Earth Matters

The Newsletter of the Geology Section
of the Woolhope Naturalists' Field Club

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CONTENTS

MESSAGE FROM THE CHAIRMAN

As your new Chairman, on your behalf let me thank those who in past years have contributed to The Woolhope Geology Section in such a variety of ways. Beryl Harding and Tony Geeson have recently retired and the Committee continues with Gerry, John, Paul and Sue, Moira, Charles and Don Evans (new Minutes Secretary), all committed to the future. I thank them for their support. Recovery from serious surgery earlier this year has made me rather more an observer than a participant, but I do believe that we have something to be proud of in following that long line of eminent geologists who first helped to form the WNFC.

Undoubtedly, the highlight of this year was the launch of 'Herefordshire's Rocks and Scenery'. John Payne must especially be thanked for his tenacity in bringing the book to fruition in collaboration with the individual authors, proof readers, photographers and Gerry's skilled draftsmanship. I dared to suggest that comments, additions and revisions might be gathered together in preparation for a possible Second Edition - only to find that John had already begun! The Section may see this as a continuing joint objective.

Are we able to offer our enthusiasms to a wider audience - especially a younger one? Field excursions shared with neighbouring clubs are on the cards. Through them, we can all be made more mindful of the preservation and conservation of our famous type-locations reported in The Transactions long ago but always with the possibility of making new discoveries. I am told by a prominent academic that (because of funding problems) unless projects are model-testing or hypothesis-driven, very little traditional fieldwork (as we have known it) is the subject of modern geological research. Our work, then (and its recording where any new exposures are revealed) is quite strategic. Perhaps we can take that forward, too.

Chris Fletcher, *Chairman*

A Thousand Years of Building with Stone – successfully delivered.

by Kate Andrew, H&W Earth Heritage Trust

AFTER four and a quarter years, Earth Heritage Trust's major building stone project, 'A Thousand Years of Building with Stone' has now been completed.

The main funder of the project was the Heritage Lottery Fund with match funding from a number of small grants and discretionary awards. The project was the first one that the Trust had delivered under the Heritage Lottery Fund 'strategic outcomes' approach introduced in 2013. The outcomes that the project needed to deliver were:

- Raise awareness and appreciation of local stone across the counties of Herefordshire and Worcestershire, providing people with a sense of place.
- Re-discover local building stone quarries
- Research the skills, techniques and people involved in exploiting this resource
- Create a useful database linking stone quarries and particular buildings

Match funding targets for this project were £96,000 of volunteer time and £23,500 of cash match funding. In fact, the value of volunteer time was exceeded by over £15,000 and cash contributions continue to come in as project staff deliver lectures and guided walks. We are very grateful to our volunteers for the time and effort they have contributed to the project and in helping to deliver all four of the project outcomes.

Cluster areas

Herefordshire and Worcestershire is a big area and so the project aimed to work on discrete regions termed 'cluster areas'. Since the Trust's previous project, 'Earth Heritage Champions', had concentrated on specific quarries, we sought 'cluster areas' away from the Champions sites. Originally, the plan was to select sixteen areas from a list of close to thirty. Data were actually collected from eighteen in total, of which ten plus part of the Malvern Hills area lie within Herefordshire.

Raising awareness

The first outcome was delivered by a busy programme of outreach activities, 108 in total, in formats as varied as exhibitions, talks, walks, roadshows, conferences and formal teaching. A series of new family-friendly activities were devised specially for the project roadshows, including 'mini builder', which allowed visitors to build stone structures with mortar and mini trowels, word searches (popular with adults waiting for children to complete other activities), projection of thin sections under a petrological microscope and two designs of pop-up castles to colour in. The team successfully achieved Arts Council funding for the Magic Minerals event which saw us working with Batik artists and we also devised an activity to create wall paintings.

Figure 1 A map showing the cluster areas.

Just under 30,000 people engaged with the project via these activities. Where feedback was collected, 78% of attendees had not previously been to an event run by the Earth Heritage Trust and our questions asking about increase in understanding indicated that an average of 73% felt they knew more about building stone as a result of attending the event.

In terms of awareness and a longer term legacy, an academic paper on the building stones of Bromyard has been published in Proceedings of the Geologists' Association and a short paper for the Woolhope Club Transactions is in preparation.

A dedicated volunteer has also created eight earth caches on-line, two of which are in Herefordshire. These are accessible at https://www.geocaching.com/play and http://www.geosociety.org/earthcache. An earth cache is a form of geocache, a very popular treasure-hunt-style activity that uses GPS technology to locate concealed caches, a modern equivalent of the letter boxes that originated on Dartmoor. (The letter box contains a visitors book and a stamp. Finders stamp the visitor book with their own stamp and stamp their own log book with the stamp from the letter box.) In order to log a geocache, rather than just find it from its GPS co-ordinates, an earth cache requires a site visit to be able to answer the geological questions. It is not possible to cheat by looking at the surrounding area on Street View or Google Earth. Nearly 300 visitors have logged completed caches and these numbers continue to grow steadily.

Building stones trail guides, in the same laminated style as the EHT trail guides but with a fresh new design, have been created for Bromyard, Bromsgrove and Malvern (a route around the springs for the 'Route to the Hills') and guides already in existence for Ledbury and Hereford are being re-purposed with new building stones content.

The project team also created a series of standard lectures that can be delivered post-project by volunteers.

Re-discovering building stone quarries

By the end of March 2017, the database had records for 2113 stone buildings and 396 quarries in Herefordshire. Within the entries, the level of information inputted varies, depending on whether information was gleaned from field visits, archival or reference sources. The table

shows the completeness of the data sets at the end of March 2017.

The Earth Heritage Trust has maintained a database of local geological sites for many years but there was surprisingly little overlap of sites between the two datasets. For example, the LGS had records for only thirty-three sandstone quarries used for building stone in Herefordshire. Towards the end of the project an exercise was undertaken to ensure that data held on LGS building stone quarries was also present on the project database.

Cluster	Buildings Recorded	No. with photo	%	No. with BS description	%	No. with stone ID	%	Quarries Recorded
Non-cluster	1981	125	6%	1480	74%	157	8%	258
Bewdley	190	142	75%	162	85%	155	82%	23
Kington	86	23	26%	51	77%	29	44%	18
Ludlow Ambitine	207	121	58%	185	89%	48	23%	85
Goodrich	31	26	84%	30	97%	76	100%	4
Hereford	93	88	95%	87	94%	117	100%	7
Leominster	11	9	82%	9	82%	6	55%	5
Kidderminster & Stourport	136	83	61%	92	68%	42	31%	2
Worcester	98	45	46%	85	87%	71	72%	3
Bromyard	235	102	43%	201	86%	33	14%	7
Ledbury & Eastnor	85	51	28%	53	62%	24	37%	24
Bredon Hill	406	178	44%	148	36%	11	3%	76
Pershore & Croome	83	35	42%	48	58%	40	48%	0
Woolhope Dome	31	22	71%	28	90%	23	74%	22
Malvern Hills	450	91	20%	275	61%	215	48%	86
Teme Valley	122	18	15%	70	57%	50	41%	7
Bromsgrove	57	33	58%	30	53%	25	44%	15
Ross-on-Wye	188	119	63%	131	70%	8	4%	33
Golden Valley	225	8	4%	129	57%	37	16%	25
	4985	1317	26%	3294	70%	1168	25%	658

The project web database has a mapping facility, if the filter for quarries is used. This demonstrates that there are far more quarries in Herefordshire than in Worcestershire. However, an early piece of research by Anne Spurgeon looking at quarry accident records showed far more quarries in Worcestershire as on the whole these were much deeper, and so were required to report accidents; those in Herefordshire were mainly shallow delves so did not have to report accidents.

Research the skills, techniques and people involved in exploiting this resource

In order to facilitate the research needed to create good database records for this project, a wide-ranging programme of training for volunteers was delivered, forty sessions in total, including everything from basic geology, through evaluation and creating trail guides to accessing original and on-line archival sources.

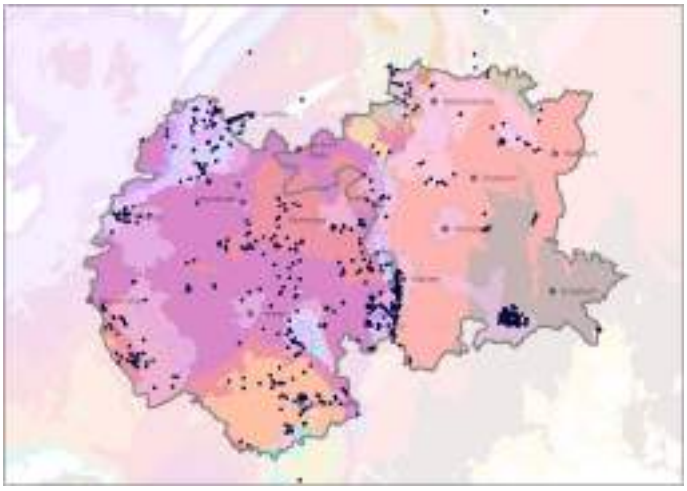

Figure 2 Map of quarries in the two counties.

Archival research undertaken as part of the project has been uploaded onto the web database as short articles and resources as well as being added, where relevant, to specific records for quarries or stone buildings. This information has come from sources as diverse as bound copies of The Builder Magazine, local history books and guides, The National Trust Heritage Record and archival sources held at The Hive and HARC (Worcestershire and Herefordshire record offices).

The closure of Hereford Record Office for most of the first two years of the project (in advance of the opening of the new facility at HARC) created a significant problem, but it did allow the project to restructure its budget and continue for an entire extra year. The closure of the Hereford Museum and Library building over most of the last two years also impacted the ability to access reference material in the Woolhope Library and the main Hereford reference library.

Create a useful database linking stone quarries and particular buildings

Whilst project staff have been overseeing the project and adding data to the database, the vast majority of information on the database was 'crowd sourced' and was contributed by our team of volunteers. 190 individuals in all have volunteered on the project with around sixty actively adding data to the site.

Over the last few months of the project, project staff and volunteers worked hard to fill gaps and to try and reach a point where the database contains a similar level of detail for each cluster and across the two counties. The *www.buildingstones.org.uk* database with its supporting web site will remain live for a further seven years and data sets are also being transferred to the county Historic Environment Records (HERs) so that the data collected remain useful in the long term.

We also contributed data subsets of Worcestershire quarry sites to the Mineral Planning team as part of the revision of the Worcestershire Minerals Plan – they aim to use this information to try to stop potential building stone extraction sites from becoming sterilised by being surrounded by development.

Web statistics indicate 96% of database usage from the UK is mainly on week days suggesting it is being used for work rather than leisure interest reasons.

Evidence linking buildings to stone sources has been very patchy and difficult to pin down.

Very occasionally, a full picture emerges of a building and the social history associated with its construction. We were very pleased to be invited by Sir Thomas Dunne to visit his estate at Gatley Park. He was able to confirm how and where the stone had been sourced for the rotunda building, (the old Leinthall Earls Quarry (now subsumed within the new quarry)), who the building was built for, the architect, the dates of the extension, an account of how the stone was extracted and sorted before building commenced and a photograph of the quarry man in front of the barn he sheltered in after setting the explosive charges. A site visit revealed clear evidence of the brachiopod zone fossil, *Conchidium*

Figure 4 The Rotunda, Gatley Park Office and the zone fossil, Conchidium Knighti, found in its wall

knighti. We were also able to see a new stone-clad building sourced from the current Leinthall Earls Quarry.

Very recently, the stone source for the end wall of no.14, The Square, Bromyard has been pinned down. Our work in Bromyard had identified that the only other buildings using a similar conglomeratic stone were medieval and ecclesiastical and that the quarry source was probably a Diocese-owned site at Bringsty. It had seemed rather odd that hundreds of years later a similar stone was sourced that had not been used in Bromyard in the intervening centuries.

Our research indicated that the end wall of no.14 had been clad in stone in 1938 following the demolition of a neighbouring building in order to widen the road into the square. A local history reference tracked down very recently indicated that the stone was re-used from the Hereford gaol, demolished in 1930 to create the bus station. Whilst this seemed unlikely, a field visit to look at the remaining building on the gaol site, The Governor's House (now a shop ('Rose Tinted Rags'); previously the bus station offices), proved a very good match for no.14 The Square. It would appear that the stone was stockpiled at a council depot and re-used.

Conclusion

This was an ambitious project for EHT to undertake. Although EHT volunteers have been used to undertaking geological field work and delivering outreach events, archival work was a new departure both for volunteers and the Trust as a whole but in fact attracted a significant new group of volunteers to the Trust. For project team members, working at arms length with volunteers on what was effectively a crowd sourced project was also something of a new experience.

The project evaluators made some useful suggestions for future project monitoring but were impressed with what the project managed to achieve and the report has now been approved by our project mentor.

We would like to be able to deliver a similar project in neighbouring counties using the database and project framework and are looking for partners to achieve this.

Reference : EJ Carter, E Andrews and K Andrew (2017) *The provenance, petrology and sedimentology of building stone in Bromyard, Herefordshire, UK*, Proceedings of the Geologists' Association, **128** (3) 480-499

Figure 5 Wall of no 14 The Square, Hereford Gaol Governor's house

HEREFORDSHIRE GEOLOGY BOOK

by John Payne

THE Geology Section's book on the geology of the county, *Herefordshire's Rocks and Scenery*, reached fruition with its publication in late April 2017. The launch event for the book was sponsored by our publisher, Logaston Press, at the Shire Hall in Hereford and was attended by about seventy people. Funding for the book the book was generously provided by Lawrence Banks and the Woolhope Club's Smith Fund.

It is worth noting that this is the first book devoted to the county's geology in the two hundred years of scientific geology. Its gestation was long, about eleven years, and proceeded rather in fits and starts. The final product is the result of many people's work, especially the authors (Robert Williams, Paul Olver, Dave Green, Moira Jenkins and Charles Hopkinson), illustrators (principally Gerry Calderbank for line drawings, John Stocks and others for photographs and Derek Foxton for aerial photographs) and a succession of editors (Mike Rosenbaum, Paul Olver and finally myself) but also the many people who read and commented on the work in draft and proof form.

The book is widely available in bookshops throughout Herefordshire and beyond and can be purchased directly from the publisher, post free. It has received a number of good reviews. One thousand copies were printed and sales are reported to be good, with the prospect of a possible reprint in a few year's time.

A number of errors have been found in the present version and these will need correction for any reprint (and there are likely also to be a few small updates and improvements in the text). For the information and benefit of section members the errors known at present are detailed below.

On p.viii, in the sketch diagram, in the note about native woodlands. it should read 'SPURGE LAUREL', rather than 'SPURE LAUREL'.

Photographs Fig.2.16 *Leinthall Quarry* (p28), Fig.4.20 *Malverns Complex diorite* (p79), Fig.8.20 *Bridgnorth Sandstone* (p162) and Fig 9.35 *Tufa at Biblins* (p193) should all be attributed to John Stocks.

Dates are incorrect on p36, in the 3rd paragraph, line 6 -- change 'c.350Ma' to 'c.230Ma'; line 7 -- change 'c.300Ma' to 'c.210Ma'; line 8 – change '(see below)' to '(see p.53)'.

On p.77, '*Precambrian rocks in NW Herefordshire*'; 1st paragraph. line 4 -- change 'Fig.2.8' to 'Fig.2.10'.

On p.66, the present Figs.4.9i and 4.9j are incorrect. Replace them with the correct photographs as below.

i) Schist : Shiny mica on cleavage surfaces

j) Gneiss : Minerals in evident bands

On p.150, caption to Fig.8.6 (*Lord's Wood Quarry*). The words 'the' and 'underlying' must be transposed. Thus *'Figure 8.6 Lord's Wood Quarry (SO 548 155) in the Llanelly Formation and the underlying Gully Oolite Formation. Note the gentle dip to the right here on the flat-lying western limb of the Ross Syncline. (© Dave Green)'*

On p.2, Fig.1.2, the position shown for Leominster should be about 5mm higher on the map, by the next river junction to the north.

On p.159, Fig 8.16, the positions of the Neath Disturbance and the Church Stretton Fault are incorrect with respect to the positions of Hereford and Kington. They are correctly shown in Figs 6.5 and 8.9. However, Fig.8.16 is, as stated in the caption, a conceptual diagram rather than an accurate depiction.

Readers are invited to notify the book editor of any other errors which they may have found.

THE KNIGHTON MAP PROJECT

by Arthur Tingley

AT THE SUGGESTION and encouragement of the Herefordshire and Worcestershire Earth Heritage Trust, I began researching the feasibility of this project in 2013 with the objective to survey the area of the Knighton Map 180 (Fig.1) over a period of three years and thence hopefully get the map published to BGS standards, along with a sheet explanation. The map area has never been formally surveyed by BGS and I have been hoping that my work might as a catalyst for BGS to commit to the project. It seems that this strategy might be about to pay off.

I realised that there is sufficient academic research

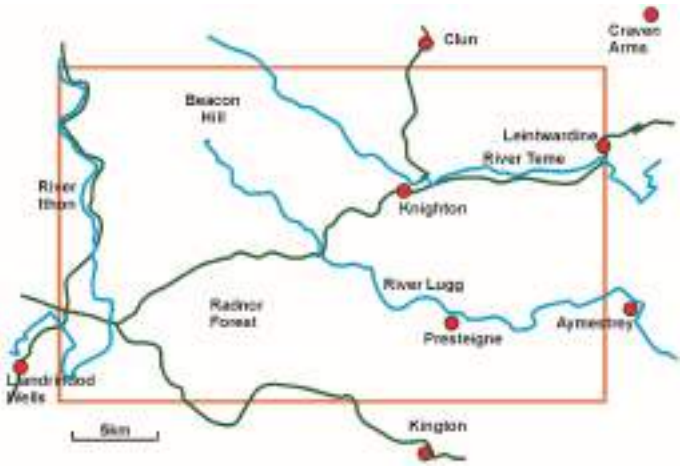

Figure 1 The area covered by the Knighton map sheet 180 (Map drawn by John Payne)

work in existence, dating from the 1800s to the 1990s and including the data on the surrounding published sheets, to provide information for a small team of amateur geologists to draw together the data needed to build a map at 1:50000 scale.

We formed a survey team of eight (Fig.2) from members of the Teme Valley Geological Society and, using the techniques which I learned as a cartographer and surveyor with IGS [forerunner to

Figure 2 Most of the members of the survey team

Figure 3 A part of the field survey team at work.

BGS], we set about surveying by traverse (Fig.3). Most of the surveyors provide notes, photographs and samples from their work. The Geologists' Association provided a small grant as funding for training, development meetings and some micropalaeontology.

I am bringing together all the data to build the maps onto paper field slips at 1:10000 scale as a permanent record of our work. Thereafter, the map is being built up at 1:25000 scale initially, which can then be field tested and then abstracted to the 1:50000 scale ready for 'publication' (although there will be 'OS copyright' issues to overcome before that can happen).

This is backed up by the Knighton Map System, developed by Mike Brooks, which eventually will house some of our photographs at *http://www.knightonmap.co.uk/map/* (Fig.4). However, because it is time consuming to place material on the system, and we need to check the data quality, our first priority is to assure the material is on paper. Also, as one of the legacies of our work we want to make sure that the superb visual record is widely available. This will probably be the first Map Sheet whose visual record will surpass the words needed to describe the geology, a weakness of many academic exercises.

We decided not to work from existing interpretations and just add our observations but to build the map from first principles, taking nothing for granted initially. This is to ensure that our observations stand up to scrutiny and, in the process, to critically assess the work of others. Indeed. this is essential as the evolution of interpretations has led to a 'rag bag' of thoughts and classification.

Thus it was necessary to build an understanding of the structure, rocks and facies across the whole map area.

My techniques are principally field survey by facies mapping [what you can see] and geomorphology, supported by BGS records such as the field slips and notes from surrounding sheets, borehole records, aerial survey mainly using Google Earth as well as spot satellite via the Open University. Original unpublished and published material has been sought, such as PhD theses; lidar data and OS mapping via EDINA; and, most importantly, personal contact with knowledgeable locals, mostly farmers, builders and building inspectors. The fortunate arrival of the Elan Valley Aqueduct Project, at Bleddfa, Knighton and Dolau, has provided a significant amount of Site Investigation material, as well as some 'down hole'

Figure 4 An extract from Knighton Map System –Photo by Mike Brooks of surveying in the NE of the map area

Figure 5 The graptolite hunters

hands-on rock!

The one area which had received no attention from previous surveyors is the Radnor Forest and the area to the north of that. So I have undertaken that survey. However, a distinctive feature of this area is that the facies are difficult to distinguish, partly because of an apparent lack of fossils. However, that in itself is a distinguishing palaeoenvironmental indicator! Watkins [1979] had set out a very detailed analysis of the communities of shelly fossils found in the Ludlow area, which might be used to identify ages. In doing so it showed that the number of fossils which can be found in a unit volume of rock is a characteristic of the facies. However, surveyors have to work fast to cover the ground and thus there is generally not enough time to search in detail for significant [age dating] fossils.

The solution to this was to engage with the Malvern U3A and the Woolhope Club who, under the guidance of Moira Jenkins [Jenkins 2016], have provided a 'Palaeontological Task Force' to search at specified strategic locations. We can then be sure, with a sufficient number of eyes looking, that whatever is or is not found will be a good representative sample of the rock type; indeed their work has been critical to the interpretation. (Fig.5)

The progress of all the survey areas is moving forward steadily, and I shall be working with each surveyor to assess what the priorities are for finishing off the work, thus handing over any material and data in order to secure the reference 'database'.

A number of barriers still need to be overcome, not least in dating some of the rocks and their lateral equivalences; microfossils do not seem to be abundant, or at least the quarzitic-locked siltstones do not yield to acid treatment. Graptolites are generally not abundant, but those which do occur are often poorly preserved and thus need expert identification; Bentonites exist especially in the west, and we are actively attempting to find a laboratory to analyse these; the rocks are not very calcareous and so isotopic determinations are unlikely.

On the other hand the trace fossils and current indicators, facies and fossil fragments imply a switching palaeoenvironment, which was frequently anoxic or dysaerobic, but becoming increasingly oxic, especially in the east. The depth of the water was probably not oceanic, more likely a relatively shallow clastic slope, and something of a quiet backwater, with limited circulation. These symptoms fit very well to the various climatic conditions described in Summerhayes [2015]. So that soft-bodied detrivors

would have consumed any organic remains on the sea floor, leaving little trace of fossils yet with virtually no bioturbation.

The evidence which is emerging fully supports the model that, during the Silurian, this area was a slope between the relatively shallow waters around Ludlow and the Church Stretton Fault, and the Welsh oceanic conditions to the west. But that slope was not simple; it was quiet with occasional disturbances. Ideas relating to the palaeogeography are evolving as a result of our work.

Figure 6 Typical scenery in the map area. This is the view from the top of Whimble, showing typical sharp gradients and flat tops of low-lying strata in relatively soft rock.

The sediments often preserve disturbances, mainly attributable to seismic or slope instability. Based upon some current direction patterns, previous workers have concluded that the sources of the sediment were from the south-west and east [Dimberline 1987]. However, this does not explain where most of the material originated. The petrology suggests that the silt and mudstone grains are mostly subangular quartz and thus have characteristics of 'loess' and as such could well be the product of windblown fallout directly into the sea. Lesser amounts [<20%] of sand and terrigenous material were clearly flushed in. I am presently modelling this hypothesis using a combination of plate rotation models [Torsvik and Cocks 2017] and a General [atmospheric] Circulation Model.

So in summary, my objective now [August 2017] is to start work on reviewing the other surveyed areas, to put all the data onto the hard copy field slips, and during winter to prepare the draft 'fair copy' at 1:25000 scale, in time for field testing during 2018.

The work thus falls into the following areas:

Primary Survey, this is approaching the end.

Second Phase; make the data safe and form a fair copy map.

Third Phase; detailed survey in critical locations; test map.

Fourth Phase; secure legacy of the project; write up, map publication, make photos and samples widely visible, and archive as needed.

The work to date has involved a very wide network of people and organisations, a lot of time and effort has been generously placed at my disposal to thrash out the details. I am deeply grateful to all of them and will acknowledge all the individuals when publication constraints allow.

References

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Dimberline A and Woodcock N (1987) *The southeast margin of the Wenlock turbidite system,* Geological Journal, v.22, pp.61-71

Torsvik T and Cocks R (2017) *Earth History and Palaeogeography*, Cambridge University Press

Watkins R (1976) *Benthic community organisation in the Ludlow Series of the Welsh Borderland,* Bulletin of the British Museum [Natural History], v.31, no.3.

The Old Red Sandstone of South Herefordshire

by John Davies (Honorary Research Fellow of the National Museum of Wales)

Abstract:

FROM 2012 to 2014, the sequence of Brownstones in Herefordshire was examined in its sunken lane exposures and compared with the Brownstones in the remainder of the Anglo-Welsh basin. Subdivisions of the Senni and Brownstones Formations of the area from Carmarthen to Cardiff and in the Clee Hills were also recognised within the Herefordshire Brownstones sequence. By comparing conglomerate sequences in the Ross-on-Wye area with similar deposits near the Senni/Brownstones Formation boundary across south Wales to Pembrokeshire, the lower part of the Herefordshire Brownstones, below the first appearance of exotic conglomerates, is seen to be equivalent to the Senni Formation of Carmarthen and Breconshire. The sequence in Herefordshire, from the base of the conglomerates upwards, thus equates with the Brownstones of south Wales. The two Herefordshire conglomerate horizons that can be compared with conglomerate horizons across south Wales are recognised in Pembrokeshire and named the Lawrenny Cliff Formation and the New Shipping Formation. It is recommended that these terms be applied in Herefordshire as in the remaining outcrop of these rocks across south Wales.

Introduction

The term 'Brownstones' was coined by Symonds (1872) and adopted by the British Geological Survey for the sediments forming the upper part of the Lower Old Red Sandstone. At present, the terrestrial facies of the Brownstones Formation forms the highest division of the Lower Devonian – the Daugleddau Group of the Old Red Sandstone (Barclay *et al.* 2014). It has an almost continuous outcrop from Llechdwni, 3km northeast of Kidwelly in Carmarthenshire, across Breconshire to the Black Mountains of Gwent and then southwards along the east and south-east crop of the south Wales Coalfield to the Vale of Glamorgan. In Pembrokeshire, the equivalent sequence to that of the Brownstones is divided into two; the Lawrenny Cliff Formation and the succeeding New Shipping Formation. These can be recognised throughout the outcrop. However, east of the Carreg Cennen Disturbance another sequence occurs above the local equivalent of the New Shipping Formation, which is not represented in Pembrokeshire, due to overstep by the Avonian. It is intended to call this additional sequence the Blaen Haffes Formation as a result of the work of Tonbridge (1981).

A large exposure of Brownstones extends from Lydney, in Gloucestershire, in a narrow belt to Lea-under-Penyard near Ross-on-Wye in Herefordshire where its exposure forms a large rectangular area. This area is bounded by Lea, Brockhampton Hill, Garway Hill and Craig Syfyddin in Gwent and the valley of the Monnow River at Monmouth. It then extends in a strip to Craig-y-dorth south-west of the town. To the south-west, the outcrop continues to Cat's Ash near Newport in Gwent. This Brownstones Formation is dominated by maroon sandstones, with much less significant mudstones in a coarsening-upward sequence. It includes exotic pebbles in the upper parts and for many years has been considered unfossiliferous.

Between the 'Brownstones' and the overlying Brecon Beacons Group lies a major break in sequence, considered to represent the Middle Devonian Acadian Orogeny.

Marstow and Ross-on-Wye Conglomerates

There are conglomerate units that crop out in two bands from Mitcheldean, through Ross itself, Goodrich, and Ganerew to Hardnock Court, near Monmouth, where they are over-stepped by the Upper Old Red Sandstone. The upper, of the two sequences, the 'Ross-on-Wye conglomerate' was described in the Ross-on-Wye cliff section by Allen (Allen 1974a) and the M50 and the A40 Ross bypass road cuttings by Allen & Dineley (1976).

Across south Wales there are also two bands of conglomerates and pebbly-sandstone recognised from Pembrokeshire in the west to just north of Pontypool in Gwent. The lower of the two coincides with the base of the Brownstones across the whole outcrop. In Pembrokeshire, the two conglomerate sequences are the lower – Lawrenny

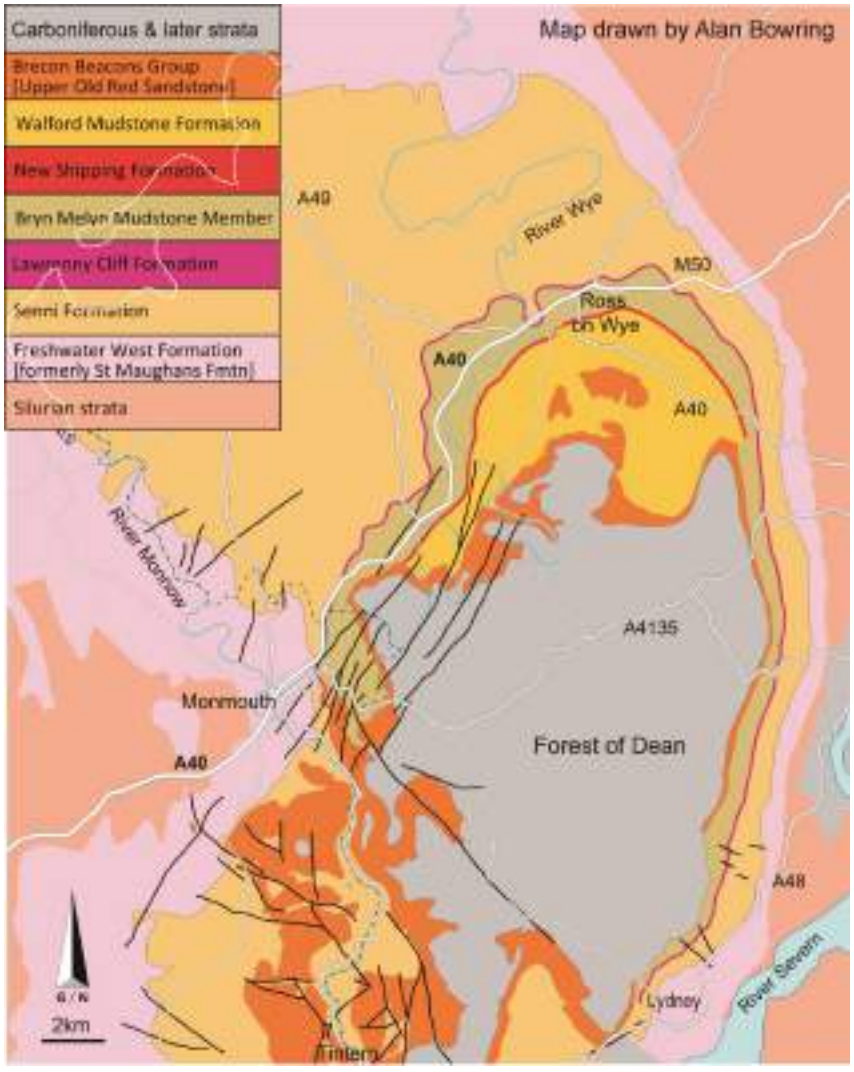

Figure 2 The Senni Formation at Fiddler's Elbow (SO527137)

Cliff Formation, and the upper – New Shipping Formation. In Carmarthenshire, the lower formation is not so significant, but the upper conglomerate has been known variously as the Pebbly Brownstones, or Caeras Conglomerate Formation. In the Brecon Beacons, the lower unit was mentioned by Cantrill (1907,1909) and described by Tonbridge (1981). In the Clee Hills of Shropshire, the Lawrenny Cliff Formation conglomerate was known locally as the Monkey's Fold Conglomerate (Ball & Dineley (1961) and Allen (1974a)). The equation of the two conglomerate sequences of Herefordshire with those of the remaining south Wales outcrops would suggest that the Herefordshire Brownstones below these should be equated with the Senni Formation in Wales.

The basin of sedimentation of the Herefordshire Brownstones is demarcated to the north-west by the Vale of Neath Disturbance and on the south-west by a linear structure that continues the line of the Clearwell Fault, which formed the south-western boundary of the Forest of Dean Coalfield to Craig-y-dorth near Monmouth and the Monnow from there to Pontrilas. Further south a ridge within this basin was formed by the 'Lower Usk

include discoid clasts of mudstone up to 6cm x 3cm in the base. The massive and parallel-bedded, maroon sandstones (in up to 3m-thick units) also include occasional bands of rounded mudstone clasts up to 2cm diameter and large (up to 10cm) blocks of red silty mudstone, similar to the Senni Formation further west, but exotic pebbles are absent. These pass up into flags, parallel-bedded fine sandstones, siltstones and mudstones with occasional nodular calcretes at the top. Greenish sandstones which are lower in the sequence pass up into the maroon part of the succession. Thus, apart from their colour, these units match the Senni Formation in the basins to the west. The whole of the exposure in the Wye gorge south of Monmouth represents the Senni Formation, the remainder of the Cosheston Subgroup sequence having been overstepped from the east by the Brecon Beacons Group. Between the east side of the Wye valley and Craig-y-dorth (SO484086) the whole of the Senni Formation is also overstepped by the Brecon Beacons Group.

In a separate area east of the Wigpool Syncline, the Senni Formation forms Breakheart Hill where several cycles of massive to flaggy sandstones occur passing up into mudstones with calcretes. The sequence is also seen in the Soudley valley on a detached part of the ridge formed by

Figure 3 Callow Hill, near Buckholt, capped by rocks of the Senni Formation.

Valley Lineament' (Gayer R, pers com and below) and the sequence has been disrupted by NE-SW faults. This lineation forms the cols between Monmouth and Goodrich, and the Wye valley to Ross-on-Wye, towards the south end of the Woolhope inlier. The eastern basin margin is the Woolhope to May Hill steep structure. South-eastwards from the Usk Valley Lineament the basin extends from Ross-on-Wye to Blakeney and Lydney.

The Herefordshire Brownstones below the Lawrenny Cliff Formation c.f. The Senni Formation

The Senni Formation is represented by fining-upward cycles of dune-bedded maroon, reddish to olive-green sandstones with some calcrete intraformational conglomerates at their bases, passing up into siltstones and mudstones. Commonly, the massive and trough-cross-bedded sandstones are loaded into underlying mudstones and

the overlying Lawrenny Cliff Formation.

The formation includes fish remains of the Pteraspid *Rhinopteraspis dunensis* (Welch & Trotter (1960)), which belongs to the species described in the Llyn-y-Fan and Abergavenny Basins from the upper part of the Senni Formation. Fragments of plant material have also been recognised in this sequence similar to the Senni Formation main outcrop. By contrast, the Brownstones above the conglomerates across the whole ORS outcrop, so far, have yielded only trace fossils.

The Lawrenny Cliff Formation overlying the Senni Formation

The base of the Lawrenny Cliff Formation can be recognised by the first appearance of exotic clasts in the sequence. It was described by Allen & Dineley (1976) in the M50 road section where conglomerates show scattered exotic pebbles of vein-quartz, acid lavas, assorted sandstones, greywackes and tuffs. The earliest appear

similar to the New Shipping Formation of the Ross-on-Wye cliff section (Allen 1974a). Allen & Dineley (1976) published a tabulated section indicating a coarsening upward sequence. Many beds are conglomeratic, with numerous exotic pebbles and cobbles as well as intraformational mudstone clasts, some boulder-sized.

Many sunken lanes expose sections, enabling the Senni Formation - Lawrenny Cliff Formation boundary, where exotic pebbles first appear, to be traced across country. (Figs.4 and 5) Thus, the base of the Lawrenny Cliff Formation is now recognisable, from the M50, west of the A40 to Wyastone Leys (SO530156) near Whitchurch, and eastwards along the eastern limb of the Wigpool Syncline to the Blakeney area of Gloucestershire.

The outcrop west of the M50 section

From the motorway section, the Lawrenny Cliff Formation forms slight ridges to the north-west of the A40. These become more significant as the dip increases in the Usk Valley Disturbance towards Wyastone Leys (SO530156). In all the outcrops, the pebbly sandstones are continued to the Wye. Across the river, a matching ridge appears to converge with the outcrop of the basal Brecon Beacons Group, thus showing an angular unconformity below the Wern Watkin Formation.

Outcrops along the east side of the Forest of Dean

The escarpment forms part of the steep south-westerly limb of the Woolhope Pericline, and then continues to crop out on the dip slope of the ridges as far as the west side of Breakheart Hill near Mitcheldean and onwards to Blakeney. Though the topographical feature representing the outcrop of the formation is continuous, outcrop is poor.

Figure 4 The Lawrenny Cliff Formation at the sunken road junction near Brampton Abbots (SO604259)

Figure 5 Conglomerate of the Lawrenny Cliff Formation

Massive, cross-bedded and parallel-bedded sandstones appear to occasionally include some thin stringers of exotic clasts up to 0.3cm diameter and may lie high in the sequence and in another section up to 1m of maroon cross-bedded sandstone occurs, with rounded quartz and rock clasts 1cm x 0.5cm.

The Bryn Melyn Member

Overlying the Lawrenny Cliff Formation is a thick mudstone-dominated sequence, the Bryn Melyn Member (a term introduced in the Brecon Beacons sections). This forms the flood-plain of the River Wye between Ross-on-Wye and Goodrich and carries the A40 road. East of the Forest of Dean, the mudstone is located in the valleys through Lea and between Mitcheldean to Littledean and the Soudley Valley. The lithology includes maroon muddy sandstones and a conglomerate of large maroon mudstone clasts.

New Shipping Formation

The Bryn Melyn Member is followed by the proximal channel-conglomerates and pebbly sandstones of the New Shipping Formation, seen in the cliff section above the road up into Ross-on-Wye from the river (SO595239 to SO596241) (Allen 1974) (Fig.6). These include trough cross-bedded sandstones in the lower part and planar cross-bedded coarse sandstones in the upper part, with quartz and rock pebbles in conglomerate and pebbly coarse sandstone wedges. Distinctive bands of ripped-up, angular mudstone clasts are present, which appear to have belonged to a single disrupted bed. Allen (1974) described a complete suite of exotic pebbles from this locality, including rock clasts identifiable with volcanics, and greywackes that occur in the Cambrian Mountains of mid- and north Wales. The sequence is very similar to the other proximal areas of the New Shipping Formation across south Wales to Pembrokeshire.

Westwards from Ross-on-Wye cliff, the New Shipping Formation sequence, including scattered pebbles of quartz and rock clasts, continues to Goodrich Castle Moat. Here it shows pebbly cross-bedded coarse sandstones with rounded quartz, and rock clasts occurring in

Figure 6 The New Shipping Formation (Ross-on-Wye Conglomerate) in the cliff in Wilton Road, Ross-on-Wye

the base of channels. These lithologies continue westwards but are truncated by the Wern Watkin Formation of the Brecon Beacons Group [Upper ORS] on the lower slopes of Great Doward. East of the Ross-on-Wye cliff, pebbly beds with rounded, exotic pebbles up to 1.5cm showing planar cross-bedded very coarse sandstones with exotic, quartz and rock clasts continue through Weston-under-Penyard and form a ridge extending southwards to Mitcheldean and beyond towards Blakeney. It appears also to form a similar ridge southwards into Blakeney Hill and Viney Hill (SO656063).

In both directions, from the proximal sequence from Ross-on-Wye to Goodrich, the conglomerates pass laterally into pebbly sandstones and the pebbles tend to become smaller and more scattered. Like the Lawrenny Cliff Formation, they are overstepped by the overlying Wern Watkin Formation.

The Walford Mudstone Member

In the area south-east of the escarpment forming the river cliff at Ross-on-Wye is another extensive platform, before the change of slope at the base of the Blaen Haffes Formation escarpment of Chase Wood and Penyard Hills. (Fig.7). This is certainly another thick, mudstone-dominated sequence. It stretches from the vicinity of Walford, in the west, towards Mitcheldean in the east, and could be named the Walford Mudstone Member. It may also match the thick mudstone sequence east of New Mill (ST443947) to south-west of Langstone in the Gaer Fawr Basin. This mudstone appears to be overstepped westwards from Walford before Kerne Bridge but is continuous along the east side of the Forest of Dean Coalfield,

Blaen Haffes Formation

This formation gives rise to the steep escarpment westward from Chase Hill to Kerne Bridge and Coppet Hill towards Symonds Yat where it is, apparently, completely overstepped by the Brecon Beacons Group. Eastwards

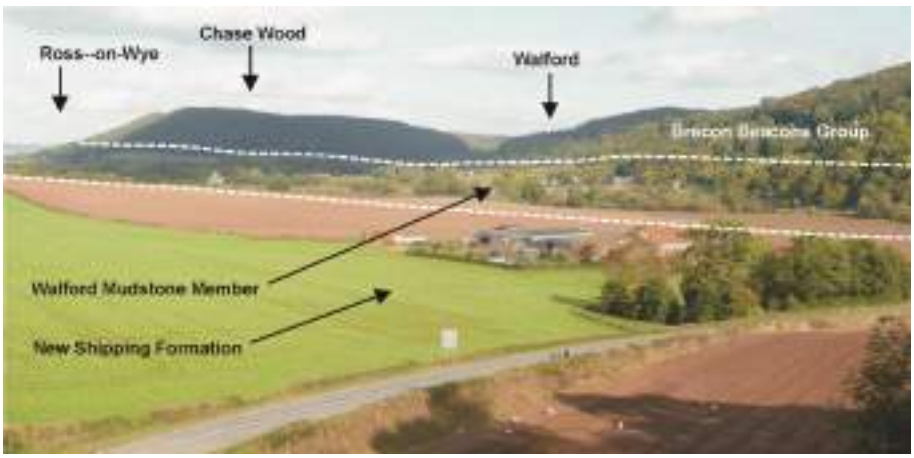

Figure 7 Walford and Ross-on-Wye

from Chase Hill and Penyard Hill, the escarpment continues around the southerly-plunging Much Marcle 'Box' anticline, into the Wigpool Syncline and thence forms the whole of the east crop of the Forest of Dean basin to Blakeney and Lydney in the south. The rocks consist of sheet-flood sandstone-mudstone cycles, which are similar to the upper part of the Cosheston Subgroup of the whole of the Welsh outcrops (Tonbridge 1981).

Brecon Beacons Group – Huntsham Hill Conglomerate Formation

The Blaen Haffes Formation is unconformably overlain by Huntsham Hill Conglomerate Formation conglomerate and sandstones of the Brecon Beacons Group. Traced across the total outcrop, overstep can be seen from east to west, from Chase Wood to Craig-y-Dorth, south-west of Monmouth, but there is only a slight change of angle and direction of dip. Between Chase Wood and Kerne Bridge, the Huntsham Hill Conglomerate Formation oversteps first the Blaen Haffes Member and then the underlying Walford Mudstone Member, to rest on the New Shipping Formation. Between Kerne Bridge and Wyastone Leys the New Shipping Formation is completely overstepped and south-west of there, the Bryn Melyn Member and then the Lawrenny Cliff Formation are similarly overstepped. By the east side of the Wye valley, the Huntsham Hill Conglomerate Formation rests on the Senni Formation, and by Crag-y-dorth, west of Monmouth – the western margin of the basin – the whole of the Cosheston Subgroup is overstepped and the Huntsham Hill Conglomerate Formation rests on the Rat Island Mudstone Member.

Conclusion

The Herefordshire Brownstones can thus be divided into several mappable units, the lower half being equated with the Senni Formation of south Wales. The first appearance of coarse sandstones and conglomerates including clasts derived from the rising Caledonian mountains of mid-Wales coincides with the Senni Formation – 'Brownstones' Formation boundary of south Wales. In Herefordshire, as across south Wales, it is now possible to replace the term Brownstones with five Formations:

Blaen Haffes Formation
Walford Mudstone Member
New Shipping Formation
Bryn Melyn Member
Lawrenny Cliff Formation

These formations have limited palaeontological characteristics, different lithological characteristics and are expressed in the topography by steep escarpments and low-lying troughs.

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Revised lithostratigraphic table, modified from Barclay *et al*. (2014). (Note that the terminology shown here is not that formally adopted by the BGS at present. The current formal names are those in the Barclay *et al.* report.)

Pembrokeshire to Blakeney		**New terms**		**Old Terms**	
Brecon Beacons Group	Portishead Subgroup	Gwern Gofal Formation			Tintern Sandstone
		Craig-y-cwm Formation			
		Wern Watkin Formation		Quartz Sandstones	Huntsham Hill Conglomerate Formation
		Pen-y-fan Formation		Plateau Beds	
Daugleddau Group	Cosheston Subgroup	Blaen Haffes Formation [JHD		Brownstones	
		Walford Mudstone Member [JHD]			
		New Shipping Formation			(Caeras Conglomerate Member = Pebbly Brownstones)
		Bryn Menyn Mudstone Member [JHD]			
		Lawrenny Cliff Formation			Monkey's Fold Formation
		Senni Formation	Maroon sandstones? Greyish-green sandstones?	Senni Beds	Clee Hills Formation
	Milford Haven Subgroup	Freshwater West Formation		Ffynnon, Pontypool and, Rhiwperra Limestones --- informal only	
			Rat Island Mudstone Member	St Maughans, Red Mudstone, Llanddeusant Formations	
			Conigar Pit Sandstone Member		
			Chapel Point Limestone Member	Psammosteus Limestone, Bishop's Frome Limestone	
		Moor Cliffs Formation		Raglan Mudstone Formation	

A Field Trip to the Lake District

by Moira Jenkins

IN JUNE, a joint field trip by WGS and West Sussex Geological Society to the Lake District was led by Dave Green and organised by John Lonergan.

Summary of Lake District Geology

The high land of the Lake District is composed mainly of Ordovician and Silurian rocks, laid down in the Iapetus Ocean. This ocean closed as Eastern Avalonia moved nearer to Laurentia resulting in a soft collision of England with Scotland that did not severely deform the strata.

The Lake District is composed of three bands running roughly south-west to north-east, with the oldest in the north-west and youngest in the south-east. The oldest are the mudstones and siltstones, early to mid-Ordovician in age, which were carbon-rich muds and sands laid down in marine conditions and which have since been metamorphosed to form the Skiddaw Slates. These are seen as high rounded hills. They have been subjected to frost action that has generated large amounts of scree.

Next is the central band, the Eycott and Borrowdale Volcanic Groups, made up of about 9km thicknesses of lavas. The lavas were erupted later in the Ordovician as the Iapetus Ocean was subducted beneath what is now the Scottish border, and were followed by explosive pyroclastic eruptions. These rocks form spectacular scenery with steep slopes and rocky crags. (see Fig.8)

The south-eastern band forms lower hills separated by wider valleys. The rock is the Silurian Windermere Supergroup. The mudstones and greywackes are less resistant to erosion. The only Devonian rocks are conglomerates found on Mell Fell, showing that the area was being eroded at the time. There was further folding and faulting at the end of the Carboniferous.

Fig.1 The Lake District, showing the positions of the sites visited (Map drawn by John Payne)

The basement of the Lake District is a granite batholith. This rose in the subduction zone and may have helped with the doming of the area, as it is less dense. The granite is now becoming uncovered by erosion. There are also other more basic andesite intrusions.

Fig.2 A black Herdwick lamb with white 'spectacles'. (Photo by Shaun Dunmal)

Around the Lake District is a semi-continuous band of Carboniferous Limestone. The Vale of Eden, to the east, is a fault-bounded basin filled with Permian and Triassic sediments.

The Lake District has been eroded by ice during the Pleistocene, producing the deep U-shaped valleys, many of which now contain lakes.

Fig.3 Chiastolite in Skiddaw Slates in the metamorphic aureole around the granite.

On the first day, in rather rainy weather, we visited the Skiddaw Slates. We saw these along the track that runs north from the Blencathra field centre (Location 1; NY303255) west of Threlkeld (NY320255).

Further along the track we saw the gradual change of the

slates in the metamorphic aureole around the Skiddaw granite. Figure 3 shows the long white medium-temperature/low pressure chiastolite crystals (a variety of andalusite) within the slates.

We went a little way up the stream, Sinen Gill (Locn. 2; NY301282), until we came to the granite. This intruded the slates in the Devonian and is being uncovered by erosion. Figure 4 shows Dave Green and John Lonergan standing on the boundary of the granite with the country rock at NY302282. Near to the granite, the slates have been baked to form hornfels. .

We followed the road that skirts the east side of Blencathra. Just north of Mungrisdale (Locn.3; NY363303), at Ravenscrag, we visited a slate quarry. The slates here have bedding and cleavage which coincide and are almost vertical. There is a sill intruded parallel to the bedding and therefore also vertical. (Fig.5)

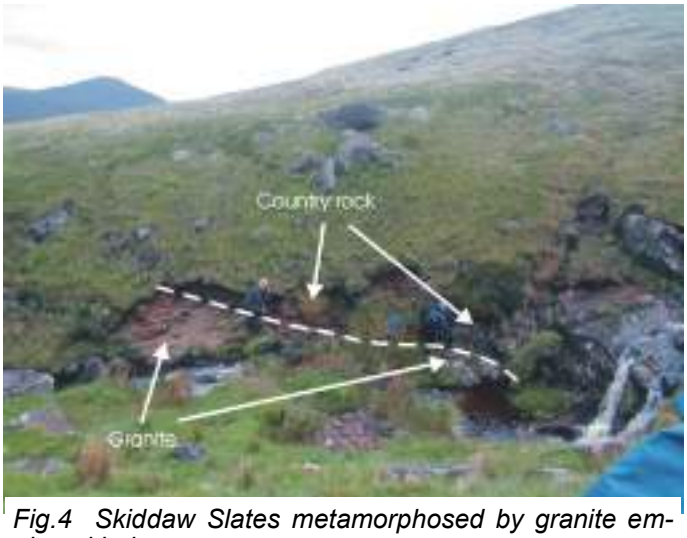


Fig.4 Skiddaw Slates metamorphosed by granite emplaced below.

Further along the hillside the rocks show slumps and disturbed bedding where earth movements have caused soft sediment deformation soon after deposition. (Fig.6)

Along the road north of Mosedale (NY357324), we stopped at outcrops of plutonic rocks, gabbro (Locn.4; NY356330) and granophyre ('graphic granite', where the feldspars and quartz components had crystallised together) (NY354336) on the slopes of Carrock Fell. These were the roots of the (~ 468Ma) Ordovician Eycott volcanics.

Fig.5 Sill intruded in Skiddaw Slates.

Fig.6 Slumped beds in Skiddaw Slates

Just beyond Murrah (Locn.5; NY388308), we saw the base of an outcrop of the Carboniferous limestones which surround the Lake District. You can see from Fig.7 that the weather was rather wet.

The Carboniferous Limestone outcrop overlaps a variety of different older rocks showing an unconformity at the base. The limestones were deposited in shallow seas which covered the area extensively early in the Carboniferous. Plate tectonic movements at the end of the Carboniferous and in the Tertiary have caused doming of the rocks in the area of the Lake District. The centre of the dome has eroded away revealing the Ordovician rocks below. The visit to the Eycott Group, the earliest of the Ordovician volcanic rocks was abandoned because of the rain.

Fig.7 Disused quarry in Carboniferous Limestone

On the second day we saw the rocks that were the next erupted, the Ordovician Borrowdale Volcanic Group. (Fig.8). These volcanoes had formed over the subducting plate and were very explosive.

Our first stop was at Stannah (Locn.6; NY321189) to see a roche moutonnée sculpted by ice in the Pleistocene. This is an andesite outcrop with black augite crystals which looked like darker spots left by raindrops. (Fig.9)

The second stop was at Sidepike (Locn.7; NY293053), a Geological Conservation Review Site, near the end of

Fig.8 Borrowdale Volcanic Group scenery

the Langdale valley, Here we saw a succession of explosive volcanics.

The succession starts with bedded tuffs with accretionary lapilli which are pyroclastic surge and fall deposits, seen in Figure 10. These are phreomagmatic, resulting from the interaction of magma with water. They are overlain by a rhyodacite (intermediate between a rhyolite and a dacite) welded ignimbrite seen in the photo below, Fig.11, formed from flattened hot, fragments of volcanic glass or pumice.

Fig.9 Kyanite in andesite outcrop sculpted by ice into a roche moutonnée

Fig.10 Fallout and surge deposits

Figure 11 shows the deposits of a pyroclastic flow with fiammé, where the melted fragments have been drawn out in the direction of flow of the extremely hot material.

Above the ignimbrite itself is a co-ignimbrite, a much finer secondary flow of the material that had been thrown up in the air from the initial flow. In Fig.12 you can see this and the over-lying bed, a breccia which is a debris flow. This shows the explosive nature of the eruption.

Fig.11 Ignimbrite with fiammé

When the Tethys Ocean finally closed the Caledonian Orogeny mountain building episode began. There was intense folding and the simultaneous erosion was very extensive, producing the raw materials for the Old Red Sandstone. There is very little ORS left in the area, only the peak of Mell Fell which we saw in the distance!

On the way back along the Langdale valley we stopped above Chapel Stile (Locn.8; NY315056) and went to a slate quarry. These slates had been formed not from muds but from beds of greenish blue volcanic tuffs. All of the volcanic ash was laid down in a caldera lake. The slates were used for local roofing.

We then drove back towards Keswick before turning south again driving along the east side of Derwentwater and then along Borrowdale to a site near Seathwaite (Locn.9; NY236121). Here we walked by the stream containing nodules with a coating of graphite which had come from an old graphite mine. The mine, on the hillside above, was associated with a dyke within the Borrowdale volcanics. This was the source of material used in the pencil making industry.

On day three we left Keswick, headed towards Penrith and drove down the A6. Our first stop was outside the working Pink Granite Quarry (Locn.10; NY560083) at the entrance of which we saw blocks of the Shap granite with large pink orthoclase feldspar crystals. This was intruded in the Devonian Period about 397 million years ago.

The second place we visited was near the end of Long Sleddale at Stockdale Farm (Locn.11; NY491053). The valley is wide with rounded hills on either side where it is eroded through the softer Silurian rocks and only becomes steep-sided and gorge-like where the Borrowdale volcanic rocks are reached higher up. Near Stockdale Beck at the Outdoor Pursuits Centre is a SSSI and type

Fig.12 Fine co-ignimbrite with overlying debris flow.

locality for the Silurian Stockdale Shales, famous for its graptolites. No hammering was allowed but we did see one poorly preserved specimen, in loose material. At the boundary of the Ordovician and Silurian is the Coniston Limestone, which has been quarried and burnt in a lime kiln. A small valley, the Rake, marks the line of the limestone. We walked up the hillside to the west to the disused Stockdale slate quarry SSSI (Locn.12; NY487058) in the next of the Silurian rocks, the Windermere Group. The rock is highly fossiliferous, laid down in calm conditions with burrows, honeycomb coral, trilobites, bryozoans and numerous brachiopods and bivalves, mainly molds with the shell material dissolved away. The hillside is crossed by lots of little faults offsetting the bedding. There are many crags of Stockdale Rhyolite among outcrops of slate. The rhyolite was erupted after the end of the main Borrowdale episode of volcanism.

That was the end of a most enjoyable field trip, expertly led by Dave Green .

Site Clearance in Herefordshire

LAST year's newsletter carried a report of the EHT programme of site clearance in the Malvern Hills area, sponsored by the AONB and the Malvern Hills Trust. This has continued with, in Herefordshire, work on three sites. As with other articles in this issue, many volunteers, including several from WGS, have given much work and time.

The roadside exposure of Cambrian sandstone and Ordovician intrusions at Hollybush on the Malverns is well known but is now much overgrown. Two stretches totalling about 50m near the road were cleared and this exposed two distinct intrusions, of dolerite and andesite, as well as the junction of the former with the sandstone, which was there converted into quartzite in a narrow band.

Part of a quarry in Coneygree Wood, just outside Ledbury, was cleared to reveal a fine anticline in the Much Wenlock Limestone, a part of the complicated folding and faulting in the Ledbury Hills.

The SSSI at Upper Hall Farm Quarry (aka. Gurney's Quarry), also near Ledbury, was partly cleared. This site shows a good example of the junction between the Wenlock rocks and the Ludlow rocks of the Silurian.

Editor's Note

THIS fourteenth issue of Earth Matters is larger than usual. A number of received articles were of greater length than I originally requested but were of much interest and relevance to Herefordshire geology and so they have all been published in full. The inclusion of items on the geology of Herefordshire, rather than out-of-county, is a major aim of the editor. I wish to thank all the contributors for the time and effort they have spent in producing their articles and for delivering them to me on time.

The first article, by Kate Andrew, describes the outcomes of a recently concluded project of the Earth Heritage Trust and, particularly, its work on the building stones of Bromyard. The project was worth several hundred thousand pounds (from the Heritage Lottery Fund), extended over four and a quarter years and employed three geology graduates and many volunteers in both Herefordshire and Worcestershire.

For the benefit of our members, a short article is included on the Section's new book about the county's geology, mainly to give details of the errors so far found in it.

Arthur Tingley's article describes his work towards generating an up-to-date geology map of the Knighton area, which includes part of north-west Herefordshire. This work has involved many volunteers from WGS and other local groups.

Knowledge of the stratigraphy of our area has been extended by the work of John Davies. By a comparison with areas further west he has identified a number of subdivisions in the local Senni and Brownstones Formations. This will prove to be important in future work in south Herefordshire.

Moira Jenkins describes the WGS visit to the Lake District jointly with the West Sussex Geological Society. This was unfortunately poorly attended by our members.

Our programme Secretary, Sue Olver, gives an account of the other Section meetings in the past year.

Lastly, we have short accounts of developments in the EHT and the Geopark over the past year.

Among important forthcoming events, members might wish to note the annual Symposium of the Open University Geological Society. This will be held in the University of Worcester from 10 to 12 August 2018. There will be a significant concentration on local geology, with lectures and field visits.

GEOLOGY SECTION MEETING REPORTS, 2016-17

by Sue Olver

Friday 27th January 2017 Early Ice Ages in Scotland

Professor Ian Fairchild introduced the Cryogenian period (850Ma – 635Ma) during the late Precambrian and its two major Ice Ages both of which affected the whole Earth. Evidence of the early Sturtian 'Snowball Earth' event, dated 710Ma, was preserved in Scotland where 1km of metamorphosed sediments show glacial tillites (diamictites) interbedded with normal sediments.

Further evidence of the same event was found in Svalbard where glacial striae, dropstones from floating ice and catastrophic slump breccias are all well exposed. Here, unmetamorphosed dolomites show some evaporite minerals such as anhydrite, indicating an arid cold desert climate.

Two of the remote and small Garvellach Islands, north of Jura, where some of Prof. Fairchild's research is conducted.

Friday 25th February 2017 Section AGM followed by dinner at The Green Dragon

Chris Fletcher, our Chairman, welcomed us all, especially our retiring Treasurer Beryl Harding who sadly was leaving us for a new home in Leicestershire. Ian Porter was welcomed as our new Treasurer to overlook the accounts for 2016 and the following year. Don Evans became our Minute Secretary.

Friday 24th March 2017 Prof. Donny Hutton – Plate tectonics in the Andes

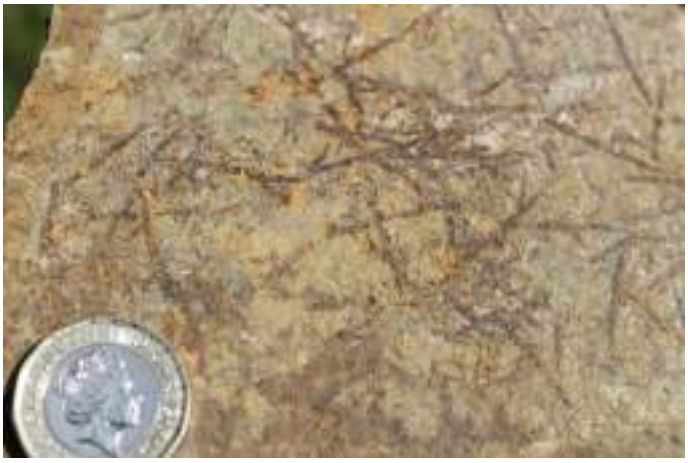
Professor Donny Hutton first described the 8000km long tectonic collision zone that is the Andes, a zone of compressional tectonics which has shortened, thickened and uplifted the local rock successions. He then outlined in detail a series of events from Cretaceous volcanism and sub-volcanic granite intrusions to Oligocene ignimbrite eruptions punctuated by periods of intense deformation within the orogenic belt.

Thursday 4th May 2017 Geology of Mercury

This was a joint meeting with Herefordshire Astronomical Society at the Kindle Centre, ASDA, Belmont Road, Hereford. A talk on 'The Geology of Mercury – new views of the Sun's innermost planet' was given by Dr. Chris Malliband (Open University) who very ably substituted for our booked speaker Dr. David Rothery who was unavailable. This gave everyone an inside feel for the complexities of mapping another planet with numerous fly-by photographs and the difficulties of interpreting the surface features. Chris is working with the European Consortium in mapping the surface so as to enable future probes to land and to discover more about the volcanism on the planet.

Saturday 22nd April 2017 Mortimer Forest

Paul Olver led a field trip to Mortimer Forest on the Hereford/Shropshire Border jointly with the Black Country Geology Society and OUGS West Midland branch. They met at High Vinnals and, at Gorsty, found graptolites, mainly *Monograptus tumescens* in the Upper Elton Beds within thinly bedded and fractured mudstones, and some calcareous bands with a few brachiopods. After-



Graptolites from the trackside bank at Gorsty in the Mortimer Forest

Pitch Coppice Quarry showing the boundary between the Much Wenlock Limestone (below) and the Lower Ludlow Siltstone (above)

wards we walked back from the High Vinnals car park to the Pitch Coppice quarry in the Lower Elton formation overlying the Much Wenlock Limestone where we saw the bentonite layer. Across the road another limestone quarry was examined along with the remains of two limestone kilns. After lunch at The Castle Inn at Wigmore, the party was taken to the view from the slopes of Wigmore Castle to see the glacial impact on the low-lying landscape and the Aymestry and Wenlock limestones. The last location was Mary Knoll Valley in the Mortimer Forest where trilobites, mainly *Dalmanites,* are found in the Lower Elton Beds.

Saturday 20th May 2017 Brymbo

Gary Brown led a return to Brymbo Fossil Forest, Wrexham with BCGS. Impressive Carboniferous fossils have been found here. Also seen was the restoration of the iron works and colliery which was well worth visiting.

Saturday 17th June 2017 Lapworth Museum

A visit to Birmingham University's Lapworth Geological Museum with BCGS, where Jon Clatworthy, the resident curator, introduced the party to the rock wall, the globe (cost of £70k), the historic changes of the building, a dazzling display of rocks and minerals and Shotton's map

The fossil forest at Brymbo

Fossil Lycopsid at Brymbo

room. In 2008 it was planned to bring the Birmingham Municipal Museum to the Lapworth Museum and money was raised by a £1.6 million lottery fund, £300k University funds and £250k from a company. The total cost was £2.7 million. The aims were to keep the academic and historic access and community outreach. The museum opened again on 10 June 2016 and certainly is now more attractive to the public.

Lake District field trip 10th – 13th June 2017

Another joint trip with West Sussex Geological Society led by Dave Green. They saw Skiddaw Slates and granite, Borrowdale volcanics, the fossiliferous Windermere Group interfaulted with igneous rocks, graphite used in the pencil making industry and Carboniferous limestone. This trip is more fully reported in Moira Jenkins's article.

(Thanks to Andy Harrison, BCGS, for the use of his photographs.)

WGS Programme for Early 2018

WOOLHOPE Geology Section talks are held at The Councillors' Meeting Room in the Shire Hall as the Woolhope Room is still unavailable. We will set up at 5.00pm for a start, the meeting commencing at 5.30pm unless otherwise stated and finishing by 7.30pm.

Note revised DATE
Friday 26th January 2018 Dr. Sue Hay - Life-style of an Oceanic Volcano

Friday 23rd February 2018

Section AGM at 6pm followed by dinner at 7:30. The location is currently undecided. Booking forms will be sent out electronically in January.

Note revised DATE
Friday 23rd March 2018 Prof. Ian Fairchild – The start of the Cryogenian: 'Let the Ice Ages begin'

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, Ian Porter, Greenings Acre, Little Birch, Hereford HR2 8BD. **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 Ian Porter.

Annual General Meeting

MEMBERS are asked to accept this as notification of the Geology Section AGM to be held on **Friday 23rd February 2018** starting at 6:00pm at a location as yet undecided; members will be notified. Dinner will follow the AGM at 7:30pm. Booking forms for the dinner will be e-mailed to members in January. The officials and committee for the coming year will be elected.

Members of the WGS Committee

(December 2017)

Dr Chris Fletcher, ***Chairman***

Dr Paul Olver, ***Secretary***

Ian Porter, ***Treasurer and Membership Secretary***

Sue Olver, ***Programme Secretary***

Moira Jenkins, ***Section Recorder***

Dr John Payne, ***'Earth Matters' Editor***

Don Evans, ***Minutes Secretary***

Gerry Calderbank, ***Geopark Representative***

Charles Hopkinson,

H&W Earth Heritage Trust

2017 has been a year of two halves, hectic during the spring and summer, much quieter in the autumn. After four busy years, the HLF-funded project 'A Thousand Years of Building with Stone' finally ended in June with a rush to get all the data onto the new database. Many thanks must go to the 188 volunteers who contributed to the project. The open access database (*www.buildingstones.org.uk*) now has information on some 5000 buildings and 700 quarries as well as other related material which may contain something of interest to you. There are also nine new geocache sites and new building stone trail guides to Bromsgrove, Bromyard, Malvern and a combined guide to Hereford Cathedral and city centre.

Work has continued in developing and testing the Apps in the 'Voyages in Deep Time' project. Local schools used them during the summer. Development work will finish this winter followed next summer by their use in more schools and, hopefully, interested amateur groups.

The Malvern Hills Sites Maintenance programmes were completed in the spring. Nine sites were cleared, five for the Malvern Hills AONB and four for the MH Conservators (now the MH Trust). There are about twenty volunteers now taking part. The 2017-18 season has already started with a similar number of sites to be maintained over this winter.

The University of Worcester's GeoGarden has been designed as an outdoor practical learning space. The Trust has assisted in this university project. Interpretation panels and leaflets are now in place around the garden and the App can be downloaded for free. (EHT has leaflets if you require any). It is well worth allowing extra time to see the garden if you are visiting St John's Campus.

The Geopark Way trail watch scheme was successfully reactivated last year and the entire length of the trail was walked this year. Anyone who would like to help next year should contact Sue Knox via the EHT Office (*eht@worc.ac.uk*). Last winter, work began on a second edition of the Geopark Way Guide book. As you can imagine much has changed since it was published in 2008: from the closure of the Schweppes Malvern Water bottling plant to major changes in geological thinking such as, moving the start of the ice age back to over 2.5 million years. Changes to the route are also needed in places. Publication and a launch event are being planned for the spring.

We are already focusing on next year's work with an emphasis on improving the Trust's resilience so that it is better able to weather whatever the future brings.

Dr Susan Hay, *EHT Chairman*

A&MH Geopark and GeoFest

The Geopark staged another good festival, diverse as ever, reasonably well attended and supported by various Woolhope Club members as usual, but we weren't able to do everything quite as anticipated because of scheduling problems.

We decided to postpone the Geopark extension celebrations until next year so that the Presidential Visit can coincide with the Geofest 2018 opening. Also, it was decided to allow for more time, plus a few additions, before releasing the two new Geopark maps. These are looking very attractive and are already much admired, thanks to Mike Brooks.

On several occasions John Stocks has done sterling work with crowds of enthusiastic youngsters when directing their searching for Carboniferous fossils in the spoil heap at Alveley – gratefully appreciated by the Severn Valley Country Park – and by the rest of us!

Iris has sometimes stood in for Georgia Jacobs [Upper Colwall & Martley] during Georgia's recent illness, from which she is now happily recovered. We both led a guided walk from Blackstone to Stourport via Burlish Top and the Staffs. & Worcs. Canal, then back along the riverside path, and I gave an illustrated (surveying) talk for the Bewdley Museum Summer Lectures Programme.

Gerry Calderbank, *WGS rep. on AMHG Forum*