Issue 1 June 2016

The Silurian

The Magazine of the Mid-Wales Geology Club

Contents

Cover Photo: Tan-y-Foel Quarry ©Richard Becker

All photographs and other illustrations are by the author unless otherwise stated.

Welcome to the first edition of "*The Silurian*". I hope you all enjoy the articles and I would like to thank all those who have contributed. I have tried to ensure a variety of topics as each of you will have some aspects of geology you prefer over others.

This is just the beginning and as with all publications, I expect it to change and morph over time into what you, the members, want it to be.

Michele Becker

Mid-Wales Geology Club members. Photo ©Colin Humphrey.

Submissions

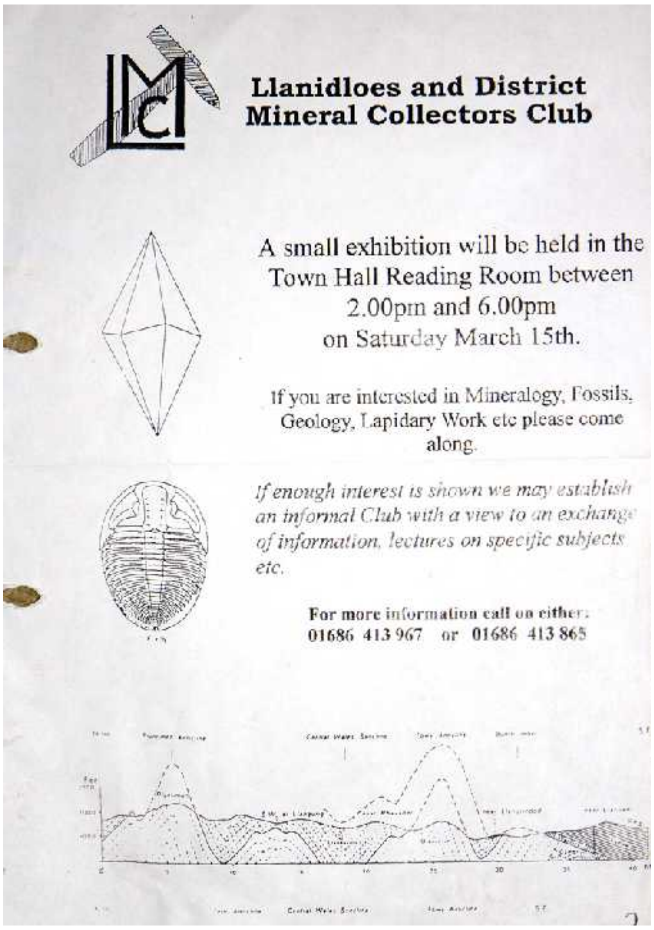
Submissions for the next issue by the beginning of October 2016 please.

Please send articles for the magazine as either plain text (.txt) or generic Word format (.doc), and keep formatting to a minimum. Do not include photographs or illustrations in the document. These should be sent as separate files saved as uncompressed JPEG files and sized to a minimum size of 1200 pixels on the long side. List captions for the photographs at the end of the text, or in a separate file.

Origin and Development of the Club

Efforts to establish a local geology group in Mid Wales were made first in the 1960s and again in the 1980s. They proved unsustainable in such an underpopulated area. A further effort in the late 1990s succeeded, by treating the whole of Mid Wales as a catchment.

The start
Mid Wales Geology Club began as the *Llanidloes and District Mineral Collectors Club* founded by Bill Bagley and the late Jim Nichols in 1997. Both keen mineral collectors, they met through site visits of the Russell Society and decided to test interest in the Llanidloes district. A one-day exhibition in the reading room at Llanidloes Town Hall on 15 March 1997 attracted forty visitors, and was followed on Tuesday 1 April 1997 by the first small meeting of interested parties at the Trewythen Arms in Llanidloes.



1997 Poster advertising the first exhibition.

The first organised evening talk took place on 22 April 1997 in the Baptist Schoolroom, Llanidloes, with Peter Williams speaking on local geology. In the first year there were six more evening meetings (four practical and two talks) and nine field visits mostly to mines and museums), some very well attended: thirty people at Dylife and twenty-one at View Edge Quarry, better than most recent field trips.

Jim Nichols at the 1997 exhibition. Photo ©Bill Bagley.

Widening the scope
During 1998 it became clear that the centre of activity had to move to Newtown. A small exhibition for one week in Newtown attracted 300 visitors, and a name change led to the *Mid Wales Minerals, Fossils & Geology Club*, with meetings held monthly in the Town Hall, Newtown. The name was simplified in 2007 to *Mid Wales Geology Club.*

The Club quickly became established in its present form. In 2002 membership reached twenty-four, holding eleven evening meetings (five with guest speakers) and nine one-day field trips (reduced to six per year in 2012). More space soon became necessary for evening talks, and the Club moved from the town hall to modern premises at Severn Media, Mochdre Estate, Newtown, remaining there for five years.

Field trip to Hendre Quarry led by Prof. David James. Photo ©Richard Becker.

We affiliated to the Geologists' Association in 1998. Since then the GA has guided our aims and objectives. Our membership of the Federation of Lapidary and Geological Societies ceased around 2005 when that federation was dissolved.

2005 saw the introduction of our most successful regular event, the Club's annual summer weekend. Members stay for two or three days. Guest leaders have shown us the geology of places like the Peak

District, Pembrokeshire coast, Anglesey and the Mendips. Growing membership led us in 2007 to the present evening venue, Plas Dolerw, a delightful community conference centre in Newtown. With a membership now in the mid-forties the Club finds itself on a secure footing, allowing the annual subscription to be held at £15 for many years..

Members with Dave Green on Nyland Hill, near Cheddar.

Recent years

2007 was a special year, with a public outreach programme, *Land Of My Fathers,* undertaken with support from the National Lottery and the Geological Society of London. In cooperation with the Welsh Mines Society the Club ran a large and well attended week-long exhibition in Llanidloes, describing the local geological history. Seven evening talks by distinguished experts described different stages of development. Two hundred primary school children enjoyed scientific activities, and there were several field trips for the public.

A second outreach programme took place in 2012. Welshpool's Geological Heritage Project involved a museum-quality exhibition in Welshpool for three months, of fossils collected locally during the 19th century, owned by Powysland Museum but on permanent loan and in store at the National Museum of Wales. A Welshpool town geological walk was established, together with numerous other activities. Once again the Heritage Lottery Fund provided support. More recently a building stones trail has also been established around Llanidloes.

Most years the Club arranges a temporary exhibition somewhere, centred around the extensive specimen collection assembled and cared for by Bill Bagley. It is one of the best in Wales in private hands. A club website was re-designed in 2012 and is populated with interesting material, including soon a digital archive of some of Bill Bagley's collection.

Although some members of the Club are experts, and the local geological professionals are very supportive, Mid Wales Geology is very much an amateur club, aiming to offer interesting activity for beginners, as well as those with more experience. The earth sciences are fun and the idea is to help people enjoy the subject and learn about our geological heritage. Recent activities have also included an evening course for beginners, and work with Central Wales RIGS (regionally important geological sites).

MWGC is one of numerous geological societies in Wales and the Borders, but the only one serving central Wales. The others are: North Wales, and South Wales Geologists' Associations; Open University Geological Society Severnside branch, based in South Wales; West Wales Geological Society, in Aberystwyth; the Llandrindod Wells Fossil Group; Shropshire Geological Society; and the Geology Section of the Woolhope Club, based in Herefordshire. Amateur geology is thriving in Wales.

Colin Humphrey

Member's Photo

I took this photo, of a stalactite forming, on 01/02/2016, in the northern side of the axial passage of the West Kennet Long Barrow, which is situated just over a mile from Avebury, in Wiltshire. Built in the Neolithic, about 3250 BC, this tomb was used for collective burials, for up to 1,000 years. The Barrow was among the first to be classified by the Ancient Monuments Act of 1882.

The tomb is constructed of Sarcen boulders (from a Siliceous layer which formed 50-70 Million years ago), collected from the Marlborough Downs. The spaces between the boulders were filled with limestone slabs, brought from Oolitic deposits 20 miles to the SW, in the Bath/Frome region, and other infill from Corallian formations 7 miles away, near Calne.

Source: Department of the Environment Official Handbook 1980 L. Vatcher MBE. And F de M Vatcher FSA.

Mel Dooley

Mineral Musings

I guess the word 'mineral' could keep interested parties debating for hours as to how it should be defined. As a chemist, I think of a mineral as being the source of some useful metal or other elements which we use to make the things we think we need or desire. They are usually chemically well defined and for which a chemical formula can easily be written (FeS_2 for Pyrite or Al_2O_3 for Corundum). This is opposed to many 'rocks' which are often non-stoichiometric, that is they contain elements which are not necessarily in nice whole number ratios to each other and whose

Cubic iron pyrite crystal. Photo ©Richard Becker

composition can vary substantially across an area or even a sample. Before my more geologically qualified colleagues start to 'tut', there are of course many, particularly sedimentary rocks, which do have a classical formula with the commonest examples being chalk, limestone and marble (all forms of Calcium Carbonate, $CaCO_3$) or dolomite (Calcium Magnesium Carbonate, $CaMg(CO_3)_2$). For the purposes of this article this is all a bit academic, my intention was to think about a few of the minerals I've come across in a quite varied career which are, or have been, used more or less as they are found and to try and find some with at least a tenuous local connection.

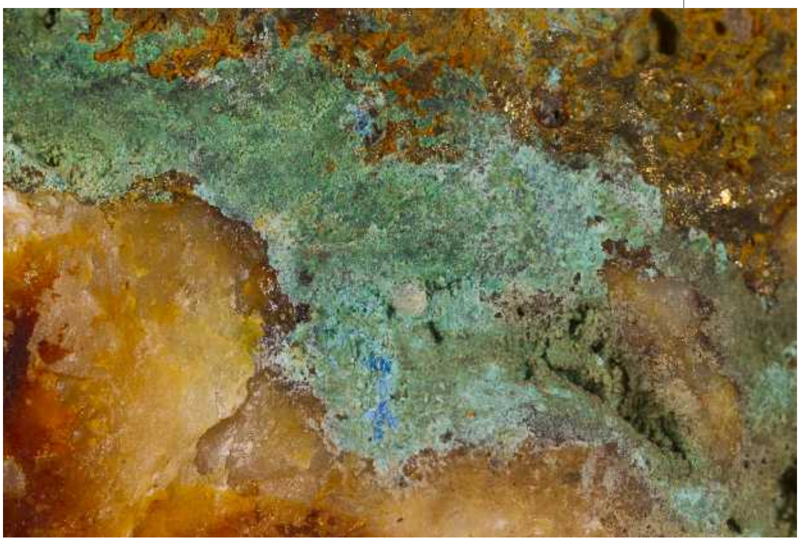
The first which comes to mind, I've already mentioned, Iron Pyrites. Pyrite is very common but many people are unlikely to be aware of it's uses in the 'natural' form. Some years ago while working with the Tube in London, we were looking at ways to improve the wear resistance of ceramic tiles and make them less slippery. In most circumstances you don't think of flooring tiles wearing out but you can imagine how many feet go through the ticket gates at say, Tottenham Court Road station in central London or up and down the steps at South Kensington to get to the Science museums. When I worked there, Victoria was the busiest station but has more access points than the previous two. Because pyrite is very hard, is refractory and its brittle cubic nature gives it sharp edges and corners, it can be incorporated into the surface of tiles and even metals. One of the most durable quarry tiles used to be produced by the Dennis company in Ruabon and incorporated pyrite into the surface. Sadly these are no longer produced but if in London, look for the brass toe-strips on the edge of the steps down to the platforms on many of the old tube stations and you can see the included mineral. Pyrite has interesting electrical properties and was used in the last century along with lead sulphide (galena) as the detector in crystal radio sets. It can be used to manufacture photoelectric cells although a synthetic material also including copper sulphide is more commonly used these days. For similar reasons, pyrite is also used in some brands of rechargeable batteries (Lithium-ion) where it acts as the cathode in the cell.

Thinking of electricity takes one very conveniently to copper. Having been fortunate to have spent quite a lot of time in Scandinavia, I am more aware than most of some of the similarities between the UK and the more northern countries of Europe including some of the geological and mineralogical ones. We are all aware of Parys mountain on Anglesey, source of copper since ancient times, but less will know that a similar feature exists in Sweden. The Falun mine is about 160 miles north of Stockholm and traditionally known in Sweden as 'Great Copper Mountain'. Like the site at Amlwch, it

The Falun Mine. Source Creative Commons by Lapplaender.

is less of a mountain and more a very large hole in the ground and was once the largest copper mine in the world. It was worked until late in the last century and is now a world heritage site. My link to copper comes from work with pigments and colours in both the ceramics and paints industries. Historically copper ores, particularly azurite ($Cu_3(CO_3)_2(OH)_2$) and malachite ($Cu_2CO_3(OH)_2$) both basic carbonates from oxidised copper ores, have been used for producing scripting inks, artists paints and for the pigments used in ceramic glazes. It is interesting to note that sometimes ancient blue paints are attributed to lapis lazuli, which is a semi-precious complex silicate when in fact the material is often actually azurite. In more recent times these minerals have been almost always imported but previously some were produced from Welsh minerals notably as a side product from other quarrying. Most recently for all but most specialised applications like artistic restoration, modern ceramic colours and glazes are usually based on synthetic zircon ($ZrSiO_4$) with vanadium included to produce a strong blue and praseodymium to make yellow and then mixed to give green.

Swedish house painted with red oxide.



Copper Minerals. Photo ©Richard Becker

There is a further link between the minerals from Sweden and Wales in that much of the copper found in both is associated with chalcopyrite, mixed copper iron sulphide ($CuFeS_2$). When smelted, a very red form of ferric oxide (Haematite, Fe_2O_3) is formed as a by-product and can be used to produce ‘red oxide’ paint.
This is the reason why so many of the traditional wooden houses in Scandinavia are painted a deep rusty red as it helps to preserve the timber. It is still possible to by cans of “Falu Röd” as it is known in Sweden from the heritage shop at the Falun mine. Other by-products of copper production from sulphide ores are antimony and selenium. Antimony which is almost as poisonous as arsenic was used in Elizabethan times as a cosmetic when the ground mineral stibnite (Antimony Sulphide, Sb_2S_3) was used as an eye liner. Today it finds uses in semiconductors and is used on the striking surface of a box of safety matches. Indeed the simplest test for identifying stibnite is to strike a safety match on the crystals which are knife-blade like and silver grey. Because of the relatively common occurrence of both copper ores and pyrites in Wales and their associated sulphur and selenium (found as Pyrite analogue, Ferroselite $FeSe_2$), levels of the latter are higher here than for the rest of the UK and also in parts of in Cornwall and Cumbria. Selenium levels are monitored by the British Geological Survey (BGS) as, whilst essential in traces to humans and in many ways beneficial, it is absorbed by grass from the top soils and hence through animals into the food chain. Whilst only a minor risk to health, supplements containing selenium are not really recommended in Wales as most people get more than they need. A similar situation arises in Derbyshire where there is already more than enough fluorine in the water supply from fluorite minerals to make fluoridation inappropriate.

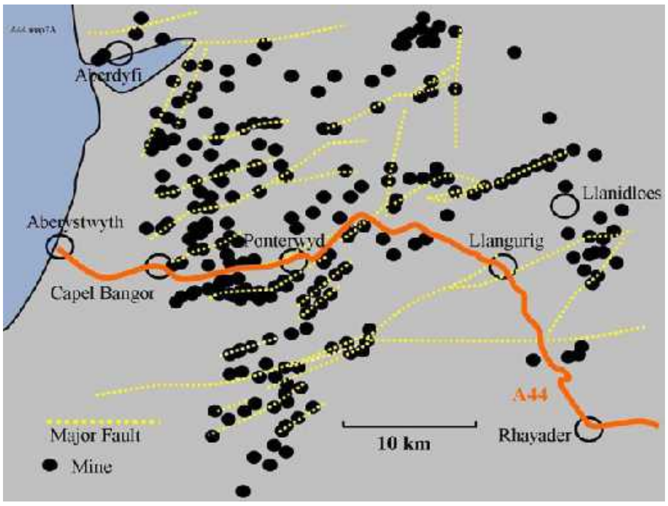
The arsenic analogue of pyrite, logically known as arsenopyrite ($FeAsS_2$) is also found throughout Wales in association with copper mines and also those where lead and gold have been extracted. At Dolaucothi Gold Mine in Carmarthenshire, the amount of arsenopyrite and pyrite associated with the gold made ore-processing so difficult that before world war two the ore had to be shipped overseas for the gold to be extracted.

Steve Moore

The Metal Mines of Mid-Wales: Where are the lodes?

(Structural & Stratigraphic controls on the Central Wales Orefield)

In November 2007 Dr David James FGS, then visiting professor at Cardiff University, gave an elegantly simple and splendidly illustrated talk to Mid Wales Geology Club in Newtown, on the factors determining



Mines in the Central Wales Orefield. Almost all the mineralisation is on ENE aligned faults (only major faults shown).

the location of the ore lodes in the Central Wales Mining District*. The facts remain relevant and worth reprise. The ores, mostly lead and zinc sulphide, are contained in rock formed in the Welsh Basin during Ordovician and Silurian times. Metals in ionic form, widely disseminated in this rock at depth, were scavenged by hot fluids flowing slowly, due either to large pressure gradients or thermal (density) gradients. The mineral-rich hydrothermal fluids used mostly faults, but also joints, to escape upwards from depth. Ore precipitation was largely the result of cooling, depressuring being of minor impact except where there was release of a gas phase. Subsequent erosion exhumed the ore deposits, leaving them close to the surface, making mining economic.

An oil industry reservoir analysis approach was adopted to explain the location of the ore lodes. The topography of the floor of the extending Welsh Basin was governed by major faults, which produced a series of half-grabens with dip slopes facing east and 'scarps' facing west. Sedimentation was therefore complex, with the development of variable facies (recognisably different bodies of rock) and a very variable thickness of the rock sequences in which fractures subsequently occurred. Lode sites were determined by differences in permeability of deformed rocks after fracturing.

There were two major phases of mineralisation, the timings of which are known from study of lead isotopes in the ores. In the first phase, around 390 million years ago, the hydrothermal fluids formed mostly from dehydration of minerals during burial metamorphism. These over-pressured fluids moved very slowly through the rock towards the surface, when permitted to do so by the developing permeability caused by uplift during the Acadian Orogeny. The rocks were strongly folded and the fluids accumulated preferentially in anticlinal apices (tops of upward folds) and in upward-pointing pinched-out strata. Fluid movement was so slow that sites of mineralisation developed 5-10 million years after rock deformation and metamorphism.

Ruined buildings at Bryntail mine, now with the Clywedog Dam looming over it. Photo ©Graham Levins

Initially the sandstone beds were around 30 percent porous, with interconnected pores creating high permeability. The original mudstones were even more porous, typically 40-50 percent but less permeable, being without comparable interconnection of pores. The country rocks in Mid-Wales were then deformed, lithified and mildly metamorphosed before mineralisation, so that porosity became very low, with permeability governed almost exclusively by fracture. Sandstones and multi-layered sand/shale sequences were relatively brittle, fracturing to form joints and faults, thus easily transmitting hydrothermal fluids. Shale horizons, more frequent and thicker in the overlying Silurian, were much less permeable, being more ductile, and therefore capping and sealing hydrothermal fluid reservoirs in the underlying sandstone. The *Monograptus sedgwickii* shale of the Lower Silurian was a particularly effective cap, as it easily deformed plastically.

Hydraulic brecciation (pressure shattering) of mudstone, in precipitated quartz. Dylife mine, Central Wales Orefield. Photo ©Bill Bagley.

Geomechanics predicts that, for a given value of vertical load stress, the greater the fluid over-pressure in the fault host rock, the greater is the chance that the fault dip will steepen from the value it would have taken at lower fluid pressure. Larger lodes in the orefield often dip steeply, 75 degrees or more, on normal faults produced during extension. Faults often show slickensides (scratch marks) indicating the direction of movement of rocks in the fracture zone. However, the character of the faults changed as tectonic conditions changed, unfortunately obliterating the evidence of earlier fault movement.

A large volume of hydrothermal fluid was needed to deposit the larger lodes, probably in a series of releases. Fracture channels would have occluded with ore, re-sealing and allowing over-pressure to re-build. Many thousands, or even a few million years later, further movement on the fault could then release another accumulation of mineral-rich fluid. Evidence of previously brecciated rock, contained within a later brecciation, indicates a multi-stage process. Fluid movement was aided by secondary porosity caused by dissolution of minerals cementing the rocks. Calcareous cement dissolves more easily than silica cement, perhaps explaining why the silica-cemented rock of West Wales does not contain useful secondary porosity. In the second major phase of mineralisation, 360 to 330 million years ago, there appears also to have been convective circulation of very large volumes of fluid, as further tectonic extension increased both horizontal and vertical permeability of the rock.

Continental collisions of the Acadian Orogeny subjected Ordovician and Silurian rocks of the Cambrian Mountains to compression and mild sinistral shear. The north-western edge along the Menai Strait was pushed down-left, and the Welsh Border was pushed up-right, leaving basin-bounding faults with NNE alignment. The region then relaxed around 390 million years ago in the early Devonian. Compression changed to extension, reversing the shear direction to dextral, and opening dominantly ENE faults within the orefield. This faulting under extensional conditions released the accumulated mineral-rich fluids from their host rocks by fracturing the impermeable sealing shales. Some of these faults in the orefield have throws of hundreds of metres.

When fluid in the rock at the top of the fault was suddenly connected to the higher pressure of fluid in the deeper rock at the bottom of the fault, the rocks at the top became more easily susceptible to fracture. Where the fracture produced a transient void at its tip, the rock might then explode and form a breccia. The speaker showed several striking photographs of orefield hydraulic brecciation. Competent rock like sandstone is more prone to brittle fracture than less competent, softer, more plastic shale. Therefore faults tended to initiate in sandstone, which explains the many productive mines in the Van Formation of the Upper Ordovician; and in the Cwmystwyth Formation, and Ystrad Meurig Grit facies of the Derwenlas Formation, both in the Lower Silurian.

Economic lodes in the orefield are generally on faults with the biggest throws; and commonly in high points

Nant yr Eira (Snowbrook) Mine. Photo ©Bill Bagley.

of the containing strata, above anticlinal closures, especially above those in thick sandstones; and where potential shale seals were not thick enough to preclude upward escape of fluids. This explains the rich lodes at Dylife, Van, Cwmsymlog, Frongoch, Logaulus and Cwmystwyth. Few ores are found in the Plynlimon Dome itself as its apex position permitted fluids to rise into Silurian rocks which have since been eroded. Between Llanidloes and Rhayader no good lodes have been found because fewer suitable fractures were initiated in the Silurian strata there, and the thicker shale of this district may not have allowed fractures at depth in Ordovician rock to reach the present-day surface.

Spoil tips, a common site in the orefield. These are at Nantiago, once known as Plynlimon mine. Photo ©Graham Levins.

The possibility of future small-scale economic mining in the orefield, subject to planning constraints, cannot be ruled out. Shallow mines would be the most attractive because deep, wet mines need to be pumped and, although metal prices have increased [they have since decreased], so have energy prices. Silver was once extracted from lead ore bearing tetrahedrite, which is a complex metal sulphide with some silver, especially found at Cwmsymlog. Zinc ore is also locally rich in silver and might form a future target. Modelling might indicate where further deposits lie. A combination of high precision GPS and digital instrumentation now offers the first realistic chance of using geophysics to locate ore shoots. Reworking of spoil tips for minerals would not be practicable. It would disturb toxic waste and be uneconomic because of the consequent environmental obligation.

* Four years later Professor James published a paper expanding on this subject: Turbidite pathways, pore-fluid pressures and productivity in the Central Wales Orefield, James DMD, Journal of the Geological Society 2011; v. 168; p. 1107-1120

Colin Humphrey

Fossils in the News

The 29th April edition of the online science blog, IFLSCIENCE (http://www.iflscience.com/) by Tom Hale reproduced a terrible news story originally in the Indian media on 26th April 2016.

In the early hours of Tuesday 26th April 2016, fire swept through the National Museum of Natural History in New Delhi destroying thousands of specimens of immense value to both science and culture for the subcontinent.

For geologists the most tragic loss will be the 160 million year old Jurassic dinosaur specimens as well as minerals and rocks from the region. Preserved botanical and zoological displays were also destroyed.

What a terribly sad day for palaeontological science and the Indian life science community. The director of the museum, Dr. Venugopal, told the Indian Express: *"All exhibits were precious. We feel really sad that all our work is gone."*

To me, it brings back to memory the loss of the north African dinosaur specimens from the Bavarian State Collection of Paleontology (including the type specimen of iconic predator, *Spinosaurus*). These specimens were destroyed almost on the same date – 25th April again by fire, after a British bombing raid of Munich in 1944.

Sara Metcalf

National Museum of Natural History, Delhi. Creative Commons.

Fossil Focus – Trilobites

What is not to like about a trilobite?

Often a complete and perfectly preserved fossilised animal, with beady eyes looking directly from the distant past straight at you. Sometimes caught in the action of enrolling. A beautiful fossil discovery to enliven up a particularly dull grey Palaeozoic mudstone!

The amazingly preserved compound eye with 'eye-shade' of Erbernochile erbeni. Picture reference Moussa Direct Ltd. image archive on Wikipedia.

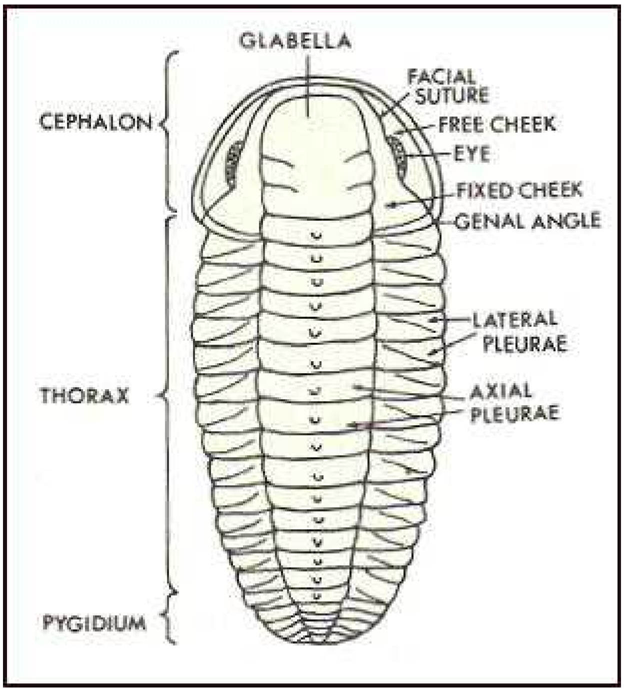
Although you all know me as the 'dinosaur lady' – I have always had a fascination for fossil bugs. Trilobites are the supreme example of a fossil bug; they practically scream 'extinct type of woodlouse' at you when you first catch a glimpse of one. When I worked at Powysland Museum, the trilobites were always the public's number one favourite fossil.

So what exactly are trilobites?

Certain trilobite species resemble large fossilised woodlice, horseshoe crabs or beetles, and they are related to all of these extant taxa being part of that vast phylum, the Arthropoda. However, they form a distinct and sadly, extinct class of arthropods rather than being crustaceans like the woodlice or coleopterans like beetles.

Kingdom:	Animalia
Phylum:	Arthropoda
Subphylum:	**†Trilobitomorpha**
Class:	**†Trilobita**

Palaeontologists believe there were 11 distinct orders of trilobites and for over 270 million years, they were one of the most successful marine animals in the Palaeozoic seas. They first appear in the fossil record in the early Cambrian and crawl, float, burrow and swim their way through all of the Palaeozoic era until finally succumbing to annihilation in the mass extinction event that occurred at the end of the Permian period.



The general body plan of a trilobite. Picture source http://www.ammonite.free-online.co.uk/ftrilo.htm

The name trilobite means 'three lobed' and if you look at a basic body plan of a typical fossil you can see where the name originates.
The basic shape (rote learnt by 1st year palaeontology students across the land) is cephalon, thorax and pygidium (tail). These parts form the exoskeleton of the beasts and are the most easily preserved in the fossil record – either as a whole animal or as individual parts left behind when the creature moulted during its life.

Trilobite 'head shields' or cephalons are probably the most fascinating parts. For a start, many sport the earliest functioning compound eyes in evolution, with individual crystallised lenses still being discernible on many a fossil find. They also have the massively inflated central part known as the glabella; it looks like a comical nose, but it actually housed the animal's stomach! The cephalon shows an arrangement of lines, known as facial sutures, which palaeontologists really get excited about because they help with classification of different species, but in life actually helped the animal moult. Underneath the cephalon, trilobites also have their mouthparts.

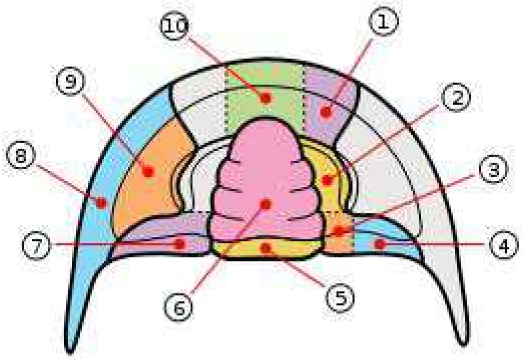


Diagram showing the detailed areas of the cephalon of a trilobite. Open source from Wikipedia. Numbered divisions 1 – preocular area; 2 – palpebral area; 3 – postocular area; 4 – posterolateral projection; 5 – occipital ring; 6 – glabella; 7 – posterior area; 8 – lateral border; 9 – librigenal area; 10 – preglabellar area.

Some species also exhibit numerous and extravagant spines, perforated sensory fringes around the edges of the cephalon, antennae that could be retracted into the head shield and all manner of ornamentation from lumps to bumps!

An extravagant looking Walliserops trifurcatus, from Djebel Oufaten, Morocco. Picture source: Wikipedia Kevin Walsh - originally posted to Flickr as Trilobite 3

The thorax of a trilobite is segmented into overlapping plates called pleurae. Underneath these segments were the soft appendages such as legs and gills. Some species have legs with claws for crawling and walking, while others exhibited feathery gill projections that were used for swimming as well as for respiration. The last segments of a trilobite are fused together to form the hard, protective tail known as the pygidium.

An enrolled Flexicalymene meeki; Waynesville Formation; Upper Ordovician; Caesar Creek, Ohio. Specimen collected by Eve Caudill. Open picture source from Wikipedia

Probably the most endearing thing about trilobites is the fact that many fossils are found rolled up, reminding us of the woodlice we find in the garden. This is clearly a defensive mechanism, with the animal attempting to protect its soft parts under the exoskeleton from whatever danger it faced. Sadly for the individual animal, but fortuitously for the discoverer of the fossil, this strategy may have worked when being threatened with an anomalocarid, sea scorpion or shark predator, but didn't help when there was an ash fall or mudslide.

If you want to find out more about trilobites I can recommend the following:

Richard Fortey (lead researcher at the Natural History Museum, London; BBC broadcaster and author of many brilliant general palaeontology books) has published countless articles on the fascinating arthropods. His book Trilobite! Eyewitness to Evolution is published by Harper Collins (2000) is available as hardcopy or Kindle version online. It is essentially a love-letter to the beasts he has made his life's work.

My Favourite Trilobite

Living for the past 9 years in mid Wales, there can only be one favourite trilobite for me: *Salterolithus caractaci* named by the renowned Victorian geologist, Roderick Murchison. This small beastie – specimens are normally between 2-3cm in length is also known locally as the 'Welshpool Bug' and their abundance in the Caradoc (Ordovician) of the town has given one site the apt name of Trilobite Dingle.

It has no eyes, but instead features a pitted fringe around the edge of its massive cephalon. Palaeontologists think that *Salterolithus* burrowed into the muddy seafloor. It is possible the pits in the frill contained sensory hairs that were responsive to changes in current direction, so that the little animal could always keep its head directed toward particles of food drifting in the current.

Salterolithus caractaci is affectionately known by Welshpool school children as 'Tiny the Trilobite'. Photo ©Colin Humphrey.

At Powysland Museum, specimens of this endearing little animal are displayed, along with a detailed description by the author and a wonderful recreation of the palaeoecology of the Trilobite Dingle by fossil artist, Bob Nicholls.

Keep Fossicking!

Sara Metcalf

Ordovician Trilobite Gravicalymene arcuata from North Wales. Photo ©Richard Becker

Geological Excursions

Sites to visit.

Excursion Number 1

Gilfach Farm Nature Reserve (Radnorshire Wildlife Trust)

Location

Signposted off the A470, 3 miles north of Rhayader, on a back road to St Harmon
Rhayader
Powys
LD6 5LF
Car park at SN953715

Gilfach Crags - Concretions in one bed, eroded away.

In some ways Gilfach geology is simple as all the exposed bedrock is from just one formation, the Rhayader Mudstones Formation. In the reserve, exposures are generally weathered and covered in lichen; but there is a comparatively fresh exposure **just outside the entrance on the A470 road cutting. (*Take care the road can be busy)*** This was seen to be an attractive green-grey fine grained rock in which individual grains are too small to be visible to the naked eye, hence it is classified by geologists as a "mudrock". It was laid down some 430 million years ago in quite deep water and is part of the Llandovery Series of the Silurian System.

The rocks show a marked directional "grain" at a steep near vertical angle dipping (or sloping) towards the north-west. This is nothing to do with the beds as they were deposited, but is "cleavage" developed much later by tectonic strain at moderate temperatures and pressures. It is less developed than in slates, so these mudrocks would be termed shales.

Picking out the signature of the original bedding is more difficult. It shows as more subtle changes in colour and texture which can be picked out dipping much nearer the horizontal. On some cleavage faces the bedding shows as a ripple effect when the direction of cleavage differs slightly as it meets different beds. This is known as “cleavage refraction” and is caused by the cleavage tending to align itself more towards the bedding direction of muddy beds as compared to sandier ones. The bedding here is quite thin, being from a few cm to tens of cm. Each bed represents an “event”, specifically a muddy flow from a shallower shelf area in the east into deeper water here. It could have been triggered by a storm or similar disturbance and is termed a turbidite. Each turbidite could have been followed by a quiet period in which very thin laminae may have been deposited from the undisturbed waters above. These are termed hemipelagites and may be dark grey, pyritic and carbonaceous if deposited in anoxic conditions, with no life surviving; or lighter grey and mottled with burrows if animals lived there. Other near vertical faces are “joints”, which are produced much later as pressure on the rock is reduced as it is brought nearer the surface by earth movement and erosion.

Along the river Marteg.

Walk back into the reserve and up to the crags on the hillside facing the parking, here you will find similar directional features. The cleavage again steeply dipping in the same north westerly direction and this is turn out to be true all over the reserve to within a few degrees. It is a “regional cleavage” and is remarkably consistent over a large area.

The bedding, however, told a different story, it dips in different directions as you look around. In some places it is folded into synclines (downward) and anticlines (upward). Displacements in the bedding occurred where small faults existed. Some beds have been partially eroded away where lines of concretions had been preferentially eroded out.

The structure of these rocks tells of a complicated story going back some 430 million years to a time when

Potholes in the river. ©Photo Richard Becker.

Wales was attached to the north of small continent which geologists call Avalonia. This was somewhere south of the equator, drifting slowly north towards a larger continent, Laurentia, later to become North America. It was starting to feel a soft collision with Laurentia. This was complicated by it not being a straight head-to-head collision, but at an angle, with some transverse movement. Further complication was introduced by the probable impact of another continental fragment, Baltica, from the east. The three way collision did not produce simple concertina folds, but something more like a crumpled sheet of paper, which is what we see in the variously dipping bedding planes. Cleavage developed much later (about 390 million years ago) in the Devonian period when the collision pressure peaked just as today in the Himalayas, where the Indian sub-continent is in collision with Asia.

After you have finished examining the crags on the hill side follow the nature trail along the river. In the river itself there are some of the best potholes you will find anywhere, some quite “Henry Moorish”! No doubt the cavities left by eroded concretions helped start the potholing process. Pebbles carried by the river in turbulent eddies when in spate complete the process by abrading, expanding and making the cavities circular.

What went on more recently during the Ice Age? The Wye valley going north is wide and there are ice eroded cwms exiting into it, so it was ice filled; but to the south it is much narrower and gorge-like so ice could well have been forced up the Marteg valley. (Ice can, of course, flow uphill on occasion!) It may even have been forced north as well, to join the great ice stream exiting along the Severn Valley. The craggy hill tops could have been exposed, particularly in later periglacial times, when they would have been exposed to freeze-thaw conditions, producing quantities of “head”, comprising debris of all sizes down to small flakes, quantities of which can be found in the ditches alongside the road.

Tony Thorp

Excursion Number 2
Onny Valley

Location
From A49 ,1 mile North of Craven Arms, turn West, this is signposted Cheney Longville, then immediately after crossing the railway line to Church Stretton turn sharp right into the car park. ***(SO430844)*** *This is a SSSI so no hammering.*

The Onny valley is an important geological site as in about 1.75km of riverbank it is possible to see the whole of the Ordovician Caradoc Series from the Hoar Edge Grits to the Onny Shales. The rocks here are recognised as the type area of the Caradoc of the Ordovician Period. The exposures along the walk range from The Hoar Edge grit (the oldest rock in the Caradoc Series) through the Chatwell Sandstone, Alternata Limestone, The Cheney Longville Flags, and the Acton Scott Group. Finally there is the famous unconformity in which the Onny Shales are overlain by the Silurian Hughley (Purple) Shales. This unconformity re-defined Murchison's Lower Silurian as the Ordovician.

A bit on the Geology.

There is a difference in geology between land on the west of the Pontesford-Linley Fault to that on the east. To the west of the fault the Ordovician rock sequence is complete from the Arenig to the middle Caradoc but the transgression of the sea eastward across the Pontesford-Linley Fault did not occur until the beginning of the Caradoc. Therefore there are no older Ordovician rocks in this area, so that these Caradoc rocks rest with a marked unconformity on Pre-cambrian and Cambrian rocks. The sequence of rocks that we find in the Onny valley reflect this. They also represent a shallow water environment with a lot of shelly fauna present.

This is a lovely walk along the river as well as interesting geologically. The trail runs along the line of the old Bishop Castle Railway that once ran from Craven Arms. Please note the grid references are for guidance only.

After a walk of about 1km **(SO42398537)** from the car park you reach the view point on the bank of the river Onny from where the famous Silurian/Ordovician unconformity can be seen. The exposure shows the Onny Shales (Ordovician) which are overlain, unconformably, by the Silurian (Upper Llandovery) Hughley Purple Shales.

The Silurian/Ordovician unconformity in the riverbank. Photo ©Colin Humphrey.

Continue on for a further 220m **(SO42088549)** to the riverside exposures of the Acton Scott Group. These are blocky, brownish- grey silty mudstones weathering orange.

A further 250m **(SO41818567)** takes you to an old river cliff with exposures of the Cheney Longville Flags. These comprise thinly bedded, grey -green, micaceous fine-grained sandstones and mudstones. Thin shell bands occur in some bedding planes and are filled with the straight-shelled, ribbed scaphopod *Tentaculites*.

Tentaculites. Photo ©Colin Humphrey.

Continue for 220m **(SO41718573)** to the old railway cutting. The exposure here shows the *alternata* Limestone. Scattered exposures in greenish brown micaceous sandstones and flagstones and lenticular grey-green shelly-limestones. The latter are packed with the brachiopod *Heterorthis alternata*.

Keep on in the railway cutting for 150m **(SO41488589)** here can be found the highest Chatwell Sandstone, which is greenish brown, well bedded with numerous shell bands.

Heterorthis alternata. Photo ©Colin Humphrey.

After 160m **(SO41328605)** there is a small quarry in typical Chatwell Sandstone. There is 6m of massively bedded, medium grained sandstones exposed with flaggy layers and thin calcareous lenses carrying abundant shells of brachiopods and other fossils. A further 250m you will meet the Chatwell sandstone again in the railway cutting.

Finally after 250m (**SO41168615**) you will reach the quarry in the Longmyndian and Hoar Edge Grit which exposes 22m of Hoar Edge Grit unconformably overlying Western Longmyndian sandstones (Precambrian). The Hoar Edge Grit comprises grey, brown and yellow-brown, medium grained calcareous sandstones, with thin, grey crystalline limestones as well as coarser quartz sandstone.

For further information see the Geologists' Association Guide Number 45.

Michele Becker

Member's Photo

Accumulation of Middle-Ordovician bivalves. From the Llanvirn Series of the Builth-Llandrindod Wells Inlier (470mya). Camnant Ravine, Powys, Wales. Photo ©Richard Becker

Bill's Rocks and Minerals

Fossil Wood :
Mineral or Fossil? (or both?).

Look in almost any reference book on minerals and you will find a listing for Wood Opal. Although commonly known as Fossil wood, it's preferred title in mineral reference books, for obvious reasons, is Wood Opal or Opalised wood. Wood Opal/Fossil wood is in fact a fossil, but because of it's mineral properties most mineral collectors would include it in their collection, as I do, although it is first and foremost a fossil.

Fossil wood.

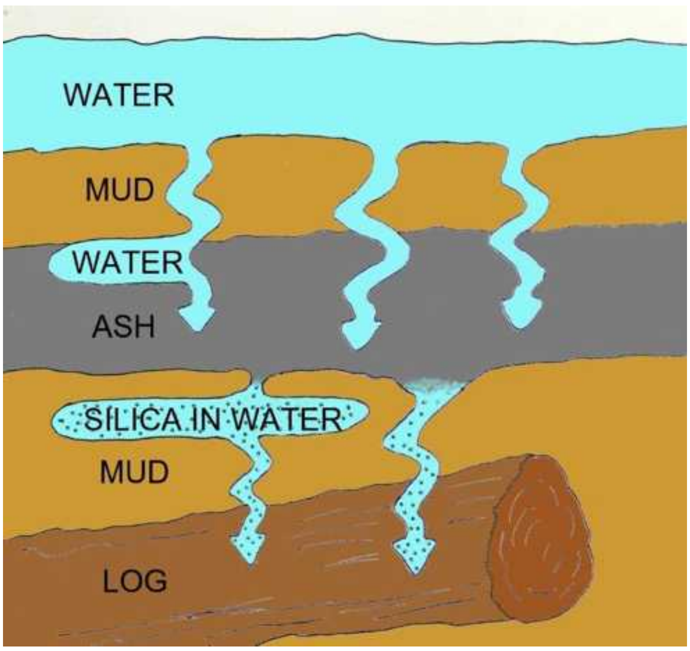
Wood Opal, Opalised Wood, and Fossil Wood are the common names for what in reality should be referred to as petrified wood. Petrification of other organic material is possible, for instance petrified dinosaur bones are not uncommon, but to explore the whole range of petrification in one article is not an option. The agent of petrification is most commonly Silica in the form of Opal or Chalcedony, however, other mediums may also be the agents of petrification, for instance iron oxides, metal sulphides, carbonates, and sulphates. Because the silicates are the most common material, and also because they offer the finest preservation of detail, this article will concentrate on these facts.

Opal and Chalcedony, both silicates, are very similar in appearance to the naked eye, requiring identification in a laboratory. Both are microcrystalline and for this reason they do not have cleavage planes, and fracture conchoidaly. Opal is hydrated silica and has a water content between 6% and 10%, and is less dense and less hard than Chalcedony, but whichever one is the agent of petrification the process is exactly the same.

The formation of petrified wood can only occur if certain conditions are observed, Very simply the conditions are firstly burial by either ash or mud, secondly a source of silica, and thirdly a good supply of groundwater.

Trees may be buried in mud, possibly as the result of a flash flood or a violent storm. or trees may have been transported by rivers into muddy deltas.Volcanic activity can flatten forests and provide volcanic ash which is a source of silica, for instance the Mount St. Helens eruption flattened millions of trees, and also deposited in some places ten inches of ash. Historically there have been much larger volcanic eruptions than Mount St. Helens, so large that even standing trees have been covered by ash. The largest example of complete forest burial (fossilised in situ ecosystem) is to be found on the Greek island of Lesvos.

Several episodes of ash and mud deposits eventually bury the trees at a depth suitable for the mineralization process to begin. The depth needed is relatively shallow, because at too great a depth the trees would be crushed, preventing mineralization. Two conditions are now fulfilled. The trees are buried, and there is a source of silica in the volcanic ash. The final neccesary condition for mineralization is a plentiful supply of ground water. The groundwater is important for several reasons. It reduces oxygen in the sediments inhibiting tissue deterioration. A good illustration of this property is found in peat bogs where even human remains are preserved. The groundwater also acts as an agent for the alteration of the ash, stripping silica ions from the ash as it perculates downwards and finally acting as a medium for the deposition of the silica in the buried trees.



The process of mineralisation.

During the initial stages of mineralisation, amorphous silica infills pits connecting cells, and precipitates on cell walls. As mineralisation continues silica replaces cellulose in cell walls. Cellulose that degrades leaves room for the emplacement of silica between and within cell walls. The more resistant lignin that remains in the cell walls continues to act as a guiding framework to preserve structure. Later silica is deposited in cell lumina (the cavity enclosed by the cell walls), and voids created by wood degradation. Trace minerals carried along with the silica, especially iron oxides add colo ration to the process, highlighting the original structure of the wood. Initially the silica is amorphous and unstable, but over a period of time, perhaps thousands of years, polymerization and water loss transitions the silica to a more stable state, and it acquires a hardness. The buried trees have now been petrified by the process of permineralization.

Petrified Forest, Arizona. Creative Commons.

Over a period of time geological changes, including uplift and erosion, bring the petrified trees to the surface. At this point it is possible to interpret the initial conditions which started the process, perhaps burial in mud, or burial in ash.

Exposed fossil forests, as in Lesvos or Arizona are littered with fossil trees and logs. Smaller pieces which are collected, are usually cut and polished, and then sold as fossil wood or wood opal. Structural details of the original wood may be perfectly preserved, even down to cell structure, and growth rings are usualy pronounced. Fossil wood can be of great interest to either palaeontologists or mineralogists.

Fossil, Mineral, or both?

Bill Bagley

Concretions and how they form.

Before we start, a definition:

We have all come across concretions of various sorts when they fall out of roadside cuttings and quarry faces. However, there are different conventions about the definitions of concretions and nodules, indeed, the words are sometimes used as equivalents. Both are hard masses within softer rock, but nodules are of contrasting minerals, whereas concretions comprise similar grains to the host rock bound together by any of the rock forming cements, such as calcite, silica, or iron carbonate. They tend to be spherical, ovoid, pancake, or bun shaped. Most of the local ones are cemented by calcite or silica.

This *(above)* is from my own stream at Dolfor. I call it a “cow pat” concretion. It is about 250mm diameter, siliceous, very hard, and needs a hefty smack with a club hammer to break it. There are some septarian cracks in it filled with calcite. It has not travelled very far as similar ones occur in the bedrock, some way upstream. The local rock is rather insubstantial thin bedded shale of the Bailey Hill Formation (Bottom Ludlow), far weaker than the concretion.

How concretions form

A typical sedimentary rock consists of particles or grains deposited by water which, during diagenesis, become glued together by a cement. Geological processes go very slowly by laboratory standards, so we are always dealing with the chemistry of saturated solutions. i.e. the solid, crystalline cement holding the grains together is in equilibrium with the pore fluids within the spaces. However, it is not a static system, it is just that the rate at which solute crystallises out of solution equals the rate at which it dissolves.

Concretions can be formed early or late during diagenesis and their formation is all to do with the precipitation and dissolution of the cementing mineral. We will consider the behaviour of calcite (calcium carbonate), which is probably the commonest cementing mineral, in some detail. We are all familiar with this common substance, it is often met in hard water areas as the “fur” deposited on kettle elements. This can be removed by using acid or by swapping kettles with someone in a soft water area where it is redissolved. Whether calcium carbonate deposits, dissolves, or is in balance has preoccupied water engineers for generations and it can be complex. However, in the 1930s Wilfred Langelier developed an empirical formula (still used today) to determine when water is in balance. It depends on pH, alkalinity, calcium concentration, total dissolved solids, and water temperature and is normally used in the form of “look up” tables.

In this formula, pH is the most sensitive control its effect can easily be demonstrated:

Demo:

We take some calcium carbonate, CaCO3 (precipitated from sod. carbonate and barium chloride) and stir it up to produce a milky liquid. Adding dilute hydrochloric acid and stirring, it quickly dissolves. Adding dil. sod. hydroxide, it re-precipitates again. This can be repeated many times. Thus, one can see that $CaCO_3$ is readily dissolved from one spot and recrystallised at another, a process which goes faster if the pH goes up and down..

But why form concretions?

Consider one $CaCO_3$ molecule on, or in, a large crystal surface. It is surrounded by other molecules. Compare it with one on a very small crystal which is sitting on a strongly convex surface, where it has fewer near neighbours and is therefore less strongly attached. Thus, in the equilibrium situation, where molecules are going into and out of solution, small particles are sacrificed in favour of larger ones.

In the absence of any other restraint, spherical bodies would develop so, as an example, a small concretion in a thick bed of mudstone, with nothing to obstruct or distort its growth, would assume a spherical shape; but if (say) it is bounded above and below, it may be restricted to a “penny bun”, a discus, or even a pancake shape. Add some slow pore water movement and it could become Rugby ball, or sausage shaped. Slow flow is important, because, with rapid flow, something quite different occurs.

This is something that water filtration engineers are all too familiar with. A common fault in a poorly maintained rapid sand filter in a hard water area is that, in months, the sand bed becomes solid and impermeable as the silica grains become cemented together by calcium carbonate. This can be very hard and is essentially a "normal" $CaCO_3$ cemented sandstone.

Thus, rapid flow of pore water leads to uniform diagenesis and a "normal" sandstone; whereas, with slow movement, the diagenesis process can proceed to concretions. Eventually, these concretions can of course coalesce to form a uniform hard sandstone.

We found a good example of this in Tan-y-Foel Quarry, near Adfa. The picture shows an exposed bedding plane in the Penstrowed Grits dipping steeply towards the photographer. The bed consists almost entirely of concretions which have nearly coalesced. Given another million years and perhaps this would have become completely homogeneous.

A bedding plane in Adfa Quarry (Photo © Bill Bagley)

Is calcite special?

Yes, however most normal rock forming cementing minerals can form concretions in a similar way, but $CaCO_3$ is probably the commonest. This is because:

1. There is a lot of it in the environment.

2. When it crystallises, it quite likes to assume an acicular form.

3. Sea water is often saturated with $CaCO_3$

4. When organisms die and end up on the sea floor, the decomposition processes involved are complex, with changes to pH and redox potential going up and down, but in general, available oxygen is quickly used up by aerobic organisms converting carbohydrates to CO_2, and O_2. and anaerobic ones continuing with the degradation of fatty material and proteins to smaller molecules, fatty acids, H_2S, methane, ammonia, etc. Within this soup experimentalists have found $CaCO_3$ microcrystals which can become nuclei on which concretions form. So in this way, dead plants and animals can trigger calcite based concretions.

5. Small fossils and shell fragments are commonly dispersed within sediments, providing similar nuclei for crystal growth.

Silicious concretions.

The next most common type of concretion locally is probably silica-cemented. This may be due to the strangely complementary chemistries of $CaCO_3$ and Silica (SiO_2)

$CaCO_3$ is dissolved in acid and precipitated in alkali. Conversely, silica is dissolved in alkali and precipitated in acid.

This may come as a surprise because a glass beaker does not dissolve when strong caustic soda is put in it. But try adding soda solution to finely divided silica – or, more easily these days - to the common drying agent "silica gel". A little heat may be needed to get things moving, but a violent exothermic reaction occurs, producing sodium silicate, or "waterglass". This used to be a common chemical, in every household. -

(Well, it still is, but everything now is proprietary, so although it is no longer used to preserve eggs, it appears as treatment for porous mortar, high temperature cement, etc. A nice "trivia" use I came across was in the U.S., where it was an approved method of scrapping a car for their "scrappage" scheme. Apparently if you put some in the sump and run the engine for two minutes, it is guaranteed never to run again!)

In geology, this complementarity is responsible for some fossils of calcareous animals, like brachiopods, being accurately preserved in silica, often within cherty beds. With changes in the pH of pore waters, calcite can be dissolved and replaced by silica. Similarly, under some conditions, calcareous concretions can be converted accurately into siliceous ones.

This is particularly notable in the case of local cone-in-cone concretions, several of which are siliceous.

Concretion showing cone in cone structure both top and bottom.

These particles are not molecules, but are responding to the impacts of molecules on them which happen at random intervals from random directions. Now, imagine the particles are grains of clay in a saturated solution of calcium carbonate being jiggled about just above the surface of a growing crystal of $CaCO_3$ represented by the bottom of the screen. As they jiggle, there is plenty of space for the (smaller) $CaCO_3$ to nip in and attach to she surface. (OK, for the pedants, the bulk of the $CaCO_3$ may be ionised Ca^{++} and CO_3" but in solution a proportion of ions are associated as $CaCO_3$, so the argument does apply!)

But now, the clay grains are driven upwards, increasing their concentration and reducing their jiggle room, so that eventually there is insufficient space for the clean crystal to grow without incorporating clay within its structure. Hence the stepwise clay layers.

Cone-in-cone (Mechanism of formation)

No really convincing explanation for the structure of cone-in-cone concretions has been published, but one can get a feel for the processes involved by looking at some related processes in a rather generalised way.

In very general terms, the “growth” structure of c-in-c concretions is reminiscent of other “competitive” processes such as crystal or organic growth. If one grows ordinary soda crystals ($Na_2CO_3.10H_2O$) from the bottom of a beaker, in contact with its saturated solution, under still conditions, the form is somewhat similar to c-in-c, as also is the organic competitive growth of plants upwards, with the stronger gaining at the expense of the weaker.

The really puzzling feature of c-in-c is the riffled nature of the “cones” that resemble stacked ice cream cones and the fact that it is replicated at smaller and smaller scales as shown by thin sections. It appears that each “riffle” is a concentration of clayey particles within a mass of cleaner silica grains.

To get a handle on this we need to look at crystal growth at a molecular level. We can't see molecules, but to visualise what is going on, the next best thing is to look at Brownian Motion. This is the random motion seen at high magnification when one looks at any fine particles suspended in a fluid (like pollen in water, or smoke particles). All primary schoolchildren should see this through a proper microscope as it is the only opportunity to (nearly) see molecules in action! The best we can now do is to look at the many examples uploaded on U-tube on the web. Just search for “Brownian Motion” + nanoparticles.

In conclusion: other concretions

This article has concentrated on local concretions. It is a vast field and there are other concretions which don't fit this model, such as the egg-like igneous ones usually in acid rocks and postulated to be produced by convection in a magma chamber working like a cement mixer with moist sand. We must of course also mention the remarkable fossils found within concretions in the Herefordshire Lagerstatten. These occur as calcite infills in a volcanic ash of Wenlock age and have been reconstructed by David Siveter and his team by a series of grinding, imaging and repeat grinding operations, followed by computer reconstruction. In this way 3 dimensional images of many soft bodied animals have been recovered. Several of us were lucky enough to hear David Siveter's talk on this discovery in Shrewsbury, a report of which can be found at;

http://www.shropshiregeology.org.uk/sgspublications/Proceedings/2008%20No_13%20009%20Siveter%20Lagerstatte.pdf

or Proceedings of the Shropshire Geological Society , 13, 58–61.

Concretions of all sizes from that of lead shot to many tons occur worldwide and their origins are various, but always interesting.

Tony Thorp

Exploring the Building Stones of Llanidloes

Stone is an important natural resource and has been used for building from very early on. Skara Brae on Orkney was built of the local Devonian sandstone about 5000 years ago. The UK has a very varied geology which is reflected in the diversity of the built environment, with some areas having a distinctive character due to the type of stone used. An example of this can be seen in the use of Jurassic Inferior Oolite in the buildings of the Cotswolds or the Carboniferous Pennant Sandstones in South Wales. In Wales the rock succession has produced a wide variety of building stone from a cross section of geological time. This can be nicely observed in some important Welsh buildings: Cambrian Caerbwdi Sandstones in St David's Cathedral; Silurian Conway Castle Grit in Conway Castle; Devonian Sandstone in Raglan Castle; Carboniferous "Pennant Blue" in Caerphilly Castle; Triassic Quarella stone in Kidwelly Castle; and boulders from unconsolidated drift deposits in Criccieth Castle.

Stone for early buildings was obtained locally due to difficulty in transportation as stone is heavy and bulky, so boulders from the beach or stone from a local quarry was used, although some early stone, for example Portland Stone, was shipped by river. Once canals and railways had been constructed stone could be brought in from further afield, which allowed the use of a much wider range of building stone. The increase in mechanisation also led to an expansion in the brick industry, as bricks no longer had to be manufactured by hand but could be made on an industrial scale. Buildings now became more ornate and elaborate. In more recent times much stone has been imported into the UK from other parts of the world, and coupled with the development of new building materials has led to the decline of stone quarrying in the UK.

Llanidloes is set in a glacial valley with deep well drained soils derived from alluvium along the valley floor. The underlying bedrock consists of relatively weak, poorly cleaved Silurian mudstones. To the north, south-west and south-east is higher ground consisting of the harder Rhuddnant, Pysgotwr and Penstrowed Grit Formations. Although the local mudstone does not make a good building stone it can be found in the walls of some old buildings, where it was used alongside wood. By 1844 trade in flannel and woollens had markedly increased the prospects of Llanidloes and this was followed by the opening of the Van mines from 1865.

Llanidloes. Photo ©Richard Becker

As wealth increased, the physical appearance of Llanidloes was transformed. Improvements in transport occurred when the Llanidloes and District Railway was completed in 1859. This was connected to the Welshpool to Newtown line in 1861 and in 1864 to a line south to Rhayader and Builth Wells. This allowed stone to be transported from much further afield and is reflected in the changes that can be seen in the buildings. Prosperity led to a remarkable burst of chapel building in the 1870s and a substantial restoration of St. Idloes Church in 1881. St Idloes Church commenced as a wooden building with straw thatch. A stone church then underwent considerable repairs during the reign of Queen Anne, (Hamer 1873) and again about a century later when the south and east walls were taken down and rebuilt. In 1881 the east wall of the chancel was taken down, pavings in the church removed, and slates on the roof replaced. As stone could now be brought in from many parts of the country, it appears that no expense was spared on the replacement materials, although many of the stones from the walls were re-used. The roof slates were replaced by Whitland Abbey slate, a green slate equivalent to Lakeland Green. The colour is due to the presence of lapilli-sized volcanic ash particles converting to chlorite during metamorphosis.

St. Idloes Church. Photo©Richard Becker

The Chancel steps are of Mansfield Stone. This belongs to the Cadeby Formation (old name = Lower Magnesian Limestone) which is Permian in age and includes two sandy, dolomitic limestone varieties known as Red and White Mansfield stone. They are the only building stones from

Nottinghamshire to have achieved any kind of national status. Lithologically they are dolomitic limestones with a high quartz sand content (up to 50%), so very durable. It forms a good freestone. The earliest geological description of the Mansfield Red quarries was provided by Sedgwick in 1829: "*On the east side of the glen, which descends to Mansfield, is a quarry which lays bare a system of beds, about 50 feet thick, of very extraordinary character. The bottom beds are about 20 in number and vary from less than 1 to 3 or 4 feet in thickness; but the planes of separation are extremely irregular, and not continuous. They are of dull red colour, and might, without close examination, be mistaken for New Red Sandstone. The thin beds are much used in building, and the thickest are hewn out into large troughs and cisterns, and in that state are conveyed into all the neighbouring counties"*

The steps to the heating chamber are of York stone, a term applied to any sandstone from the Carboniferous (Millstone grit – Namurian) and/or coal measure (Westphalian) sandstones of Yorkshire. The sandstones from the Millstone Grit Group are likely to be coarser grained and silica cemented, with cross bedding, in contrast to the sandstones of the Pennine Coal Measures Group which are finer grained and micaceous. Other steps in the church generally are Pennant sandstone. Similarly the term "Pennant Sandstone" is used to cover all sandstones quarried from the Carboniferous (coal measures – Westphalian) sandstones of South Wales.

Baptist Chapel. Photo ©Richard Becker.

Stone from the Penstrowed Grits Formation was used for facing the new chancel. The Penstrowed Grits and the Aberystwyth Grits were known as "Blue Stone" by the builders and were often used in conjunction with a pale coloured sandstone for decoration. This combination was used to good effect in those chapels designed by Robert Owen. There are three of these in Llanidloes and you can see that they all are built to a similar style: "Blue Stone" walls with either Grinshill or Cefn Sandstone features at the front of the building, and brick on the other three sides. The three chapels are: the Calvanistic Methodist on China Street, The Baptist Chapel on Shortbridge Street and the Wesleyan on Longbridge Street. Cefn sandstone also forms the front of the town hall on Great Oak Street. The "Blue Stone" used in the Wesleyan Chapel is from the Aberystwyth Grits, whereas that in the Calvanistic Methodist is from the Penstrowed Grits. This information was obtained from building specifications for the chapels, otherwise it would have been difficult to tell them apart. Both formations are Silurian; the Aberystwyth Grits are mid-Llandovery and the Penstrowed Grits are Wenlock in age. Both are the result of turbidity currents which carried a mix of sand and mud, mainly from the south-west, into the Welsh Basin.

The Cefn sandstone originates in north Wales and was quarried at Cefn Mawr near Ruabon. The sandstone is Upper Carboniferous in age and was laid down in a fluvio-deltaic environment. It is a pale, buff coloured, fine-grained stone in which cross bedding is apparent. This differs from the Grinshill sandstone in the buildings which is also pale coloured but is Triassic in age and was laid down in an arid environment. Grinshill stone is interesting because of its durability as a building material and its variation in colour, from white to cream, and through to red. The colour variation is produced by an original film of haematite (iron oxide) which was deposited around each grain under arid conditions. This is preserved in the red sandstones but has been removed, probably by the hot fluids expelled from a Tertiary igneous intrusion (dyke) causing chemical reduction and removal of iron, to produce the white sandstone. One distinguishing feature of the Grinshill stone is the pale veins of silicate minerals running through it. They are harder than the sandstone matrix and therefore stand proud of the surface as the stone weathers. If you look through your hand lens you will find that the grains in the Grinshill stone are well-rounded and have a frosted appearance but the grains in the Cefn stone

Cefn sandstone column on the Town Hall. Photo ©Richard Becker.

are more irregular.

The United Reform Chapel on Short-Bridge Street is set back from the road and has a classical façade dominated by giant columns on high bases. This Chapel was founded in 1824 and rebuilt in 1878 by John Humphries of Swansea. The columns and window frames are composed of Jurassic Box Ground Limestone, a type of Bath Stone, which is a beautiful cream-coloured limestone quarried and mined in the hills south and east of Bath. Bath Stone is a general term covering a group of stones quarried within an area about 10 km across from the west of Bath to Corsham. They have been worked for building stone throughout the last thousand years at least and can still be recognised in many medieval buildings. Bath Stone formed in a warm shallow sea and in places the sea floor was covered in spherical grains of calcium carbonate. Each round fragment or oolith has a microscopic nucleus of a skeletal fragment or pellet around which concentric layers of calcium carbonate have grown. There are usually fragments of shells to be found in the stone. Bath Stone varies in quality depending on where it is quarried. The quality depends on the strength that comes from the crystalline spar cement between the ooliths. This cement is derived partly from the carbonate leached from the shell fragments mixed in with the ooliths, which re-crystallises after it is buried. Box Ground stone is the most durable. If you get up close to the columns of the United Reform Church then you will see both the ooliths and the shelly fragments.

Trace fossils in the wall of Castle House. Photo ©Richard Becker.

After looking at the chapel turn your attention to the wall of Castle House which runs alongside the lawn at the entrance to the chapel. This wall is coursed in a variety of stone. A superb feature of the wall is the trace fossils to be found on some of the stones. These criss-crossing trails are possibly deep water trace fossils of the Nereites ichnofacies -The interpretation is of "*meandering feeding traces on bedding plane surfaces usually found in the abyssal plains and often associated with turbidites and deep pelagic muds. They all display some sort of pattern of meandering or zigzagging across the bottom showing that the animal was systematically mining the sea floor for food and detritus."* (from *Fossilised Behaviour,* Prothero 1998)

Many of us have stood in the queue outside Barclay's bank for the cash machine but how many have noticed that the stone making up the walls is in fact Carboniferous limestone full of fossils including corals, brachiopods, and crinoids? Next time you pass have a look, you may also notice the presence of stylolites. These are the result of a pressure solution front, due to the weight of the overlying rocks, progressing through the limestone bed, collecting up and concentrating insolubles like clay. They appear as a zig-zag pattern when seen in cross-section.

As you wander throughout Llanidloes you will notice that may of the buildings are of brick and terracotta. We shall come to these in the next issue.

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