Earth Matters

The Newsletter of the Geology Section

of the Woolhope Naturalists' Field Club

No. 4 December 2007

The Geology Section is an Affiliate Member of the Geologists' Association.
The Woolhope Naturalists' Field Club is a Registered Charity, No. 521000

Contents

Message from the Chairman

It's been another good year for the WGS. Despite medical problems, I seem not to have missed too much of the action, plenty of which is reported in the following pages - and what a diverse and interesting programme we have enjoyed, thanks to Sue Hay. As merely a passive listener or participant, I found all the talks and excursions fascinating and on each and every occasion there seemed some new 'angle' or aspect of our leader's exposition that left me contemplating deeper issues!

The past year has seen the usual close liaison with the Hfds & Worcs Earth Heritage Trust, as coordinated by their Chairman John Payne, and here I must observe that, of various bodies associated with Trust, the Woolhope Club certainly pulls its weight. This is reflected in both the make up of the Trust Executive and, most importantly, by the active participation of our members in fieldwork conducted by Moira Jenkins throughout the County when researching the Trust's field guides, etc. Sadly, I've missed out on such field excursions recently but look forward to joining in again as my stamina improves. Noteworthy, was the joint enterprise between WGS and EHT in conjunction with Mike Rosenbaum's 'Marches Festival of Geology' whereby we mounted a very successful Rock & Fossil Roadshow in Leominster. Likewise, Paul's Victorian re-enactment passed off smoothly; the weather was kind and we all had a thoroughly enjoyable time. Incidentally,his replaced our usual Murchison Lecture - but more anon!

Finally, what an utterly enthralling FC Morgan Memorial Lecture we enjoyed in the Shire Hall in October. Prof. David Dineley was in sparkling form, choosing to concentrate upon the Devonian fishes. The coverage was global, reflecting his far-flung research, and the delivery was graced with his usual touches of wit and humour.

Gerry Calderbank, Chairman

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Some vertebrate fossils from the Messel Pit; a bird, a turtle and a primitive horse

tributed ultra-fine-grained smectic clays that eventually imprisoned and thus preserved any dead organisms settling on the lakebed. Preservation was exceptional because of the intensely anoxic conditions. Whereas the vertebrate fossils are truly spectacular (and undoubtedly the main tourist attraction) their botanical counterparts far exceed them in both variety and numbers. Algae were the chief factor in the hydrocarbon formation. Microscopic spores provide much of the dating evidence. Following the initial and most active vulcanism, there were periodic

The Reis crater, extending to the distant butte

emissions of toxic gases over the next few million years and it was this toxicity that contributed much of the avian and terrestrial fossil fauna.

DAY 7. At the Steinheim Crater we gained a vantage point overlooking the inner meteoritic impact zone. Like the much larger Ries Crater nearby, this is Miocene in age and both have been dated to about 14.7Ma. It is thought that the craters represent parts of the same low angle impact event whereby an incoming asteroid / comet disintegrated upon entering the atmosphere. Steinheim received the smaller fragment so that penetration was shallower than at Reis (it didn't reach the basement rocks) and there were consequently less lithological effects. However, physical disruption of the Jurassic bedding was considerable, including fallback ejecta plus huge blocks of country rock dislocated by thrusting. A prominent central dome formed when the country rocks reactively 'bounced' upwards, probably within seconds of the impact. Also within the crater are extensive Tertiary lake deposits overlain by Quaternary infilling.

From a Nordlingen hilltop we saw the vast 24km diameter Reis crater in its entirety. We paused at the summit quarry and then drove on to the nearby Goat Quarry. The day ended at a Miocene quarry exposure that was capped with an intriguing 'crust' of lacustrine limestone derived from the former crater lake.

DAY 8. A morning tour of the Rieskrater Museum included a fascinating video simulation of the meteoritic impact. At the disused Ötting Quarry near the periphery of the crater we were able to examine specimens of suevite, an impact breccia much favoured as a local building stone. Paul explained that, of the varied impact ejecta (mainly Moldavites and Bunte Breccia), this 'fall-out' suevite represents the final depositional phase.

Moldavites are typically 'glassy' bombs derived in the initial airburst from the target rocks plus meteoritic fragments. Aerodynamically formed, they were strewn mainly in the vicinity of the impact zone although some have been found as far afield as Moldavia in the Czech Republic. On the other hand, the Bunte Breccia is simply a mega-breccia of Jurassic and Triassic clasts within a similar fine-grained matrix, but typically distributed in massive sedimentary blocks.

The suevite occurs in two forms. Largely inaccessible because of its depth, the 'crater suevite', with a thickness of up to 400m, has been proven by core sampling. The 'fall-out' variety was likewise formed at high tempera-tures and pressures, but it is generally glassier than crater suevite. Furthermore, since the metamorphosis occurred at high altitude in the airburst as the final ejecta event, it is thought to have settled (unconformably) perhaps a couple of hours after the underlying Bunte episode. Both forms of suevite contain microscopic diamonds, magnetite and other minerals characteristic of such high-grade metamorphism. Geochemically, both suevite varieties

Suevite building stone

Fossil hunting in the Plattenkalk Limestone

have been linked to the predominantly plagioclase-biotite gneissic basement rocks.

A pleasant drive took us to the dramatically sited Jura - Museum Eichstatt where the Director showed us their celebrated *Flugsauri*, including a superb specimen of *Pterodactylus elegans*, and also the avian fossil collection featuring *Archaeopteryx*, together with fossil dragonflies and other creatures, all preserved in the famous Plattenkalk limestone. Thereafter we wandered at will. Altogether, a marvellous experience!

DAY 9. Next morning the Museum Director conducted us around three of the local Solnhoffen Plattenkalk lithographic limestone quarries, at the last of which we prospected for fossils. During Early Tithonian times this micritic limestone was deposited in environmentally harsh lagoonal conditions at the margin of a reef platform bordering the Tethys Sea. Here, a series of lagoonal basins were only partially or periodically linked to the Tethys, possibly because of a (postulated) barrier reef, whilst evaporation was generally intense. Periodic hyper-salinity-density stratification, extreme stagnation, and the consequent localised concentration of life-threatening anoxic sump-water resulted although the surface waters maintained fairly normal life for much of the time. Periodic storms swept these basins, upsetting the precarious balance of life. Storm-induced shoreward surface currents brought influxes of less saline oceanic water and introduced large quantities of algal limey mud and also clay sediments. Into these intensely calcareous sediments the newly dead fauna were swept either directly from the open ocean or from the algal reef mounds and were then duly fossilised - hence the Hunsruck Lagerstätte. A long drive then took us to Andernach.

DAY 10. Our final excursion was to the East Eifel Volcanic Field (EEVF). The first stop was at the Laacher See, the site of the most recent volcanic episode in North Europe. A typical *maar* volcano, it erupted 11000±50 BP, as ^{14}C-dated from charcoal inclusions, organic sediments and some underlying distal ash deposits. Regionally, the earliest vulcanicity dates from >700000 years ago, with the intervention of at least three further pulses recognised. At EEVF there is still some slight activity. Hot toxic gases periodically bubble up, sufficient to melt the ice cover in winter and, occasionally, to asphyxiate the waterfowl! We examined part of the crater rim where quarrying had exposed the tephra sequence. This consisted mainly of dust deposits with ashes and displaced clasts of country rock. Whilst searching for tiny phonolitic haüyne crystals I ventured down to the lake shore, where the water seemed faintly sulphurous.

A disused section of the Wingertsbergwand basalt quarry is laid out with rock-mounted information boards facing a stupendous 50m-high cliff exposure of volcanic ash strata. These tuff layers are littered with volcanic bombs and, by reference to Paul's handout diagrams, it was possible to infer both the direction and mode of impact. Mostly, I interpreted the larger blocks as 'bounced ballistic blocks'.

The tephra cliff at Wingertsbergwand basalt quarry

Our brief visit to the Mendig Lava-Dome Museum included a visit to the Lavakeller. This is a disused basalt mine, with a subsequent history of beer storage, where the stone was formerly winched out via a shaft. Suitably clad in waterproofs and helmets, we descended a long flight of steps for the tour. We saw the remarkable columnar jointing, particularly in the supporting columns and on the roof, that resembled an inverted Giant's Causeway!

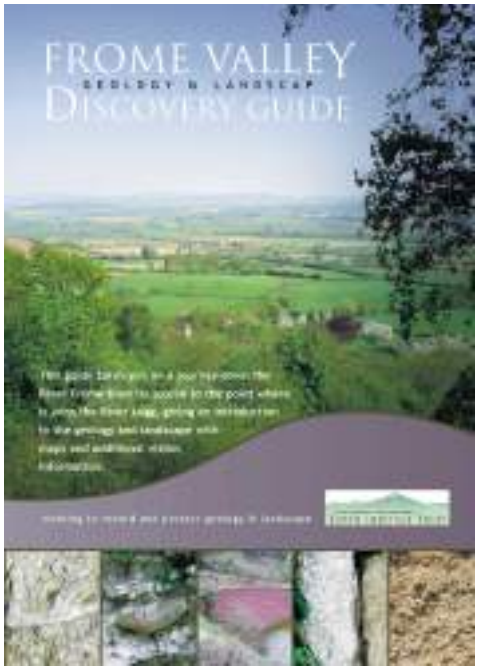
After dinner on our final evening we feted Paul and presented him with a token of our gratitude for a truly outstanding experience. The next morning we parted company. Paul entrained for Berlin to receive his award for services within the EU whilst, under the care of Sue, we began our day-long coach, ferry and minibus journey to Hereford. And so ended yet another triumphal 'Olver Study Tour' for WGS and friends!

Frome Valley Geology and Landscape Discovery Guide

Moira Jenkins

Herefordshire & Worcestershire Earth Heritage Trust

The River Landscapes Discovery Guide Project has explored the parishes through which the River Frome flows. A guide describing the geology and landscape of the Frome Valley has been printed. This beautiful and little known part of Herefordshire has so much of interest for the visitor. There are many places with beautiful views to the Malverns in the east, to Clee Hill in the north and to the Black Mountains in the southwest. This project was part financed by the European Union EAGGF and DEFRA through the LEADER+ Herefordshire Rivers Programme. A grant from Awards for All paid for the printing of the guide. The guide tells visitors about places they can visit to see geology and landscape features for themselves. It is illustrated with photos, maps and diagrams. There is also information about places to stay and other visitor attractions in the area.



The River Frome rises in Herefordshire and its entire course is within the county. The topography in the Frome Valley reflects the underlying geology. Around Bromyard the river cuts a deep valley into the hills. Here it flows across the Devonian St Maughans Formation, which have a higher percentage of sandstone bands that are more resistant to erosion. South of Bishop's Frome, it meanders in a wide valley through peaceful countryside until it joins the River Lugg. In this part of its course the Frome crosses the more easily eroded Raglan Mudstone Formation (uppermost Silurian in age) and is one of the muddiest rivers in the country.

The Frome Valley has a variety of interesting geology, though this is not immediately obvious. The oldest rocks in the area studied can be found on Shucknall Hill and in the Woolhope Dome These are Silurian limestones and siltstones formed in warm seas, teeming with life. Both areas have been upfolded by earth movements. In some rock layers we can find abundant fossils such as the brachiopods and bryozoan seen in the picture on the next page.

The River Frome near Yarkhill

A fossil bryozoan from Shucknall Hill

At the end of the Silurian Period the seas shallowed and then the area became a semi-arid land surface crossed by seasonal streams bringing down sediments eroded from the newly formed Welsh mountains. Mudstone was worked at the former Linton Tile Works and this can be seen from the Recycling Site near Bromyard.

The picture above shows an outcrop in the former railway cutting in the Bromyard Industrial Estate. A river channel was cut into a sandstone layer and has been infilled with coarse material.

Fossils are rare in the Raglan Mudstone Formation (Upper most Silurian in age) and St Maughans Formation (Lowest Devonian in age). Occasional fragments of some of the earliest land plants and primitive fish fossils are sometimes

found. At the boundary between the Silurian and Devonian is the Bishop's Frome Limestone, named after outcrops in this area. This is a chemical limestone formed when lime rich ground water was drawn to the surface and evaporated leaving concentrations of calcium carbonate in the soil.

Hewitt's gravel pit

The effects of the Ice Age can be seen on low ridges west of Bishop's Frome. Here gravels, deposited by a cold-water stream, which was a predecessor of the River Lodon, are being worked. The picture shows a visit to look at these gravels. In the Devensian,the latest glacial phase in the Pleistocene, the ice did not reach this part of Herefordshire.

During more recent Flandrian times since the end of the Ice Age, the Frome has captured the Lodon, which used to flow west past Monkhide to join the River Lugg. The former valley was used as the route of the Hereford to Gloucester Canal and now has no stream. Another fluvial feature is an abandoned meander of the Frome, which can be seen at Hyde Farm near Avenbury in a section of the valley where the stream is incised.

Grateful thanks are given to a keen band of volunteers from the local community, who have helped with the field surveys and contributed information and photographs. As part of the project, eight sites have been designated as RIGS (Regionally Important Geological / Geomorphological Sites). A guided walk was held on what turned out to be one of the wettest days of the year. A talk about the geology and landscape of the area was given and an event was held to launch the guide.

Loitering in the Lake District

Charles and Jean Hopkinson, Woolhope Geology Section

The truism that 'Spectacular Scenery Means Interesting Geology' has been brought home to us the last couple of years. A walking holiday in Donegal - in the words of one authority “the most geologically complex region of Ireland” - was followed this year by four days in the Ullswater district of the Lake District.

We had as our guide Robert Prosser's ‘Geology Explained in the Lake District’, which has been recently reprinted, and found it pitched at just about our level. The author's black and white drawings gave a personal touch which seems to us to be missing from computer generated material.

Whilst out walking, we treat geology as if it were a computer programme running quietly in the background; we call upon it from time to time as we loiter, as well as taking a breather, at a feature of the landscape. On one such occasion we found a disused quarry where the Devonian Mell Fell Conglomerate, predominately of Silurian material eroded from the Caledonian Orogeny, lay unconformably on the Ordovician Borrowdale Volcanic Series.

Haweswater

A mile and a half walk up the Glenridding Valley is the site of the Greenside Lead Mine. Originally developed at the end of the 17th century by Dutch entrepreneurs, it had a chequered existence as the largest lead mine in the Lake District until its final closure in 1962. We found a specimen of galena as a string, a very small vein, in a piece of quartz, the mineral from which the lead was mined.

We spent an instructive afternoon at the head of Haweswater where all the elements of glaciology we had read and heard about were on view. The Haweswater Glacier was largely fed from two impressive corries and standing on the lip of Small Water Corrie the standard features were plain to see. Turning round and looking down several hundred feet of the steep morainal slope - it must at one time have constituted a spectacular icefall - there was at the bottom the drift from the small glacier of the mini-Ice Age of about 11000 years ago. Beyond, the valley of the lake had the classic glacial profile.

We tried with varying success to get our heads round the many facets of the district's complex geology, not least the variety of igneous rocks when expert advice would have been valuable, and we left for home with the thought that we were leaving behind much unfinished geological business.

GEOLOGY IN PETROLEUM EXPLORATION

Dr Derek South

Woolhope Club, Geology Section

Introduction. This article outlines a presentation given to the Geology Section of the Woolhope Club in November 2006. It attempts to identify those specific aspects of geology which are used in the search for oil and gas, and to demonstrate how these are applied in the exploration industry. Especially emphasised is the importance of an understanding of a broad range of specialist fields.

Oil and Gas as a World Resource. Currently oil and natural gas provide approximately two thirds of the world's energy consumption, but it is recognised that this is a limited resource. During the early part of this century supply will go into rapid decline, and by the end of the century oil and natural gas will provide less than a quarter of the energy consumed. The continuing work involved in identifying and producing our remaining oil and gas resources will become increasingly difficult, and will provide an increasing technological challenge.

Figure 1. Drilling an exploration well in the Libyan Sahara in the 1960's. Well locations were based largely on the mapping of structural and stratigraphic traps.

The Classification of Petroleum Resources. Crude oil and natural gas are classified as conventional petroleum resources, while heavy oil, tar sand and oil shale are classified as non-conventional petroleum resources. This article considers only the dominant conventional resources, oil and natural gas, which are sourced and normally found as oil or gas accumulations (fields) in sedimentary rock sequences. Conventional oil and gas resources are those trapped in the pore space of subsurface rock formations (reservoirs) which are themselves overlain by impervious strata (seals). The commonest geological structure to contain trapped oil and gas is the anticline. Through the mapping of these, many of the early discoveries were made.

The Significance of Drilling. The drilling process is paramount in finding oil. We can speculate as much as we like as to whether a certain area is or is not oil bearing, but until the rock section is penetrated by the drill we cannot say for sure if oil and gas are present. The industry has progressed from simply drilling an exploratory well on an anticline in the hope of a successful discovery (Fig. 1). An enormous amount of detailed technical work is undertaken before a high cost exploration well programme is planned and drilled. Costs for a typical North Sea exploration well can be of the order of 50 to 100 million USD, so it is important to make every effort to reduce the risk of failure. Even today however, in known petroliferous provinces such as the North Sea, we still work with probabilities of success of around only 25 to 30%, and many wells are disappointingly dry.

An Economic Discovery. Having made an oil or gas discovery it is necessary to estimate its size so that a decision can be made as to whether or not the petroleum can be economically produced. This decision is also dependent on many other factors such as location, depth of the reservoir, water depth (for offshore fields), current price of oil, the cost of development and transport, not to mention the political situation in the country concerned. Field size is measured in barrels (or cubic metres) of recoverable oil, and fields of >500 million barrels are known as giant fields. Examples of giant oil fields include the offshore UK Brent Field, of 2.5 billion barrels, and the onshore Saudi Arabian Ghawar field (Fig. 2), of 82 billion barrels. Field size can be measured by calculating the volume of the oil-filled pore space in the saturated reservoir rock, subtracting for any water content, and estimating what proportion of the volume underground can be produced to surface.

The Four Criteria. The exploration process leading up to the drilling of an exploration well would normally include a countrywide or basin-wide geological review, to identify areas of interest. Subsequently an oil company would then need to compete with other interested parties to obtain a licence entitling them to undertake further

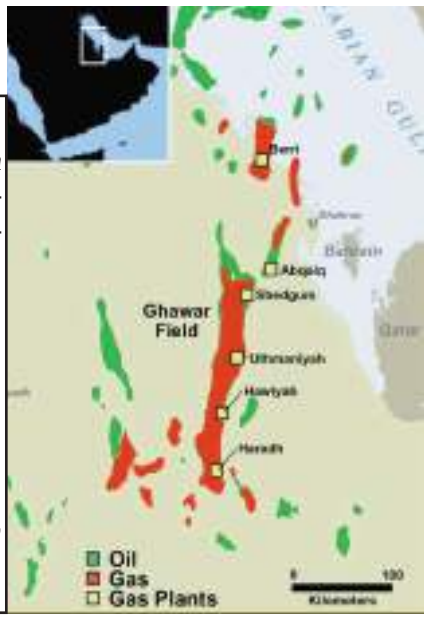


Figure 2. Examples of giant fields.

The map of the Ghawar Field in Saudi Arabia illustrates the enormous size of Middle East reservoirs

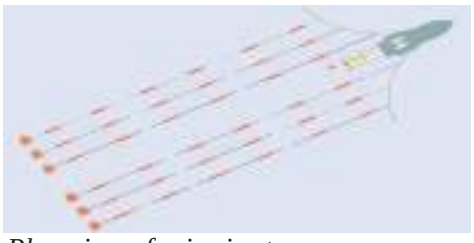
UK, Brent, 2.5 bill bbls, 1971
Norway, Statfjord, 3 bill bbls, 1974
USA, Prudhoe Bay, 9 bill bbls, 1968
Iran, Ahwaz, 10 bill bbls, 1958
Iraq, Kirkuk, 17 bill bbls, 1927
Kuwait, Burgan, 75 bill bbls, 1938
Saudi Arabia, Ghawar, 82 bill bbls, 1948
Abu Dhabi, Zakum, 18 bill bbls

work on a specific area and committing them to a drilling programme. To identify areas of interest and subsequently a suitable location for drilling, four critical criteria would be examined for both the area of interest and finally for each defined drilling prospect. These are trap, source, reservoir, and seal.

In order to evaluate all four criteria, the stratigraphic framework for the area has to be clearly understood. This is normally built up from a correlation of seismic data and any data obtained from previously drilled wells. [Well data are very significant for the description of the source, reservoir and seal horizons. When a well is drilled, a much more precise overview is obtained of the rock sequence at that particular location. Samples from the drill cuttings and from continuous cores provide a basis for the description of the lithological column; and microfossils, so small that they are not broken up by the drill, can be used for biostratigraphic and palaeo-environmental analysis.]

Trap. The criterion which has traditionally been considered of most significance has been the trap. A trap is a situation in which oil and gas can accumulate. It is normally identified through the mapping and interpretation of the geological structure of an area. In the early days, this would have been done by field mapping, but today it is normally mapped from seismic reflection data and integrated with any available relevant well data. Seismic surveys have become increasingly sophisticated in recent years, with the need to improve data quality and to penetrate deeper into the subsurface and often in deep water (fig. 3). The rapid development of computing capacity has meant that enormous quantities of seismic data can be processed to enhance data quality. From these results, structure contour maps are produced on several horizons within the subsurface and prospects are outlined, based on the presence of trap mechanisms, such as anticlines, fault structures, salt domes, etc. The data have of course to be interpreted in terms of a feasible geological model. Two types of trap are recognised; structural traps, formed by differential rock movement, and stratigraphic traps, formed when there is a change in the stratigraphy. Some traps are a combination of both.

Typical seismic trace in cross section



Plan view of seismic streamer array

Figure 3. Geophysics today

Large quantities of seismic data are recorded, processed and interpreted today to produce high quality maps on subsurface horizons in order to identify potential traps for oil and gas.

Seismic vessel with several geophone streamers

Source Rocks and Migration. An oil or gas field is dependent on the nearby presence of a fine-grained rock (usually clay) which originally contained organic matter in an anoxic environment. Burial and consequent heating of this organic matter converts it into kerogen

and subsequently oil and/or gas. In time this can migrate out of the source rock and move eventually into porous and permeable strata. Being lighter than water, oil and gas will always move upwards through a water bearing sequence until it is trapped or leaks to the surface. Knowledge of the quality and maturity of the source rock is important in assessing the probability of success for the prospect. The quality of a source rock can be determined by measuring the amount of organic carbon present, and the maturity can estimated by measuring the reflectivity of vitrinite particles or by comparing the colour of spores and pollen. Further detailed geochemical analysis can also help to define quality and maturity of the source. The final factor relating to source is the mapping of possible migration routes between the main source rock and the potential reservoir in a prospect.

Reservoir Rocks. A reservoir rock is one in which oil and gas can accumulate. It is both porous and permeable. The porosity of a reservoir rock, usually microscopic in size but often forming a significant proportion of the rock volume, is important for large quantities of oil and gas to be stored. Permeability (connected pore space) is also important as this enables oil and gas to flow through and out of the reservoir and into a producing well. Sandstones, limestones and dolomites are the commonest reservoir rocks. The nature and distribution of the reservoir is largely determined by the depositional pattern of the original sediments, as well as by the changes which have subsequently taken place affecting the porosity and permeability. Depositional environments such as deltas, turbidity flows and carbonate reefs commonly lead to high quality reservoirs.

Microscopic study of the petrographic characteristics of reservoir rocks is often required to understand the nature of the individual rock components, the mineralogy, type of porosity and permeability, cementation and solution; all of these factors can be of significance in the interpretation of reservoir quality and distribution.

Seal. For oil and gas to accumulate in a reservoir rock, an overlying seal is required, so that oil and gas, being lighter than water, migrate to the high points in a structural or stratigraphic trap and are contained. A seal has no

permeability and usually very little porosity. It often consists of fine grained, compacted clay or claystone.

Conclusions. A petroleum geologist thus needs to have a good background in structural geology, together with an appreciation of stratigraphy and sedimentology. He/she should also be able to coordinate his/her work with results from detailed studies by palaeontologists and organic geochemists. The probability of success (or risk analysis) for a well being drilled on a prospect is estimated by evaluating the probability of occurrence of each of the four criteria mentioned earlier.

The increased demand for oil and the marketing of this diminishing resource will put even greater emphasis on our ability to successfully apply our geological expertise, even to exploring for the last drop! This article has only touched on some of the detailed research fields which lie behind today's oil and gas discoveries, but it hopefully illustrates how important this expertise is to the exploration process.

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MEETING REPORTS

by Dr Geoff Steel

Friday 20th October 2006 : Members' Evening

We began by looking at rock samples brought in by members. Starting in the Devonian period Rob Williams showed pieces of the Bishop's Frome limestone and also trace fossils from Tredomen near Talgarth. Continuing the local theme we looked at cobbles from Brampton near Madley. They were rounded by river action before being transported by glaciers. Sue Hay took us to the Himalayas to see 'Cashmiri white'. This is a metamorphosed sandstone with large garnets. Derek South showed a 2.5kg uncut sapphire from a jeweller's shop in Vietnam, and also a polished ruby with its characteristic reflection of light as a six-pointed star. Jumping back to Lyme Regis we looked at a fossilised Cornish pastie, actually an ammonite partly enclosed in mudstone. From the Devonian we saw local fish fossils including a teraspis head shield, a canthodian jaw bone, and some remarkable specimens of *Filaspis simonsi*, a fish which had wing-like extensions with water jets underneath. Staying Devonian we looked at sandstone and bioturbated siltstone from John o'Groats, and finally samples of the Townsend Tuff from near Hay on Wye.

Alan Stone has been monitoring progress on the new Transco gas pipeline. It will run from Swansea to Tirley near Tewkesbury. The pipe will be 48" diameter and placed two metres below ground. He showed maps of the proposed route around the north side of the Brecon Beacons to the Wye valley, including a tunnel under Cusop Dingle. The meeting ended with photos of the recent Cornwall trip shown by Gerry Calderbank.

Fossil hunting at Whitman's Hill Quarry

Friday 24th November 2006 : Geology in Petroleum Exploration

Derek South has worked in the oil exploration industry for many years and gave us a talk based on his own experience. His talk is outlined in his article on page 12.

Friday 8th December 2006 : Pegmatites - Crystals both large and unusual

The Chairman, Dr Paul Olver, gave this Friday evening talk. He began by describing pegmatites as coarse-grained igneous rocks which form at a late stage in granite intrusions. They are a product of high temperatures (400 to 600 degrees Celsius) and high volatile concentrations. Around the Cornish granites they typically form veins through the adjacent rocks. Large crystals of tourmaline, topaz and fluorite are particularly characteristic of this environment together with minerals containing rare elements such as beryllium, lithium, tungsten and tantalum. The Precambrian Nissedal area of Norway with its Tordal Granite pegmatites, including those in the famous Hoydalen Quarry, were then described and fully illustrated by specimens from the speaker's collection.

Saturday 20th January 2007 : Wenlock limestones at Storridge and Ledbury

Dr Abigail Brown from the Earth Heritage Trust met us on this sunny winter morning at Storridge village hall. She led us up a narrow lane to Whitman's Hill quarry. It closed in 1988 and has recently been acquired by the trust under a ten year lease.

The quarry reveals a section of Silurian rocks from a soft shale of the Coalbrookdale Formation up into the Much Wenlock Limestone. The latter has two hard layers separated by a nodular layer of poorer quality, this being very similar to the well known section at Wrens Nest. Most of the quarry worked the lower and nodular layers, with the upper layer only seen at the very top. A set of nine ben-

tonite clays form clearly visible weaknesses in the main face, varying in colour from orange to pale grey. They are volcanic ashes, but the source is not known. Compared with Wrens Nest the fossil fauna is less diverse and represents conditions further from the coastline.

After lunch at the Wellington near Colwall we drove to Ledbury School quarry. Here the Wenlock limestone section continues from that seen in the morning, with the upper hard layer visible at the quarry base, followed by a further nodular layer, then an obvious change to grey mudstone of the Elton beds. Again bentonite clays form clearly visible weaknesses, two in the mudstone being marked by lines of grass.

Friday 26th January 2007 : Annual General Meeting

Dr Paul Olver has been Chairman of the Geology Section for its first three years. He recalled the wide range of activities, including overseas field trips, and the great variety of subjects covered, from Quaternary ice ages to petroleum geology. He also laid out some aims for the future: to issue publications, to increase contacts with local groups such as the Cotteswolds geologists, and especially to recruit some younger members. At this meeting Gerry Calderbank took over as Chairman, with Paul replacing him as Secretary. We finished the evening with a meal at the Green Dragon.

The party at the Oxford Museum of Natural History

Saturday 24th February 2007 : Oxford Museum of Natural History

Twelve members of the section travelled by train to visit the museum. The fine Victorian building resulted from the initiative of John Phillips who is well known to us as the author of the first Geological Survey memoir on the Abberley and Malvern Hills. We admired the many supporting columns. These exhibit a wonderful array of decorative stones, especially the many forms of Carboniferous Limestone, and the fossil collection. Many of the Silurian fossils in particular are from our area. We were treated to a talk by staff member Kevin Walsh on the 'Minerals of Zimbabwe, Ancient and Modern'. He described the various methods of gold extraction which are practised in that country. These range from what are essentially cottage industries to large industrial works. Gold production has fallen sharply in recent years due to lack of foreign investment. He also described the role of Arab traders in exporting the country's products in the past through their trade routes from the coast to the ancient city of Zimbabwe.

Friday 16th March 2007 : Geohazards in the Built Environment

In this talk Professor Mike Rosenbaum gave us an introduction to his specialist field of Engineering Geology. He described a typical university course as starting with the Precambrian and working upwards, yet in engineering terms the surface layers are the most important so he recommended the reverse order of teaching.

Problems occur whenever there are unexpected ground conditions. Often this involves soil deformation when compression is removed by stripping away the top layers. There are additional hazards whenever water is present. It can dissolve or erode away the underlying rocks without any surface evidence until triggering a sudden failure.

In Britain a particular set of problems relates to the large areas of abandoned coal mines. The long-wall method of mining was designed to allow gradual subsidence and works well provided the ground is of uniform structure. However faults can cause sudden movements which seriously damage any buildings on the surface. In this respect Mike gave an insight into the cold hard world of economics: although it is possible to design buildings to withstand such conditions it is cheaper not to and instead to pay for compensation claims. Many of the mines are now filling with water which is forcing gas to the surface. In the next few decades the leakage of methane and carbon monoxide is likely to cause serious problems.

Sunday 3rd June 2007 : Field Trip to Raggedstone Hill

Dr John Payne led this trip to the southern end of the Malvern Hills. It was a joint trip with the Black Country Geological Society. We began by visiting a most unusual ‘Earth House’ being built close to the A438 at Hollybush. The owner, Simon Watts, explained the insulating properties of the concrete and stone construction. Excavation at one side has revealed a thrust plane in the Precambrian rocks, the thrust itself marked by a band of light brown clay about two inches thick.

From there we walked to the top of Raggedstone Hill and stopped for lunch. This is the point where in 1853 Hugh Strickland gave a lecture on geology and scenery to a joint meeting of the Woolhope, Cotteswold and Malvern

Inspecting the Frome Valley guide after a tour of Raggedstone Hill

Bill Barclay explains Tredomen Quarry.

Naturalists' Field Clubs. On the east summit there are quartz layers which may indicate metamorphosed sediments, while on the west there is an andesite dyke of Ordovician age. At the nearby Whiteleaved Oak quarry we examined an exposure of the boundary between the Malvernian and Cambrian rocks, which proves the Precambrian age of the former.

Beaconites trace fossils at Pennsylvani Quarry

A short diversion took us to Gray's Cottage waterfall in which Triassic rocks can be seen, then we continued through Whiteleaved Oak to study the numerous Ordovician dykes which intrude the Cambrian shales. The igneous and sedimentary rocks support notably different flora. Finally we returned to the A438 where Westfields quarry reveals the same andesite as seen on Raggedstone Hill.

Friday 10th and Saturday 11th August 2007 : Geological Mapping

Dr Bill Barclay of the British Geological Survey gave an evening talk entitled 'What's in a Feature?' in which he described the methods used in map making, both traditionally from the time of William Smith (1815), to modern techniques including aerial and satellite imaging. A recent culture change within BGS has led to a move away from 2D mapping and into 3D digital modelling.

On Saturday he led a field trip entitled 'What's New in the Old Red Sandstone?'. We started in the Golden Valley by examining the Bishop's Frome Limestone which forms the upper boundary of the Raglan Marl. Above it is the St Maughans Group which we studied in Pennsylvani Quarry. After lunch we drove to Talgarth to look at exposures of the Raglan Marl along the River Enig. Here it includes a thin green volcanic tuff bed. We then visited Tredomen Quarry, the site of some spectacular recent discoveries including fish, plant remains, and also a primitive fossilised spider. Finally we visited the waterfall at Pwll y Wrach where important microfaunas and fossil fish remains have been found.

The thick band of Bishop's Frome Limestone at Blackbush Farm

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.*

A Picnic in Siluria

Dr Paul Olver

Vice-President, Woolhope Club

After delving into the early history of the Club for my talk in January 2007 on the 'Perambulations of the Early Presidents', I realised that the importance of that history to the science of geology was certainly worth celebrating and the idea of a full re-enactment of an early field excursion slowly emerged.

The main Club Committee was very supportive of the idea and an early excursion around the Aymestrey area was selected. The Club was fortunate in that the Geological Society of London decided to mark its 200th anniversary by a series of countrywide events in late 2007 and called on local groups to become involved. It was then that the Woolhope Field Excursion re-enactment was definitely given a September 2007 date to coincide with these celebrations.

The date chosen was the 14th September 2007, the day after the Ludlow Symposium so that some of our guests from outside the county would already be staying in the area. Whatever we achieved on that day, the Club felt that it should be recorded for posterity and the idea of making a DVD of the proceedings began to take shape. After talking with Woolhope members Tim and Katya Coupland, who run their own media company Field of Vision and had agreed to produce the DVD, the suggestion that it would be a useful adjunct to the school curriculum gradually developed. Overall social history, the early enthusiasm for natural history through field clubs such as the Woolhope, the involvement of the local landowners and clergy, and the earliest explorations of our Herefordshire geology could all be usefully included.

Sir Roderick Murchison and Richard Banks inspect Sir Roderick's recently published book, 'The Silurian System'

It soon became apparent however, that given this brief, the field excursion chosen would need to be an amalgam of several field excursions to incorporate key elements in our story of the development not only of geology but also of the overall style of the field excursions undertaken by our Victorian forebears.

The Third Meeting on September 21st 1852 to Aymestrey, under the able leadership of the early Woolhope member Rev TT Lewis, a renowned parson-naturalist, in whose parish the trip was largely confined, was selected as the key excursion on which the day would be based. The Club were also keen to involve Sir Roderick Murchison in any re-enactment as it was his drive and enthusiasm that combined with local support to found the Club in the winter months of 1851. Sir Roderick was also playing a major role in the development of the geology of the Marches at this time after the launch of his book The Silurian System in 1839. Unfortunately, he gave his apologies for this particular excursion with the following note:

"I have only just got your letter, and much regret that I cannot be at Aymestrey, having been kept so long in Ireland. Offer my kind regards to all the Silurians, and assure them that my heart is with them". Bangor Sept. 20th 1852

Quarries in the Aymestrey area close to the present Riverside Inn had been visited on that day and lunch had been taken on the ridge at Croft Ambrey hill fort, "a spot of unequalled grandeur and beauty" where the whole geology of the Borders presents itself from Titterstone Clee Hill to the north-east right round through the Malverns and the Breconshire Beacons to the Radnor Forest and the Wimble to the west. The excursion finished at Mortimer Cross Inn Aymestrey, where dinner was taken and where the President thanked the Rev. Lewis for his excellent leadership to the "many interesting and instructive spots in the day but also for the bountiful supply of fruit which he had sent for the dessert". The Rev Lewis thanked the members for the compliment paid to him and suggested that they should hold one of the 1853 field meetings at Leintwardine to complete the geology of the Silurian strata of North Herefordshire.

The second meeting from which key elements were incorporated took place on June 12th 1855 to the Malvern Hills, where 150 ladies and gentlemen of the Cotteswold (Gloucestershire), Woolhope and Malvern Clubs met at noon on the summit of the Worcestershire Beacon to hear an address by Sir Roderick Murchison. He was accompanied by Sir Charles Lyell, whose ideas on uniformitarianism were often in conflict with the catastrophism proposed by Sir Roderick to explain many geological processes, and by Sir Charles Hastings MD, founder member of the Malvern Club and also of the British Medical Association. The Rev. Lewis of Aymestrey and the Rev. Symonds, then President of the Malvern Club and also a Woolhope member, and Professor Buckman also joined the group on that day. Sir Roderick's importance to the development not only of the Woolhope but to early geology itself together with his distinguished guests could not to be ignored and it was therefore decided to 'transfer' the Murchison oration from the Worcestershire Beacon to our own Croft Ambrey and

also pick up some of the personal relationships and interactions between Murchison, Lyell and his key Woolhope contact the Rev TT Lewis during short filmed conversations.

The Club has also been very fortunate in gaining the support of Mr. Lawrence Banks of Ridgebourne House, Kington, who kindly allowed us to examine the Banks archives in June 2006. His great great grandfather, Richard Banks, was President of the Woolhope Club in 1860 and led geological field excursions to Downton Gorge, Leintwardine and Presteigne during his year. Lawrence Banks agreed to join us on the day playing his ancestor as President of the Club and brought with him his original field satchel, suitably full of Silurian fossil delicacies!

Travelling in mid-Victorian times to any field excursions was initially by horse-drawn brake and often entailed a 7am departure from Hereford. Breakfast was then arranged for 9am at a suitable hostelry on arrival in the field area. The Woolhope Club enthusiastically embraced the arrival of the railways in Herefordshire during the 1850s and took advantage of the newly-laid lines to get near to the required field locations. The incorporation of these elements into our re-enactment was important to provide a strong contrast to today's car and minibus orientated excursions and also to offer an insight into aspects of Victorian society and its social mores.

September 14th duly arrived and the weather was predicted to be sunny intervals and occasional periods of light drizzle; very much the same as on the original field excursion of September 1852. The first stop was the Riverside Inn at Aymestrey, then called the Crown, where costumes from about seven different sources were donned. Crinolines with their hoops, reticules on the ladies' arms and colourful bonnets of all shapes were the order of the day and contrasted with the elegant frock coats, colourful waistcoats and cravats of the Club's gentlemen members. Professor Hugh Torrens, of Keele University, a guest lecturer at the Ludlow Symposium had kindly agreed to take the lead role of Sir Roderick Murchison and was joined by his wife, Shirley. She was suitably attired as Charlotte Murchison, who as Sir Roderick's wife persuaded him to divert his enthusiasm into geology after his retirement from an active military career.

Breakfast was taken promptly at 9am with the gentlemen and ladies in separate areas of the inn as was the custom at that time, partaking of devilled kidneys washed down with a good ale. Sir Roderick spoke to the gentlemen members outlining the excursion plans for the day and drew heavily on his recent research into the Silurian strata of the Marches.

For filming purposes, the party's earlier arrival at the recent railway station and their transfer by horse and trap to Aymestrey was then re-enacted at Titley Junction station, now in the private ownership of Lesley and Robert Hunt, who had kindly agreed to become Kingsland for the day as this would have been the arrival point. A steam engine and a Victorian six-wheel coach were at the ready for the party who crowded onto the platform and waited their turn for transport to the Riverside Inn.

A welcome tea and coffee break was provided by Lesley and the party took advantage of the views to discuss some of the nearby glacial features from the last Ice Age. Moira Jenkins gave an excellent impromptu introduction to the drumlin trains visible to the north of the river valley.

It was then onto Croft Castle and up to Croft Ambrey by kind permission of the National Trust. Here the party enjoyed an excellent 'picnic' from hampers and surrounded by other carefully selected Victoriana. Some Woolhope members were dressed as locals who would have assisted the gentlemen and ladies on their collecting excursions and also prepared the lunch at the 'Ambrey'. Fossicking in mid-Victorian times was very much in vogue and mattocks, adzes and scythes were needed to clear vegetation and extract the much-prized trilobites!

The party picnics at Croft Ambrey

It was here that Sir Roderick addressed the assembled crowd after being introduced by the Woolhope President, Richard Banks, played by his great great grandson Lawrence Banks. The final scene was re-enacted outside Aymestrey Church where the then incumbent, the Rev TT Lewis played by myself, thanked Sir Roderick, other important guests, and the members with their ladies for what had been a very enjoyable and profitable excursion. He took the opportunity to suggest, as in the original 1852 excursion, that the members organised a similar trip to Leintwardine during the following summer. The filming over the colourfully attired party braved the 21st Century and the busy main road through Aymestrey to return to the Riverside Inn.

The film will form the core element of a 30 minute DVD for schools which will be 'topped and tailed' by an introduction on the importance of these excursions both scientifically and socially in mid-Victorian times and will also update the viewer on the changes in the area since the 1850s most notably the large quarry operations at Leinthall Earls and at Dolyhir, near Kington.

Finally I would like to thank the present Woolhope Club President, George Charnock, our distinguished guests who took part with such enthusiasm and all our members for turning into reality what was just an idea on the back of an envelope.

Members of the WGS Committee

(December 2007)

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

Work on the Museum Resource & Learning Centre progressed rather more slowly than we hoped over the summer but by October, the end is finally in sight.

Once complete, the centre will house an exhibition open from 10am to 4pm, Mondays to Fridays with a reception point to contact staff for research visits, booking the lecture room and so on. A lecture room with a hearing loop and a microphone system that can seat up to 80 or be divided into two smaller acoustically distinct meeting rooms, both equipped with digital projectors and interactive white boards with a choice of adult-sized conference tables or adjustable height tables for children, upholstered or plastic seated chairs. A preparation room to get sessions ready, lift access, toilets, a kitchenette area, lunch eating tables for children's (or indeed adult) groups and cloakroom facilities. The building also provides extra staff accommodation and an additional workroom plus a quarantine area and walk-in freezer to be used as part of the collections management process.

Disabled parking is available on the site and cheap day-time parking is available on the other side of the bus depot (£1 for 3 hours, £2.50 all day) at the Military Club. Otherwise, the Greyfriars car park is the nearest council car park.

Meanwhile work has been underway preparing the collections for the moves, including the geology and natural history collections. This has included packing natural history specimens into drawers and a considerable amount of work on the West 'Herefordshire Rocks' stratigraphic collection by Tess Ormrod. Tess located the original unpublished catalogue of this collection of some 250 specimens, written in the early 1940s, in the library collection and has painstakingly transcribed and edited it. Support from the West Midlands Natural History Subject Specialist Network has funded the publication of the catalogue and the somewhat eccentric geological views of George West, the collector. West felt that encouraging an interest in local geology could reduce what today we would term antisocial behavoir, though in the 1940s, George West termed it a decline in ethics.

Katherine Andrew

H&W Earth Heritage Trust

The Earth Heritage Trust (EHT) has continued to thrive in the past year. It currently has seven paid workers, mostly full time, and a team of keen volunteers. Several well-known names in the Section figure highly in EHT also. Projects which have been completed in the year include a geology trail guide to Midsummer Hill in the Malverns and two further guides in north Worcestershire. Moira Jenkins's programme in the Frome Valley produced a trails guide and a number of RIGS designations. Work on Whitman's Hill Quarry, near Storridge, was completed with the production of reports and information leaflets. A large number of parties have already made visits. The Botany section of the Club had a major input, which continues.

Current projects include work in the Arrow Valley and on Phase 2 of Geodiversity Action Plans for the two counties. In the latter, Moira would welcome volunteer assistance on Herefordshire field excursions. Ongoing too is the establishment of the Geopark Way, a 100 mile trail from Bridgnorth to Gloucester. The Geological Survey is to publish a geological map of the Geopark with an accompanying book. A further project is under way to promote the Geopark Way for use by 'walking for health' groups. Lastly, work is nearing completion to provide information on surface deposits and fluvial geomorphology to Worcestershire County Council.

EHT has been awarded a major new project to start early in 2008. This 'Champions' project will establish groups to participate actively in the geology of their locality and encourage public awareness.

John Payne