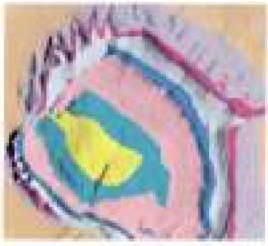
Earth Matters

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



No. 2 December 2005

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

I am pleased to welcome all Woolhope Club members to the second issue of '*Earth Matters*', the annual newsletter of the Geology Section. From the outset, the newsletter has intended to be broad in its scope and cover a range of earth science as well as record the specific yearly activities of the Section. I hope you find it enjoyable even if you are not a committed 'rock basher and fossicker'.

One of my challenges for my Woolhope Presidential year 2005/2006 was to work closely with other geological societies. This has been achieved through a very successful joint trip to Brittany with the Farnham Geological Society in April 2005 which features as one of our main articles. In addition, we have continued our association with the Black Country Geological Society with a return trip to view the spectacular limestone mines of the Wren's Nest at Dudley.

The inauguration of our Section coincided with the very welcome development of the Geopark in the Malvern and Abberley Hills. I hope our Section continues to become actively involved in its work and I see our initial visit this year to Martley as a potential area of fruitful co-operation.

The year has been unfortunately been overshadowed by the sad loss of our Vice-Chairman, Peter Thomson, whose lively contributions and excellent company were a feature of our Section meetings. He will be greatly missed.

Finally, I would like to thank John Payne, our Editor, and all our contributors to this issue for their commitment to our Newsletter. Without their vital enthusiasm 'Earth Matters' would never see the light of day.

Dr Paul Olver

President of the Woolhope Naturalists' Field Club and Chairman of the Geology Section

GEOLOGY SECTION PROGRAMME FOR EARLY 2006

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

Friday January 20th *Section AGM*
Followed by dinner in the Pizza Express opposite the Library (see note on this page).

Friday February 17th 3rd Murchison Lecture : *'Soft bodied sensations from the Silurian of the Welsh Borderland'*
Speaker: Dr Derek Siveter (Oxford University)

Friday March 3rd
Lecture *'Investigating the Leominster Canal'*
Speaker: Gerry Calderbank.
Joint WARS/ WGS event at Bunch of Carrots.

Sunday March 5th
Field excursion to the *Leominster Canal*
Leader: Gerry Calderbank
Joint WARS/WGS event.

Saturday March 25th
Visit to the *Lapworth Museum, University of Birmingham*

Friday April 21st Lecture
'The geology and geomorphology of Bredon Hill'
Speaker: Les Morris

Saturday April 22nd
Field excursion to *Bredon Hill*
Leader: Les Morris

May 14th to 20th
Week-long excursion to *Cornwall*
Leader: Dr Paul Olver
(If you are interested, let Paul know very soon.)

Further information for all events unless otherwise stated from: Sue Hay, 01432-357138 (evenings and weekends) or e-mail susan.hay@ hhtr.nhs.uk

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3RD MURCHISON LECTURE : 17TH FEBRUARY

This lecture is particularly recommended to members. It will be given by Dr Derek Siveter of Oxford University. He will describe his team's current work on Silurian fossils found, uniquely, in a Herefordshire location. This is a world-class geological research site on our doorstep. The research results are very exciting in revealing for the first time the fine details of many soft-bodied creatures. The presentation contains many remarkable and spectacular images of the researchers' reconstructions of these creatures.

EDITOR'S COMMENTS

Welcome to the second issue of 'Earth Matters'. I hope you will enjoy reading it and perhaps reliving some pleasurable moments from your geological activities of the past year.

Earth Matters continues to be principally a record of the Section's activities although, necessarily, many good things have to be omitted for reasons of space. This issue contains brief accounts of several of our outings and lectures, admirably recorded by Geoff Steel, as well as a detailed description of our major excursion to Brittany and two of our evening lectures. Moira Jenkins has written about the Herefordshire Rivers Project, recently completed by the Earth Heritage Trust. Charles and Jean Hopkinson have provided an interesting summary and observations of the geology local to their home in Little Cowarne.

I am indebted to all of the contributors in meeting their deadlines (well, nearly!) and in particular to Geoff Steel, who has written seven of the sixteen pages presented here.

Contributions on any aspect of earth science, especially local ones, will be welcomed for the next issue in a year's time. Observations on particular sites in Herefordshire should be sent to Moira Jenkins, our new Section Recorder, for her report in the Transactions.

I would like to thank the members of the Section committee for their help and support and also WGS members for kind comments on the first issue.

John Payne, *Editor*

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SUBSCRIPTIONS

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

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ANNUAL GENERAL MEETING

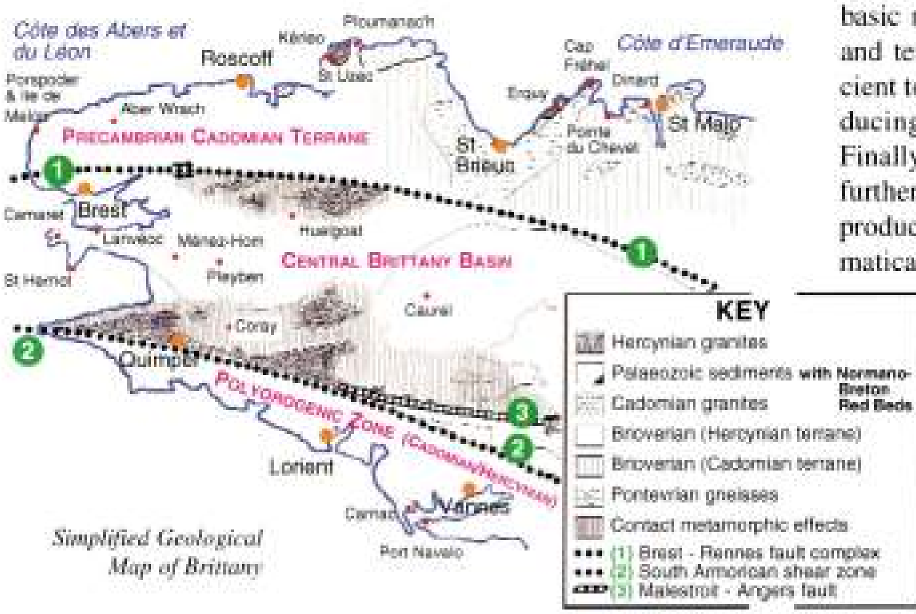
Members are asked to accept this as a reminder of the AGM to be held on Friday 20th January 2006 at 6:00pm in the Woolhope Room. After the AGM we will retire for dinner to the Pizza Express across the road from the Library. Meals must be ordered in advance. If you are coming to the dinner, you will need a copy of the menu in advance. To obtain this, send a stamped, addressed envelope (big enough for three sheets of A4) to Beryl Harding, 'Bramley', Lugwardine, Hereford HR1 4AE.

BRITTANY DIARY : 2005

Gerry Calderbank and Dr Paul Olver

Geology section, Woolhope Naturalists' Field Club

The April 2005 excursion to Brittany was held jointly with the Farnham Geological Society. It included much of archaeological interest but description of this is omitted from this account. Days 1 and 2 were spent in travelling to Dinard, via a stop at Mont St Michel. The leader was Dr Paul Olver, our Chairman.



Simplified Geological Map of Brittany

Day 3 - Dinard to St. Brieuc, exploring 'The Emerald Coast'

An early start, then a stroll down to the sea front where Paul gave an outline of the geological sequence of events throughout Brittany. He characterised Brittany as consisting of three zones: the granitic and metamorphic Precambrian Cadomian Terrane in the north; the Ordovician/Silurian rocks of the Central Brittany Basin; and then the high-grade metamorphic rocks of the Polyorogenic Zone in the south, as defined by the Malestroit-Angers Fault and by the South Armorican Shear Zone. This latter zone is clearly reflected by the 'grain' of the land between Redon and Quimper.

The Emerald Coast rocks are predominantly late Precambrian, consisting of two major Proterozoic units; the PENTEVRIAN - a crystalline basement complex; and the BRIOVERIAN - a series of volcanics (including pillow lavas) and their detrital sediments. However, recent research has led to a revision of their dating since it has shown that some of the lowest Pentevrian (adjoining the Icartian Gneiss basement) is now attributable to the Archaean (middle era of the Precambrian), thus correlating with the Channel Isles and Cherbourg rocks of similar composition and age (c.2000Ma).

It transpired that, in Dinard, we were looking at the Pentevrian Gneisses on the foreshore and (most spectacularly demonstrated as highly deformed migmatitic gneiss) in the adjacent stone walling of the promenade. These started as detrital sandstones of quartz and feldspar fragments, load structures, mudstones and shales that were subjected to orogenic pressure, initially metamorphosed into pelitic schists and psammites, and then intruded by basic magma dykes. Next, increasing pressure and temperature led to partial melting - sufficient to penetrate the basic intrusions - and producing banded gneisses featuring 'augen'. Finally, the plastic flow stage occurred, with further degradation of the remaining dolerite to produce 'schlieren' of amphibolite and ptygmatically folded veining. Massive pegmatite veins, dating from the end of this orogenic phase, have later dissected these structures.

We proceeded via the St Jacut peninsula to the Pointe du Chevet (pegmatitic and ptygmatic veining, some tourmalines and a very impressive basic dyke) where granodiorites were observed at the Fort de la Latte. These are attributable to the first metamorphism (older igneous phase) of the Cadomian Orogenic Cycle (595-541Ma).

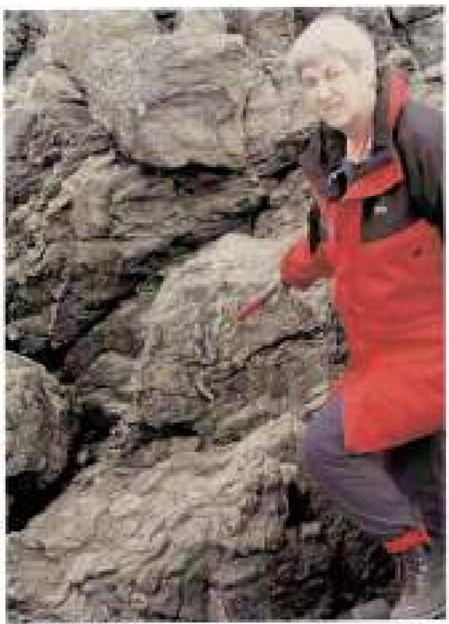
Near Erquy, at Cap Fréhel, we encountered post-Brioverian 'Red Beds' - midst driving wind and rain! Suitably recovered, we re-boarded our coach before parking near a cliff path in order to examine the conglomerates, exposed on the beach by wave action. These rest unconformably upon the previous Cap Fréhel series. Down to the town, where a short walk from Erquy promenade led us across the beach to a minor headland (isolated at high water) to view the Pointe de la Heussaye pillow lavas. These are Brioverian-aged spilites, which are part of the Erquy volcanic formation - another product of submarine volcanism - together with their hosting grey-green greywackes.

Dinard Promenade - Migmatitic gneiss (Day 3)

Day 4 - St. Brieuc and the Breton Corniche

Our first stop was Ploumana'h to view the beautiful red granite formations and associated intrusive features. The granite rosé is of Hercynian age, part of the Ploumana'h intrusive complex. Although spectacularly colourful, it is very similar in most other respects to our own Dartmoor and Bodmin rocks.

After lunch, we made further visits to examine the granite outer contact zone in the nearby Kérleo quarry. Here was an exposure of fine-grained granite bearing porphyritic rafts, aplitic features and xenoliths.



Migmatites at Point du Chevet (Day 3)

Day 5 - St. Brieuc to Vannes, traversing the Central Brittany Basin

This was a day of Palaeozoic sedimentary rocks, many with low-grade metamorphic features.

A recent roadside cutting near Caurel has exposed a series of (Late Silurian) slates, reputed to be fossiliferous but rather unproductive during our visit, except for a few graptolites. Allons! - aux Lac de Guerlédan, an artificial feeder for the Canal de Nantes à Brest. This lake is situated in dense woodland but we were skilfully guided to the shore where wave action has exposed the Upper Ordovician slates with a brachiopod and trilobite fauna, albeit deformed by the cleavage planes. Most interesting, however, were the numerous andalusite crystals, which are here the product of a late-stage, low pressure/medium temperature (regional) metamorphism associated with the Rostrenen - Plélauf Granites. It differs from most of the rest of the Central Brittany Basin where the corresponding rocks are merely slightly slaty or even uncleaved. Day 6 was spent exploring the archaeological sites around Carnac.

Day 7 - Vannes to Quimper, and the South Brittany 'Polyorogenic Zone'

First, we drove around the Golfe du Morbihan to view the (extremely intricate!) geology of the Port Navalo area, part of what has been termed the 'Ligerian Mobile Zone'. The region is bounded to the north by the South Armorican Shear Zone. This defines our third and final 'unit' of Breton geology, having previously dealt with the PRECAMBRIAN CADOMIAN TERRANE and then the CENTRAL BRITTANY BASIN.

It is a zone of high-grade metamorphism, extending from Pointe de Raz in the west to Vendee in the east, and is said to be 'polyorogenic' in nature since it has interactive structures that are separated on a vast chronological scale, ranging from 600 to 370Ma. Whereas most orogeny is attributable to the collision of plates, in this case there is thought to be an 'Andean' analogy whereby ocean floor was subducted under a pre-existing sequence of Brioverian sediments deposited upon a granulite basement. The full sequence is complicated with seven distinct stages being postulated.

The whole morning was devoted to a detailed examination of this complex of migmatites, granites, schists and gneisses exposed on the shores around Port Navalo, including a (fruitless) search for garnets - but a successful find of sheaves of the neosilicate sillimanite. Our lengthy coach journey to Quimper was broken by a detour to an elusive and extremely overgrown quarry near Lorient where we were shown a good exposure of Moelan Granite. This (extremely hard!) pink granite is synorogenically associated with the Hercynian orogeny and is layered with biotite and hornblende set in a microlitic groundmass of quartz and orthoclase.

Day 8 - Quimper to Coray and the Crozon Peninsula

We stopped first at La Croix near Coray where, after a false start, numerous large brown staurolites ('Staurotides' in French and, in twin form, the celebrated 'Croissettes de Bretagne') were uncovered in the hedgerow where they had weathered out from the underlying mica schists in the form of iron-aluminosilicate orthorhombic crystals - but no twinned croissettes! Staurolite is another neosilicate occurring in aluminium-rich rocks within medium temperature/pressure metamorphic zones, but away from the granite contacts.

At work on the migmatites at Port Navalo (Day 7)

On the beaches near Camaret, a succession of Lower Palaeozoic rocks rests unconformably upon the Upper Brioverian (Proterozoic) basement. Around L'anse de

Camaret the sequence that we viewed is mainly Ordovician, the chronological equivalent of our own Arenig - Llandeilo series. At Veryarc'h Bay the low-tide conditions enabled us to examine some remarkable faulting and folding around the headland. Elsewhere, the Crozon Peninsula features Silurian and marine Devonian rocks.

En route for Quimper we crossed the Lower Ordovician quartzites (les Grès Armoricans) and gained the panoramic viewpoint of Ménez-Hom (330m) where we were rewarded with magnificent views in all directions.

Day 9 - Quimper to the Crozon Peninsula

The whole morning was devoted to the superb 'Maison des Minéraux' at St. Hernot, a privately funded enterprise whose proprietor had opened on a Sunday especially for our convenience! Despite the title, his exhibits were of more general geological interest than might have been supposed, although the emphasis was certainly mineralogical, culminating in a spectacular and artistic display of "... des minéraux fluorescents septaria, calcite, quartz, semi-opale, et fluorite".

We lunched in nearby Crozon and then drove to Le Pointe de Lanvéoc where a Lower Devonian marine sequence was examined at the cliff face beyond the beach. The succession consisted of fairly massive sandstones together with ferruginous quartzites, and various (fossiliferous) siltstones with thin bluish limestone bands.

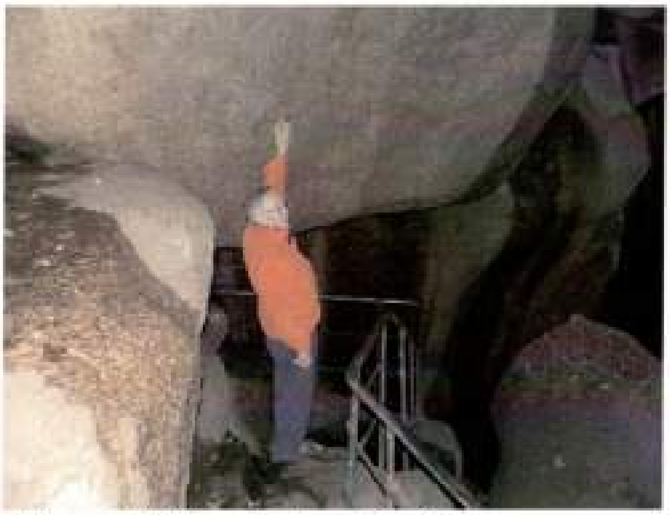
Day 10 - Quimper to Roscoff via the Armorican National Park

At Huelgoat, we strolled through the town to the 'Valley of the Rocks'. In my opinion this was quite the most remarkable feature of our tour; the sheer scale of the huge granite boulders - and the manner in which they came to be there! It beggars belief!

The assimilation of aluminous sediments has given rise to an abundance of cordierite crystals. This is yet another silicate of aluminium, magnesium and iron. It is sometimes difficult to distinguish from quartz in the field and even under the microscope. Cordierite occurs mostly as a product of the thermal metamorphism of argillaceous sediments (e.g. hornfelses) and may therefore be accompanied by andalusite, biotite, spinel and corundum. Less commonly, it is also found in basic and in acid igneous rocks (Huelgoat) where it probably represents the imperfectly digested xenolithic relics of argillaceous material. We photographed a fine example in a local stone wall.

Day 11 - Roscoff to le Pays de Léon

Our final day was spent on the Côte des Abers et du Léon, with visits to L'Aber Wrach and then to Porspoder. Spanning a line between Llanildut and Guisseny, there is a tectonic junction between Hercynian-aged rocks on the SE flank and older rocks to the NW of this frontier. Firstly, we stopped at the Aber Wrach viewpoint where an abandoned cut-off afforded excellent parking with fine views of the narrow estuary that is very reminiscent of similar drowned river valleys in Pembrokeshire and our SW Peninsula coastal region. In the roadside cutting there were, undoubtedly, the most convenient exposures of migmatites yet encountered.



Valley of the Rocks at Huelgoat (Day 10)

We hunted for tourmaline crystals and evidence of extensive shearing midst the granites of Porspoder beach. Nearby, on the granite causeway connecting L'île de Melon we found an enormous xenolith that retained much of its original structure. However, logistics required a timely return to Roscoff - interspersed with an essential shopping spree! - and then another convivial restaurant meal followed, early next morning, by our return to the UK. We arrived in Hereford at 2 p.m.

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.

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ERRATUM The caption to the photograph of Woodbury quarry in Peter Oliver's article in Issue 1 was in error. The red boundary in the photograph is due to material washed from the top of the quarry. The error is the Editor's, not the author's.

Reverend T T Lewis and Studies of Silurian Geology

The second Murchison Lecture

Delivered at the Section meeting of 19th November 2004, jointly by

Dr John Ross and Martin Allbutt

The name of Sir Roderick Impey Murchison is well known in relation to the Silurian strata which he studied and documented in great detail, working in the Herefordshire, Shropshire and Radnorshire area. Perhaps less well known is that he relied heavily on the observations of others, among them being Thomas Taylor Lewis, the vicar of Aymestrey.

Lewis was born in Ludlow in 1801 to a family with strong geological connections; they owned the Knowbury coalfield and the ironworks at Titterstone Clee. He was sent to school at Cheam in Surrey where he met Eliza Penfold, the daughter of a wealthy family. He continued to Cambridge where he studied for the Church and also attended geology lectures given by Professor Adam Sedgwick. In 1827 he married Eliza and her family obtained for him the position of curate at Aymestrey. Sadly just two years later Eliza died of puerperal fever following the birth of a healthy daughter.

Rev. TT Lewis c.1853 (Courtesy of Mrs Hodges, Garden House, Aymestrey, and Ludlow Museum)

Along with his pastoral duties Lewis took a great interest in the local geology, collecting fossils and working out the stratification. Having only the most elementary books for reference he was unable to name the fossils with any degree of certainty. All the work was done completely alone until 1831 when Murchison, who was staying at New Radnor, heard of his studies. They met in July that year and toured together for several days. Afterwards they kept closely in touch, with Lewis sending many crates of fossils and providing valuable information to Murchison in London. It was said that Lewis considered publishing his observations but "cheerfully resigned the subject, rejoicing that it had fallen into the hands of a geologist whose practical knowledge was much greater than his own."

From the vicarage at Aymestrey a footbridge crossed the river Lugg to Yatton Court, where Admiral Woodhouse lived with his daughter Elizabeth. She and Lewis fell in love, much to the anger of her father who had the bridge cut down! They were married in 1838. They had three daughters and one of their descendants, Mrs Gardener, still lives at Yatton Court. She is 102 years old.

Murchison's publication of 'The Silurian System' appeared in 1839. There was no mention of Lewis in the preface (where seventeen others were thanked) but the text on the Aymestrey area stated that "... its fossil contents have been elaborately worked out by my friend the Rev. T.T. Lewis". The inadequate credit was criticised and in 1854 when Murchison published his great definitive work 'Siluria' he did include Lewis in the preface.

Early in 1858 Lewis suffered a slight stroke, and deteriorating health led to his death in October the same year. He was remembered by the Woolhope Club as "One of Herefordshire's best and most accomplished men" and by the Gentlemen's Magazine as "One of those unostentatious labourers to whom science often owes much more than it acknowledges".

Scientific study in the same area was continued by the Geologists' Association who conducted a week-long field excursion to Ludlow in 1872. This was followed in 1884 by the publication of a handbook to the Geology of Shropshire by J.D. La Touche, himself also a vicar.

It was in the early years of the 20th century that the next significant steps were taken, led by a remarkable trio of ladies: Ethel Wood, Gertrude Elles and I.L. Slater. By studying graptolites in the Lower Ludlow rocks Ethel Wood recognised their value as zone fossils, by which the rocks could be correlated over extensive areas. She published her first paper on the subject in 1900 and a further one in 1904. At the same time Elles and Slater were studying certain characteristic fossils which they found to occur only in specific layers. In their 1905 paper 'The Highest Silurian Rocks of Ludlow' they established a system for naming the individual layers based on their fossil content. Hence the origin of names such as Rhynchonella Flags and Eurypterus Shales. The work culminated in 1918 with publication of the monograph on British

Graptolites by Elles and Wood.

Recognition of zone fossils allowed mapping of Ludlow strata to be extended to more distant areas and by this method Dudley Stamp produced his geological map of the Bucknell district in 1918. It was published at the large scale of two inches to one mile and included a detailed cross-section.

In 1925 Professor W. Watts of Birmingham University published his review of the graptolite zonation in which a far more detailed succession was recorded (although there were still no species known above the Aymestry Limestone). This enabled T. das Gupta to survey the calcareous siltstones of the Long Mountain, with publication of his map in 1932.

There followed an important step by yet another dedicated lady, this time Mrs F.E.S. Alexander. She mapped the Aymestry Limestone in great detail and in doing so found a very thin sandstone at the top. This outlined a scoop-like feature at Church Hill which she recognised as a submarine channel. Her map appeared in 1935. It was followed by John Earp's survey of the Kerry Ridgeway in which he drew attention to the highly contorted Wilsoni Grits on the banks of the upper Teme.

After a pause due to the war Professor Straw of Manchester University organised a systematic attack on the Silurian during the 1950s. Most of the work was carried out by his students: J.D. Lawson, C.H. Holland and J.H.'Mac' Whitaker. In his map of the Knighton district (1958) Holland introduced the concept of a 'type section', a section illustrating the key features of a particular stratigraphic element. The method was extended to a complete set of 'standard sections' for the Elton-Bringewood-Leintwardine-Whitcliffe-Downton stages, published in 1963. At the same time Whitaker identified the Church Hill channel as a submarine canyon-head formed by turbidite currents.

The 1970s saw extensive forestry planting in the Ludlow area which provided an unexpected bonus to geologists. Many miles of roads and tracks were cut to reveal a wealth of new sections. This allowed a complete revision of the graptolite zones, including species above the Aymestry Limestone, published by Lawson in 1973.

Work continues in the area to this day. In particular the unique protected environment of the Church Hill channel (now an SSSI) is the subject of detailed study. Fifty species of starfish have recently been identified there.

Reported by Geoff Steel

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MEETING REPORTS

by Geoff Steel

Friday 25th February 2005 - Meteorites

Dr Geoff Steel displayed a collection of meteorite samples including stones, irons and tiny fragments from the Moon and Mars. His lecture is summarised in a separate article.

Friday 18th March 2005
- Quaternary Landscape Evolution in Herefordshire

Dr Andrew Richards described the local quaternary deposits, which are some of the best in England. They begin with high level gravels in the easternmost part of the county which are about 2.5 million years old and indicate rivers flowing from the east, across the Malvern axis.

A gap of two million years is followed by deposits from the Anglian glaciation which covered most of Herefordshire. In the valleys of the Stretford and Humber brooks there are gravels 0.5 million years old which contain fragments of coal indicating a northern source. They were deposited by rivers in cold conditions with freeze-thaw activity. Above the gravels are the Anglian glacial deposits of the Risbury formation. The glacier flowed from the west (not north as stated by BGS).

Finally there was the Devensian glaciation, with its maximum extent 18000 years ago. Again flow was from the west, this time extending only half way across the county to end in terminal moraines near Leominster and Hereford. Cores taken from kettle holes show excellent preservation of pollen and even hazel nuts, allowing accurate reconstruction of environmental conditions. Much work remains to be done on this valuable record.

Friday 22nd and Saturday 23rd April 2005
- Malvern Hills

On Friday evening Dr John Payne gave us an introduction to the geology of the Malvern Hills and the history of its research. He drew special attention to the deep

'Hyperconcentrated' flood gravel at The Vauld

underlying structure of the area, revealed by recent seismic surveys.

On Saturday he took us on the Geology and Landscape Trail to Wyche and Purlieu, with its trail guide published by the Earth Heritage Trust. We began by studying Precambrian granite and diorite at the Wyche cutting. Orthoclase crystals in the granite have a pink colour due to silver impurity, and some of the rocks are green due to epidote. We continued westwards onto Silurian rocks exposed in quarries of Much Wenlock limestone. These rocks were formed when Britain was in a tropical environment south of the equator, similar to Australia today. Above them lies the Lower Ludlow Shale which is softer and has eroded into a valley parallel to the Malvern axis. Finally the hard Aymestry Limestone forms a conspicuous line of hills to the west.

Finding Martley rock

After lunch we went down into Malvern. The upper part of the town is built on a shelf of Triassic sandstone. A spring behind a car park shows deep red coloured rocks and the same can be seen in a temporary exposure on a building site by the main road.

Much Wenlock Limestone on the Wyche & Purlieu trail

Thursday 2nd June 2005
- International Geopark Week

Professor Aubrey Manning, the President of the Abberley and Malvern Hills Geopark, opened the Abberley Hills Trail. He began with an inspiring talk at St Mary's church in which he described his background as a biologist and how that led him to an interest in geology. He then accompanied us on a tour of both churches in the village to study the use of local stones in their construction. After lunch Dr Peter Oliver guided us around the trail. He included a visit to Shavers End quarry to see its steeply dipping Silurian limestone.

Saturday 26th June 2005
- The Martley Rock

Just to the west of Martley, at SO 745596, the geological map shows a small Precambrian inlier. It was mapped in the nineteenth century when exposed in a quarry, and was described as Cambrian quartzite overlain by sheared Precambrain granite. It is on private land. With permission from the landowner Dr Paul Olver took us to the site. The quarry has been filled in and planted with trees. From the adjacent field we collected samples of both quartzite and granite, the latter indeed showing evidence of shearing. To investigate the bedrock we dug a small pit at the edge of the field, and only a foot down came to a solid layer of granite. We have been given permission to excavate the whole site, hopefully to be planned for the near future.

Saturday 16th July 2005
- Wren's Nest and Dudley Canal

Six of us met with the Black Country Geological Society for this joint field trip led by Graham Worton. He summarised the local geology as Silurian shelf deposits overlain by coal measures, the latter including the 36-foot 'Dudley Thick Coal', the thickest seam in England.

He took us up the Wren's Nest hill through a set of quarries forming two distinct lines in the Much Wenlock Limestone. The middle part is nodular and of poor quality so only the upper and lower bands were quarried. At the top he showed us how Hercynian folding has produced anticlines with North-South axes, unlike the usual Hercynian direction and not Caledonian either. This may indicate a deep underlying Precambrian structure. At the western side of the hill there are spectacular steeply inclined slabs of nodular limestone with ripple marked surfaces. We stopped nearby for a picnic lunch and found an amazing abundance of fossils, for which the Wren's Nest is famous. They indicate a complete sequence of the Much Wenlock Limestone, some layers being missing at Wenlock Edge itself.

In the afternoon the field trip finished with a boat trip through tunnels on the Dudley Canal. The tunnels follow limestone mines. Even though most levels are now flooded the remaining caverns are huge and continue for several miles.

Sunday 7th August 2005
- Presidential Field Trip to the Forest of Dean

This coach tour was led by the President, Dr Paul Olver. We began at Longhope where a road cutting exposes a section through upper Silurian strata, dipping gently westwards. There are abundant fossils, particularly brachiopods, which separate easily from the friable siltstones. Morning coffee at Blaisdon was followed by a journey up the Soudley valley. We stopped at Upper Soudley. At this point the very steep dip allows several rock layers to be seen along a short distance of railway cutting. The track crosses an unconformity from lower to upper Devonian sandstones, followed by Carboniferous limestone.

Waiting for the train at Lydney station

At lunchtime we travelled to Norchard. It is the site of an old colliery and is now the start of the Dean Forest Railway. We took our places in a 1960s carriage for a journey by steam to Lydney and back.

The afternoon was planned as a trip along the coast. But the road was closed. So a rapid bit of re-planning took us to the site of an old railway cutting near Blakeney. Although the area is a coalfield it is rare to see coal at the surface because most was taken long ago. However at this point there is indeed an exposed seam, about two feet thick. It was overgrown and difficult to reach but well worth the effort.

The tour finished with a buffet at the Victoria Hotel in Newnham and a visit to the churchyard with its view over the river Severn.

Sunday 25th September 2005
- Hanter Hill and Dolyhir Quarry

This was a joint field trip with the Open University Geological Society. An inlier of Precambrian igneous rock has been brought to the surface by movements on the Church Stretton fault and eroded to form a line of hills, of which Hanter Hill is the largest. The geological map shows dolerite, gabbro and acid rocks, intruded in that order. We began at a footpath on the north side. Here we found both dolerite and acid rock, the latter being much lighter in colour and containing pieces of dolerite, hence confirming their relative ages. Continuing to the top we found exposures of gabbro with very large crystals up to 4cm across.

In the afternoon we visited the nearby Strinds and Dolyhir quarries. Both have Precambrian sedimentary rocks overlain by Silurian limestone. In Strinds quarry the unconformity is difficult to see, but in Dolyhir quarry it is a clear and obvious. The Precambrian sandstones dip steeply westwards, and above them there is an undulating layer of quartz pebbles then horizontal limestone.

Saturday 8th October 2005
- Herefordshire Quaternary Exposures

Continuing from his March lecture Dr Andrew Richards led a tour around sites included in his PhD studies and now designated as RIGS. We started at a small gravel pit near Stoke Prior. Here there are clinoforms (beds laid down at a steep angle) showing deposition into a glacial lake which was dammed by ice flowing from the west. The exposure is of Anglian age and is part of the Risbury Formation. At the top there are Devensian gravels but they are now mostly overgrown. In a nearby quarry at Blackwardine we saw similar clinoforms offset by normal faults. Water level increased until a break formed underneath the ice at Risbury where very fast flowing water dug a deep channel. At the edge of this channel, just next to Risbury bridge, horizontal beds of the Humber Formation can be seen underlying the steeply dipping Risbury Formation.

From there we drove north to The Leasows where an impressive terminal moraine of Devensian age crosses the Stretford Brook. A recently exposed section shows complex structures formed by ice pushing up frozen material.

Andy Richards explains the Humber and Risbury glacial formations

Lunch at the Railway Tavern in Bodenham was followed by a visit to The Vauld near Marden. In this quarry the glacial deposits, again Anglian, include boulders up to a metre in diameter set in a matrix which shows evidence of frost shattering. Finally we travelled to Sutton Walls. At the edge of the hill fort a section is seen through the highest of the four post-Anglian terraces formed by the river Lugg. Here the deposits show mainly northern derivation but lower terraces have increasingly western-derived material, including Hanter Hill gabbro which proves existence of the river Arrow at that time.

River Landscapes since the Ice Age

Moira Jenkins

Geology section, Woolhope Naturalists' Field Club

Herefordshire and Worcestershire Earth Heritage Trust received funding from the European Union and DEFRA as part of the LEADER+ Herefordshire Rivers Programme. The project, recently successfully completed, was entitled 'River Landscapes since the Ice Age' and has produced five trail guides, with interpretation panels along each of the trails. The trails are designed to be self guided, to tell the general public more about the geology and landscape along sections of the valleys of the Rivers Lugg and Wye. Also as part of the project twenty Regionally Important Geological and Geomorphological Sites (RIGS) were designated. Community involvement was an important part of the project. Talks have been given to local societies. Walks have been led for people living in the area and for the Herefordshire Walking Festival. Members of communities have helped with local information or assisted with field work.

Guided walk by the meanders of the River Lugg near Byton

Trail Guides

The glacial diversion of the River Lugg is described in the *Byton and Kinsham* guide. Members of the local community have helped to clear a path, create a new viewpoint and erect an interpretation panel on Wapley Hill. From this vantage point you can see the beautiful scenery of northwest Herefordshire, the former course of the River Lugg blocked by mounds of glacial moraine, the site of the glacial lake which was formed and the new course of the river through Kinsham Gorge.

The *Wye Gorge* trail guide describes the spectacular scenery of the gorge and explains its formation. It looks at the rock sequence on Little Doward Hill, from the terrestrial Devonian Quartz Conglomerate to the marine Carboniferous Limestone. The trail ends with a visit to King Arthur's Cave. An interpretation panel has been erected near the foot bridge at the Biblins with the help of the Forestry Commission.

The *Hampton Bishop* trail looks at the 'Stank' flood defence barrier protecting the low flat land between the Rivers Lugg and Wye and describes the river terraces, formed during the Ice Age, which are above the river in times of flood. Red Bank Cliff and other river features are visited on the trail in the stretch of the Wye where bee eaters nested this year. The interpretation panel is to be seen by the Stank near Mordiford Bridge.

The *Queenswood and Bodenham* trail explores ancient and modern river deposits. The first and third river terraces and the suballuvial gravels were formed in the Pleistocene. The Devonian rocks seen in Queenswood Country Park formed nearly 400 million years ago and show current-bedding of an ancient river and a fossil soil developed in arid conditions. A launch of the trail guide was held at the Country Park, with a display, talk and walk. Rangers at the Country Park have constructed a ramp to make easier access to the site of the interpretation panel describing the geology in a disused quarry.

The *Ross-on-Wye* guide examines the magnificent exposures of Lower Devonian Brownstones Formation in the old river cliffs at Wilton Bluff, a SSSI. These were laid down by flash floods and contain ripped-up mud clasts, pebble beds and lenses of sandstone filling former river channels. There is an interpretation panel by these cliffs. The trail guide also looks at the river terrace at Wilton and the abandoned meander of the Wye, which used to flow behind Chase Wood and Penyard Park.

RIGS Designation

An important part of the project was the designation of RIGS. Ten fluvial and ten glacial Regionally Important Geological Sites were chosen which are examples of fluvial processes in operation or sites which show examples of the glacial history of Herefordshire. The sites were chosen because of their scientific, aesthetic, educational or historical importance.

Fluvial RIGS on or near the River Lugg

The meanders at *Combe and Byton* in particular contain an example of a meander cut-off, or oxbow lake, which still has water in it, although beginning to naturally silt up. (Since the end of the project another meander cut-off has developed upstream in this section of the river.)

Kinsham Gorge, formed by water overflowing from a pro-glacial lake in the Presteigne basin, is a dramatic, steeply sided valley. The gorge was cut by a greater volume of water than flows there today and the river meanders do not follow the curves of the valley. The exposed banks of the river also show imbrication, the stones in the gravels leaning in the direction of water flow at the time of deposition.

Sned Wood Valley is a classic glacially formed valley, with its flat-bottomed, steep-sided, U-shaped profile. It follows a geological fault, a line of weakness.

Where the moraine blocked the proto-Teme at *Yatton*, a large delta fan of gravel was deposited. The ridge of moraine at Yatton was eroded by the proto-Lugg on its southern side, creating a cliff-like profile. The gravel has since been commercially extracted.

Just downstream from the bridge at *Mortimer's Cross* the river cuts into the high bank on the east side and exposes the end of a deposit of glaciofluvial moraine.

The small waterfall beside the lane near *Bodenham* shows a rare example of a Tufa waterfall. The spring water emerging from the Bishop's Frome Limestone deposits calcareous tufa.

RIGS on or near the River Wye.

At *Brobury Scar*, on the outside of an incised meander bend, is the largest exposure of red marls of the Raglan Mudstone Formation outside Pembrokeshire and a SSSI. It has been given RIGS status as well to emphasise its geological importance and educational value.

The RIGS at Lockster's Pool, on the River Wye near Clifford

The River Wye through Herefordshire exhibits classic examples of fluvial processes on a large scale. *Lockster's Pool*, near Clifford, consists of a large point bar and incised meander bend, demonstrating the active processes of erosion and deposition. On the outside of the bend the river is undercutting the bank, causing active widening of the channel. On the inside of the bend gravel is being deposited. An overflow or flood chute has developed across the neck of the meander, that may in time lead to a cut-off occurring. Downstream of the bend backwaters have been created by bank failure and slumping. Further downstream at *Turner's Boat* is distinctively hummocky topography of kettle moraine with depressions which often fill with water as there is no outlet for drainage.

RIGS near the River Arrow, Herefordshire

The site known as *'The Rainbow'* or *'Hell Wood Channel'*, is a curved, steep-sided, dry valley with a slightly humped longitudinal profile. The raised centre section appears to indicate that this valley was carved out by melted water underneath a glacier.

Glacial RIGS in Herefordshire

The oldest Quaternary deposits in the region (Anglian glaciation) at *Risbury Bridge*, show gravels of a northerly derived cold stage river system, overlain by Anglian glacial deposits from a piedmont ice-lobe, which extended from Wales across Herefordshire as far as the Cradley Brook valley on the western margins of the Malvern Hills.

During a recession of the Anglian ice-sheet, when meltwater became impounded against the southwestern flanks of the Bromyard Plateau, a lake, 'Glacial Lake Humber', developed. A large 'Gilbert-type' fan delta formed. This is exposed at *Blackwardine* and *Stoke Prior*.

Overflow from the ice-dammed lake at Risbury Bridge ran southwards under the southern margins of the impounding ice-sheet, incising through the Risbury and Humber Formations and a further 2.5 metres into the underlying St. Maughans Formation, cutting Hill Hole Dingle.

The deposits at *Franklands Gate* and *The Vauld* were emplaced in a channel that was partially supported by the snout of the ice-sheet, during a recession phase of the Anglian ice-sheet. Extensive tectonic structures that characterise the exposures at Franklands Gate record minor oscillation of the ice-front. The gravels, containing large boulders, at The Vauld present a fine example of a 'hyperconcentrated' flood deposit. At *Much Cowarne* are deposits of a precursor to the modern River Lodon which must have had a much larger catchment area, forming part of a major, northerly derived drainage pattern that was re-initiated immediately after Anglian Cold Stage glaciation.

Following the Anglian glaciation, flights of four associated river terraces developed in the Lugg Valley. *Sutton Walls* forms the type section for the deposits of the oldest, the 4th Terrace of the River Lugg. The area around *Kingsfield* includes representatives of the Kingsfield (3rd Terrace of the River Lugg), Marden (2nd Terrace) and Moreton-on-Lugg (1st Terrace) Members of the Lugg Valley Formation.

The Devensian Glaciation was less extensive and mainly to the west of the modern Lugg Valley. The headwaters of the Lugg were cut and the River Wye became the dominant river in the area in the latter parts of the last Cold Stage. At *The Leasows*, a hummocky ridge, that formerly extended across the Stretford Brook Valley, forms the best morphological example of a terminal moraine in Herefordshire apart from the linear ridges that characterise the Late Devensian end moraine immediately northwest of Hereford.

The Holocene is represented on the margins of the *Dudales Hope Valley*, where morphological forms characteristic of mass movement, including back-scars, accumulation lobes and extension cracks are seen.

Members inspect the moraine at The Leasows

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GEOLOGY IN LITTLE COWARNE

Little Cowarne is a parish of some 280 hectares four miles south-west of Bromyard. The predominant bedrock is St Maughans sandstone and mudstone with the boundary between them and the earlier Raglan sandstone and mudstone close outside the southern and western boundaries of the parish. There is a small bed of St Maughans calcareous mudstone around grid reference SO612517.

Rock lies at or near the surface over much of the parish. There is an impressive exposure of sandstone on the south bank of the Sidnall Brook at SO600512. Here, near the base of the St Maughans Formation, the freestone has been undercut and at two places raised polygonal patterns can be seen on the underside of the lowest bed. This is evidence of desiccation and cracking of sediments below the bed. Cross-bedding is evident whilst the greyer rock of part of the exposure indicates the washing out of iron.

The British Geological Survey has identified three sites of Bishop's Frome Limestone within the parish. This limestone is a chemically deposited calcrete formerly called 'Psammosteus Limestone'. It is associated with the boundary between the St Maughans and Raglan Mudstone Formations. The BGS indicates a bed about 500 metres long and 50 to 60 metres wide along a ridge between approximately SO601508 and SO597507. At the western end is a pit marking the site of a lime kiln, demolished in 1931-2. It was fed from a number of workings in a small bed of limestone to the south-west of the kiln in the neighbouring parish of Ullingswick, and also from another bed some 600 metres to the north-east where a large but shallow quarry, which was filled in c.1950, can be identified. No workings have been found along the ridge.

A glaciofluvial deposit of sand and gravel, its centre at SO604507, was worked until the 1960s. The name of a house, 'Poplands' at SO604515, means 'pebble land' and close to the house there is a shallow depression marked on the 1905 Ordnance Survey Map as a sandpit. This and other similar deposits in and around the parish are associated with pre-Devensian glaciation.

A brick kiln stood some 50 metres west of the church but was demolished c.1930. Clay was dug from an extant, adjacent pit and from a further one, which has been backfilled, some 300 metres to the west. Bricks were fired for the construction of the two hop kilns with their distinctive brick roofs and other buildings at Little Cowarne Court c.1860-1880.

In one of the farm buildings use has been made of concretionary cornstones (calcrete nodules in a limestone matrix) which are found locally. Examples of cross-bedding can be seen in the sandstone of the church tower, close to the south-east angle about two metres above ground level.

The earthquake of 17 December 1896 caused slight damage in neighbouring parishes but none was recorded in Little Cowarne. During the winter of 1946-7 there was a landslip along a steep hillside running north/south through SO591509 which appears to have escaped the notice of the BGS. The landslip affected about one and a half hectares to the extent that mature trees were moved upright to a new position down the slope without visible damage.

We are most grateful to Paul Olver for his advice on several points in this note.

Charles and Jean Hopkinson

METEORITES

Dr Geoff Steel

Geology section, Woolhope Naturalists' Field Club

Introduction

Most of us have seen meteors, or 'shooting stars'. They are small particles, about the size of sand grains, which enter the Earth's atmosphere and burn up due to friction. Occasionally a much larger object, perhaps the size of a football, may come in. It gives a spectacular display. Lighting up the sky it can be brighter than the full moon and leave a trail lasting for several minutes, followed by a sonic boom which sounds like thunder. It falls to the ground as a meteorite.

Meteorites have been collected and studied for hundreds of years. There were many fanciful ideas about their origins. Serious scientific study began in 1794 when Ernst Chladni established that they were indeed extraterrestrial in origin, as opposed to volcanic. Invention of the petrographic microscope in the 1860s provided the basis for detailed analysis but studies were always limited by the great rarity of meteorites, there being a total of only about two thousand in all the world's museums until the 1960s.

Then in 1969 came a remarkable discovery. A group of Japanese glaciologists were working in the Yamato Mountains in Antarctica. One of them found a meteorite. They looked around and found eight more on the same patch of ice. Not knowing the significance of their discovery they simply packed them away for later study. On return to Japan the samples caused amazement. What mechanism had concentrated them into one place? And could there be more? Both Japan and America organised meteorite hunting expeditions.

Antarctica is a vast dome of ice. It flows outwards from the centre carrying with it any meteorites which happen to fall, the flow taking thousands of years. It is a treasure trove of meteorites but almost all are lost as the glaciers break away at the edges into icebergs. However if a glacier is impeded, say by a rock ridge underneath, then some ice becomes stagnant and its surface is ablated away by the wind. Any solid objects are left on top. Such a place is called a meteorite stranding surface and it was one of these that the Japanese had accidentally discovered.

The Antarctic expeditions have been greatly successful. We now have over thirty thousand meteorites. Their study has opened up an entirely new understanding of the early history of our solar system and the formation of the planets.

Meteorite Classification

Three kinds of meteorite have long been recognised: '*stones*', '*stony-irons*' and '*irons*'. *Stones* are themselves divided into two different types. To understand the full classification it is helpful to start in familiar territory. Figure 1 shows a cross section of a planet like the Earth. At the centre is an iron core surrounded by a mantle made almost entirely of olivine. On top is a thin crust, mainly of basalt (olivine + pyroxene + plagioclase). The planet is described as 'differentiated', meaning that at some time in its history it was completely molten, allowing the layers to separate like oil and water.

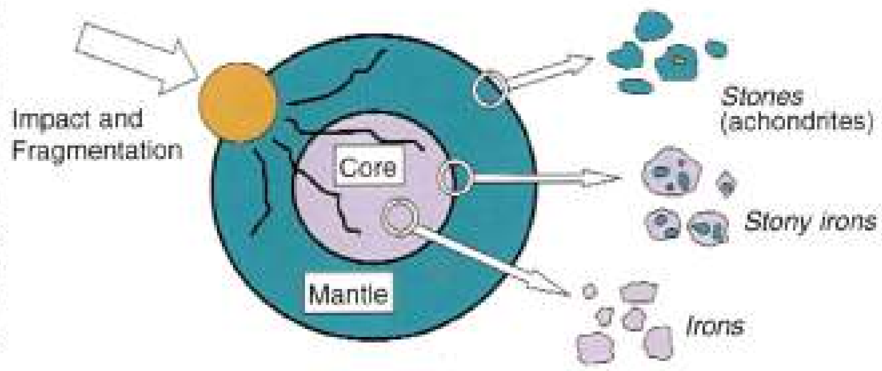


Figure 1 Origin of the differentiated meteorites.

It seems that the early solar system had many such planets, most of them far smaller than the Earth. Sometimes there were collisions. Impacts caused fragmentation into small pieces, which we now collect as meteorites. They are described as 'differentiated' meteorites due to the nature of their parent bodies. The figure shows *irons* to originate from the core, *stony-irons* from the core/mantle boundary, and *stones* from the crust. These particular *stones* are called achondrites.

The above description raises an obvious question: What were such planets originally made of before they differentiated?

In fact the differentiated meteorites are all quite rare. Over 80% of all meteorites are remains of the original material. They are *stones* called chondrites. The name refers to their primary constituent which is tiny spheres about 1mm in diameter. The spheres are called chondrules. Figure 2 shows a typical example.

Individual chondrules are composed mainly of olivine and/or pyroxene. Laboratory experiments show that they formed by sudden heating of dust particles, followed by rapid cooling. They are set in a dark matrix of olivine and pyroxene, with glass-like fragments of plagioclase and

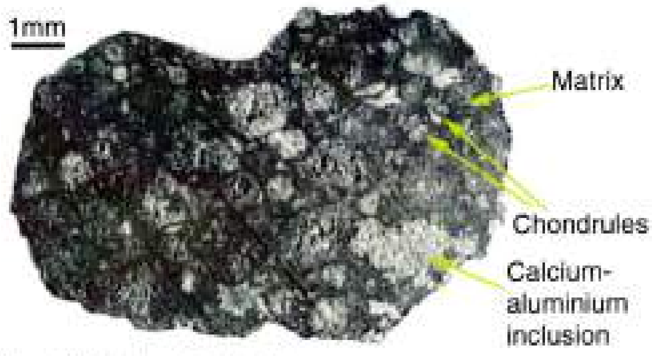


Figure 2 Section of a chondrite

traces of carbon. The matrix was originally dust and has been compressed to a solid. Some chondrites also contain iron particles and irregular inclusions of calcium and aluminium minerals.

Early investigators identified what appeared to be a metamorphic sequence within the chondrites. Some appeared unaltered, while others showed increasing effects of heating. The grades were numbered 1 to 6. The same sequence is still used today. However, it is now known that grade 3 actually represents pristine chondritic material, with increasing thermal metamorphism to grades 4, 5 and 6, but aqueous alteration producing grades 2 and 1. Classification is summarised in figure 3.

Class	Group	Metamorphic Grade					
		1	2	3	4	5	6
Carbonaceous	CI, CN, CR	■	■				
	CO, CV			■			
Ordinary	H, L, LL			■	■	■	■
Enstatite	EH, EL			■	■	■	■

Figure 3 Classification of the chondrites (grey = exists)

It is only in the carbonaceous chondrites that aqueous alteration is found. The presence of water indicates formation in a cold region and the same meteorites also contain organic compounds such as amino acids, which would be destroyed by heating. The amino acids are a mixture of left-handed and right-handed forms, showing that they were not biologically produced, but there has been much speculation about their significance as a supply of organic material to early life forms on Earth. Carbonaceous chondrites are divided into several groups based on chemical composition.

By far the most common meteorites are the 'ordinary' chondrites. They are divided into groups H, L and LL based on their iron content (high, low and very low). All were formed at temperatures too high to contain water, and most show thermal metamorphism.

Finally there are the enstatite chondrites. Enstatite is magnesium silicate (one of the pyroxene group of silicates) and only forms at high temperatures. There is a division between high and low iron contents, EH and EL respectively, with thermal metamorphism common in both types.

The Asteroid Belt

Some meteorites have been observed accurately enough when falling to calculate their original orbits. All have come from the asteroid belt. Hence it is that part of the solar system for which they provide the most detailed information.

Observations of young stars show that they form at the centre of flat spinning discs of gas and dust. In the outer part of the disc the clumps of dust attract by gravity, forming many small planet-like bodies called planetesimals. The process continues until all the dust is used up. The planetesimals themselves accrete to form planets. In our solar system the fifth planet, Jupiter, became so large that it prevented formation of any other planet nearby, any large object being torn apart by tidal forces. The result was the asteroid belt. It is the region between Mars and Jupiter where there are many small planetesimals (asteroids) that have never formed a planet. They are remnants of the original solar disc and we are fortunate to have meteorites as samples. The process is summarised in Figure 4.

In some parts of the solar disc the dust was heated above its melting point, forming the small spherical chondrules. The exact mechanism of heating is not known and is a subject of great debate among meteorite specialists. After cooling the chondrules were mixed back together with dust, perhaps by the early solar wind, and accreted into planetesimals. Those which accreted close to the sun included high temperature minerals like enstatite, while further away it was cold enough for water.

Older text books describe accretion as taking tens or even hundreds of millions of years. Meteorite studies show that it was actually a much faster process. The evidence comes from radioactive decay of the aluminium isotope ^{26}Al. Flat spinning disks from which stars originate are themselves formed by compression of gas clouds and in our case compression was caused by a nearby supernova. It produced the heavy elements up to uranium along with ^{26}Al which has a half-life of just 0.73Myr.

Figure 4 shows that, immediately after accretion, a planetesimal would have uniform composition of pristine chondritic material, in this example shown as L3. But decay of ^{26}Al caused internal heating. The result was metamorphism to successively higher grades towards the centre, leading to an 'onion skin' composition (metamorphic grades 3 to 6, as in Fig. 3). If the planetesimal was large enough (greater than about 20km diameter) the process continued to the point of complete melting, resulting in a differentiated body. Internal heating would be effective only within the first few half-lives of ^{26}Al. Therefore the whole process of accretion, metamorphism and differentiation must have been completed within about three million years.

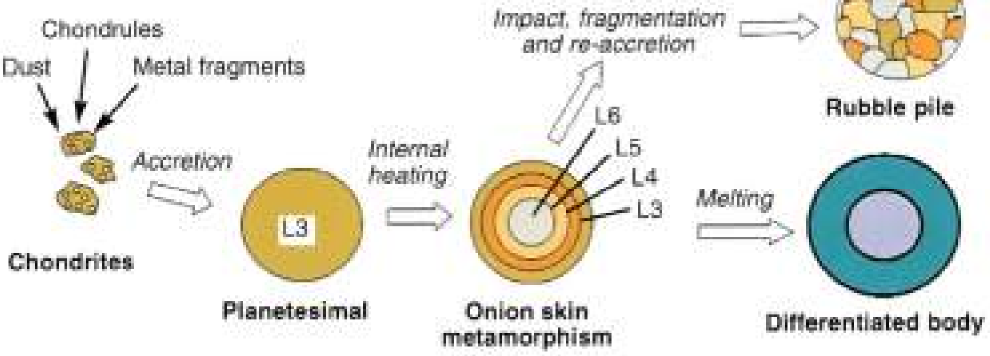


Figure 4 Asteroid formation

Most carbonaceous chondrites do not show the effects of heating. They contained the same concentration of ^{26}Al but they also contain water. The latter has such high heat capacity that the energy released by radioactivity caused hardly any temperature rise.

Figure 4 also shows that a planetesimal may be fragmented by a collision but reformed into a 'rubble pile'. Evidence for this comes from the many chondrites which are breccias made up of pieces with varying metamorphic grades. Further evidence comes from recent fly-bys of asteroids by the Galileo and NEAR spacecraft. Chondrites have a density of around 3000kg/m^3 but asteroids Ida and Mathilde were measured at 2600 and 1300kg/m^3 respectively, indicating significant internal voids.

Spectroscopic studies of the asteroids show a remarkable correlation with meteorite composition. Asteroids on the inner edge of the belt, close to the orbit of Mars, have spectra which match the enstatite chondrites, known to have formed at high temperature. At the centre the spectra match ordinary chondrites, while at the outer edge, in the cold region towards Jupiter's orbit, the spectra match carbonaceous chondrites.

HEDs, SNCs and Lunaites

Dating by Rb/Sr shows that almost all meteorites have the same age: 4.56Byr. This fixes very precisely the formation of the solar system. However a very small number are newer. They are all achondrites. Their composition is similar to basalt and their age indicates parent bodies large enough to retain sufficient heat for volcanism long after differentiation.

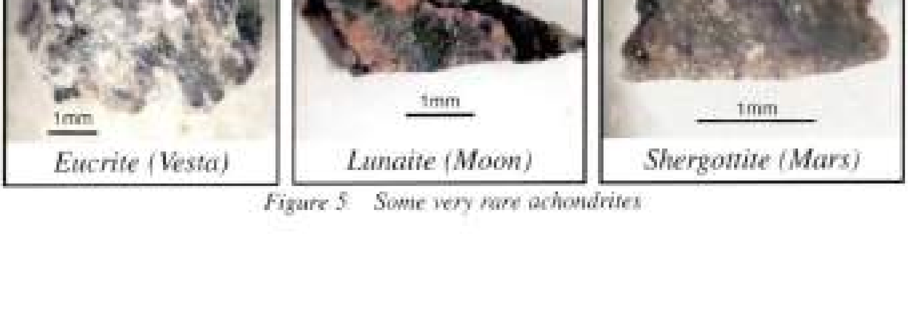
The oldest group are the HEDs at 4.4Byr. The initials stand for Howardites, Eucrites and Diogenites, all crustal materials. Spectral studies show that they match exactly with Vesta, one of the largest of the asteroids. Vesta's orbit is not in a position where material could easily reach Earth but there are several small asteroids called Vestoids, with identical spectra, which appear to be pieces knocked off it. They do have suitable orbits and are believed to be the source of the HEDs.

At the newest age are the SNCs, pronounced 'snicks'. The initials stand for Shergottites, Nakhlites and Chassignites, again all being similar to basalt. Their date is only 1.3Byr which implies a parent body much larger than Vesta. It was long suspected that they were from Mars. Unfortunately there were two powerful arguments against that theory. Firstly there was the mathematics. Analysis of crater formation showed that to achieve escape velocity would require an impact of such high energy that all ejected material would melt. But the SNCs have not been melted. Secondly there was a statistical problem. It is far easier for an object to reach us from the Moon than it would be from Mars, but comparison of achondrites with samples from Apollo showed that there was not a single lunar meteorite.

The problem remained unsolved until 1982. In that year an Antarctic expedition discovered an unusual meteorite quickly recognised as being lunar. Several more have now been found, they are called Lunaites and have ages between 3.1 and 4.0Byr. A notable feature is that they have not been melted. This forced a re-think of the mathematics, which predicted that Lunaites, like SNCs, should have melted. It was found that a very low angle impact could indeed cause acceleration to escape velocity without melting, and that the impact would produce an elliptical crater. Such craters do exist on the Moon.

So that brings us back to the SNCs. They really are from Mars. It is amazing that billions of dollars are being contemplated for a mission to Mars to bring back samples, yet we already have some!

Being so rare the HEDs, SNCs and Lunaites are priceless. But tiny fragments are sometimes available to collectors. Figure 5 shows magnified views of three examples. My thanks to John Payne for his skill in taking these photographs.



Eucrite (Vesta) *Lunaite (Moon)* *Shergottite (Mars)*

Figure 5 Some very rare achondrites

Members of the WGS Committee
(December 2005)

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

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Dr Sue Hay ***Programme Secretary***

Moira Jenkins ***Section Recorder***

Kate Andrew ***Heritage Services Representative***

Dr John Payne ***Newsletter Editor and Earth Heritage Trust Representative***

Charles Hopkinson

H&W Earth Heritage Trust

The past year has seen the Trust add further Geological Trail Guides to its already extensive list. The new trails are for Hampton Bishop, Woolhope Dome, Ross-on-Wye, Bodenham & Queenswood, Wye Gorge and Abberley Hill.

A new venture, in conjunction with the Geopark, is the planned use of Whitman's Hill quarry (near the county boundary, at Storridge) for educational purposes. The Trust has taken a ten-year lease of the quarry and has appointed Dr Abigail Brown as Project Manager. This project will greatly enhance the Trust's educational activities, already strong through the continuing programme of Rock & Fossil Roadshows.

In Summer 2006, EHT is to organise two Fun Days for schoolchildren. One will be held in Worcester, the other in Hereford. Volunteers to assist in these are keenly sought. If interested, please phone EHT : 01905-855184.

EHT's much-improved web site is now operating : www.EarthHeritageTrust.org.

The Trust is pleased to announce that Professor David Dineley, an expert on the Devonian and its fossil fishes, has agreed to become its President.

John Payne, *H&W EHT Representative*

Abberley and Malvern Hills Geopark

For the Geopark initiative to succeed, local communities must work together to preserve, protect and promote the geological heritage of the Geopark. To facilitate this the Geopark is funded by English Nature via the Aggregates Levy Sustainability Fund to employ a Community Liaison Officer.

The Community Liaison Officer will liaise with stakeholders, organisations and local schools primarily within three target areas. These were established as part of the pilot Local Geodiversity Action Plan produced by the Geopark and include the Teme Valley, May Hill and South Shropshire areas. Strategic partnerships will be established and community groups will be encouraged in the development of future initiatives and participation in community-based events. These events and initiatives will be communicated via our newsletter and website.

Another aim of the Community Project is to create a series of trails within former aggregate quarries. The geology and biodiversity trails will be free of charge to groups and individuals. Three of these trails will be launched in International Geopark Week in June 2005.

Contact Rona Davis for further information on the Community Liaison Initiative: rona.davis@worc.ac.uk; 01905 855185

Dr Cheryl Jones,
Director, Abberley and Malvern Hills Geopark

Herefordshire Heritage Services

The refurbished facility opened in December 2004 and since then we have welcomed 329 visitors to study specimens, objects and reference material, 393 others in 47 tours and a further 345 visitors in three open days.

We have also been planning for the new build extension which will create a display area, a learning room to seat up to sixty people and enough space to house all of our collections and staff. The decision on funding will be made at the end of this year.

One aim is to offer adult education day schools and evening classes. A number of providers are interested in using the centre for this. As a pilot, we will be running a day school of Fossils at the centre on Saturday, 18th February 2006 through the University of Warwick.

We wish to hear from people wanting to use the centre in future for classes, meetings or a group visit. If we obtain our funding, the contractors will be on site from March 2006 to April 2007 and during this period we won't be able to offer group visits. If your group would like to visit, please contact us soon to book (01432-383383 or herefordmuseums@herefordshire.gov.uk).

Kate Andrew, *HHS Representative*