with the classic unconformity, where horizontally bedded limestones wrapping round the valley overlie the vertically bedded slatey mudstones. Before approaching the waterfall, we examined an outcrop above the path where this could be seen in detail. The upper bed is grey flat bedded fossiliferous limestone with a thin pebbly layer at the bottom. The time gap represents about 180 M years, and the pebbly layer at the base of the Carboniferous limestone is formed on the sub-aerial, eroded surface of the Ordovician mudstones. (Figure 32). This basal conglomerate varies greatly in clast size and bed thickness across its outcrop in Yorkshire.

Figure 32

Thornton Force

SD 694 753

At the waterfall, the unconformity is dramatic, first described by John Phillips in the early 19th century. Below the force, on the outcrop, the beds are vertical, younging to the south, on the northern limb of the Skirwith Syncline. (Figure 33). Above this is the massive, flat-bedded Great Scar limestone, which is more resistant to erosion than the weak slates beneath.

Figure 33

Glaciation has a part to play in the next part of the trail. The valley was plugged by glacial debris then the river diverted to the east and cuts through this before plunging over the falls.

We continued north and the glacial trough of Kingsdale came into view. (Figure 34). From the map in Figure 29, Kingsdale runs north-east / southwest and has numerous lateral and terminal moraines that have been identified and discussed in the literature of this area and are part of the interesting glaciation story that was only briefly mentioned.

Figure 34

Figure 35

The trail continues in an easterly direction. Figure 35 shows, across Chapel-le-dale, the active Ingleton Quarry where Ingletonian slates are quarried for roadstone and to the left are the slopes of Ingleborough, with the stepped strata of the Yoredale Group overlying the Great Scar limestone. On the right in the middle distance are the Craven lowlands and in the far distance, the Forest of Bowland.

The trail heads south down the valley of the River Doe with pleasant views, then into the incised valley of Twistleton Glen. Continuing downstream we stopped to examine slate workings with a man-made rock platform at the stream's edge. Bernard pointed out after examining the outcrop that we were in the northern limb of the isoclinal syncline we had first seen in Swilla Glen, and the same slates had been quarried here. (Figure 36).

A narrow outcrop had been extensively quarried away from the river. (Figure 37). In the geological literature, three dykes have been identified injected into the Ingletonian slates during faulting. However, these were difficult to identify in the undergrowth, although there were one or two outcrops thought to be "candidates". Some time was spent examining the sedimentary structures in the mudstones/slates and possible "climbing ripples" were identified.

Figure 36

Figure 37

Continuing down the trail, we passed yet another waterfall, Snow Falls, then into another quarried area on the south limb of the syncline, after which the valley opens out - the trail having crossed the North Craven Fault, back onto the limestone and the zone between the North and South Craven Faults.

There are old limestone quarries (Storrs Quarries) alongside the trail. (Figure 38). Ingleton was on the railway network and building stone had been transported from here for the development of Bradford and Leeds in the 19th century. Close examination of the limestone quarry faces identified some interesting features of faulting - big blocks of disturbed limestone and slickensiding indicating that we were in the damage zone of the North and South Craven Faults Also identified was a narrow band of seat-earth and some fossils, mostly coral.

Reaching the end of the trail and the return to the car park included a stroll back through the attractive village of Ingleton.

Figure 38

Report by Hilary Jensen, photos by Hilary Jensen