Earth Matters

The Newsletter of the Geology Section

of the Woolhope Naturalists' Field Club

No. 5 December 2008

The Geology Section is an Affiliate Member of the Geologists' Association.
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Message from the Chairman

Last year we provincials commemorated the 200th anniversary of the Geological Society of London and now Paul, Sue, Iris and I are preparing a small exhibit for the impending 'G.A. 150' celebrations in London. As one of the GA affiliated groups, we considered it appropriate to 'splash out' once again. Paul has already prepared some splendid block-mounted photographic enlargements that, unsurprisingly, feature Italian volcanoes. This seemed most appropriate for the occasion since his Italian excursion this year was conducted under the auspices of the GA.

Likewise, I have designed a WGS banner to surmount our display; the latter will also be block-mounted and is currently printing in Ross. To forestall any fears from our Treasurer, we believe it should prove useful for any future WGS events and might therefore be regarded as an investment!

As the last hangover from Secretarial duties, I still maintain the WGS Database, for which Beryl feeds me the details of new members from time to time, and so I seize upon this opportunity to welcome such newcomers to the Section. It is most gratifying to observe our continued development in this way. Last year we decided to add an extra database field to our records and so I requested details of your e-mail addresses but received little response. If any members have such data, or if they have changed their ISP or e-mail address (or postal address, etc.), then Beryl and I would be grateful for such notification.

Finally, I wish to thank my WGS Committee colleagues for their sterling work throughout the past year, and to thank all of you for the high level of your continued support to the Section. Of the various societies to which I belong or have past experience, you are certainly the most participant bunch - so thank you again!

Gerry Calderbank, Chairman

Geology Section Programme for Early 2009

Lectures and the AGM are held in the Woolhope Room, Hereford Library, Broad Street commencing at 6:00pm unless otherwise stated.

Friday January 23rd. AGM, followed by dinner at a nearby restaurant. Information regarding bookings for the dinner will be available from Sue Hay in early December.

Friday Febuary 20th. 'Shining Water: the Lugg'. A film made by the late Harry Williamson, a Woolhope member, with geological input from the late Peter Thomson, and additional comments on the evening from Moira Jenkins.

Friday March 27th. The Murchison Lecture
'The pivotal role of Welsh Borderland fossils in reconstructing pioneering land plant vegetation' by Professor Dianne Edwards, University of Cardiff. The talk will show how fossils collected from the Hereford and Ludlow areas have contributed to understanding the nature of land plant vegetation in the Silurian and Devonian, to the interaction of plants and animals in terrestrial ecosystems and to transforming both the atmosphere and land surfaces.
(Note : This talk will be held at the Resource Centre in Friar Street.)

July. A week-long trip to Shetland is planned. Mainly geology but some archaeology. If you are interested, please contact Sue Hay as soon as possible.

Further information for all events unless otherwise stated from: Sue Hay, 01432-357138 (evenings and weekends) or e-mail svh.gabbros@btinternet.com. If you would like to join our e-mail circulation please send Sue an e-mail so that she can pick up your correct e-mail address.

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Editor's Comment

Welcome to the fifth issue of Earth Matters. The articles represent mostly various activities undertaken by the section but we are pleased to include also an item describing the individual interests of a member (Alan Stone). Such articles are strongly welcomed, especially if they represent an aspect of Herefordshire's geology.

John Payne, *Editor*

Subscriptions

The annual subscription to the Geology Section is currently £7.00. This is due on 1st January (as for all other WNFC subscriptions). Please pay this directly, and on time, to the Section Treasurer, Beryl Harding, 'Bramley', Lugwardine, Hereford HR1 4AE. **Do not** send it to the WNFC Secretary with your WNFC subscription. Cheques should be made payable to 'Geology Section / WNFC'. Members are encouraged alternatively to pay by Standing Order; forms are available from Beryl.

Annual General Meeting

Members are asked to accept this as a reminder of the Geology Section AGM to be held on Friday 23rd January 2009 starting at 6:00pm in the Woolhope Room. After the AGM we will retire for dinner to a nearby restaurant. Information regarding bookings for the dinner will be available from Sue Hay in early December.

A proposed change in the Section's Constitution will be voted on. Paragraph 5 of the Constitution is currently:

"*The Section shall have its own Chairman, Vice-Chairman, Secretary, Treasurer and Programme Secretary as Officers and four elected committee members with the power to co-opt others when necessary. Ex-Officio members may be invited on to the Committee.*

Officers will be elected annually and not serve for more than six years in any one post."

It is proposed to change the final sentence to: "*Officers and Committee Members will be elected and/or approved annually by the AGM.*"

Subject to the change being accepted, all of the present Committee members will stand for re-election to the Committee. Nominations for election to the Committee must be received by the Secretary by 7th January 2009, in writing (letter or e-mail) and with the name of a seconder.

Some New Web Sites

Readers are probably aware of the major series of authoritative (and expensive) books which constitute the Geological Conservation Review series. Under a wide range of headings, the volumes, currently thirty four in number, review and interpret the latest scientific information on the most important geological and geomorphological sites in Great Britain. A respectable number of these are in Herefordshire. The publisher, the Joint Nature Conservation Committee, has recently placed many of the articles on the internet. These comprehensive articles may be found at *www.theGCR.org.uk*.

The Google Earth web site is well known (*earth.google.com*). It offers satellite photographs of the Earth's surface with resolution of less than a metre and contains altitude information which allows relatively crude lateral views of the scene.

Whilst this shows sufficient detail to help in much geological field work, a more useful development is the 'where is the path' site (*wheresthepath.googlepages.com /wheresthepath.htm*). This combines the satellite photography with 1:50000 Ordnance Survey maps and allows easy identification of locations on the photographs. A very useful feature enables grid references to be determined to within one metre.

Last, and with specifically local interest, are the papers from the Ludlow symposium. See Mike Rosenbaum's article on the facing page. (*www.shropshiregeology.org.uk /SGSpublications*)

The Ground beneath our Feet: 200 years of Geology in the Marches - a symposium to celebrate the 200th anniversary of the world's oldest geological society

Professor Mike Rosenbaum

Rocks represent our main source of evidence for interpreting the past, and the Marches include representatives from all twelve internationally recognised periods of geological history, from the Precambrian to the Holocene, spanning 700 million years of Earth history. Included within these are four which were defined on the basis of the evidence discovered here: Cambrian, Ordovician, Silurian, Devonian, and a fifth, the Permian, was subsequently defined on the basis of techniques first worked out in the region.

Our current level of understanding of the 700Ma evolution of the Marches is based upon detailed evidence acquired through diligent collecting and recording by generations of enquirers, notably a number of Woolhope NFC members such as Timothy Curley (drainage engineer for Hereford) and the Reverends Thomas Lewis and William Symonds. Its interpretation is due to the skills that geologists are able to employ to read it. However, many questions remain unanswered, awaiting discovery of new facts and interpretation, or re-interpretation, as new ideas emerge.

The impact of our understanding of the ground on the lives of those who live in the area is considerable. The industrial revolution began here, with ironstone nodules brought down from Clee Hill to be smelted at Burrington using charcoal. This was followed in Broseley and Coalbrookdale by ironstone and limestone being fired with coal and an upsurge in industrial output along the banks of the River Severn in Ironbridge Gorge. Mineral extraction is still active, nowadays primarily for construction and roadstone; the groundwater is a major concern both to domestic consumption and agriculture; the landscape attracts tourism, arguably now the most important source of income, and its configuration determines the potential for sustainable development of the region.

On a local level, the public understanding of geological science has been developed, most notably in the Marches by the work of the late John Norton, who had a remarkable gift for encouraging youngsters to take an interest in the ground around them, and Peter Toghill, who founded the Shropshire Geological Society in 1979, which has since become a leading player in the national Natural England RIGS scheme. For many years he has promoted the wider public understanding of geology through lectures and field meetings, as well as advising local authorities and museums, and publishing several guidebooks. When the Geological Society of London set up the Geological Conservation Committee in 1980, Peter served as its first Secretary (until 1985). That Committee has since transformed itself into the GeoConservation Commission, and it owes much to his early work.

Many have therefore felt that the role of the region in the development of geological science should be reflected in the Bicentennial Celebrations of the Geological Society of London, the world's oldest geological society, especially as it was just over 175 years since the first visit by Sir Roderick Impey Murchison, who is generally acknowledged as the person who unravelled the Transition rocks, those beneath the Coal Measures that hitherto had defied scientific description.

A number of organisations in the Marches therefore agreed to collaborate to run a festival to celebrate these anniversaries. Events led by the Woolhope NFC included a Rock and Fossil Roadshow, in Leominster, and a re-enactment of the early field excursion attended by Lewis, Lyell and Murchison at Aymestry. The events led by the Shropshire Geological Society began by preparing a series of GeoTrails, in part to support workshops and fieldtrips for the Festival, and in part as self-discovery guides. These are now available on-line (details below) and include:

- in front of the last glacier in South Shropshire
- the landslides of Ironbridge Gorge
- a revision to the Teme Bank Trail (the first edition was a printed leaflet available from the Ludlow Museum Resource Centre)
- a reprinting of the Mortimer Forest Trail, originally prepared by Jim Lawson
- the building stones of Ludlow

A one-day symposium in Ludlow lay at the centre of the Festival, on the theme of 'The ground beneath our feet: 200 years of geology in the Marches'. One hundred and forty geology enthusiasts from across the country thus gathered in Ludlow on Thursday 13th September 2007. The invited speakers had a special interest in the geology of the Marches and their contributions provided authoritative and up-to-the minute accounts of their specific fields. These were intended to appeal to the curious public as well as the committed geologist and focused on five themes of general as well as regionally significant interest:

- The mark of distinction: local character shaped by landscapes and building stones
- The Marches in the past: on the edge of a lost ocean
- Geology in the community: evolving perceptions and realities
- The Ice Age: on the edge of a glacier
- The future for geology in the Marches

Each of these talks is being written up as a paper which will be published in the next volume (No.13) of the Proceedings of the Shropshire Geological Society. Drafts of many are already available on-line. Details are on the Society web site:

http://www.shropshiregeology.org.uk/SGSpublications

A Visit to Vulcano

Margaret Flint and Dr Paul Olver

Introduction : In April 2008, nine Woolhope Club members joined twenty other participants on an excursion aimed at visiting all five active Italian volcanoes namely Vesuvius, Solfatara, Etna, Vulcano and Stromboli. This excursion was part of the Geologists' Association 150th Anniversary programme and was led by Dr Paul Olver and Dr Derek Rust (University of Portsmouth).

View southwards from Belvedere in Lipari towards the island of Vulcano

This report by Margaret Flint focuses on our day visit to Vulcano. It is set in the Aeolian archipelago in the Southern Tyrrhenian Sea, one of the two active volcanic arcs in the Mediterranean. The group as a whole lies about 40km from the north-east Sicilian coast and consists of seven inhabited major islands all of which are totally volcanic in origin.

Our Day in Vulcano : We were ten days into our field trip to the volcanoes of southern Italy. We had climbed Vesuvius (along with hundreds of others!) and seen the lava of the 1944 eruption only now being colonised by plants. We had seen the effects of the AD 79 eruption of Mount Somma on Pompeii and Herculaneum. We had been to the Phlegraean Fields, deep into the crater of Solfatara and experienced a geological baptism in its steaming clouds of hydrogen sulphide. Then we had slowly made our way up Etna by coach, funicular and finally by foot, deep in snow for the last few hundred metres and with a spectacular view of the Valle de Bove, a large area on the eastern side being pushed out by magma rising along a fault. A fast-moving hydrofoil then took us to the Aeolian Islands north of Sicily and our base on the island of Lipari. From here the party visited both Stromboli and Vulcano, the only two islands currently showing major volcanic activity.

It is Vulcano which gives the name to the geological feature and as we arrived at the harbour the smell of hydrogen sulphide greeted us before we stepped off the hydrofoil. The plan was to visit the main eruption area, La Fossa, in the morning and move on to the smaller northern Vulcanello after lunch. From the harbour, we walked westwards on the roadside, the 400m-high volcano on our left. We deviated through an abandoned garden and on to a ¼ mile long exposure of trachyte lava from the 1775 eruption. It had all the features of a typical viscous glassy lava flow with abundant flow banding within its black lustrous surfaces and some signs of early devitrification.

Vulcano has erupted approximately every 100 years since Roman times. After 1775 the pressure built up slowly before erupting in 1888, blowing out huge solidified old magma blocks. Then the new magma exploded suddenly and dangerously as spindle-shaped lava 'breadcrust bombs'. These bombs remain littered around and reach sizes of up to 270cm in length. No lavas were erupted in this highly explosive event. Further explosive activity

View from La Fossa towards Vulcanello, joined by narrow isthmus, with Lipari in the background

mantled the northern half of the island with a fine, black, cinderitic ash which now forms much of the isthmus joining Vulcanello to Vulcano.

Moving back to the road we continued and saw a good section of the rhyolite dome of Monte Lentia to our right. It showed how chamber magma had swollen and cooled in a radial pattern, the innermost magma being hottest and therefore most fluid. We turned off the road onto a well trodden wide black ash path at the base of Vulcano. The ash was from the 1888 eruption. The vegetation on this northern side was sparse and scrubby, indicating very poor acidic soils. Although Vulcano rises only 400m, there was a definite 'tree line' seen from below. The wide path followed the north side by means of hairpin bends. Two thirds of the way up the black ash stopped suddenly and the path then became brown, the sides steeper and very heavily gullied as it was cut into highly weathered fine ashes. This was at the tree line.

Not far from the top, near the crater's edge, the path narrowed considerably and slight climbing skills were required to continue. Due to the vertiginous drop on one

side, which I was unable to cope with, I waved on my companions and stayed, waiting their return. The wait proved interesting. Many people passed and greeted me. The Germans and Dutch wore stout footwear, as one would expect. The French and Italians, particularly the

Sue Olver closes in on the active fumaroles on the eastern rim of La Fossa

ladies, wore shoes more suitable for an evening at a beach restaurant. The ladies, generally loudly protesting, were always way behind their menfolk who did not assist them one bit. They all made it up and around the rocky ledge, though!

Probably few of the visitors knew the volcano was due an eruption in its 100-year cycle. In fact, major seismic activity occurred between 1987-88, during which time the carbon dioxide content of crater fumaroles increased and a major landslide occurred on the north-east side of the volcano. It is constantly monitored from the Osservatorio Geofisico in South Lipari as it is too 'jelly-like' to transmit the full range of seismic data. However, water-based tiltmeters on the sides are stable at the moment.

We returned to the harbour area for lunch and thence to Vulcanello passing the beach at Baia di Levante. Here is a large thermal mud pool and a small 65m high mount, La Faraglione, with fumaroles. About ten years ago I was here and the mount was far more active with large num-

Tourists enjoy the bubbling mud pools close to La Faraglione, Vulcano

bers of small fumarolic vents. Many of these had a person (usually German) sitting over it and wrapped in a tent-like towel to catch the vapours. The mud pool, now empty bar two people, was full of those seeking skin cures. It was a clear demonstration of how quickly geological activity can change.

Vulcanello, so close to Volcano, could not be more different. It was formed in 164 AD when it had three eruptions in one year. The first exploded fine pumice, then, after a pyroclastic cone had built up and all the gases vented, a big laval eruption of potassium-rich leucite tephrites occurred and finally a sticky trachyte lava was erupted. The lavas erupted from three vents resulting in a lozenge shape rather than the 'standard' cone. Another eruption in about 1550 caused an ash cloud which deposited sufficient material to make the first causeway joining the new island with Vulcano.

The walk up Vulcanello was not as easy as Vulcano despite it being so much smaller. Our hindrances were due to the path being blocked by a new house and garden. We obtained permission to continue but then had to fight our way through dense undergrowth on the old upward path. The crater was well colonised by plants and bushes but we had good views of the cone's structure. The red trachyte lava could clearly be seen. Within the crater a tunnel

The party takes a well-earned rest at the prehistoric village in Southern Panarea

entrance was present, the remnant of 19th Century mining attempts for alum and sulphur.

The day on Vulcano had been reasonably strenuous, two volcanoes, not very large, but steady walking nonetheless. We had learnt early on in our field trip that each volcano is unique. These two, Vulcano and Vulcanello, so close and so different, proved the point yet again.

Present and Future Activity in the Aeolian Islands
Since the last eruption in 1888-1890, the main conduit of La Fossa has been obstructed and fumarolic activity has been centred on the northern rim of the active crater and on the beach of the Baia di Levante, as mentioned above.

The fumaroles at the crater rim have shown considerable variations in temperature over recent years, well beyond the normal 100C, with 300C in 1987 and 700C in 1993. They are typically rich in hydrogen chloride, hydrogen fluoride and sulphur dioxide with smaller amounts of boron and bromine derived from greater depths and incorporated into the shallower meteoric component. There are indications that the hotter the fumaroles the closer the magma is penetrating towards the surface. Temperature gradients currently suggest that the magma lies at a depth of 2250m below the volcano.

Lying at the intersection between the Alicudi and Tindari-Letojanni Fault Systems increases the possibility of strong seismic events at Vulcano and also of magmatic ascent as intruding dykes. This could lead to destabilisation of the slopes of the volcanic cone such as has recently occurred at neighbouring Stromboli in its 2002-2003 eruption. The resultant landslides within the Sciara del Fuoco triggered a tsunami, an additional hazard associated with such activity.

One of the authors (PO) has been visiting Vulcano since 1971 and over the intervening years has seen many changes in the number, location, temperature and composition of the fumaroles. However, given its proven 100-year eruptive cycle, we await its next overdue move!

Approaching Stromboli, currently the only other active volcano in the Aeolian Islands. The active area of the Sciara del Fuoco is on the left

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A Dry Weekend in Wales: North Pembrokeshire

Alan Stone

The geology of Pembrokeshire includes all periods from Precambrian to the Carboniferous, and most of these are found on its long coastline. The Pembrokeshire Coast Path runs from the Teifi estuary to Amroth on the Bristol Channel, giving access to some of the most magnificent coastal scenery in Britain.

In June 2008 Sheila and I decided to look at the stretch between Cardigan and Strumble Head. Our B&B overlooked the Gwaun Valley and the tiny harbour of Lower Fishguard, the original settlement. Early mariners found a safe haven in the 1km ria at the end of this valley, which is now recognised as part of a complex system of meltwater channels cut during the Pleistocene.

Fig. 1 : Pillow lava, Strumble Head

Ordovician sedimentation in this part of the Welsh marine basin between the Irish Sea Landmass and the English Midland platform was affected by varying sea level, tectonic movements and substantial volcanic episodes.

Volcanic activity is certainly much in evidence on the Strumble Head peninsula. Llanvirnian rhyolitic lavas and breccias are overlain by basaltic sheet and pillow lavas (*Fig. 1*) with intercalated volcaniclastic turbiditic sandstones and occasional tuffs, followed by more rhyolites. Columnar jointing can be seen at Pen Anglas.

We found the track from the lighthouse to Pwll Deri very hard going, with its vertical ridges and occasional swampy hollows. The wealth of early summer wild flowers gave some compensation.

For easier walking next day we headed north-east to the Caradoc sediments around Ceibwr Bay. This inlet behind cliffs is the termination of a major meltwater complex extending several kilometres inland. The Coast Path descends from the cliffs here to cross the little misfit stream over a slate-slab clapper bridge. The old limekiln here is a relic of the past importance of seaborne trade to this area: coal from St.Bride's Bay would have been loaded into small craft beached at high water, sailed around St. David's Head and discharged here.

Across Ceibwr Bay the folded and fractured sedimentary rocks at Ynys Fach cliffs are well displayed. On the headland (grid ref. SN108458) a raised beach, (Ipswichian?)

Fig. 2 : Raised beach, on wave-cut platform, Ceibwr Bay

Fig. 3 : Complex structures in stack, Ceibwr Bay

rests on a platform cut in steeply-dipping blue shale. (*Fig. 2*)

A pleasant walk on springy turf along the edge of the cliffs (*Fig. 3*) with views of fulmars, puffins and house martins, took us to the 'Witch's Cauldron' (SN102451). Here crumpled and faulted sediments have collapsed into a sea-cave, forming a steep-sided crater. (*Fig. 4*)

The Dinas Island Formation consists of turbiditic sandstone, mudstone, slumped beds and conglomerate and is well exposed from here to the Teifi estuary. Shale slabs were formerly quarried at many coves along this coast and shipped out for building. The 'island', a rough pentagon 1½km across, seems to have been carelessly stuck on to the mainland, since the join (another meltwater channel) barely reaches 5m OD. Footsore or weatherstruck travellers can take this shortcut instead of the superb high level circuit around the island cliffs. The pub at the west end (SN006399) made a fitting end to an excellent weekend.

Fig. 4 : Collapsed sea-cave ('The Witch's Cauldron') near Ceibwr Bay

Sources :

1) WALES (British Regional Geology), M F Howells, BGS, 2007

2) 'Pembrokeshire', B S John, in 'The Glaciations of Wales and adjoining regions', ed. C A Lewis, Longmans, 1970

3) 'Pembrokeshire Coast Path', Brian John, Aurum Press,

Folding at Ynys Fach, Ceibwr Bay

Needle Rock, Dinas Island

THE GRAND STAIRCASE

Dr Sue Hay

The Colorado Plateau in the mid-west of the USA extends through the states of Colorado, Utah, Arizona and New Mexico, covering over 130,000 square miles. It is underlain by some 25 miles of continental crust and bounded by zones of intense deformation, such as the Rocky Mountains to the east. The plateau appears to have enjoyed unusual stability since the close of the Precambrian and is certainly a displaced terrane.

Fig. 1 : An amphitheatre at Bryce Canyon

In the Precambrian there were at least two episodes of sedimentation followed by uplift, folding and metamorphism and finally erosion. For much of the Phanerozoic vast shallow oceans covered the area and the rocks laid down during that time record a history of emergence, submergence and re-emergence.

Fig. 2 : Cliff House Sandstone

In the late Mesozoic (65Ma), the Laramide Orogeny commenced when the westward moving North American crust was compressed by the eastward moving Pacific Ocean Crust forming the far western mountains of the USA. The Plateau resisted this compression but started to rise. The end of the Tertiary saw another period of uplift when continued compression formed the Basin and Range province to the west of the Colorado Plateau.

Since the Laramide Orogeny the plateau has been uplifted a total of some two miles and in the process has been spectacularly eroded into canyons and escarpments. The gently northward dipping, relatively undisturbed, sediments combined with the desert-like conditions with very little vegetation over much of the plateau allows us to see the stratigraphy almost completely, like a geological staircase. In particular, the region between Bryce Canyon, south through Zion and on to Grand Canyon has a series of sharp cliff lines which together are often referred to as the Grand Staircase.

This short article cannot cover the complete geological succession, but rather will gradually descend through the stratigraphy concentrating on those parts of the rock succession which give the major sites (mainly National Parks) their special characteristics.

Bryce Canyon is not really a canyon but rather a series of amphitheatres (Figure 1) cut into the easterly-facing cliffs above the Paria River, a tributary of the Colorado. These are the Pink Cliffs at the top of the Grand Staircase, composed of the horizontally bedded Wasatch Formation, laid down in an Early Eocene lake system. As the lakes expanded and contracted so deposits varying from pure deep-water limestones, calcium-rich muds, and sandstones and conglomerates of the shallower waters and shorelines were deposited.

Post-depositional uplift accentuated vertical faulting through these horizontal beds. Weathering and erosion, intense summer thunderstorms and freeze-thaw in winter proceeded rapidly along these natural lines of weakness resulting in upstanding hoodoos that are capped with more resistant material, producing the Badlands topography we see today.

In the Upper Cretaceous, fine-grained sands were deposited at Mesa Verde National Park. These now form the Cliff House Sandstone, a massive cross-bedded sandstone typically 400ft thick representing a shifting shoreline deposit. Lenses with snails, clams and fish teeth are found in the top 100 feet. These sandstones are porous and permeable but the underlying shale is not so there are springs and

Fig. 3 : Zion Canyon from a side canyon

Fig. 4 : Sentinel Mesa and West Mitten Butte

seeps at the junction. Action of wind and water has cut natural alcoves in the Cliff House Sandstone immediately above the level of the shale horizon. These alcoves became home to the Anaszi at about 1100AD such as the Spruce Tree House (Figure 2) which is thought to have accommodated about 100 people.

Dinosaur National Monument is 300 miles north of Mesa Verde. It is centred around the Carnegie Quarry, named after the Carnegie Museum whose director sponsored its early exploration. Here the lower Jurassic Morrison Formation has yielded many fossils including several plant-eater dinosaurs such as a complete articulated Diplodocus, Pterodactyl, crocodiles and turtles. In fact over twenty complete skeletons and parts of over 300 creatures have been found. It is thought that most of the carcasses were washed down the river, coming to rest on sandbars, usually on their sides, with the lower side well preserved and the upper side often dismembered.

Zion Canyon is simply magnificent, over 3000ft deep, cut into Triassic and Jurassic rocks by the Virgin River (Figure 3). The main walls of the canyon are almost vertical with the highest peaks capped by the Temple Cap Formation, red-coloured silts and clays laid down in streams that flooded over the underlying Navajo Sandstone desert dunes. The Navajo Sandstone is a remarkably homogeneous fine-grained very pure (98% quartz) sandstone laid down about 150Ma. There is extensive cross-bedding and vertical jointing. These are the white cliffs of the Grand Staircase. In fact, the top half is light red and the lower half light tan but they appear white in contrast to vivid reds below. This permeable formation covers much of southern Utah and northern Arizona, forming a great aquifer. A spring line marks its junction with the underlying less permeable Kayenta Formation. The red and mauve silt and sandstones of the gently sloping Kayenta Formation were deposited in streams, channels and floodplains in a warm wet climate similar to today's northern tropical belt. Dinosaur footprints have been found.

Monument Valley is owned by and is sacred to the Navajo Nation. Major rivers such as the San Juan and Colorado and their tributaries have incised into the sediments, downcutting to produce the fantastic mesas, buttes and spires including the famous ‘mittens’ (Figure 4). The valley floor comprises Permian coastal-marine sandstone with the buttes and mesas standing on sloping bases of Permian Organ Rock Shales. These are alternating sands, shales and silts of terrestrial origin that accumulated on tidal flats. They erode to form slopes with ledges of harder sandstones. The vertical cliffs are composed of Permian De Chelly Sandstone, a salmon-pink coloured sandstone that covered much of the southern Colorado Plateau and is up to 1000ft thick. Some of the buttes have unconformable caps of Triassic sandstone or conglomerates. Desert varnish is visible on virtually any of the sandstone cliffs. It is a dark lustrous coating rich in manganese or iron oxide. It is usually thicker and darker on upper sun-facing surfaces; i.e. high temperatures seem to help its formation possibly by leaching from the rock.

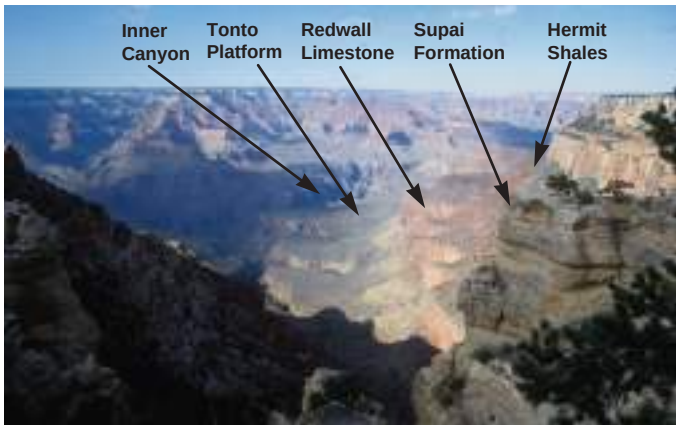

Fig. 5 : Grand Canyon from south rim

Our final stop is the Grand Canyon. The canyon varies from less than one mile to 18 miles across. It is in places over one mile deep and is 277 miles long. This exposes rocks from the Permian down to the Precambrian. The latter is not exposed elsewhere on the Colorado Plateau. The ancestral Colorado river flowed to the east of the Grand Canyon and out into the Gulf of Mexico. As the Gulf of California opened some 4-5Ma ago, a river eroded headward up from the Gulf of California and captured the Colorado, which then began to cut the Grand Canyon.

The top of the outer canyon wall is composed of three pale-coloured Middle Permian deposits (Figure 5). The Kaibab Limestone and underlying Toroweap Formation (sands and limestones with gypsum) were deposited in a warm shallow sea which in the case of the lower formation documents the advance and retreat of marine conditions. Both are very fossiliferous. They are underlain by the pale-coloured Coconino Sandstone (400ft) which records the deposition of a great desert like the Sahara, which covered much of northern Arizona.

There is now a distinct colour change to the bright red Permian Hermit Shales which form a low-angle slope and represent a floodplain environment. These are underlain by the ledge forming red-coloured Carboniferous Supai Formation composed of silts and sands deposited in a swamp. Both contain plant fossils.

Beneath these are the visually striking cliffs (400-650ft) of Carboniferous Redwall Limestone (Figure 5). Actually

grey fossiliferous limestones and cherts deposited in shallow, warm-water oceans, they are stained red by rainwater dripping down from the overlying Formations, .

At the base of the outer canyon, the Devonian is represented by the Temple Butte Limestone, reddish-purple and grey thin-bedded dolomites but both the Silurian and Ordovician are missing.

The Tonto Platform, the flat surface in Figure 5, marks the boundary between the outer and inner canyons. It is composed of the Cambrian Tonto Group and records a transgression. Beneath the platform of weak Bright Angel Shales is the resistant Tapats Sandstone which forms the cliffs at the top of the inner canyon. This is a coarsening upwards sequence deposited in shallow and turbulent coastal waters of a sea advancing from the west.

The so-called Great Unconformity between these rocks and the underlying Precambrian can be seen in Figure 6 and is clearly an angular unconformity. Some 1500ft of

Fig. 6 : Precambrian rocks in the inner canyon

Precambrian shales and sandstones, now schistosed, intruded by granites is visible in the walls of the inner canyon. Here, beside the Colorado River, we have reached the bottom of the Grand Staircase.

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A Geodiversity Action Plan for Herefordshire : Geodiversity Audit

Moira Jenkins

Herefordshire & Worcestershire Earth Heritage Trust

Supported through Defra's Aggregates Levy Sustainability Fund

Introduction : From August 2007 to March 2008 Herefordshire and Worcestershire Earth Heritage Trust has carried out an audit of geological sites in Herefordshire. This was funded from Natural England through Defra's Aggregates Levy Sustainability Fund as the 2nd Stage of the development of a Geodiversity Action Plan (GAP) for Herefordshire. Field work for the audit of sites was carried out with the help of a wide range of enthusiastic volunteers. They are gratefully thanked for their valuable assistance. It is intended to apply for more funding for Stage 3, during which the results of the audit will be fully written up and published with the Action Plan to carry out the objectives identified by the partners.

Fig. 1 : Precambrian Malverns Complex rocks in Gardiners Quarry

Herefordshire's Little-Studied Geology. Herefordshire is a county with a wide range of geology but is an area which has been little studied. The British Geological Survey has produced 1:50000 maps with memoirs only for the sheets covering Hereford, Worcester, Tewkesbury and Monmouth. There are provisional maps without memoirs for Ludlow, Ross-on-Wye, Hay-on-Wye and Talgarth. The area in north-west Herefordshire which will be covered by the Knighton sheet does not yet have a geological map. Herefordshire's geology ranges in age from the late Precambrian Malverns Complex of the Herefordshire / Worcestershire boundary in the east to widely scattered Quaternary deposits. Only the Triassic, Jurassic, Cretaceous and Tertiary are unrepresented in the county. The audit of geological sites has filled in some of the gaps in our knowledge but there is still a great deal to be found out.

Some Examples of the Wide Variety of Geodiversity in Herefordshire. The county's **Precambrian** rocks are of three main types. We are all aware of one of the largest and best-exposed outcrops of Precambrian rocks in England to be found on the prominent ridge of the Malvern Hills. Figure 1 shows rocks of the Malverns Complex at Gardiners Quarry which may be one of the sites for the Earth Science Champions Project, just started by the EHT, which aims to involve local communities in looking after special sites in their area. Ten sites will be

chosen throughout Herefordshire and 'Champions' will be trained for each site.

Herefordshire also contains volcanic rocks of the Warren House Formation seen at Clutters Cave. In the Pedwardine area are rocks of the Brampton Formation, similar to the Precambrian rocks of the Long Mynd, which are coarse sandstones with some conglomerate layers.

Cambrian rocks outcrop to the west of Midsummer Hill, Raggedstone Hill and Chase End Hill with small inliers within the Malvernian outcrop. They show a transgression of the sea across the underlying Precambrian rock. Recent heavy rains have created fresh exposures of Malvern Quartzite Formation, which show a complicated relationship with the Precambrian,

Fig. 2 : Kionoceras virgatum, Aymestry Limestone, Hoopers Oak

Fig. 3 : Boulder in Lower Leintwardine Formation which has settled into soft sediment below and has later sediment draped over it

sometimes unconformable and sometimes faulted. These rocks are interpreted as having developed along a shoreline, adjacent to a landmass from which Malverns Complex rocks were being eroded.

During the **Ordovician** fine sediments were deposited in deep water. Igneous rocks were also intruded as dykes or sills.

Silurian rocks are found in the north and north-west of the county, to the west of the Malvern Hills, in the Woolhope Dome and in the May Hill area. These rocks were formed in shallow marine conditions with water deepening to the west. The Pridoli Series, which is found in the lowlands of much of central Herefordshire, is now included in the Silurian.

There are many highly fossiliferous horizons. Figure 2 shows a fine specimen of the orthocone *Kionoceras virgatum* found in the Aymestry Limestone at Hoopers Oak.

In the Leintwardine area and south of Wigmore Rolls it can be shown that the time of deposition of the Lower Leintwardine Formation was one of great instability, leading to the development of submarine channels and many manifestations of soft sediment deformation. Submarine canyons were cut into the underlying beds, at their greatest depth to the level of the Coalbrookdale Formation. At the base of the Lower Leintwardine Formation south of Wigmore Rolls and in the Mocktree area are boulder beds in these channels. Figure 3 shows a large boulder at the base of the Lower Leintwardine Formation seen by the roadside near Lower Lye. The boulder can be seen to have depressed the unconsolidated sediment below. Later layers have been draped over it.

Lower Old Red Sandstone rocks, Pridoli in age, (formerly Downtonian, now Raglan Mudstone Formation) occupy the central part of Herefordshire. They comprise, in ascending order, the Downton Castle Sandstone, Raglan Mudstone and Bishops Frome Limestone. Figure 4 shows a fossil gastropod, Platyschisma, found near Kington, in

Fig. 4 : The gastropod Platyschisma

Fig. 5 : Channellised sandstones on the Cat's Back

the vicinity of the Ludlow Bone Bed, which forms the base of the Downton Castle Sandstone Formation. This marks the change from marine to semi-arid terrestrial conditions, shown by the red colour of the rocks.

The **Devonian** rocks commence with the continuation of the Lower Old Red Sandstone in the Dittonian Group and the overlying Breconian Group, with the deposits of seasonal streams. The Lower Devonian Senni Formation underlies the Brownstones Formation in the far south-west of the county.

Fig. 6 : Pseudotealliocaris etheridgei fossil from Great Doward

Figure 5 shows cross-bedded sandstones and slumping in the Senni Formation. These outcrop on top of the narrow steep sided ridge, the Cat's Back (Black Hill). To the left is the cwm at the head of the Olchon Valley, with the level plateau surface of the Black Mountains beyond. There are magnificent views in every direction. The Senni Formation is characteristically green or purple in colour and is dominated by channellised sandstones. The Ffynnon Limestone below is a calcrete, which forms the boundary between the St Maughans Formation and the Senni Formation.

The **Carboniferous** Lower Limestone Shales Formation consists of thinly bedded limestones and argillaceous sediments. These rocks are found in the Great Doward and Wye Gorge area and as far north as Howle Hill. A very exciting discovery of a shrimp-like fossil has been made during this survey (Figure 6). This is similar to the Malacostraca, *Pseudotealliocaris etheridgei*. These specimens are remarkably well preserved. Further research is continuing to find out more about this nationally important site.

A small area of Upper Coal Measures is found in the core of the Howle Hill syncline. The beds are assigned to the Trenchard Formation. They consist of grey mudstones and siltstones and include the Trenchard Coal, which was worked at Great Howle opencast site from 1972 to 1977. A temporary exposure of the Trenchard Formation was recorded during this survey.

The type area of the **Permian** Haffield Breccia occurs in Herefordshire south of Ledbury and this site was included in the present survey. It is a disused quarry which gives a fine section through the Haffield Breccia. The rock was formed by a catastrophic event related to the movement on the East Malvern Fault system and contains unsorted angular fragments in a finer matrix.

Structural Diversity In Herefordshire. Major fault systems which cross Herefordshire include the Church Stretton Fault Complex, the Swansea Valley and Neath Valley Disturbances. There has been severe deformation along the Malvern Axis. Figure 7 shows a fault line exposed in the quarry on Herrock Hill, with sheared rock associated with the Church Stretton Fault system

Soft-Bodied Fossils from the Silurian - the Herefordshire Lagerstätte. Figure 8 shows a trilobite, *Tapinocalymene*, preserved in a nodule, found at the Herefordshire Lagerstätte, where soft body parts of fossils have been preserved. The location of this site has not been divulged. There are good reasons for this. A similar site in Scotland has in recent times been plundered by fossil collectors and valuable scientific information has been lost. There may be hundreds more nodules but the Herefordshire exposure is small. It represents a treasure trove, with many fossils showing details that have not been seen elsewhere and with species that are only known from this site. The only protection at present is that the location of this site is being kept secret. The Partners will discuss how the Geodiversity Action Plan can best help to look after this globally important site, which is very vulnerable.

Fig 7 : Fault zone with sheared rock associated with the Church Stretton Fault Complex

Fig. 8 : A calcareous nodule which has formed around a nucleus, in this case a trilobite fossil preserved in three dimensions

MEETING REPORTS

by Dr Geoff Steel

Friday 19th and Saturday 20th October 2007 : The Geology of Bottled Water

Professor John Mather gave this Friday evening talk on bottled water, illustrated by examples from all over the world. Bottled water is classed as 'food' and therefore comes under different regulations from tap water. There is a popular misconception, often repeated on bottle labels, that pure water comes from deep underground. In fact underground water collects many dissolved minerals. So the purest water is that which has not been deep; it is essentially just rainwater. This is confirmed by chemical analysis, which for rainwater indicates sodium and chlorine (from sea air) but not much else. Longer time and greater depth typically add minerals such as calcium, magnesium, bicarbonate and sulphate depending on the local geology.

On Saturday John took us on a tour around Malvern to see the wells, springs and water tanks left from the days when it was a spa town. He described the punishing regime known as the 'water cure' which began in the 1840s and involved walking around the wells dressed only in wet sheets. On the highest ground we visited St Ann's Well which gives pure water from rainfall on Precambrian rocks, and for contrast we visited the chalybeate (meaning 'iron-rich') springs at the Winter Gardens on the low-lying Triassic rocks.

Members inspect the collection at Ludlow Museum

Friday 16th November 2007 : Members Evening

We began the meeting by looking at exhibits brought in by members. Moira Jenkins showed a sample of the Ludlow bone bed with fish scales, ostracods and brachiopods. Hugh Torrens brought a tabulate coral from Leinthall Earls and stressed that these Silurian fossils are not related to modern corals. In 1951 Bryan Betts travelled to Greenland on a geological mapping expedition. He showed us photos and records from his base at 74° north. Charles Hopkinson showed Dalradian quartzite from Donegal, Iris Calderbank brought a piece of ash-flow tuff from North Wales, and from the Golden Valley Alan Stone brought a sample of Bishop's Frome Limestone. In an exciting new development Rollo Gillespie brought fossil crustaceans (probably related to malacostraca) showing exceptional preservation. He discovered them, just two weeks prior to this meeting, in the Carboniferous lower limestone shales of the Doward hill.

John Payne then amused us with his photos of 'Geology at Flower Shows'. While great care is taken to exhibit the plants to their maximum beauty they are often surrounded by rocks providing a 'natural' setting which is totally unrealistic.

Finally Gerry Calderbank showed two short films provided by the visitor centre at the Reis Crater impact site in Germany. Their cartoon-like style revealed their age but they were very informative about the site, which was visited on the April 2007 field trip.

Wednesday 5th December 2007: Ludlow Museum and Resource Centre

A small group of WGS members was shown around the geological collection at Ludlow Museum by the Curator, Daniel Lockett. The collection of about 140000 geological items is stored in a modern system donated by the quarry company Hanson. Cataloguing of the collection is on-going and so far covers about one third of the items. A good deal of time was spent inspecting especially the Palaeozoic fossils and some useful work was done in identifying members' own specimens. The pride of the collection is its set of mammoth bones excavated from a north Shropshire kettle hole during the 1980s.

Friday 25th January 2008 : AGM and Dinner

This year's AGM was again well attended, extra seats being needed from the library. In his annual review the Chairman, Gerry Calderbank, thanked the committee for their support in a busy year, especially with respect to the GA. Celebrations. John Payne summarised the closely related EHT activities, Moira Jenkins described the forthcoming geodiversity action plan, and Charles Hopkinson gave an update on progress of the Publication Working Party towards a geology guide to Herefordshire. Sue Hay proposed an archaeology/geology trip to Shetland in 2009 and received enthusiastic support for the idea. Finally it was voted to retain the existing committee in their present positions. The meeting was followed by dinner at the nearby Spread Eagle, in which loud bass beats from the downstairs bar accompanied a menu of traditional bangers'n'mash.

Friday 15th February 2008 : A Grand Staircase in the USA

Sue Hay's talk is included as a separate article.

Friday 7th March 2008 : Volcanic Geology of Snowdonia

To provide a scale for things to come Eddie Bailey introduced this talk by showing photographs of the 1980 Mount St Helens eruption. He then took us on a 'virtual field trip' from Tryfan to the Devils Kitchen where the Ordovician rocks formed above a subduction zone at the south side of the Iapetus Ocean.

The traverse began with pyroclastic deposits from an eruption ten times larger than Mount St Helens. Marine shales followed, then welded tuff from an explosion more than double the previous size. After a further group of marine deposits came the Lower Rhyolitic Tuff Formation, from an eruption one hundred times larger than Mount St Helens! Having emphasised the enormous scale of this volcanic activity Eddie described the underlying structure as a set of parallel faults, with intervening blocks moving like piano keys. Hence the centre of activity was continually changing, generally in a north-east to south-west direction.

Saturday 19th April 2008 : Hanter Hill

On this wet and windy day we were guided around Hanter Hill by Sue Hay and Geoff Steel. The hill is a Precambrian igneous intrusion brought to the surface by displacements on the Church Stretton fault. Some over-enthusiastic gorse clearance in December 2006 led to an uncontrolled fire, leaving an extensive area of freshly exposed rock to the delight of geologists.

Sue and Charles study Hanter Hill

We began by studying fine-grained dolerite at Knowle Barn. Next to this we crossed a boggy patch of Wenlock mudstones to an area of gabbro which intrudes the dolerite. At this point there are later dolerite dykes, perhaps of Ordovician age, which we could see to be in a less metamorphosed condition. At the fire-cleared area we examined tourmaline crystals, a puzzle as this mineral is not normally found in basic rocks. A clue to its origin may be some later acid intrusions which occur nearby. They have a distinctive pale cream colour and at one location we found a dark vein leading into the adjacent gabbro. At the top of the hill we searched for a reported chilled margin in the gabbro but this area was obscured by vegetation. Anyone got any matches?

The party discusses the unusual occurrence of tourmaline on Hanter Hill

Saturday 21st June 2008 : Huntley and the Blaisdon Fault

Under the leadership of Dave Owen from the Gloucestershire Geology Trust we spent the morning looking at the influence of the Blaisdon Fault in the new Huntley Quarry Geological Reserve. He showed us the very gritty Llandovery May Hill Sandstone, which is thought to be an estuarine deposit, and then the Huntley Quarry Beds which are faulted against Triassic Mercia Mudstone. One section appears to show horizontal Huntley beds but a second section shows that they are actually folded. Finally, by the church we saw a small exposure of red-coloured Triassic Bromsgrove Sandstone.

After lunch at the garden centre we walked up the hill at Longhope to visit Hobbs Quarry, a geological SSSI. This has a superb example of a Wenlock ballstone reef, so-called because the coral-rich reefs were circular in cross section. They continued to grow upwards forming column-like structures, to keep up with limestone sedimentation around them. The quarry face now appears to have undulations due to compression of the sediments between the more rigid reefs.

Saturday 19th July 2008 : Pyrddin Valley

Eight members spent the day exploring the geology of the Pyrddin Valley under the guidance of Steve Howe from the National Museum of Wales. We spent the morning walking along the Little Neath river. It has a steep valley cut into a glaciated surface, the result of rejuvenation of the river system at the end of the Ice Age. There is a strong correlation between landscape and geology, such as the narrowing of the river bed over sandstones, widening out again over the weaker mudstones. Starting at the base of the Lower Coal Measures we walked up to the Scwyd

Gladys waterfall which is formed where Namurian sandstone outcrops in the river bed. Whilst the base of this sandstone is erosional, the top surface is covered in root impressions. After lunch we walked back past the Cwm Gored Mine, one of the many silica mines that worked the pure quartzites of the Pontneddfechan area.

At the end of the afternoon we had time to visit Craig y Ddinas where Carboniferous limestones are exposed within the fault zone of the Neath Disturbance. This superb example of monoclinal folding is now very overgrown - some geoconservation is urgently required.

A large erratic boulder near Scwyd Gladys, near Pontneddfechan

Sunday 7th September 2008 : The Builth Inlier

This joint trip with the Mid Wales Geology Club was led by Dr John Davies. Its aim was to examine the Ordovician sedimentary and volcanic rocks of the Builth Inlier with particular emphasis on their structure and tectonism. We began at Builth Castle from where we could see the westerly dipping volcanic rocks forming rough features on the hillside in marked contrast to the smoother contours of the underlying mudstones. Then a short drive took us to Llanelwedd Quarry. The basalt here is easily recognised by its large feldspar crystals and is quarried for roadstone.

The Camnant stream section, Builth inlier

We then drove on a traverse

A silica mine in the Pyrddin valley

across the inlier starting at the east side where John explained how the steep dip suggests a thrust and partly overturned margin. Lunch was at Camnant Cliff, a well-known exposure (studied by both Murchison and Gertrude Ellis) in which a fine-grained tuff overlies dark mudstones. A further stop gave a view of the central part of the inlier which forms an obvious anticline.

Finally we drove to Cefn Llys near Llandrindod. Crossing a flooded stream and waterlogged fields led to a track up the hill in which tuffs and lavas are well displayed, followed by mudstones with several layers of bentonite clay. The structure here is a faulted syncline.

Friday 12th September 2008 : Preview of 'A Picnic In Siluria'

Tim and Katya Coupland have completed a preliminary version of the DVD showing last year's re-enactment of a Victorian field trip. We met at the Resource Centre in Friar Street for a preview, with an introduction given by Professor Hugh Torrens. We were joined by Lawrence and Elizabeth Banks of Ridgebourne, and Robert and Lesley Hunt from Titley Junction Station. Katya praised the high quality of acting, saying that almost all of the film was good enough to use, and she asked for comments and general feedback to help her compile a final version.

CLUB INSURANCE *Each person attending a meeting does so on the understanding that he/she attends at his/her own risk. The Woolhope Naturalists' Field Club has Public Liability Insurance Cover for field and indoor meetings, but Personal Accident cover and Personal Liability cover remain the responsibility of the participant. Members with house insurance will probably find this included. Members should also note that they will be required to take out appropriate travel insurance for any overseas event.*

Members of the WGS Committee

(December 2008)

Gerry Calderbank ***Chairman***

Dr Geoff Steel ***Vice-Chairman***

Dr Paul Olver ***Secretary***

Beryl Harding ***Treasurer***

Dr Sue Hay ***Programme Secretary***

Moira Jenkins ***Section Recorder***

Kate Andrew ***Heritage Services Representative***

Dr John Payne ***'Earth Matters' Editor and Earth Heritage Trust Representative***

Charles Hopkinson

Alan Stone

Herefordshire Heritage Services

It's almost a year since Heritage Service took possession of the completed Museum Resource and Learning Centre, with staff moving in in November 2007 and the atrium opening to the public in January 2008.

During the year three volunteers, Tess Ormrod, Tiiu Ligema and Robin Thorndyke have worked with museum staff Kate Andrew, Sarah Skelton and Sally Mansell to move, sort, catalogue and re-order the geological collections. For much of the year, the collection has been spread out on tables in the new volunteer workroom as a systematic order was shaped from a collection previously stored partly by size of specimen and in a mixture of drawers and boxes. In the last week, the last of the new metal drawers have been put away in the cupboards. Natalie Jolley and other members of the front of house team have been entering Tess's handwritten catalogue entries onto the museum database.

This lengthy process means that staff now have a much better understanding of the coverage of the collection. This has already paid dividends with a tailored session at the centre for the U3A geology group. The Woolhope Geology Section have also met a couple of times in the new learning room when the Woolhope Room has been unavailable.

The geological history of the county also now features in the Herefordshire Time Line, a fantastic frieze of woodblock style images running around the museum gallery at Hereford Museum & Art Gallery. The time line is one of the main obvious features of a complete re-display of the space being undertaken in-house which has seen geological specimens re-appearing in the gallery. Work is ongoing, but do visit to check on progress. An exhibition is also being created for the atrium in the Museum Resource and Learning Centre which will highlight the collections cared for at the site.

Katherine Andrew

H&W Earth Heritage Trust

The Earth Heritage Trust (EHT) has completed a number of projects since last year's report. At that time, the second phase of the work towards Geodiversity Action Plans for our two counties was in progress, involving audits of the exposed geology. Many Section members and a number of paid professionals assisted in this. Previously unrecorded exposures were logged and a lot of sites worthy of RIGS designation were found. The Herefordshire aspect of the work is described in Moira Jenkins's article in this issue. Funding for phase 3 of the work is much delayed but it is anticipated that this work will start soon.

A small but important project was the drawing up and testing of a form to allow a simple but accurate assessment of the condition of RIGS sites. Such assessment is needed in order to use any site maintenance money in the best way. This form is now adopted nationally and will be a most useful tool in geological conservation.

A paper study is soon to be completed on local building stones including information on their sources.

The 'Champions' programme is progressing well, with the initial moves towards setting up local groups. Whitman's Hill Quarry is seen as a good model and is included.

Moira completed her Herefordshire Rivers work with the publication of a trail around Kington and Hergest Ridge. The much larger project to establish the Geopark Way long distance footpath from Bridgnorth to Gloucester is considerably delayed but publication of the guide is planned for February 2009. (At some time in 2009 the Geological Survey will be publishing a book dealing with the geology of the Geopark.).

The Geopark has undergone major organisational change in the past year. The Partnership Committee has been reformed with many new and important Partners, for example the Malvern Hills Conservators and the Malvern HIlls AONB. This should greatly strengthen its working.

John Payne