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Front cover picture: Daisy gypsum from Kirkby Thore, Eden Valley Cumbria (see page 52).
Specimen LIV.1964.115.U in the mineral collection of National Museums Liverpool.
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THE NORTH WEST GEOLOGIST
(Formerly THE AMATEUR GEOLOGIST)
~ Number 16 ~

CONTENTS **PAGE**

Editorial

I am most grateful to the authors who contributed for this issue of North West Geologist for providing such an interesting variety of articles from technical to historical, from national to international and all aspects of the geological world around us. As this editorial is being written we are under a cloud of volcanic ash from Iceland, a timely reminder perhaps of how geological processes can affect us even if they are distant. Finally, it is sad to mention the loss of Fred Broadhurst who was well known to many members of the geological societies in North West England and will be greatly missed.

Wendy Simkiss

Notes for Authors

Articles and suggestions for future issues are most welcome and should be sent to either Chris Hunt, Department of Earth Sciences, The University, Liverpool L69 2BX or Wendy Simkiss, Earth Sciences, World Museum Liverpool, William Brown Street, Liverpool, L3 8EN,
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Articles should preferably be emailed, or if very large files, be presented on disk in MS Word. They may be up to 3,000 words in length. Figures should be designed for reduction to fit a maximum frame size of 180 mm by 125 mm.

Cover pictures can either be photographs or digital images and must include the name of the photographer or owner, the society to which they belong and information about the image including the location. The cover picture will be around 92 mm by 72 mm and, if sent as a digital image must be at least 300 dpi.

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THE USE OF YOUR DIGITAL CAMERA TO RECORD SITE DETAILS AND PREPARE PLANS

By Peter Rankilor

This is part four of a series of short articles on how you make your digital camera more versatile, how to get more out of it, and how to make your geology more interesting by using your digital camera in conjunction with your computer.

In this fourth article, I show how the digital camera can, without any cost, be used to record a great amount of information about any geological site or area of interest. That information can comprise a visual 'database' from which details can be extracted to prepare relevant spatial plans of what was observed - if and when they might be needed.

This latter point is very important since most surveying processes require the pre-knowledge of what it is that needs surveying, and the extraction of data before the results can be viewed. This digital camera technique stores a very large quantity of data that you might need at some time in the future. If and when you do need it, then you can extract it. In the meantime, you can inspect the photographs for visual information.

In my previous articles we have looked at recording micro-data, and now we can consider what we could call mega-data; small to large scale data all recorded by the digital camera.

The Essence of the Process

This short paper usefully follows on from article three in the series, which covered the use of the digital camera to create three-dimensional photographic pairs. This procedure is much the same, but the objective this time is to obtain two overlapping sets of photographs, so that spatial data may be extracted from them.

The concept is that the geologist takes overlapping photographs of a view from two positions. The positions are marked in the field with two ranging rods. The distance apart of the ranging rods is known, as is their orientation with regard to the compass. Two more ranging rods are placed at right angles to the first two. From this set of photographs an approximate site plan sketch can be prepared after the event.

Typical Photographic Setup

The sketch overleaf shows a typical scenario for the taking of appropriate photographs in the field.

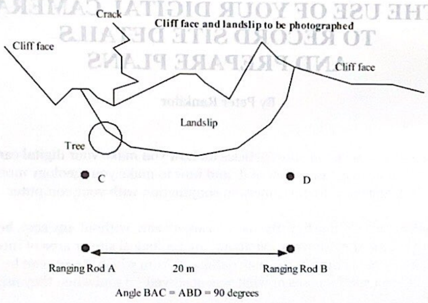

Figure 1.
Plan sketch of a hypothetical site, where the geologist wishes to record the scene with a possible future need to create a site plan. The details of the site are unimportant since this is a hypothetical case for the sake of illustration. What is important is the layout of the ranging rods.

In this case, there has been a landslip and an engineering geologist has been sent out to record it. Naturally, he or she will take a photograph of the slide. With the advent of digital cameras, it is now no more expensive and hardly more time consuming to set up two ranging rods[1] A and B at a measured distance apart and preferably (though not necessarily) at a known magnetic orientation, and two more (C and D) at right angles, before taking photographs. The distance of C and D from A and B is not required, but if measured at the time, becomes a piece of additional information that may be useful at a later stage.

Summary of Information Needed

Distance between A and B must be measured. C and D must be set out at a known angle from the line A-B. This is usually a right angle for ease of setting out. However, strictly speaking, as long as the angles CAB and DBA are known, then the procedure may be followed.

In this article it is assumed that these two angles are 90 degrees. A 90 degree angle can easily be constructed using a tape measure, by constructing a 3:4:5 sided triangle. Thus if the distance from A to B is 20 metres, as above, then a triangle measuring 15:20:25 metres must be set out using the tape. Two tapes are easier to handle than one. Since the baseline is 20, simply measure away from A to C a distance of 15 metres, and simultaneously measure a distance of 25 from B to C. Where the two lengths meet, is at point C, and similarly point D can be constructed. The two points are automatically at right angles to the line A-B if 3:4:5 triangles have been constructed.

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[1] It is not necessary that the marker poles be ranging rods - any vertical pole will perform this function. The main benefits of ranging rods are that they have a sharp spike at the bottom and give an indication of scale on the photograph - those things are useful.

Taking the Photographs in Series

Overlapping photographs can then be taken of the scene from A and then from B as shown below.

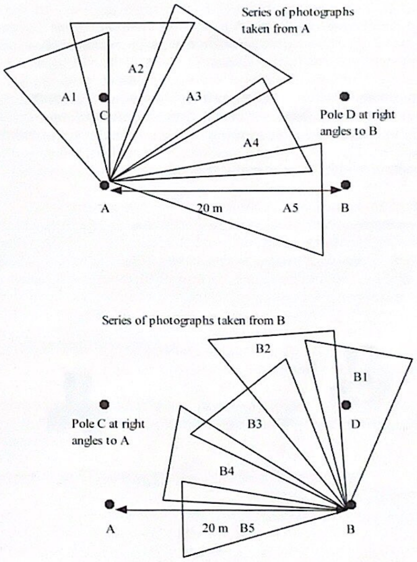


Figure 2.
This figure shows the required pair of overlapping photographic panoramas - one taken from A to include rods B and D, and one taken from B, to include rods A and C.

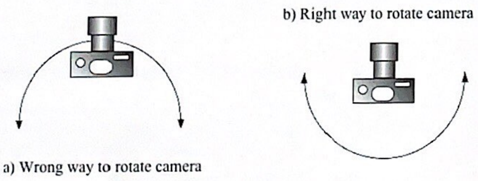
The compass direction between A and B can ideally be set at west-east, or north-south, but this is not necessary as long as the direction is taken with a compass and therefore known. The map plot can then be sketched with an approximate north sign on it.

The two sets of photographs A1-A5 and B1-B5 **(Figure 2)** need have no further work done on them other than saving them to hard disk or other storage medium such as a CD or DVD disk.

This is the exciting and important part of the procedure. You have now stored all the necessary data to either prepare a full approximate site plan, or to identify the position of any individual feature that you may require in the future. But you have not had to do any work other than take ten free overlapping digital photographs and drop them onto your hard disk. It is all done!

One of the interesting by-products of the overlapping photographs is that many will form exaggerated stereoscopic pairs that will allow you to view the site in 3D using a stereoscope or by crossing your eyes (see my article no.3 in this series, North West Geologist issue 14). That, in itself, can provide a lot of qualitative data and prompt the memory with regard to what existed on the site. It can be most useful.

Another useful hint can be made at this point. When asked to take a series of panoramic overlapping photos, a photographer will usually take them as shown in Figure 3.a, rotating the camera around his or her head. I have read that this technique results in incorrect overlap, and that the proper way to do it is as shown in **Figure 3**.b. If you are very keen on this, then special rotating tripod heads can be purchased to ensure that the rotation is accurate.



b) Right way to rotate camera

a) Wrong way to rotate camera

Figure 3.
How to rotate a camera to get the best overlap effect for panoramic images. Most people will simply rotate the camera around their head, as in a), but the best method is to rotate the camera around a more central point in the camera. This might best be a position just forward of the optical image chip for short focal length lenses, and even further forward for long lenses.

Having taken your photographs, if a sketch plan of the site is subsequently required, the ten overlapping photographs allow you to make a plan by a process similar to the old 'plane-table' method used hundreds of years ago.

In the old days, when I was a young geologist, the procedure involved using the ten photographs on paper, developed and printed by a chemist's shop, and then sticking them together to form two panoramas, using tape, or similar. We thought we were very sophisticated and clever when we started to use 'invisible' tape to join our photos together - we could draw on invisible tape, which is not possible with the shiny surface found on most tape.

Today, however, the A1-A5 photo series, and the B1-B5 photo series can be 'stitched' together electronically because they are digital photos. There are several different computer programs that allow you to stitch photos together. I believe that Microsoft Windows has a proprietary one, and so does Adobe's Photoshop and Adobe Photoshop Elements (a relatively inexpensive program). The photos are stitched together to form two separate panoramic views - one taken from point A and one from point B.

These two panoramas are then used to create a plan sketch by the method described below.

If required, this procedure is equally effective for the sketching of more comprehensive plans by taking overlapping photographs right round 360 degrees from each of the two points. The principles and methods described below are the same, but only two ranging rods are needed, since each will be recorded twice as the camera from point A goes round starting with photographing ranging rod B and ending back at ranging rod B. Similarly, a circular panorama is created from point B photographing a circle starting with a view of ranging rod A and finishing with a view of ranging rod A. Then on the taped-up panorama, the physical distance on the panorama between rod A on the left and rod A on the right equals 360 degrees.

Note that it is safer to use a fixed focal length camera for this work. **If a zoom lens is used, it is vital that the zoom is not varied** during the taking of both series of overlapped photographs.

Stitching the Photograph Series Together

Within, say, the Adobe Photoshop Elements program, select the overlapping photographs, ideally as taken from left to right. This is not essential, but makes the auto-fit process easier since the program lines up the photographs from left to right in the order they are selected.

Then allow the program to auto-join them in the process called 'stitching'. This will make a single panorama, which we shall call A. The other panorama, when made, will be called B.

A simple example of three photos of a road cutting is shown below in **Figure 4**, together with the 'stitched' panoramic version in **Figure 5**. This shows how well the auto-stitch process works.

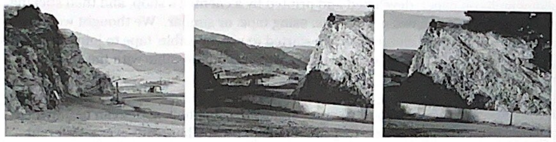


Figure 4.
Three separate photographs taken from left to right, prior to stitching

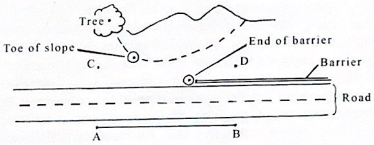
Figure 5.
A stitched panorama made (in Adobe Photoshop Elements), from the three individual photographs above.

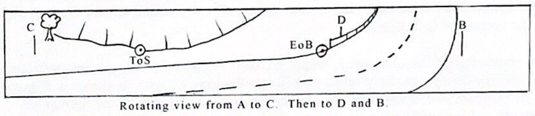
In all, two panoramic photographs are created.

Generally, in photographic packages, all this cutting, pasting, stitching and altering is done on JPEG files which have the extension .jpg. Always use the highest quality .jpg setting. JPEG is an easily handled format. However, some Computer Aided Design packages will only import PICT files with the extension .pct. So, before closing Adobe Elements, if necessary, export the panoramas into PICT or other appropriate format for use in the relevant CAD (Computer Aided Design) package. Check the CAD package for information as to which it will accept. Some CAD programs will permit the pasting in of a .jpg file directly onto a layer, and if so, then that image can be adjusted as necessary in Photoshop or similar, before being pasted into the CAD package.

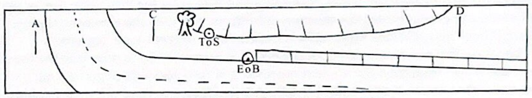
The panoramas, once stitched, are imported or pasted into the CAD program for analysis as shown below.

A CAD program is normally just used for the creation of scaled drawings. In this case, it can be used to measure the dimensions from the two imported panoramic photographs and prepare the approximate site sketch plan.





Rotating view from A to C. Then to D and B.



Rotating view from B to D. Then to C and A.

Figure 6.
This figure shows two stitched panoramic photographs, one above the other. They are respectively taken from the equivalent positions A and B of Figure 1. The upper panorama is supposed to have been taken from position A and the lower one from position B. Typical measurements are shown on the panoramas from ranging rods to toe of slope.

Figure 6 shows a fictitious arrangement of two panoramas and lateral measurements on them. The upper one shows physical 'on-paper' measurements made from ranging rod C at the left hand side, to the toe of the slope, and the lower one shows the dimension from ranging rod D on the right to the toe of the slope.

You can either, print out these photos onto paper and do the following procedure by hand, or you can do it using a CAD (Computer Aided Design) program or drawing program on your computer, assuming that the drawing program allows you to measure distances between points on the screen. The principle is the same whether done by hand on paper or done on a CAD package.

The essential concept is that, on panorama A, the physical distance between ranging rods C and B may be, say, 180 mm on the sheet of paper. Since the camera was rotated during photography, we know that the distance on the paper represents directly an angle of 90 degrees between rods C and B. Thus if, for example, on the paper, 180 mm represents 90 degrees, 2 mm represents 1 degree. This is measured from left to right on the printed picture.

A piece of graph paper is taken on which to draw the plan, and a scale chosen. Then according to that scale, a line A-B is drawn measuring 20 metres, being the scaled distance between points A and B in the field. The lines A-C and B-D are drawn, vertically upwards, at right angles to line A-B. Then, using panorama A, as you measure off distances from C, left to right to various objects, such as the toe of the slope or the end of the road barrier, you can convert that to degrees and draw the appropriate angled lines (see **Figure 7**). The same process is repeated with the panorama taken from pole B, but in this case, the measurements are made on the paper photographs from right to left. Measurements are taken from pole D on the photograph panorama, and measured to the left to, for example, the toe of the slope or the end of the road barrier.

Any measurement to an object from poles C or D (**Figure 6**) can be converted into an angular measurement and plotted on a simple diagram to scale, as shown in **Figure 7**. In that instance, it has been measured that 200 mm represents the right angle between poles C to B on the upper panorama and A to D on the lower one. Let us say that in the upper panorama, the measurement from pole C to the toe of the slope is 49 mm, then the angle this represents is 49/200 x 90 degrees = 22 degrees. Similarly, on the lower panorama, if the distance measured from pole D to the toe of the slope is 100 mm, then the angle it represents is 100/200 x 90 degrees = 45 degrees. When these are plotted, the intersection of the two lines gives the position of the toe of the slope in relation to the line A-B shown in **Figure 7**. You have just created a true scale site plan! That could well be a plan of a geological site showing the position of a large fossil, the position of a mineshaft, or the position of a mineral cluster, for example.

The important thing about these overlapping panoramic photographs is that they store all the information you might need at some future time, without having to actually take those measurements in the field. For example, after the completion of some landslip remedial works, there might arise the question of where some feature was that is now covered up. Or in the case of a fossil location, the panorama technique will allow the preparation of a scaled map showing the position of the fossil. Of course it is best that several other fixed features are also plotted, in order to provide positions for field measurements to locate the required item.

The panorama technique will at least allow an approximate assessment of the position of an item whether visible at a later date or not. Furthermore, the shots can be viewed stereoscopically at any time and additional information extracted.

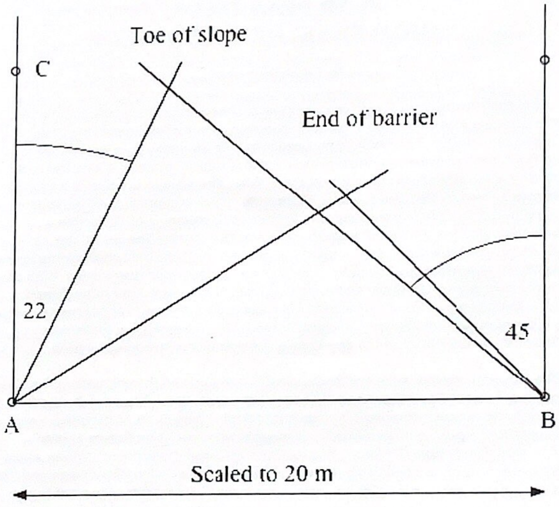


Figure 7.
Triangulation method converting distance into degrees. This figure shows the plotted positions of the toe of the slope and the end of the road barrier in relation to the scaled position of ranging rod A (first camera position), and ranging rod B (second camera position).The plotted distances for the toe of the slope convert to an angle of 22 degrees from the left and 45 degrees from the right.

Overall, this recording method is inexpensive on materials and time because it uses digital camera recording and because no triangulation work need be done unless specific information is required - a nice easy way to record information for the future, especially if it is raining at the time, since you can do your work in the comfort of home, or a warm pub!

LIMESTONE QUARRIES AND LAVA FLOWS NEAR PEAK DALE, HIGH PEAK, DERBYSHIRE.

By Derek Brumhead

Although Carboniferous Limestone gives rise to the beautiful scenery of the White Peak, it is also one of our most valuable economic resources and quarrying is an important industry. Tunstead quarry (grid reference SK 093693), originally opened by ICI in 1929 and now operated by the Tarmac Group, is located 4 kilometres east of Buxton in the High Peak of northwest Derbyshire. The main face, which is 2.5 km long, is located in the Chee Tor Rock (**figure 3**), which is approximately 125 metres thick, and one of the purest limestones in the world, averaging 98 % calcium carbonate ($CaCO_3$,) with certain beds exceeding 99% purity. The overall dip is constant, averaging 1:7 to the east. A series of faults, progressively up-throwing to the south has exposed almost all of the Chee Tor succession, while that portion south of a fault IVa brings up the upper beds of the underlying Woo Dale Limestone (**figure 3b**). The geology of the quarry area has been described by Ineson and Dagger (former president of the Manchester Geological Association), the geology of the area by Stevenson and Gaunt, and the limestone and dolomite resources by Harrison.

The quarry is near the village of Peak Dale (SK 090762) and there is a convenient parking space at **P1** on **figure 1**.) Although not private, it is often used during the week by limestone lorries, so it is advisable to double park at the eastern end. From here follow a track south-eastwards to a magnificent view (**A** on **figure 1**) into Tunstead quarry from the footpath, a right of way, which runs, not too closely, along its northern edge. A labelled photograph of this view is provided (**figures 3a** and **3b**) and I am grateful to Steve Hill, the estates manager, for identifying the plant for me.

Quick lime (calcium oxide), hydraulic lime (calcium hydroxide), milk of lime, cement, ground lime and aggregates are some of the products of this quarry which are put to an enormous variety of uses in our everyday life. High purity limestone is used in a number of industries where the chemical properties as basic oxide, flux, neutralising agent or source of calcium are important. It is used in the manufacture of soda ash (sodium carbonate), glass, metallurgical flux, in sugar-beet refining, wire drawing, water treatment, paints, rubbers, limestone aggregates, and many more products. Cement is an important product at Tunstead, since clay which occurs in wayboards (thin seams of volcanic ash), joints and fissures is available in large quantities from washing at the crushing plant. A new dry process cement plant was opened in 2004 and a second plant is the subject of a current planning application.

Tunstead, along with the adjacent Old Moor quarry, is the largest producer of high purity limestone in Europe, with over 5.5 million tonnes produced annually. One of the most recent uses of limestone is in flue gas desulphurisation at coal-fired electricity generating stations. Nearly a million tonnes a year is sent to the Trent Valley and elsewhere. Woo Dale Limestone is slightly less pure with a $MgCO_3$ (magnesium carbonate) content making it unsuitable for some chemical uses. Much of it is therefore used for concrete aggregate and road stone.

At the time of writing in June 2009, a Maerz Kiln is being built (**figure 3**). The design makes it possible to burn limestone of particle size ranging from 10 to 30 millimetres, which could hitherto not be burned in shaft kilns. The kiln is characterised by the parallel flow of limestone and combustion gases in the kiln, and the regenerative preheating of combustion air. Two shafts containing the material to be calcined are connected to each other by a crossover channel at the bottom end of the burning zone. Both shafts are charged alternately.

On returning along the track, a huge mountain of spoil is seen on the left. This is associated with the working of a thick dolerite sill at Waterswallows Quarry which was extracted by Tarmac before it closed (**figure 1**). Returning to the cars, drive to a small parking space (**P2**) just over Buxton Bridge. Alternatively, or on weekdays when this may be occupied, park in Peak Dale village (**P3**). In either case, the next view point (**B**) is on the road to Peak Dale (figure 1.) From here is an instructive view showing clearly the outcrops of two horizontal lava flows, the Lower and Upper Millers Dale Lavas separated by limestone beds. These lava flows were deposited on the sea floor interrupting the deposition of the limestone. They form distinct ledges and minor scarps in the landscape (figures **4a** and **4b**).

From here, re-cross Buxton Bridge and take a rough track south-eastwards. Quite soon, a stream is seen flowing down a shallow valley. Surface streams such as this are unusual on the limestone, but this originates from a spring thrown up where basalt lava is faulted against limestone (**F** on **figure 1**). Continue for about one mile, at the end of which is a low cliff forming a fine outcrop of the Lower Millers Dale Lava. A viewpoint (**C**) over the impressive shaft kilns and railway provides a convenient place for lunch. The original tiny ICI quarry can be seen next to the railway line. Opened in 1929, this was adjacent to the then Midland Railway line from Manchester to Derby and London, with a link to the ICI Cheshire chemical works. Sidings were built to convey the limestone away and today these have been greatly extended so that hopper trains can be directly loaded under cover with lime, cement and aggregates.

From here continue along a rough field path, passing through some stiles, until reaching a magnificent view (**figure 5** and **D** on **figure 1**) into Old Moor Quarry. This quarry (linked to Tunstead Quarry by a causeway over Great Rocks Dale, which carries the railway), has been in operation for nearly thirty years, and has four bench levels or 'lifts'. Later, there will be a fifth level cut which will reach down into the Woo Dale Limestone. This limestone is about 400 metres thick, and a borehole locally has shown that at its base is an unconformity with rocks of possibly Ordovician age. Evidence of the quarrying technique can usually be seen here, a row of drill holes punched by a rig along the edge of the limestone face. These drill holes are filled with explosives which blast down the limestone into heaps for removal by 100 tonne dumper trucks and taken for processing into Tunstead Quarry.

From this point you can return to your car using the same route back or if you have time or the inclination it is possible to extend the walk to the hamlet of Tunstead to see the memorial to James Brindley. Brindley was a canal engineer and millwright, who was born locally. The paths taken to return from here are marked on the sketch map **figure 1**.

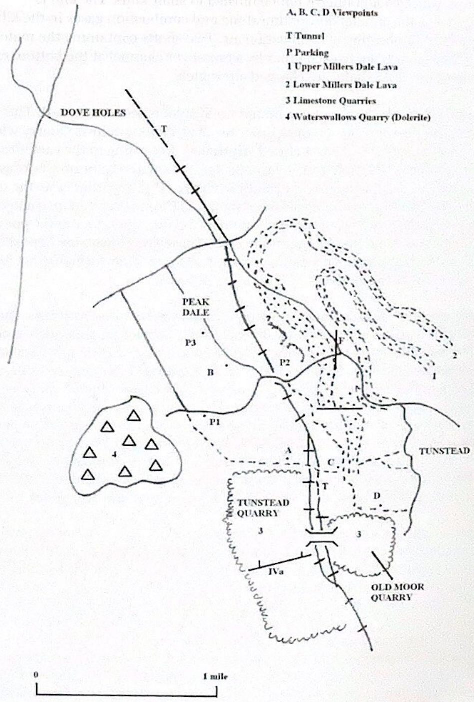


Figure 1.
Sketch map of localities named in the text.

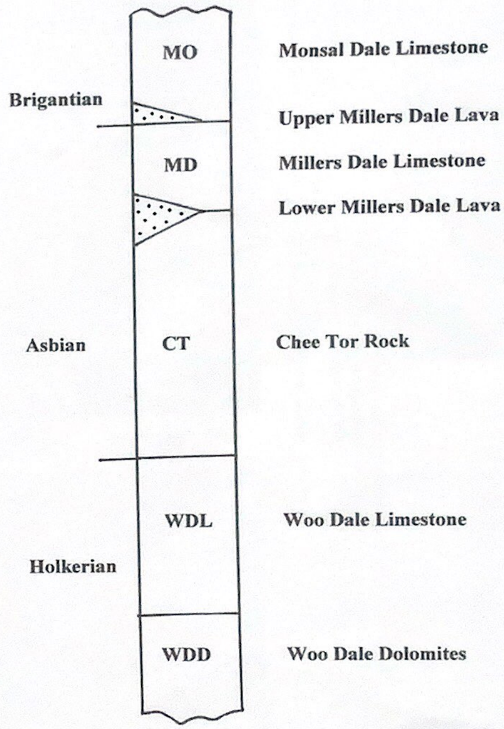


Figure 2.
Generalised vertical section of the local geology. Redrawn from geological 1: 25 000 Sheet SK 07 (Buxton), Institute of Geological Sciences, 1951.

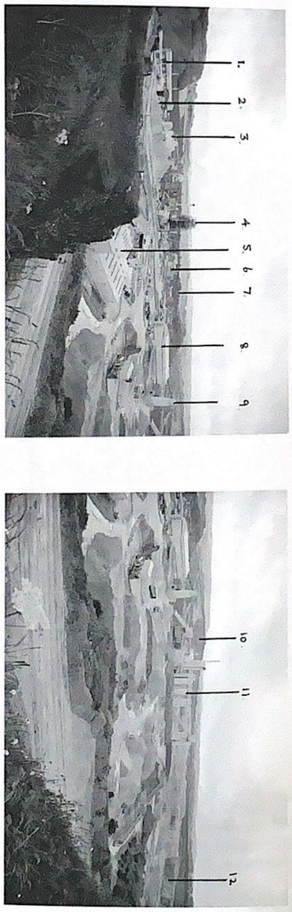


Figure 3. Viewpoint A. Tunstead Quarry. Key: 1. Shaft Kilns. 2. Kiln Feed. 3. Hydrated lime and milk of lime. 4. Maerz Kiln (under construction).
5. Cement Bagging Plant. 6. Aggregate Plant. 7. Old Moor Quarry. 8. Imported materials for Cement Plant: sand, clay, mill scale, gypsum, coal, petcake. 9. Limestone silo for Cement Plant. 10. Woo Dale Limestone. 11. Cement Plant. 12. Chee Tor Rock. I am grateful to Steve Hill, Estate Manager, for information about the plant.

Figures 4a and 4b.
Viewpoint B. This is a view of the horizontal Lower and Upper Millers Dale Lavas separated by limestone strata. There are two limestone quarries and Figure 4b is the view to the right of 4a. Key: 1. Upper Millers Dale Lava. 2. Lower Millers Dale Lava. 3. Limestone.

Figure 5.
Viewpoint D. Old Moor Quarry. Note the drilling rig, with the line of holes awaiting explosives, taken in June 2009. Excavation of a further level will expose the Woo Dale Limestone.

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June 2009.

A VICTORIAN GEOLOGICAL TREASURE TRAIL

By Marjorie E. Mosley

We are fortunate today to be able to take advantage of the numerous geological guides encouraging us to explore the geodiversity in our towns and countryside. However, geology trails are not a new idea. Over one hundred and fifty years ago, the architect Abraham Stansfield and the geologists James Horsfall of Healey Nursery and Robert Law F.G.S. of Todmorden created one of the first geology trails in the country. This trail was not over rugged moors or through the picturesque White Peak but in a newly opened urban graveyard in Lancashire.

Rochdale cemetery, consecrated in April 1855 by the Bishop of Manchester served Anglicans, Catholics, and Non-Conformists. While the primary purpose of the stones making up the geology trail was, in the words of local geologist and teacher, James Maxim, who documented the trail in the 1930s, to "educate and instruct others in the science of the earth", they also fulfilled an essential practical requirement as a boundary marker separating the Anglican burial ground from that of other denominations.

The thirty geological specimens used in the trail comprised a Start and a Finish Stone, both inscribed with biblical quotations, 27 individually dressed and inscribed pillars, mostly around three to four foot high and one sandstone trough. In a lecture to members of Rochdale Literary Scientific Society in June 1881, following a field trip around the cemetery, Professor Sir William Boyd-Dawkins F.R.S. and F.G.S., described the pillars as "collectively reflecting the whole range of conditions throughout geological time and representing some of the most important stages in the history of the world". According to the inscriptions of the Start and Finish Stones, Horsfel and Law arranged the stones in order of antiquity as determined by the geological knowledge and understanding at the time. In the light of current knowledge the trail remains remarkably accurate and only in the case of the first seven specimens is there some imprecision.

The Start Stone, located against the Sandy Lane boundary wall, is a fine-grained sandstone and bears the inscription

> "In the beginning God created the Heaven and the Earth. This series of pillars commencing here with Lava and in ascending order, terminating with Boulder Stones, elucidates the arrangement of the strata of the Earth's Crust in the order they were formed by the Creator of old hast thou lain the foundations of the Earth."

The trail begins with three pieces of basalt (1), considered at the time to be the oldest rock. The specimen is cemented on a sandstone plinth inscribed

> "Basalt from the Giant's Causeway, Ireland, Presented by Councillor
> Mr. Edward Ashworth".

Basalt is a fine-grained, extrusive igneous rock and the specimen has retained vestiges of hexagonal columnar jointing. Modern knowledge places this basalt from the Eocene 65 million years ago. Two pieces of basalt have fallen from the plinth, one of which is lost.

The next two specimens are metamorphic rocks. Both are badly weathered and discoloured and the inscriptions are barely legible. One, described by Maxim, as 'green porphyrite from North Wales' (2) inscribed "Serpe" is probably either weathered gneiss or a quartz-mica-schist. Its provenance is possibly the Pre-Cambrian Monian Supergroup of Anglesey, aged 540 million years. The other, Maxim describes as a "pink serpentine, Ireland" (3), in which veins of serpentine are visible. It is probably from Clew Bay, North West Ireland.

Next are two specimens showing little sign of weathering. Both bear the inscription

> "Aberdeen granite from mcdonald's polished granite works Aberdeen".

One is pale grey and medium-grained **(4)** from Rubislaw Quarry, Aberdeen. The other is red and medium-grained **(5)**, from Corrennie Quarry, fifteen miles inland from Aberdeen. These are plutonic igneous rocks emplaced during the Grampian Orogeny, Ordovician and formed 470 million years ago.

Following the granite comes the only rock from outside the British Isles and Ireland, the Italian Carrara Marble **(6)**, considered incorrectly by Maxim to be the third oldest. The inscription is barely legible but the granular texture and saccharoidal weathering is visible on a small clean area; this marble was formed by contact or thermal metamorphism of Jurassic limestone, 205 million years ago.

The last of the misplaced specimens is an octagonal pillar of slate inscribed

> "Cambrian series, clay slate from Dinorwic quarries, Bangor, North Wales".

This slate (7) is a metamorphosed Cambrian mudstone, 542 million years old, dark purple, fine grained with a slaty cleavage. Unfortunately, the specimen is showing signs of splitting along cleavage planes.

Across from the Dinorwic slate the 428 million year old sedimentary rock labelled "Silurian Wenlock limestone, Salop" **(8)**, is badly weathered and covered with mosses and lichen so the inscription is hardly legible. However, weathering has resulted in fossils standing proud and rugose corals, brachiopods, and crinoids are clearly visible on the back of the specimen.

The next pillar, "Old Red Sandstone Dumbartonshire" **(9)**, is Lower Devonian sandstone from Auchensail Quarry. Cemented on top of the pillar, as a separate specimen, is a septarian nodule traversed by mineralized fissures. The provenance and age of the septarian nodule is at present unknown. Auchensail Quarry is a SSSI (Site of Special Scientific Interest) because of its well-preserved and abundant carbonaceous plant remains found in the Lower Devonian (Emsian) Teigh Sandstone, between 395 and 410 million years old.

Three different limestones, with illegible inscriptions, represent the Lower Carboniferous series of around 359 million years ago. They are Black Marble from Galway **(10)**, Encrinital Marble from Limerick **(11)** and Mountain Limestone from Dove Holes Dale, Buxton **(12)**, with "marble" being a stonemasons' term for easily polished limestone as neither have been metamorphosed. The black marble is a dark grey limestone containing a few shelly fossils and is from Anglihan Quarries, Galway. This was exported to London and America, demand was so great in the mid-nineteenth century it was named the London Bed and was traded as "London Black." The Encrinital (crinoidal) Marble, probably from Carrigparson, Limerick, is a fossiliferous limestone with a mass of crinoid stems, plainly seen on the weathered surface. The Mountain Limestone is irregularly shaped, containing a few crinoids, and shows evidence of the corrosive action of water found typically in limestone caves and karst landscapes.

Seven sedimentary rocks **(13 - 19)** Cannel Coal from Wigan and six specimens of sandstone, five of which were quarried locally, were intended to represent the Upper Carboniferous around 318 million years ago. Wigan was well known for its cannel coal **(15)** as early as 1540 when the antiquarian John Leland described the excellent properties and availability of the cannel found on Sir Roger Bradshaigh's estate in Haigh. It is a high-ranking bituminous coal with a sub-conchoidal fracture and formed in lakes from the deposition of humic mud composed of spores, algae, and vegetable matter. At present, the nine cubes of cannel that should be in the inscribed sandstone trough are missing.

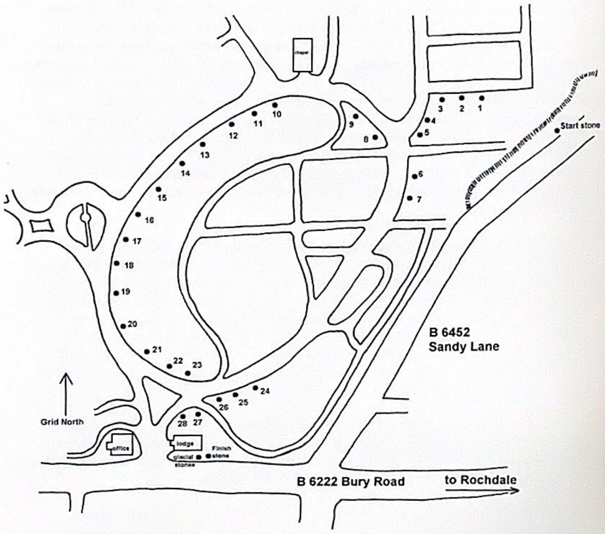
All six sandstones have clear legible inscriptions, a testament to their competency. The first, "Coal Series, Millstone Grit from Blackstone Edge" **(13)** is part of the Edale Shale Group. A corner of the top moulding has been broken off which allows a close examination of the coarse, poorly sorted, pink quartz grains.

Next along is a fine-grained well-sorted sandstone "Coal Series, Sandstone from Clough Head Todmorden" **(14)** - the Milnrow Sandstone. The arched specimen has two sides differently dressed and the back left rough. Clough Head Quarry is part of Todmorden Moor RIGS site, managed by West Yorkshire Geology Trust.

This is followed by the pale buff, fine-grained, well sorted "Coal Series, Flagstone from Middle Hill" **(16)** - the Rough Rock of the Lower Coal Measures quarried from Whitworth. The quarry is still in operation, producing gritstone for walls, paving and building use.

The fourth specimen, the top of which has been worked into a pyramid, "Coal Series Sandstone from Bagslate" (**17**) is fine-grained, and very well sorted. Rochdale Golf Club now obscures the probable source of this sandstone.

Sketch map of the Victorian Geology Trail in Rochdale Cemetery



"Coal Series Sandstone Middle Hill" (**18**) is a specimen of fine-grained, well-cemented sandstone quarried in Whitworth, the top of which has been cut into small steps, each with individually dressed faces.

The sixth sandstone, "Coal Series, Sandstone from Craigleith Scotland" (**19**) is a fine-grained well-cemented sandstone actually from the Lower Carboniferous Limestone Series in Scotland, and around 330 million years old. Craigleith Quarry, situated about three kilometres to the northwest of Edinburgh city centre, was once one of the largest quarries in Scotland with a worldwide reputation for high quality building stone. The quarry, now in-filled, is the site of Sainsbury's supermarket. Behind the supermarket, some of the upper part of the quarry face remains and is now a geological trail with a leaflet "Craigleith Quarry" produced by Lothian and Border RIGS Group.

Representing the Permian, of 299 million years ago, is a hexagonal pillar of magnesium limestone, made up of calcite with between 5-10 percent dolomite content. Mosses and lichens cover this specimen and the inscription "Limestone from Roche Abbey" (**20**) is barely legible. The source of this rock is the Roche Abbey Quarry near Maltby.

From the early Triassic period of 249 million years ago is a sandstone pillar from Runcorn Hill Quarry, "Salt Series New Red Sandstone from Runcorn" (**21**). It is pale red due to iron oxide, with fine grains of well-sorted, frosted quartz and reflects the desert environment of that period.

The gypsum (**22**), a hydrated calcium sulphate, easily dissolved by exposure, has disappeared. Maxim thought this specimen to be from either the Permian or Triassic period.

Four specimens represent the Jurassic period, approximately 199 million years ago; various limestone fragments from Whitby to Lyme Regis (**23**), Stonesfield Slate (**24**), Corallian Limestone (**25**), and Portland Stone (**26**).

Of the limestone fragments, only the small sandstone marker inscribed "Various limestone fragments from Whitby to Lyme Regis" remains. Maxim had noted

> "A small collection of nodules, some calcareous stones, and a few septaria."

The well-cleaved Stonesfield Slate is a dimension stone from the village of Stonesfield in Oxfordshire. It is a fissile sandy limestone from the base of the Great Oolite bed obtained from adits driven into valley sides or shafts 20 - 70 feet deep. From around the sixteenth century onwards, the practice was to dig up the stone in pieces, known as 'pendles', around Michaelmas, keep them damp and after three or four frosts the stone would cleave thinly. The slate was light and the least porous of local roofing material, greatly prized for prestigious roofs such as those of the Oxford colleges. The slate yields many marine fossils as well as material washed in from nearby land.

The irregular shaped piece of heavily weathered Corallian Limestone, also known as 'Coral Rag' is a hard rubbly, fossiliferous limestone from Headington Quarry, Oxford. The stone, used for many of the buildings in mediaeval Oxford, can be found in the city walls and St. Michael's Tower. Headington Quarry was designated a conservation area in January 1971.

The pillar of Portland Stone is discoloured and covered with mosses and lichens but ooliths, (rounded, concentric formations), can be observed in a small clean area. The inscription on the raised shield is now illegible. Maxim records the specimen as 'Portland Stone from the 'Mag. . . Quarry Isle of Wight, but this claim is highly questionable. As yet, however, it has not been possible to identify the site of the Mag . . . Quarry.

The two samples representing the Cretaceous, around 145 million years ago, are both limestones; Bethersden Marble (**27**) from Kent and Kentish Rag (**28**) from Iguanodon Quarry, Maidstone.

Bethersden Marble (known locally as winklestone) is a lower Cretaceous limestone found in the Wealden Clay. It is a mottled limestone with a hackly fracture and is one of two types known as Small *Paludina* and Large *Paludina*. The limestones are composed of either the small or the large species of the freshwater mollusc *Viviparus*. Small *Paludina* are the small species *Viviparus* elongates and the Large *Paludina* are *Viviparus sussexiensis*. Bethersden Marble contains the large *Paludina* and due to weathering the molluscs can be clearly seen. Use of the stone was made in the building of Canterbury Cathedral and it is still useful for walls and domestic paving today.

Kentish Rag is Lower Cretaceous limestone from the Lower Greensand Group. The original Kentish Rag is missing, but the examination of a sample from the old quarry at Ditton near Maidstone shows it as medium grey, rather sandy, with dark specks of glauconite visible through a hand lens. It also contains two little black phosphatic nodules visible to the naked eye. Kentish Rag can be seen in the external walls of the Tower of London but was not used internally as it has a reputation for 'sweating'.

In addition to the main collection, a number of glacial cobbles, locatable by a small marker inscribed "Drift Series, Boulder Stones found on this Cemetery," are to be found buried in leaf litter. These are awaiting identification. The trail ends with the Finish Stone, fine-grained sandstone hidden under Rhododendron bushes, bearing the inscription

> "He made the Earth by His Power
> He hath Established the world by His wisdom.
> The series of pillars commencing here with Boulder Stones,
> and in the descending order terminating with Lava
> elucidates the arrangement of the Strata of the Earth's crust
> in the order they were formed by the Creator
> Speak to the Earth and it will teach thee"

The future of this historic geology trail is assured. Work continues on the provenance and geological history of the specimens and funds have become available from Natural England for restoration and replacement work to be carried out over the next year.

Sir Boyd-Dawkin's praise of the trail as "one of the most extraordinary collections of geological specimens which he knew of" is not misplaced. With the exception of museums, it is unlikely that such a fascinating and illuminating collection of British and Irish geology could be found anywhere within such a small area.

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A DISTINCTIVE OUTCROP PATTERN ON AGUJAS GRANDES VOLCANO, GRACIOSA, CANARY ISLANDS

By Duncan Woodcock

Graciosa is one of three small volcanic islands off the north end of Lanzarote. Graciosa is inhabited and served by a daily ferry (**figure 1**) from Orzola. **Figure 2** shows a view of Graciosa from the Famara cliffs of north west Lanzarote. The two other islands of Montana Clara and Alegranza can be seen behind Graciosa on the left and centre horizon respectively. The Famara cliffs in the foreground of **figure 2** comprise a stack of horizontal basalt flows that were erupted during the "shield-building" stage of the construction of Lanzarote.

The rocks exposed on Graciosa post-dates the shield-building stage and are similar to rocks of similar age on Lanzarote (Fuster et al. 1966). These rocks are principally alkali basalts that have erupted both effusively and explosively to produce composite volcanoes comprising lava flows and pyroclastic materials. Much of the lower part of the island is mantled with carbonate sands; exposure is relatively poor except around the coast and on the slopes of the volcanoes.

The highest ground on Graciosa comprises two volcanoes known locally as Las Agujas. The southernmost volcano, Agujas Grandes, is referred to as Montana Pedro Barba on some maps - not the first time I've noticed different names for the same features in the Canary Islands! The distinctive outcrop pattern (**figure 3**) on the southern flanks of Agujas Grandes is an obvious feature of geological interest; if visibility is good it can even be seen from Lanzarote (**figure 2**).

I had the opportunity to examine the pattern at close quarters during the visit to Graciosa in 2008. Like all outcrop patterns, it is produced by the intersection of the erosion-sculpted land surface with the geological structure - in this case a sequence of "angle of repose" bedded pyroclastics with strong colour contrasts between individual layers. **Figure 4** shows a close up view of the area around the three distinctive "v s" along the lower boundary of the pattern. At this location, erosion has cut down into a light brown layer that is overlain by a much darker grey brown layer. The three "v s" are produced by three gullies with a slope that is less than the local angle of dip of the beds.

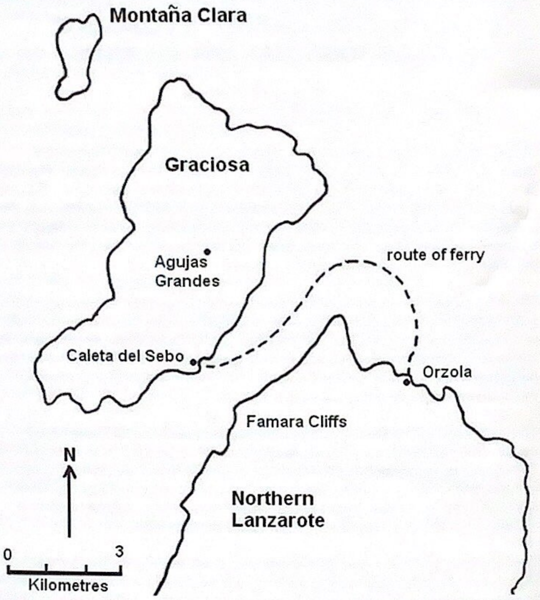

Figure 1
Map of the north end of Lanzarote and Graciosa island showing location of Agujas Grandes.

Figure 2
Graciosa from the Famara cliffs of NW Lanzarote. Agujas Grandes is the large hill immediately above the port of Caleta del Sebo. The distinctive outcrop pattern is just visible.

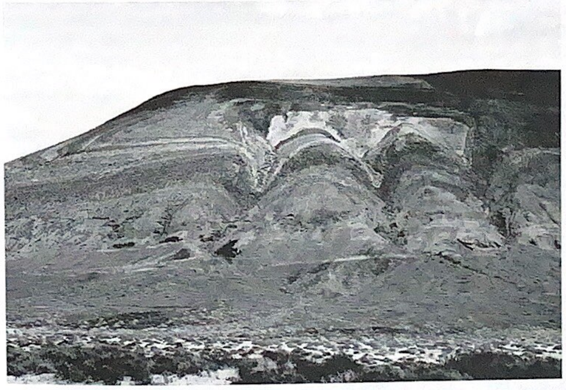

Figure 3
Distinctive outcrop pattern on the southern flanks of Agujas Grandes.

Figure 4
Close up view of the eastern half of the outcrop pattern on Agujas Grandes.

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MANCHESTER GEOLOGICAL ASSOCIATION WEEKEND TO THE LAKE DISTRICT AND MORECAMBE BAY 18 - 20 SEPTEMBER 2009

By Fred Owen, Mary Howie and Jane Michael

A weekend Field Excursion to the Coniston area was arranged for members of the Manchester Geological Association to investigate the Windermere Supergroup, one of three lithostratic units within the Lake District Ordovician/Silurian inlier in Northwest England. The excursion was led by Dr Chris Arkwright, current President of the Manchester Geological Association, and also included Borrowdale Volcanic Group and Carboniferous rocks.

Saturday 19 September 2009

Outgate roadside quarry (grid reference NY 356 003) Locality 1

We met up, on Saturday morning, at a rather grotty roadside lay-by on the B5286 between Ambleside and Hawkshead to look at a sequence of poorly sorted mudstones and greywackes, the Wray Castle Formation, which is the topmost layer of the Coniston Group.

Christine told us that this was a distal turbidite deposited at the edge of a deep-sea submarine fan and asked to look for evidence of erosion, laminations and ripples. None of these was easy to distinguish, but after a lot of scrabbling about in the brambles and piles of road metal, we were able to make out two layers of lighter coloured, coarser material parallel with the bedding of a massively bedded, very fine grained mudrock.

There were many joints but no obvious cleavages. We found some slickensides as evidence of movement. The rock is dipping gently to the southeast. We could find no evidence of an erosion surface.

High Cross Plantation Quarry (grid reference SD 328 985) Locality 2

In this large disused quarry we looked at two formations:-

The Brathay Formation, the lowest layer of the Tranearth Group, and the Birk Riggs Formation, which lies above it.

The Brathay Formation

The big slabs on the northwest side are the Brathay Formation. We could see two evident dips, (~30° and ~ 40°), both much steeper than dips at locality 1. The rock is a hard, bluish-grey mudstone containing a few thin laminae (2-4cm wide) of a buff siltstone. These were very evident on the fallen blocks

		NEW NAMES		OLD NAMES	
Silurian	Windermere Supergroup	Coniston Grp	Wray Castle Fm	Upper Coldwell Beds	
		Tranearth Grp	Coldwell Fm	Middle Coldwell Beds	*instability and variation in sea level and bottom currents due to local tectonics as Iapetus Ocean was narrowing*
			Birk Riggs Fm	Lower Coldwell Beds	
			Brathay Fm	Brathay Flags	
		Stockdale Grp	Browgill Fm	Browgill Beds	
			Skelgill Fm	Skelgill Beds	
Ordovician		Dent Grp		Coniston Limestone Fm	*marine transgression*
		— — —	unconformity	— — —	*emergence*
		Borrowdale Volcanic Grp			

Figure 1
Ordovician and Silurian rocks around Coniston showing relative sea-level changes due to closure of the Iapetus Ocean
(Interpretive data - Moseley, 1978; new stratigraphic names - Gunner, 2008)

(see **figure 2**) and also visible higher up. The joints were mineralised, a horizon of calcareous nodules and small-scale ripples were also found there.

Figure 2
High Cross Plantation Quarry (SD 328 985) northwest side of the quarry. A fallen block of the Brathay Formation. A hard bluish-grey mudstone with buff siltstone laminae (photograph by Mary Howie)

The Birk Riggs Formation

The right hand end of the northeast quarry face is the Birk Riggs Formation. Here paler-coloured greywackes overlie the darker Brathay Formation. The junction between the two formations was not easy to find, being obscured by vegetation, but the Birk Riggs rock was much finer grained and paler in colour (see **figure 3**). We could see very obvious sole marks (or possible tool marks). Many beds appeared to fine upwards, the very striking cleavages at the top of the individual beds being evidence for this (see **figure 4**).

Figure 3
High Cross Plantation Quarry (SD 328 985) northeast quarry face. Here the paler Birk Riggs Formation overlies the darker Brathay mudstones
(photograph by Mary Howie)

These formations of proximal turbidites were laid down in higher energy regimes than that at **locality 1**, with many sea level fluctuations, formed as the Iapetus Ocean closed up.

Figure 4
High Cross Plantation Quarry (SD 328 985) northeast quarry face cleavage seen in the Birks Riggs Formation
(photograph by Mary Howie)

Tarn Hows (grid reference SD 330 997)

After lunch, taken in the busy National Trust car park (grid reference SD 330997) at Tarn Hows, we explored outcrops of the Borrowdale Volcanic Group (BVG) on the western, northern and southeastern fringes of the tarn. These rocks comprise the ca 6 kilometres thick central lithostratic unit of the Ordovician/Silurian inlier, which forms the Lake District. The southern edge of this unit lies unconformably beneath the 8 kilometres thick Silurian sediments of the Windermere Supergroup; the unconformity passes through the Tarn Hows area.

The BVG comprises two phases of volcanism. The first phase, represented by the Lower BVG, consists mainly of basic to intermediate lavas and sills while the second phase, the Upper BVG, consists of intermediate to rhyolitic, volcaniclastic explosive deposits with some lacustrine sediments. The deposits seen here mainly belong to the Upper BVG and are represented by ignimbrites, ashfall tuff and some fining-up laminated rocks formed by airbourne ash settling in shallow water. **Figure 5** looks east across the tarn to the softer, underlying Windermere Supergroup which has been has been glacially sculptured to form a more gently rolling landscape than in the harder BVG landscape to the west. The Brathay Fault runs northeast-southwest down the centre of the tarn to form the valley which it now occupies.

Figure 5
Glacially sculptured Windermere Supergroup looking east over Tarn Hows (photograph by Fred Owen)

We walked northwards on the path west of the tarn, stopping first at SD 327997. Here we saw greenish-grey, fine-grained chloritised ash of the Tarn Hows Formation. The rock is an andesitic felsic tuff. Post deposition of quartz in joints and fault fractures indicate that mineral rich waters once circulated through the rock. In one exposure there were fining-up laminations indicating ash deposition in shallow water.

Further along the path towards the tarn shore was an outcrop containing small pieces of flattened pumice, called fiammé. These were formed during an explosive eruption when gassy, porous pumice fell to the ground in a pyroclastic flow which was compressed to form a welded ignimbrite. The fragments here were too small to photograph clearly but an example of one found in a glacial erratic of the same rock is shown is shown in **figure 6**.

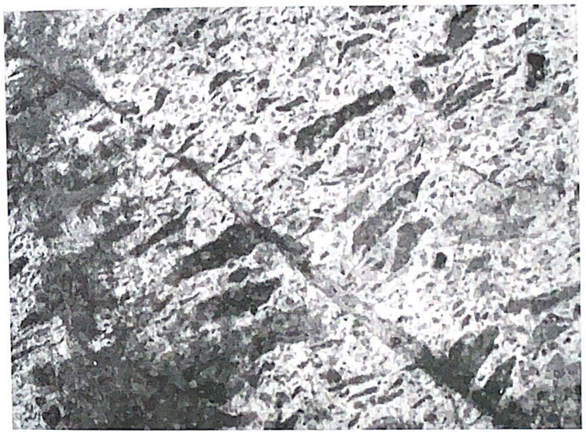

Figure 6
Glacial erratic of welded andesitic ignimbrite with fiamme
(photograph by Fred Owen)

After crossing the Brathay Fault at the north of the tarn we walked uphill and south, across the BVG/ Windermere Supergroup unconformity to an old quarry in the Brathay Formation; an anoxic, fine-grained ocean floor sediment, seen earlier at **locality 2**. Earth movements caused the bedding plane dip to the south and formed two intersecting cleavages which can be seen in **figures 7** and **8**. Turning westwards we came across a fossil-rich siltstone outcrop of the Kirkley Bank Formation, in the Dent Group at the base of the Windermere Supergroup, containing lime-rich nodules. This rock was burned in local limekilns to produce agricultural lime. Acidic rainwater has weathered out the limey nodules to leave large holes in the rock to give it the texture of Gruyere cheese.

Figure 7
Main picture of Brathay Formation in old quarry
(Photograph by Fred Owen)

Figure 8
Enlarged portion of bedding and two cleavages in the Brathay Formation shown in Figure 7 (Photograph by Fred Owen)

The roche moutonee shown in **figure 9** is a porphyrytic grey-green andesitic tuff

representing the top of the Upper BVG. It has been smoothed on the up-glacier surface by ice scouring while leaving a steeper, jagged down-glacier surface. In this case the glacier was flowing away from the camera.

After returning to the car park we drove to Tilberthwaite.

Figure 9
Roche moutonee (photograph by Fred Owen)

Tilberthwaite (Grid reference NY 307 009)

From Tarn Hows we drove northwest along narrow lanes through picturesque countryside to Penny Rigg Mill at Tilberthwaite (SD 307 009). This was one of the main copper mining areas of the Lake District, extracting chalcopyrite from a mainly quartz gangue. Several derelict buildings remain of this thriving mining community close to the southeast margin of the BVG, represented here by silicic volcaniclastic rocks which were later mineralized, possibly at the time of the Eskdale and Ennerdale granite intrusions. The rock mined from the mineral veins via adits, like the one in **figure 11**, was crushed and milled in a water-driven mill so that the chalcopyrite could be separated, both manually and by water, for recovery of the copper. The host BVG rock is fine-grained and highly cleaved giving rise to subsidiary slate quarrying. The party scoured the extensive spoil heaps, **figure 10**, for chalcopyrite and lead samples with some success.

Figure 10
Spoil heaps at Penny Rigg (photograph by Fred Owen)

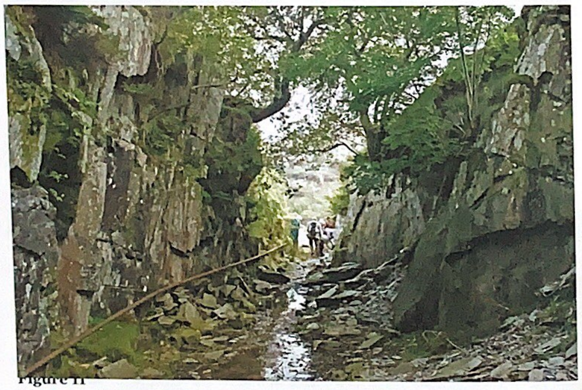

Figure 11
View from Horse Crag deep adit entrance (photograph by Fred Owen)

Sunday 20 September 2009

Trowbarrow Quarry (GR: SD 480 758)

The party met early on Sunday morning in the RSPB car park at Leighton Moss to avail themselves of coffee and facilities (including the purchase of a new bird feeder by Jane) and then drove the half mile to park by the entrance to Trowbarrow Quarry Country Park.

The quarry had produced limestone, lime in a Hoffmann kiln (now removed) and limestone aggregate, with much of the aggregate being coated with tar to form "Quarrite, the new dustless paving", first used on Blackpool Promenade. Chris explained that the name Trowbarrow represented the geology: the weaker bedded mudstones forming a trough (Trow) and the more competent limestone a ridge/hill (barrow). The Country Park is a Local Nature Reserve and has unusual flora (orchids) and fauna (moths). There were also many spiders' webs outlined by the dew. The age of the rock is Lower Carboniferous.

Six locations were visited which formed a circuit of the inside of the quarry. The rock which was removed was the Upper Urswick Limestone (UUL). On the west side of the quarry however, evidence was seen of the Woodbine Shales (WS), Lower Urswick Limestone (LUL) and Park Limestone (PL) (the base of the Carboniferous). The line of the rail incline used to move the quarried stone to the nearby Carnforth/Ulverston railway was also seen in the west part.

Locality A displayed vertical beds of UUL and time was spent looking for way up structures. The rock is very fossiliferous: colonial corals and some trace fossils (*thalassinoides*) could be identified. The colonial corals seemed to suggest a way up structure. They appeared to be in a life position but are they at the top or bottom of the bed? Their demise is considered as due to an influx of limey muds (a relative sea level change) burying them. However, confirmation of way up did not come until later. More competent feeding burrows were also seen together with a few large productids. The vertical beds have been identified as being part of a monocline.

Figure 12
Trowbarrow thalassinoides at locality A (photograph by Jane Michael)

Locality B was further along the east quarry wall and showed large productids and corals. However, to see these, binoculars were required. The quarry wall is used as a climbing wall. The fallen blocks were a source of fossils.

On the wall, one large burrow could be seen (see **figure 13**)

When the top of the cliff was viewed, vertical cracks and fluting could be seen. After some discussion, Chris explained that we were looking at present-day karst scenery. The cracks were the result of unweighting as the rock was exposed at the surface. There was fluting down the vertical bedding represented clint and gryke formation in action: solution weathering. There was also some evidence of ice age erosion.

Figure 13
Trowbarrow burrow in wall (photograph by Jane Michael)

Figure 14
Fluting representing clint and gryke formation at the top of the cliff.
(Photograph by Jane Michael)

Locality C confirmed the directional way up of the vertical beds. At the far end of the quarry, three reddened bedding surfaces could be seen. These were palaeosols and represented fossil karst surfaces. The uneven red surface confirmed aerial exposure and as this was to the right of the beds (pointing east), that was the direction of the younging. The karst surfaces demonstrate that each episode of deposition started with the land above sea level and many episodes of relative sea level rise and fall could be identified. Robin Grayson, a PhD student of the MGA Vice President, Tony Adams, logged the quarry succession, in 1975, and identified coal and bentonite horizons, but these were not easy to locate on this brief visit.

Locality D was in the west side of the quarry where there was another reddened karst surface. This had holes and depressions clearly visible which were where plants and trees once grew. No roots fossils were found. The area behind this bed, to the west, was in the 'etrough' of the Woodbine Shales. The trough was narrow and filled with trees and bushes.

Locality E covered the area where the PL blends into the younger LUL. LUL is competent with vertical bedding but the PL is a weaker rubbly rock with possible horizontal bedding. Chris postulated that the difference in rock competency was probably due to the depositional environment. The LUL perhaps formed in shallow water which was frequently exposed. During these exposed periods, rainwater percolation could have promoted early precipitation of calcite cement resulting in a very hard rock. Whereas the PL may have formed in deeper water and lacked the early rainwater cementation thus giving a weaker rock. The possible difference in bedding dip could be due to a fault in the monocline which has moved vertical LUL next to horizontal PL. But, the evidence for such a fault is inconclusive because the bedding dip of PL is very difficult to ascertain.

At **locality F** after searching through the undergrowth, David Tyler found remnants of the Woodbine Shales. It is not known whether the shales had eroded naturally or had been quarried out. It is reported to be fossiliferous demonstrating that there were periods when fauna thrived. There must also have been at least one period of clear water as there is a narrow band of limestone within the shale.

On the return walk to the cars through the lush woodland, one member of the local community appeared: a giant caterpillar: **(figure 16)**

Figure 15
Chris chats through a point with Fred Owen at Trowbarrow
(photograph by Jane Michael)

Figure 16
Giant caterpillar at Trowbarrow
(photograph by Jane Michael)

Heysham Head

The group moved to the beach area at Heysham for the final location of the trip.

The rocks here are Namurian (Millstone Grit - circa 300 Ma), the youngest seen over the weekend. Two formations were seen: the Roeburndale Formation (Rbd) and the overlying Ward's Stone Sandstone Formation (Wrst). The Roeburndale Formation comprises a very thick layer of alternating sands, silts and muds which are considered to be turbidite infill of the basin. Ward's Stone Sandstone is a much coarser poorly sorted suite of rocks with a few shale beds. These are thought to have been laid down in a fluvial delta top environment. Interfingering of both formations are seen near the contact.

Before looking at the rocks themselves, the group visited the ruins of a small religious settlement situated on the cliff top. Originally Viking in age, Anglo-Saxon and Medieval remains have been found. Graves of differing sizes are seen and the smaller ones are possibly ossaries.

Figure 17
Heysham Chapel ruins (photograph by Jane Michael)

The Wrst Formation was visited first at Heysham Head. The rocks dip around 20° west with a north-south strike, forming the western limb of the Heysham Head Anticline. Some bedding is visible in the top half of the cliff. Generally poorly sorted and coarse-grained, angular clasts could be seen. Iron staining is apparent in the reddened soft rip-up clasts. The softness demonstrated that the clasts had never lithified properly. The iron staining is attributed to haematite leaching, probably from Permian beds which have subsequently been eroded away, possibly during recent glaciations.

Further south along the sandy beach, rocky outcrops are seen. Inspection showed these to be the axial core of an anticline - the Heysham Head Anticline. The nose plunges south with the Roeburndale Formation in the centre.

The anticline is evidence of tectonic movement in the area. The faulting is mainly thrust faulting, striking north-south, with a shallow dip angle similar to that of the Wrst beds seen earlier. Both faults and folds indicate an east-west compression. This movement is likely to have occurred during the Variscan Orogeny. Overlying all of the rocks is a layer of glacial till containing many erratics.

Cracks are seen in the sandstone and these, plus little veins, contain barytes. The source is not clear but barium is more soluble in hot water than calcium. It could therefore have been sourced from post-Carboniferous hydrothermal activity.

A 200 metre section of cliff in the Rbd Formation shows a suite of different types of faulting: normal, reverse and conjugate. Differences in rock competencies account for this. It is certainly a very striking area.

The following sedimentary features are seen in this area: cross-bedding, some ripple marks and trace fossils. The latter are generally Diplocraterion and show clearly the effect of relative sea level changes.

Figure 18
Heysham faults (photograph by Jane Michael)

Eventually, towards the far end of the section of beach visited, the Rbd Formation disappears under the Wrst Formation. The Rbd dips sharply whilst the Wrst dip is gentler. There are, however, some thrust planes and normal faults visible which bring the Rbd back over the Wrst. Chris advised us that this was likely to be the junction between the two as erosion surfaces are identifiable. Initially however, it does look rather messy.

The group climbed up the cliff and walked back along the top. This weekend investigating rocks from the Ordovician to the Upper Carboniferous had proved fascinating and confirmed again that the north west of England has a wide variety of rock types which demonstrate many sedimentary and tectonic features.

Chris was thanked warmly for leading the trip and giving us the benefit of her insight into the fascinating geology.

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LIVERPOOL GEOLOGICAL SOCIETY: VISIT TO THE BRITISH GYPSUM BIRKSHEAD MINE AT LONG MARTON NEAR PENRITH

By Tom Metcalfe

Members and friends met at the mine on the 21st of May 2009. A good turnout, ten in total, considering an early start and an unusual weekday visit, in order to be there during the mine's normal working week.
We were met by the mine manager Jim Davies, who despite protesting that he was not a geologist, proceeded to introduce us to the Permian evaporites of the Eden Valley.

The general picture

From Devon, the English Midlands the Vale of Eden, North-east England, Western Scotland and Hebrides, Permian rocks, dating from between 298 to 251 Ma, occur widely onshore in Britain.

Leaving aside its rather complex structural history, the Vale of Eden is a roughly north-south trending fault bounded basin (half graben) bounded to the east by the Carboniferous and earlier Palaeozoic rocks of the Askrigg and Alston blocks and to the west by Carboniferous rocks covering the flanks of Lake District mountainsides.

The earliest Permian rock in the basin is the Penrith Sandstone, an aeolian sandstone characterised by dune cross bedding on a Saharan scale and rounded grains typical of windblown desert sand. Near the edges of the basin close to the uplands, the cross bedded sands pass into horizontally bedded sands then pebble or boulder beds, some of which are very coarse and known locally as 'Brockrams'. It seems reasonable to assume that the Brockrams are the product of desert flash flood processes, a basin margin sequence of alluvial fan breccias. The main exposures, consisting of Carboniferous limestones and sandstones, probably derived from the local highlands to the south west, are found at the south western non-faulted edge of the Eden Valley, but there is no reason to suppose that there are not similar sequences beneath the Upper Permian rocks close to the Pennine Fault bounded north eastern edge of the valley, indeed pebbles of Whin Sill material are recorded in Brockrams in the vicinity of Appleby.

Thus to the Upper Permian, wherein our interests lay this day, it is not well exposed in the Vale of Eden and it is only due to its workable gypsum deposits that much is known about the sedimentary history of the Upper Permian in the Vale of Eden.

The Lower Eden Shales consist of red and grey mudstones, siltstones and thin sandstones. They include four main sequences of carbonate sulphate evaporites, from the lowest bed designated A Bed through B and C to D Bed. It is thought that the Lower Eden Shales below the D Bed, formed in an interdune lacustrine environment in which deposition was possibly influenced by the movement on the Pennine Fault Complex, combined with high and low groundwater levels. This water was at times, as indicated by the sulphate deposits, highly saline. The cyclic nature of the deposition is argued to be linked to transgressions and regressions of the Bakevellia and Zechstein Seas. It should be noted that there is no evidence of the incursion of the Bakevellia Sea into the Vale of Eden, the few marine fossils found in the Belah Dolomite which occurs at the base of the D Bed may indicate the incursion of the Zechstein Sea from the east. The Upper Permian above the D Bed is fairly typical of similar rocks in the rest of Britain. This probably can be taken to mean that local conditions no longer contributed to sedimentation although fan breccias are still to be seen around the edges of the basin.

Gypsum ($\mathrm{CaSO_4.2H_2O}$) is the hydrated form of calcium sulphate.
Calcium Sulphate ($\mathrm{CaSO_4}$) in its naturally occurring form is better known as anhydrite.

Gypsum and anhydrite are widespread in the Permo-Triassic rocks across England but since gypsum is formed by hydration of anhydrite and is soluble once formed, once at or even close to the surface it dissolves quite quickly. This means the resources of gypsum are fewer than those of anhydrite and are also unpredictable. Demand for gypsum is principally led by the construction industry and its demand for plaster, plasterboard and cement. It is thought, present economic situation excepted, there is likely to be an increasing demand for gypsum products in the future.

It is worth noting here that there is increasing use of synthetically produced gypsum, particularly in the manufacture of plasterboard. The main source of the synthetic product is flue gas desulphurisation, a process which involves the use of calcium carbonate ($\mathrm{CaCO_3}$) to remove sulphur dioxide ($\mathrm{SO_2}$), the major cause of acid rain, from the flue gases of coal-fired power stations. The increase in supply of the synthetic product desulphogypsum is questionable over the long-term since its production is a parasitic load on power stations

Although costs are comparable at the moment, should the use of low sulphur coals and transport costs increase significantly, then the synthetic product would become uneconomic.

When gypsum is pulverised and heated in 'kettles' at about 1600C all but one quarter of its combined water is removed, the resulting compound known as a hemi-hydrate plaster ($\mathrm{CaSO_4.1/2H_2O}$), also known as Plaster of Paris is produced. As we probably all know from our childhood, the product when mixed with water returns to gypsum. It is worth noting that the process is reversible, making recycling a possibility.

Anhydrite, which is frequently found in intimate association with gypsum, has few uses on its own. On mining a mixture of anhydrite and gypsum is ground and combined with cement clinker in the production of Portland cement, the mixture is particularly important in controlling (retarding) the setting time of concrete. Historically, anhydrite was used as a source of sulphur for the manufacture of sulphuric acid (H_2SO_4) and ammonium sulphate (NH_3SO_4) used as an artificial fertiliser. Anhydrite per se is no longer mined in Britain, for the manufacture of sulphuric acid.

Visit to the mine

Quarrying of the B and C Beds in the area of Newbiggin and later by mining led to the discovery by borehole of the A Bed at depth below the higher beds. The mine workings are now more than 300 metres below ground, it being unusual to find gypsum at such depths. It may well be that Birkshead is the deepest gypsum mine in the world.

Our journey to the mine workings began with safety instructions and the issue of hard hats, lights and emergency breathing apparatus. Then a drive down inclines to the working areas of the mine. Remember that the rock below us is Penrith Sandstone, this is overlain by a mudstone followed by the lower section of the A Bed evaporite sequence some 10 to 15 metres thick known as the Lower Sulphate Beds. These generally contain too high a proportion of anhydrite and so are unsuitable for the production of plaster products.

We were shown some beds in which some rehydration had occurred producing nodules of selenite of distinctive appearance which the miners call 'daisy beds'. Clearly at this depth the source of the water wasn't local rainfall and it is thought that the source was the underlying Penrith Sandstone. The Upper Sulphate Beds, some 15 to 20 metres thick contain a higher proportion of gypsum as selenite. A fibrous form of gypsum known as 'satin spar' is present which raises the commercial viability of the upper beds. Pillar and stall mining using specialist machinery is used to extract that part of the bed which will be crushed within the mine before being transferred by conveyor to the BPB board mill at Kirkby Thore, a short distance away.

All in all a great day out, an experience and an education well worth the early alarm call. It remains for me, on behalf of the Liverpool Geological Society to thank Jim Davies and British Gypsum for enabling the visit.

There are companies today which do not look favourably on requests for such visits.

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OBITUARY: FRED BROADHURST
5 February 1928-1 October 2009

By Derek Brumhead

Frederick Munro Broadhurst, always known as Fred, was born in Withington, Manchester, an only child for parents May and Fred. Fred spent his childhood and early adulthood in Burnage where he attended the local primary school, known as The Acacias and later in 1939, the William Hulme School.

In 1946, at the age of 18, Fred volunteered to become a 'Bevin Boy' at Bradford Colliery in east Manchester. Working underground, managing the coal trucks and transport of the coal to the surface, inspired his love of geology (especially the Coal Measures.) He decided to further his education and whilst working down the pit he attended day release and night school at Stockport College, studying science subjects to enable him to gain entry to university to study geology full time. In 1948 he left the pit and with the help of the ex-serviceman's grant, he attended Manchester University to study geology.

In 1951 Fred graduated with a First Class Honours degree and became an Assistant Lecturer, then soon after a Lecturer, going on to gain his MSc in 1953 and his PhD in 1956. He subsequently became a Senior Lecturer, and PhD supervisor.

One highlight of Fred's career was the discovery in 1960 of the near-complete skeleton of a 14 foot long plesiosaur. The remains were found at Ravenscar (Alum Shales of the Upper Lias) on a field trip with his students and caused great excitement at the time. Later, Fred returned with his students and spent ten days excavating the reptile. For many years it was displayed in a large purpose-built showcase outside the Geology Departmental library (1970-90), and is now in the Manchester Museum.

Over thirty years ago I arranged for Fred's rough sketch of the plesiosaur (with baby added!) to be used on the Association card. It is now the Association's logo. At the time many knew of the logo's origin although unfortunately no official note was made. So it is appropriate that MGA members should be told or reminded of the origin of their logo. It's Fred's!

Hundreds if not thousands of people all over our region knew Fred from his wonderful WEA, Extra-Mural (later CCE) and Wimslow Guild classes, day courses, field excursions and visits abroad. You could not meet any person interested in geology who did not know Fred. His passing leaves a gap that will never be filled. The success of his teaching was a result of his boundless enthusiasm for his subject, his patience and courtesy in dealing with everyone he met and how he made those with little knowledge of the subject feel just as important as the knowledgeable ones, so that no-one felt left out. I spent most of my career in liberal adult education and I can say that Fred was the greatest adult educator I ever met. I have never known a person so universally appreciated and admired. So, how appropriate that in 2000 he should receive a national award as Adult Tutor of the Year in North West England at the 'Dome' in London.

Fred also contributed greatly to the summer school held at Bangor University which was held jointly by the WEA and the Extra-Mural Department each year. Ian Foster and Fred worked together to deliver a weekend course there as recently as 1996, combining their specialist knowledge as 'Rocks and Rails'.

In 1990, Fred retired from Manchester University to concentrate on his work with the WEA and CCE lecturing at many day and night classes and organizing foreign geological trips with the Wilmslow Guild. With Paul Selden, he was leader and guide writer for visits to places such as Norway, the western USA and New Zealand (1993-2000). The work involved in the academic preparation and infrastructure of each course was immense, but the huge ability and attention to detail of Fred and Paul ensured some memorable trips.

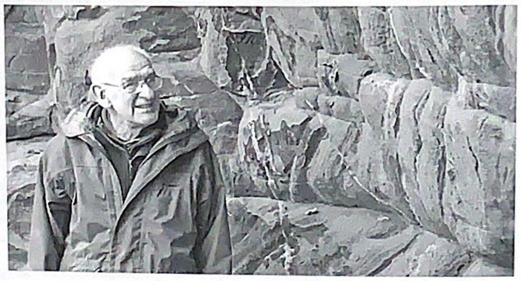
A 'professional' appreciation of Fred and his career will appear elsewhere. Suffice to say that he published over 50 articles often in association with other eminent geologists and in journals of international repute. In 1982, he was awarded the prestigious John Phillips Medal of Yorkshire Geological Society for major contributions to our knowledge of the geology of Northern England, and later was awarded the Silver Medal of the Liverpool Geological Society. Despite his academic eminence, it was very easy to discuss with him any aspect of the subject. But members will more likely know of his more general writing - the popular 'Rocky Rambles in the Peak District' (which brought out his skill as an illustrator), the guide to the building stones of the Trafford Centre, and the recent superb revision of the 'Guide to the Building Stones of Central Manchester (with Morven Simpson).This last book, first published in 1975, was a pioneer in opening a new field in the teaching of geology, and over the next few years a plethora of town and city guides for the UK appeared. The work involved in drawing up these guides shows Fred at his best (along with Morven), tracking down architects and stone masons and discovering the names of the often unusual rock types. Such work could involve delicate negotiation (for example arranging with management for students to be allowed to crawl around the floors of the Trafford Centre!), something that Fred was excellent at.

I first met Fred just forty years ago leading a geology trail in Lyme Park, and I still have my notes. Over the succeeding years we met many times and I benefited so much from his knowledge and expertise imparted with much generosity; always up to date, of course, with the latest developments and theories, and this continued into his 'retirement'. The last walk I went with him was with the MGA group at Styal in July 2009. It lasted an hour and a half, with Fred going at his usual 150 mph. At the end when we were all looking forward to a cup of tea, Fred said he must be off to take a second group around. What more can one say?

He had a lovely sense of humour. My favourite example (worth repeating for those who may not already know of it) was when we were in Dublin, thirty years ago, with the Palaeontological Association. We both came across a bus stop sign which said - 'The following buses do not stop here'. We both fell about laughing and took a slide each. No doubt his will still be there among the many thousand others. What a treasure trove there must be amongst those?

It's only a few months ago since we were emailing each other about re-arranging his talk to the New Mills Local History Society ('New Mills 300 million years ago' !) and getting down to finishing a trail on the Torrs gorge. What is shocking is that such a seemingly indestructible person should be taken so quickly in this way. When we lose someone like Fred, it reminds us all of our own mortality.

Despite his enormous commitments, Fred was a wonderful family man. Having met Rosemary at a University Union dance, they married in 1958, and had a son and daughter. Now, there are also four grandchildren. Fred took great delight in his children and grandchildren and had a fantastic relationship with them. He had a real love of mountains and walking in the Peak District and as a family they all loved it too, and this continued until summer of this year when he started to feel poorly. At the wonderfully simple ceremony, the grandchildren each gave a moving appreciation of their 'inspirational' grandfather. His presence will be missed but the 'Fred effect' will pass on for generations to come.



Other Publications

Liverpool Geological Society

The Geological Journal

Rock around Liverpool

Rock around Wirral

Rock around Chester

The William Smith map

A field guide to the continental Permo-Triassic rocks of Cumbria and North West Cheshire

Contact: Bob Bell, 5 Brancote Gardens, Bromborough, Wirral CH62 6AH
Telephone 0151 334 1440

Michel Levy Charts*

Stereographic Projections*

*Contact Mr N C Hunt, Department of Earth Sciences,
University of Liverpool, PO Box 147, Liverpool L69 3BX or email: scfc@liv.ac.uk

Manchester Geological Association

A Lateral Key for the Identification of the Commoner Lower Carboniferous Coral Genera (£2.25) available from Niall Clarke, 64 Yorkdale, Clarksfield, Oldham, Lancashire OL4 3AR

Geology Trail of Styal Country Park, Wilmslow (£1.50)

Geology Trail of Knutsford's Buildings and Cobbles (£1.50)

Available from Fred Owen, 29 Westage Lane, Great Budworth, Northwich, CW9 6HJ

A Building Stones Guide to Central Manchester

Available from Rosemary Broadhurst,
77 Clumber Road, Poynton, Stockport SK12 1 NW