Farnham Geological Society

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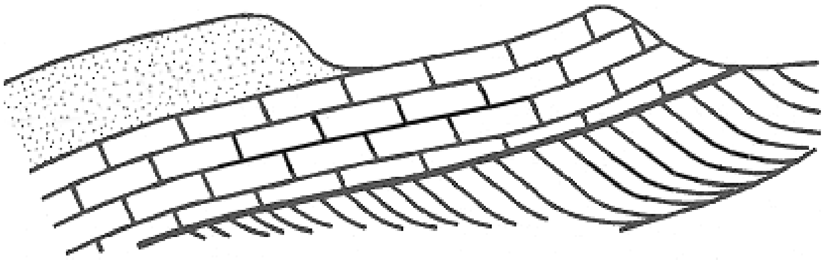
Farnhamia farnhamensis



A local group within the GA

Vol. 12 No.2

Newsletter

June 2009

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Editorial

In the later editions of British Regional Geology there are sections dealing with the economic aspects of geology that are a rich source of information concerning the use of natural deposits. In the London and Thames Valley edition a section headed "*Geology and Man*" has an opening paragraph which neatly summarises the theme of this editorial:-

"*Much of the geology discussed so far in this guide has been concerned with the ancient history of the region, but this chapter deals with aspects of the science that are of crucial importance to our everyday lives. Virtually all fuels and raw materials for industry are obtained, directly or indirectly, from natural deposits, and knowledge of geology is fundamental in mineral prospecting and extraction. Most of the world's drinking water is pumped from rock strata, and an understanding of hydrological processes is essential for the proper utilisation and conservation of groundwater resources. Some knowledge of geological processes and of the physical properties of geological formations is also important for those involved in the construction industry*".

Since the beginning of the Industrial Revolution in this country there has been a dramatic increase in the use of mineral resources and building materials for sustaining the pattern of life which we now take for granted. However, one must not lose sight of the fact that ancient man became very skilled in the manufacture of weapons and tools from material like flint and obsidian and also, in civilisations like Egypt and Meso-America (Olmec. Mayan, Inca) the extraction and fashioning of stone for building important structures was well advanced. There was also from early times the extraction of gems and precious metals for the fashioning of ornaments and the production of salt for flavouring and preservation of food.

It is not possible to cover in the short space of an editorial the history of man's dependence on the earth's treasure trove for developing modern civilisations. If one were to single out one item for further comment it would be the use of stone for building. In the February 2008 edition of this Newsletter you will recall the article written by Barry Eade, supported by a suite of photographs by Graham Williams, on "The Origin and Development of

Stone Structures in Britain". It is well worth re-reading this article to trace the development from short stone walls to standing stones by early Britons to the expertise of the Romans in stone working, followed by the Normans and Mediaeval architects.

Peter Cotton

Remaining programme of lectures 2009

Date	Speaker	Title
12th June	Alun Lewis Royal Holloway College	Perils of Science Journalism
10th July	Members evening	
11th September	Dr Donny Hutton Consultant	Dolerite emplacement and continental breakup: the Theron Mountains, Antarctica
9th October	James Ford	Brick Making and Chalk Mining Hazards in Reading
13th November	Dr Julian Murton Sussex University	Ice Age England
11th December	Paul Olver	The Star of Bethlehem

Field excursions June to October 2009

Date	Field trip	Leader
June 7	**Avebury to Swindon**	Dr Graham Williams and Mike Rubra
June 19	**Evening walk - Shere**	Dr Graham Williams
July 5	**Farringdon & Abingdon**	Dr Graham Williams
Aug 30 – Sep 5	**Aberdeen & The Grampians**	Donald Milne
Oct 4	**Watership Down**	Dr Graham Williams and Mike Rubra

June 7th, Sunday – Avebury to Swindon - led by **Mike Rubra and Graham Williams**

Mike will lead us through the enigmatic stories behind the East Kennet, Silbury Hill and Avebury Circle Neolithic structures. The huge Avebury Circle stones are Sarsens - we will examine the complex processes that led to their formation. Old quarries and railway cuttings near Swindon expose another famous building stone - Portland Limestone. The sequence includes late Jurassic sandstone and limestone beds, rich in fossils.

June 19th, Friday – Shere: mid-Summer's eve walk - led by **Dr Graham Williams**

This evening walk will circle Shere to see how the Lower Greensand - Gault - Upper Greensand - Chalk sequence affects the landscape; there is even a rare Bargate Stone outcrop. We will see some of Shere's 15th to 18th centuries buildings, terminating in the White Horse two bay timber framed open hall house, built around 1450, to examine some important ales!!

July 5th, Sunday – Farringdon & Abingdon - led by **Dr Graham Williams**

See the world-famous Farringdon Sponge gravels of the Lower Greensand (age equivalent to our Bargates). The rocks were deposited in a valley in the sea floor during a storm and contain superbly preserved fossils including the sponges, ammonites, echinoids, brachiopods and bryozoa; dinosaur and plesiosaur remains have been found, derived from Jurassic sediments. Many of the fossils are rare and are named after the quarry and the local town.

Then to Dry Sandford nature reserve near Abingdon where an old quarry exposes richly fossiliferous Corallian Beds (M Oxfordian 140my ago). The sediments were deposited in shallow coastal waters close to coral reefs. The succession includes the Lower Calcareous Grit, Trigonia Beds, and the Urchin Marl and Coral Rag of the Osmington Oolite Fm, with brachiopods, ammonites and corals.

August 30th to Sept 5th – Aberdeen and the Grampians led by **Donald Milne**

Don is an old colleague of mine and can be best described as a true Scottish gentleman. Don has worked all his life in the oil industry, primarily with BP, and is now a respected consultant and a very good friend. We will see some internationally famous sections; we plan:

- Highland Boundary Fault and Highland Boundary Series at Stonehaven; Devonian Old Red Sandstone conglomerates and volcanics south of Stonehaven.
- Metamorphics (the classic Barrovian zones) and granites along the Stonehaven to Aberdeen coast section.
- Granite and Gabbro around Aberdeen;
- Devonian Rhynie Chert;
- Permo-Trias of Morayshire;
- Aberdeen's oil industry, ideally a visit to BP or other company to view a data cave in action. Also to see offshore supply vessels, drilling equipment etc.
- Archaeological and historic sites around Aberdeen.

October 4th, Sunday – Watership Down - led by **Mike Rubra and Graham Williams**

This walk follows some of the adventures described in Richard Adams' book of the same name. The sequence is Cretaceous, and there is also an extremely fossiliferous London Clay exposure nearby. We will see the effect of the rocks on the landscape, and how various Roman structures also were influenced by the landscape.

I hope this programme will provide something of interest for everybody - interesting places, beautiful countryside and seascapes, wild life and plants, ancient and modern rocks, building stones and archaeology. Please contact me if you wish to join any of the trips.

Graham Williams

FGS's photo album site

Liz Aston has been very busy setting up a FGS photo album site on the world wide web. This will allow many more detailed pictures of the Society's field trips to be made available than could otherwise be contained in a typical Newsletter article. To get the album off the ground, Liz has uploaded to the site a comprehensive set of photos covering last year's trips to Brittany and the Lizard.

The photo album site can be accessed at: http://picasaweb.google.co.uk/fgsfieldtrips . After accessing the website, left click on album of interest, then left click ***Slideshow*** (located above top left hand image) to automatically view the pictures - the timings of the slideshow can be changed at the bottom of the screen. [Note: If you lose the address given above, the photo album can also be accessed by left-clicking on the link which can now be found near the top of the *Field Trips* page of the FGS website.]

The field notes that accompany each picture can be viewed by placing your cursor over the thumbnail view of the photos in any particular album - general notes can be viewed down the right hand edge of the thumbnail page. The photo album is very versatile, and is worth getting to grips with all its capabilities. It is hoped that most if not all future field trips will be featured in this way.

The album will only flourish if members come forward with an offer of help in providing Liz with a set of photos and their descriptives – so please bear this in mind when going on any future field trip. Our thanks go to Liz for getting this feature up and running, and to the members who provided the pictures and words for the first two albums.

Michael Weaver

How the turtle got its shell

Fossilised remains of the most ancient turtle yet discovered are helping scientists to unravel the Kiplingesque puzzle of how the animal grew its shell. Only the underside of the turtle is covered by a fully formed protective shell, giving researchers an invaluable glimpse into how it evolved.

The discovery of *Odontochelys* semi*testacea* - "half-shelled turtle with teeth" - is being hailed as the long - sought missing link between turtles that have full shells and their shell-less ancestors. Three fossilised specimens dug up near Guanling in the southern Chinese province of Guizhou have been dated at 220 million years old and the species has been identified as the ancestor of all other known turtles.

Fossils from the dig have now enabled researchers to discount the theory that the shell originally formed from bony plates, like those on a crocodile, which expanded and fused together. An international team has concluded that the rival theory that the shell was created when backbones and ribs spread out and joined up to form a hard bony cover is likely to be correct.

Xiao-chun Wu, a palaeontologist at the Canadian Museum of Nature in Ottawa and a member of the research team, said: "Since the 1800s, there have been many hypotheses about the origin of the turtle shell. Now we have these fossils of the earliest known turtle. They support the theory that the shell would have formed from below as extensions of the backbone and ribs, rather than as bony plates from the skin as others have theorised."

Olivier Rieppel, of the Field Museum, in Chicago, added: "This is the first turtle with an incomplete shell. It's difficult to explain how it evolved without an intermediate example."

Because the shell was incomplete the researchers were able to conclude that the shell on the underside of turtles, the plastron, developed before the upper section, the carapace.

All three specimens were found last year and were described as "remarkably intact". Among the features never before seen in turtles were the rows of stumpy teeth on both jaws. The turtle would have had a pointed snout and the researchers, who reported their findings in the journal *Nature,* are confident that it could swim. They said that the development of armour on the underside suggested an aquatic lifestyle because it would have offered protection from being attacked from below. The discovery of fossilised marine reptiles and invertebrates close to the three turtles also indicated that the species lived by the sea or in river deltas.

Odontochelys is ten million years older than *Proganochelys,* which was found in Germany and had a complete shell. It is 55 million years older than another primitive turtle, *Eileanchelys waldmani,* which was discovered on the Isle of Skye and was announced only a week ago in a scientific journal as likely to have been the earliest aquatic turtle.

Lewis Smith, Environment Reporter - The Times, Thursday 7 November 2008

London Building Stone – a historical perspective

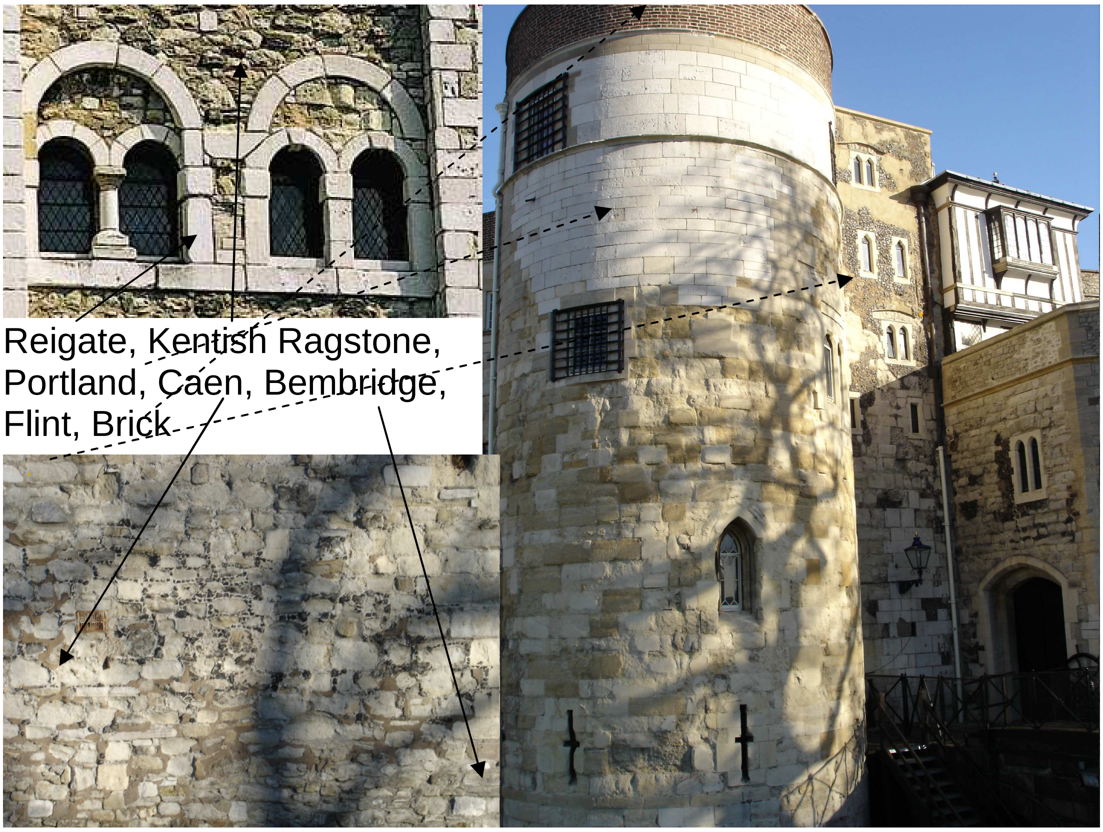
Summary of January lecture given by John Williams, Member FGS

One only has to visit Southwark Cathedral and look at in situ remains preserved at the east end of the cathedral to view the variety of building stones employed in the history of building with stone in London. Remains of the Lady Chapel, and elements of the Roman Road, a priory and pottery kiln are now featured in public displays

In looking at a map of the Geology of London it will be found that there is no significant source of building stone available in the area. The nearest source is Chalk of the Chilterns and North Downs but the chalk, if sufficiently hard, is rather inaccessible as it would need to be brought overland. The Romans used the Rivers Medway and Thames for transport and brought suitable stone from the Greensand beds around Maidstone. consisting of sands and sandy limestones (The sandy beds known as Hassock and the limestones - Ragstone) The Greensand is a marine deposit including glauconite and has a high silica content making it very hard to dress. The Romans were aware of the beauty of “Purbeck Marble” (a polished freshwater limestone from the Isle of Purbeck) and used it extensively for decorative purposes.

From the onset of building with stone in London the availability of transport has determined what stone would be used. Until the canals and railways arrived, sea and river were the main means of transporting raw stone to the city. A limited amount of stone was brought overland from the Reigate area but it had to be transported by cart over the North Downs

The Saxon used local materials such as flint, pudding stone, chalk and Sarsen stone in their ecclesiastical buildings but it was the arrival of the Normans in 1066 and their comprehensive building programme of castles and then cathedrals that introduced French masons and so Caen Limestone to the area. Local stone such as Taynton Stone from the western end of the Thames valley was also introduced.



In Medieval times Reigate stone (Upper Greensand mines owned by the Crown) and stone from the Jurassic beds of Oxfordshire was used extensively.

In 1619 Inigo Jones Surveyor to Charles 1 used a white oolitic limestone from the Isle of Portland for the Banqueting House in Whitehall. This was transported from cliffside quarries on the island, around the Kentish coast and up the Thames. Forty seven years later Christopher Wren, the next Surveyor, used Portland stone in his rebuild of the city of London after the Great Fire and so laid down the pattern of stone that we see today, a Portland Stone building resting on a Southwestern England granite base. The granites of Aberdeenshire were also starting to be used.

The Victorian age brought along canals and railways and the ability to transport stone over land, it also coincided with a desire to rebuild buildings in the “Gothic fashion” and to decorate the interior of churches and mansions. Great swathes of Central London were re-developed including the area from The Mall to Oxford Circus. In the suburbs houses were being built to accommodate the every increasing population.

Stone was brought from around the country, in particular Welsh and Lake District Slate was used to roof most of the new dwellings whilst ‘exotic’ granites and marbles were imported to enhance the interior of the great houses. Roads were developing with granite setts and kerb stones edged Korkstone pavement slabs. Local granites were being used but were being exhausted so large imports of Scandinavian granites came via Aberdeen and were given names such as “Imperial” or “Balmoral” to imply a British origin; some local marbles were used but the majority came from Carara in Italy. Exteriors were mainly of Portland stone with some exceptions - Magnesian Limestone was brought from quarries in Yorkshire to rebuild the Houses of Parliament.

This set the pattern until after the second World War when by the Sixties major rebuilding was being carried out. Stone could now be brought from around the world and stone from South Africa, South America and subsequently India was being used. British quarries had by this time been worked out or were restricted by the increasing objections of the environmental lobby.

Today a stroll along any City street will probably take in Chinese Granite setts, with Indian sandstone paving slabs, alongside buildings of South American cladding doorways floored with Travertine (from Tivoli north of Rome or Turkey) and the interiors decorated with Chinese or Korean panels. You will pass pre-War pubs with exteriors of Norwegian Larvikite, and bars with serving areas topped by “look alike” Shap or Dartmoor granite. The only local materials are likely to be the occasional Portland limestone building and, if in the City of London, Yorkstone paving.

John Williams

Role of geoscience in serious crime investigations

Abstract of March 2009 lecture given by Dr Duncan Pirrie, Helford Geoscience LLP

Geology and botany can be used as part of an overall forensic strategy in the investigation of serious crime, particularly in murder enquiries. There are two main areas in which geology is used; search and location and trace evidence enquiries. Search and location investigations aim to remotely locate (ie without excavation) areas where an object, or objects have been concealed. This might include clandestine grave sites, weapons or drug stashes etc. This type of search and location predominantly use shallow geophysical techniques, although geochemical methods can also be used. Once a target has been identified, it is the role of the forensic archaeologist to lead the excavation. Trace evidence enquiries commonly fall into two groups; (a) where rocks or ceramics have been used as weapons or during the disposal of objects, and (b) using soils and sediments to identify whether or not an individual has been at a particular place.

A common principal of forensic science is that "every contact leaves a trace". The geology of the UK is highly variable and consequently soils in the UK are very distinctive. There are a number of different analytical techniques which can be used in the analysis of soils, but we have pioneered the use of automated scanning electron microscopy in forensic geoscience. Automated mineral analysis allows us to analyse thousands of particles in a single sample allowing very detailed characterisation of the samples. Examples of forensic case work will be presented. In the UK there are a small number of geologists who carry out forensic work either on behalf of the prosecution or defence; it is not a role for the faint hearted.

Duncan Pirrie

The physics behind Polonium-210

Abstract of May 2009 lecture given by Prof. Paddy Reagan, Dept. of Physics, University of Surrey

In late 2006 the world became acutely aware of the mysterious substance polonium-210 in the notorious fatal poisoning of former Russian spy Alexander Litvinenko – but what is polonium-210, how is it made, what does it do and how is it harmful? Paddy Regan, Professor of nuclear physics at the University of Surrey, UK revealed that, in addition to the more macabre uses, this isotope is of major fundamental significance, not least in explaining why there is a limit to the stable elements which occur in nature. He discussed polonium-210 in a historical context with a story which included famous names in physics from the past including Marie Curie and Ernest Rutherford. Finally, he described how one might use sub-atomic gamma-ray and alpha spectroscopic techniques developed for fundamental nuclear structure physics research to detect this substance to avoid smuggling such material in the future.

Paddy Reagan

D-Day: a brief summary of events as seen on the FGS visit October 2008

As we left Granville and crossed the Cotentin Peninsular we were all aware that we were coming to the sixty miles of Normandy's coastline where the Allied invasion that was to free Western Europe from German occupation had started.

The landing areas (Figure 1) were chosen carefully, using expertise from many disciplines. Air cover, a nearby port, over-beach supply and access to good road systems were important; ideally the beaches would not be too heavily defended but should be defensible. The coast between the River Orne in the east and Cotentin in the west was chosen although it had no port. After Dieppe it had been recognised that the capture of an intact major port was impossible; the Allies would bring theirs with them.

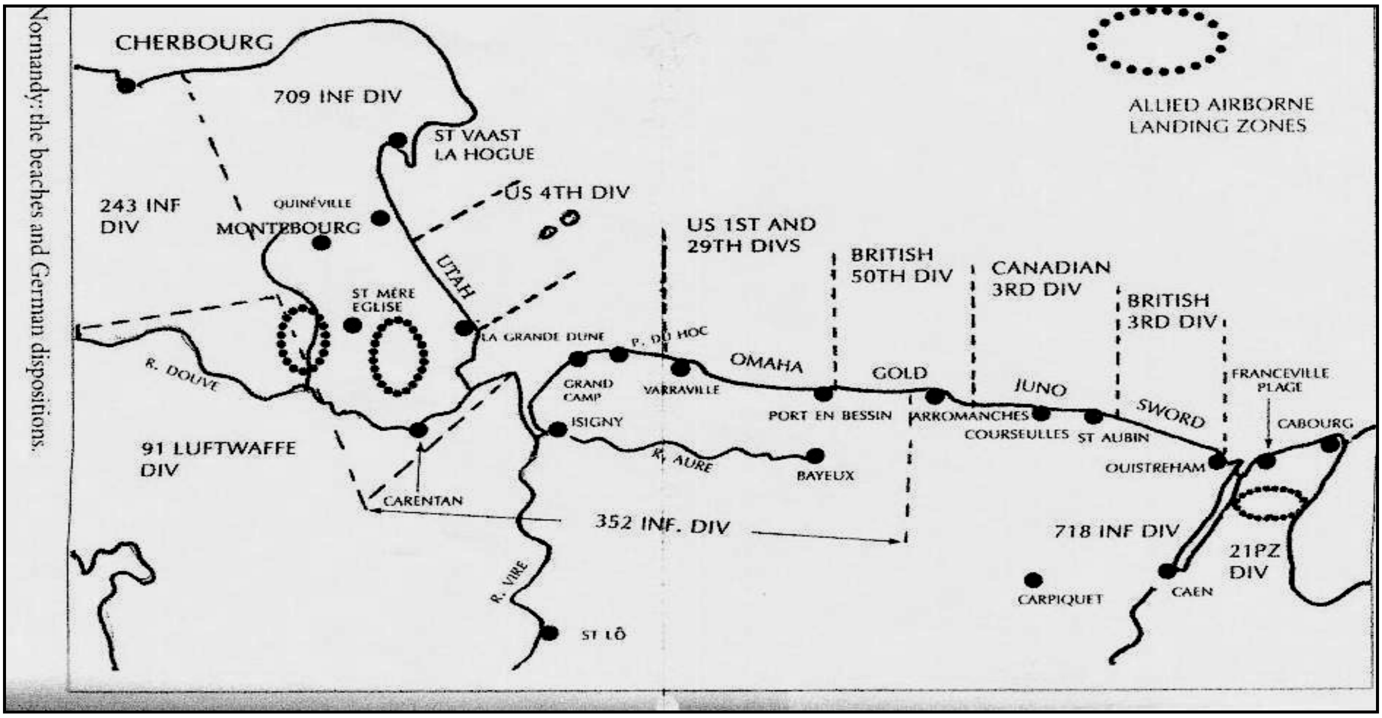


Fig 1: The Normandy invasion beaches (*Buckingham 2004*)

Apart from the Divisions garrisoning the defences there was a Luftwaffe Division, an infantry Brigade and 21 Panzer Division all within a few miles. Two more Panzer were an hour or so away, two more and a Panzer grenadier Division perhaps 150 miles way. Speed in establishing the beachheads would be critical.

In the very early morning of June 6th 1944, 20000 American, Canadian and British airborne soldiers landed at each end of this stretch of coastline to protect the flanks of the main forces, secure the critical landward side of the beaches and prevent German reinforcement. Graham Williams showed us, from a hill near Monfreville in the west and near the River Dives in the east, that this difficult countryside had few landmarks to guide the pilots except coast and the rivers (Due to operational losses and on-going bomber requirements there was a shortage of navigators and equipment). As the Americans crossed the coast they ran into low cloud and heavy flaq, many pilots became disoriented, losing formation and height. In the east the British and Canadians too ran into cloud and flaq and fared little better. Because of these problems many of the pathfinder groups, tasked with marking out landing and dropping zones for the main airborne forces following behind, were badly out of position, had dropped into rivers and marsh or had been lost. Without their "zone markers" many of the main forces also became widely scattered and many men and much crucial equipment was lost.

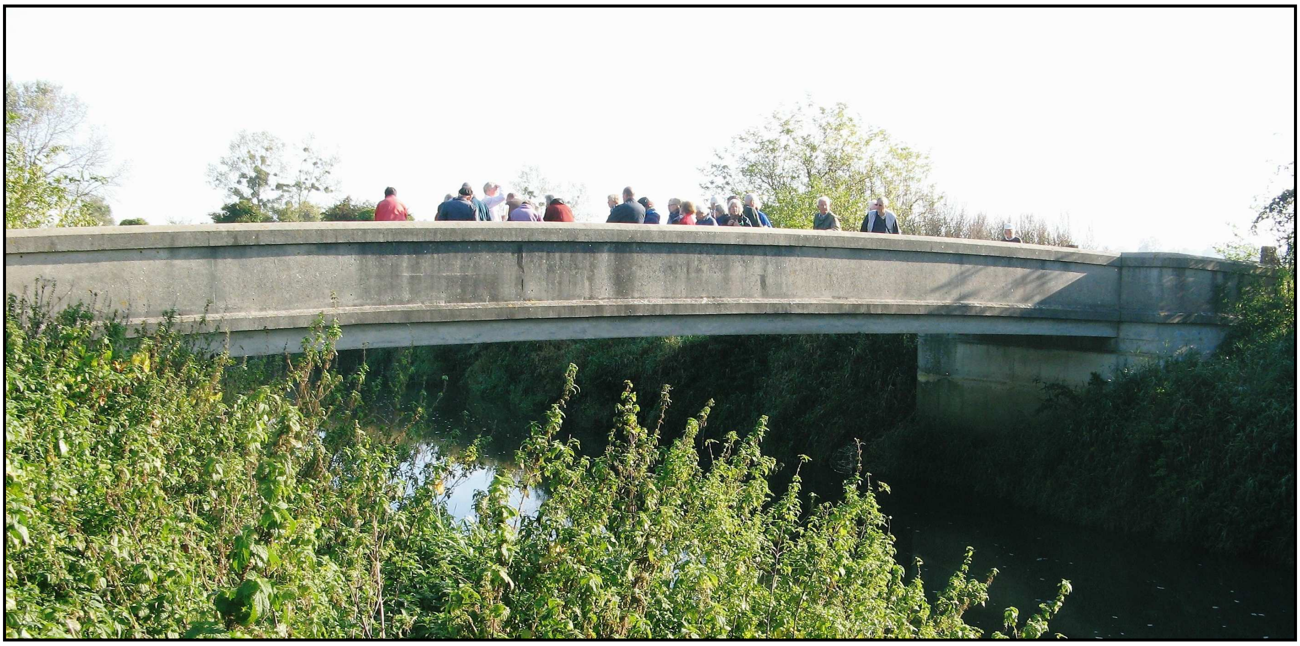


Fig 2: FGS members on Capt. Juckes Bridge over the R. Dives (replacing the original).

Fig 3: The replacement Pegasus Bridge over the Orne canal

Fig 4. Gondree Cafe, the first place to be liberated on D-Day.

Many failed to reach their rally points, or were late and designated tasks had to be carried out by seriously under-strength and under-equipped teams. Remarkably, despite the poor delivery, all the Canadian and British objectives were completed on time albeit sadly with heavy losses. We saw for ourselves the fiercely contested Merville Battery captured in the Airborne operation, where the expected four 150mm guns had been replaced by old 100mm Skoda howitzers. We also visited two of the five Dives and Bures bridges, including Juckes Bridge (Figure 2), which were destroyed by the airborne. With considerably more accuracy than many other of the insertions that night the glider and parachute landings to capture the Orne canal and river bridges (now known as the Pegasus and Horsa bridges), Figures 3 & 4, were a total success, preventing German reinforcements while keeping a route open, the story well illustrated in the impressive Airborne museum by Pegasus bridge.

The American airborne deliveries were even more widely scattered and here too many men and much essential equipment was lost in the flooded and marshy land. As in the east many targets were attacked with severely depleted and under-equipped forces but, as the main forces landed, most of the bridges and critical batteries had been destroyed, although a major crossroads at St Mere Eglise and the Douve Bridge remained as threats. The crucial landward exits from Utah were secured.

While the airborne were securing the east and west flanks of the 60 mile invasion front some 250 minesweepers were clearing routes to the landing areas while warships were manoeuvring into position for their dawn bombardment of the Atlantic Wall, battleships attacking batteries and strong points while cruisers and destroyers saturated beach defences, continuing the bombardments of the air-forces.

We saw the results of these attacks at Longues-sur-Mer, a Kriegsmarine battery of four 152mm guns that threatened Omaha, Gold and the intended site of Mulberry B. Here an understanding of the strength and design of the defences facing the Allies was again brought home to us. Despite bombing and the shells of a battleship and four cruisers (to Navy chaps that is 12 x 12" plus 34 x 6" guns) all having a go throughout the day the battery continued to shell the beaches at Colville and Aznelles and ships off shore until finally, in the evening, it fell silent, the gunners surrendering to the British the next day.

As the landing craft approached the shores US Rangers landed and climbed the cliff at Point du Hoc using fire service ladders mounted on DUKW amphibians and rocket launched grapnels to attack a battery of six 155mm guns that threatened the Utah and Omaha landings. With the Navy's guns keeping back the defenders, the Rangers reached the cliff tops, but with heavy losses, only to find that the battery "guns" were dummies. Five of the guns were found in an orchard and disabled but the Rangers were driven back and several times almost overwhelmed, with many more losses. Their relief did not get through until the 8th when the Germans, fearing encirclement, withdrew. The five landing areas between the Cotentin Peninsular and the River Orne were codenamed, from west to east, Utah, Omaha, Gold, Juno and Sword with the US 1st, 4th and 29th Divisions on Utah and Omaha, the British 50th and 3rd on Gold and Sword, the Canadian 3rd Division on Juno, Rangers and RM Commandos landing with the main forces and attacking special targets, a total of nearly 250000 soldiers (see sketch map).

Although there is not room to discuss this here, there is a popularly held idea, and one perpetuated by the film industry, that all the landing areas except Omaha were relatively easy, a days hard fighting securing all D-Day's objectives. But the reports, books and documentaries I have seen tell a very different story.

In this 60 mile stretch of Normandy's coast there were about 75 assorted field defences and 19 artillery batteries, with Ouistreham and Caen very heavily defended. All the beach landings were tough and there were casualties, although Utah, perhaps because the lighter defences were attacked more successfully, was a lot easier. All the Allies lost some of their "swimming" Sherman DD and special beach clearing tanks to gunfire and the rough seas although the losses at Omaha were frighteningly high as crews tried to counter cross currents and were swamped. The tanks were needed to assist the infantry over the beaches, their loss was serious. As the landing craft neared the beaches and as the infantry disembarked, ships and men became targets from defences largely left intact despite the heavy bombing and naval shelling. At Utah the landing drifted 2000 yards south of target, fortunately to a lightly defended section whereas at Omaha many craft, taken east by a tidal current landed opposite one of the most heavily defended access points on that beach with disastrous results.

Marshall Rommel had ordered a programme to upgrade the Normandy Atlantic Wall. The defences facing the British and Canadians in the east had virtually been completed, those at Juno and Sword probably the strongest in the whole sixty miles. The batteries all had long range and their arcs of engagement gave overlap along the whole coast. All the seafront villages along this coast had formed a part of the defences, streets were barricaded and houses strengthened into strong points. Seawalls hampered the tanks on the beaches and the only way through these villages was by house-to-house fighting. Our hotel at St Aubin-sur-Mer was on Juno and we could see across to Sword, the Orne and Ouistreham, a vast length of beach, then heavily defended, but with no cover.

Fig 5. Remnants of Mulberry B at Arromanche-les-Bains

Very few of the main force objectives were completed until the morning of June 9th, the capture of Caen, a Day 1 target, was not achieved until Julyl9th. But despite these difficulties the programme continued. On the afternoon of D-Day the convoy of components for the two Mulberry Harbours A and B left England, assembly starting the next day offshore at Vierville-sur-Mer (Omaha, A) and Arromanche-les-Bains (Gold, B) with both operational by the 18th. A violent storm wrecked Mulberry A, and components from it were used to repair B - "Arromanche Port Winston". It is said that this harbour landed 2.5 million men, 500000 vehicles and 4 million tons of supplies in its 100 days of service. (US troops also used the beach at Utah). As a monument to its design we could still see many elements of the port on the beaches and in the sea at Arromanche (Figure 5).

Air cover was vital as the invasion moved inland but fighters were reaching the limit of their range from England. On the loess plateau at Ste Croix-sur-Mer behind Gold we visited the site of an airstrip, one of several, that was operational by June 11th, using "runways" of mesh and hessian. RM Commando had only captured Port-en-Bessin (Gold) on the 7th after very stiff resistance, but by the 14th it was a supply port and by the 25th a terminal for fuel from tankers offshore. Air cover had been safeguarded and the Panzer threat could be met.

D-Day had been a remarkable achievement against one of the best, most professional and well-equipped armies there was, in strong and well-prepared positions. But losses had been high.

A secure and continuous defended base had been established along this long stretch of Normandy Coast, supply ports, pipelines and airfields were in place. Now it was time for the next formations to continue the task.

Further reading and sources:-
Stuart Hills: By tank into Normandy. 2003 Cassell.
William Buckingham: D-Day, the first 72 hours. 2004 Tempus.
Yves Lecouturier: The Beaches of the D-Day Landings. 1999 Editions Quest-France. Major and Mrs Holt, Normandy Landing Beaches. Battlefield Guide. 2004 Leo Cooper.

Mike Rubra

Snowdonia, North Wales – A brief geological history of volcanism

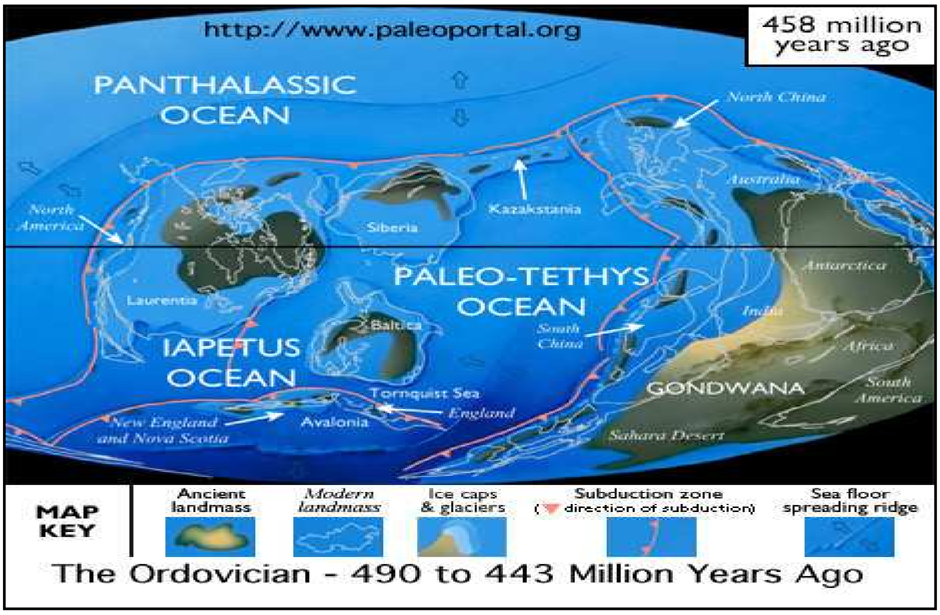
An accord of the geological history of Snowdonia National Park in North Wales necessarily warrants a basic understanding of global tectonics that positioned the Snowdonian region near to the centre of the British Isles during Ordovician times (Map 1). It was at this time in Earth history that extremely mobile and complex plate tectonic movements led to island landmasses known as Laurasia and Avalonia impacting each other (Fig 1). This resulting major collision zone let to extremes of volcanic outgassing that lasted for ~8 million years, during which time periodic effusive and explosive activity in North Wales was at its most intense. The events of this period were encapsulated by the stage name 'Caradoc' fashioned by Sir Roderick Murchison in 1834, who later became President of the Geological Society of London and the Royal Geographical Society simultaneously.

The Ordovician System

Caradoc (the king of Welsh border tribesman) was a time division by Murchison (1792-1871) when, (after Murchison's death) Sir Charles Lapworth (1842-1920) proposed the formation of an Ordovician System in 1879 ('Ordovicies' a Welsh border tribe). The system was inserted between the then Cambrian ('Cambria' Latin for Wales) named by Prof Adam Sedgwick (1785-1873), and the Silurian ('Siluri' another Welsh border tribe) named by Murchison following their collaborative works on rock formations based upon a type section in the Arenig-Bala district of Merioneth in 1820-34. Considerable stratigraphic and palaeontological data had been collated hitherto by Murchison and Sedgwick, and later research by Professors' Hicks (1875), Ramsey (1881) and Bonney (1882), and in the early 20th century, and by Groom (1902), Elles (Ordovician fossils -1909), Jones & Pugh (Snowdonian volcanics -1916), and Cox et al

(Snowdonian structures -1930). A consolidation of these works by Lapworth et al (1879) ultimately led to a time division of British Ordovician successions.

Fig 1



At a symposium in Aberystwyth in 1969 the Ordovician System was re-classified with new data added (Skevington 1969). Murchison's Caradoc Group was incorporated and use of the term 'Bala' as a time stratigraphic division was ostensibly dropped for reasons of a time gap found to exist in the succession. The system was re-correlated again in 1976 (Williams) following the outcome of increasingly new findings (Table 1). Further studies on the Snowdonian trilobites by Whittington (1964), who later become a pivotal palaeontologist in 're-classifying' fossils of the now fêted Burgess Shale, Williams (1969), an acknowledged researcher on Ordovician stratigraphy, Howells (1970) of Liverpool University who is 'the' authority on Caradocian volcanics, and Olver (1975) a highly revered life-member of this Society who contrasts in a (unpublished) doctoral thesis, the ancient volcanics of North Wales to that of modern eruptive volcanism and styles in southern Italy.

Table 1

Caradocian Succession (duration 10ma)

(After Stevenson 1971)

(Ordovician) CARADOC (458-448 Ma)		
	ONNIAN	Cadnant shales 115-140m
	ACTONIAN	
	MARSHBROOK	
	LONGVILLIAN	Calcitised tuffs = attenuated Crafnant VF
	SOUDLEYAN	Coetmor ashes 220m – U Brecciated lavas 200m = Capel Curig VF
	HARNAGIAN	Bodlondeb ashes 20m - Lower banded rhyolites 427m
	COSTONIAN	Purple & grey slates

Prior to deposition of the Caradocian successions, much dynamic tectonic activity in the north of Europe had commenced much earlier during Precambrian times (~600 Ma) when continental collision and crustal disruption led to uplift in vast coastal regions thereby initiating an elongated mountain chain (cordillera) known as the Caledonian (Celtic) Orogeny.

Tectonic History

The Caledonian mountain building phase formed much of the central highlands of Scotland and the high peaks and uplands of Norway, Sweden, NW Newfoundland and the (depleted) Appalachians belt of NE America . It is now a widely held view as a result of British structural research, that a broad ocean designated 'Iapetus' once bisected the British Isles during the early-Ordovician (Fig 2). Closure of this ocean was first indicated by the disappearance of shelly faunas *(Brachiopoda, Arthropoda, Mollusca)* from northern (Avalonian) and southern (Laurasian) oceanic margins by late Ordovician times (~440 Ma). The period was marked by dominant igneous and metamorphic activity indicative of wide scale subduction to the SE and the onset of a phase of orogenic activity that gave rise to formation of the Cambrian Mountains in North Wales. While ocean closure (suturing) continued at the start of the Ordovician (~500 Ma) due to oblique NE-NW subduction, it was sustained well into late-Ordovician times. However an orogenic belt similar to that of the Caledonian cordillera, indeed compared with Himalaya today, never fully developed.

Major rifting and uplift during the Caledonian orogeny had an affect of 'reworking' the late Precambrian sediments in most parts of Wales (McLeish 1986). The swiftly advancing Avalonian micro-continent continued to cross the equator (towards Laurasia) during late- Cambrian times and a tectonic setting of oceanic island arcs was in the process of being created. Subduction of Iapetus beneath the northern margins of Avalonia led to a complex back-arc shelf development of deep and shallow marine basins in North Wales as the landmasses closed on each other (Fig 2). The end of this period was delimited by a worldwide mass extinction event evidenced from abrupt faunal absences (in the fossil record) that resulted in devastation of marine ecosystems as suturing continued along the fault line. Ongoing tectonic dynamics led to eustatic sea changes and polar ice caps developed in the northern latitudes of the supercontinent of Gondwana (Fig 1).

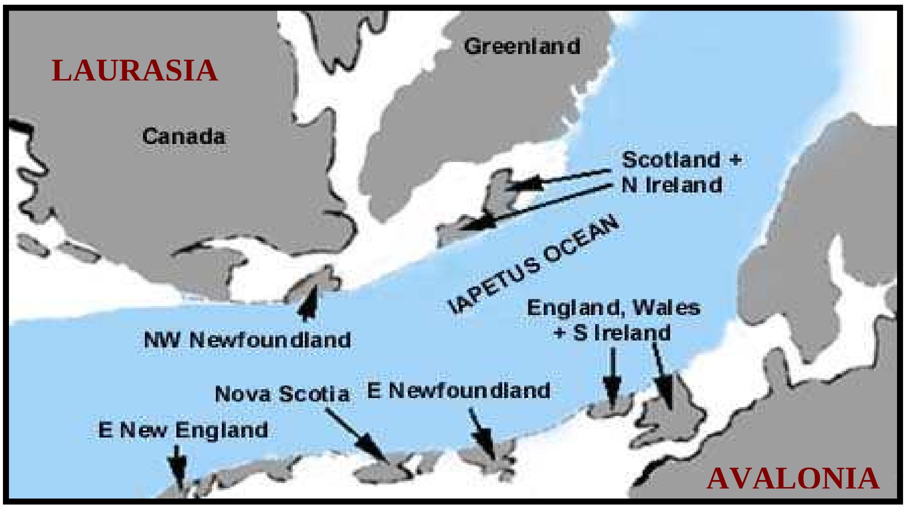


Fig 2: Iapetus Closure

The Caradocian Series.

When Prof Charles Lapworth (1879) erected the first Ordovician system it comprised two divisions only; the place names 'Arenig' and 'Bala' in deference to Sedgwick's work in 1862. Murchison's Llandeilo and Caradoc Groups he created himself and later encouraged Hicks (1881) to propose inclusion of the Llanvirn (Williams et al 1976). The Ordovician was thus divided into five stages based on shelly faunas and the volcanic successions to which the Caradoc and Ashgill epochs were taken to be equivalent of the Bala Series (Skevington 1969 – Table 1). As a result of these proposed changes the Caradocian (volcanic) rocks were divided into three general areas of outcrop; **1)** The volcanic rocks ringing the Harlech Dome to the west, **2)** the volcanic belt extending from Conway in the north through Snowdonia to the Lleyn Peninsula, and **3)** the thinner volcanic deposits of NE Wales trending towards Llangollan and the borderlands.

Volcanic Activity in Snowdonia.

RHYOLITIC DOME
Fig 3a: Castle Peak, Montserrat (1990)

BASALTIC VOLCANISM
Fig 3b: Mt Etna (Nov 2002)

Fig 3: Bi-model Illustrations of Volcanism

The Snowdon Volcanic Centre of North Wales comprised bimodel basalt-subalkaline associations resulting in basaltic lavas, rhyolitic pyroclastic flow and surge deposits, high-level intrusions and domes as illustrated by contemporary bimodel comparisons illustrated in Fig 3. During the Lower Ordovician volcanoes erupted from a number of centres in the county of Gwynedd and later more were identified to the south and east of the region contained within the Snowdon and the Dolwydellan districts (Howells 1970).

The areas close to Conwy in the north, and Capel Curig in the south and east of Snowdonia were the earliest volcanic centres to become active, erupting tuffs, ignimbrites and rhyolitic lavas from localised vents simultaneously. Ignimbrites, the product of extremely explosive nuée ardentes, now referred to as pyroclasts (surges and fall deposits), were characterised by volatile emissions of tephra (volcanic debris) and high incandescent ash clouds. Tephra materials emanate from deep degassing and explosions at the top of silica-rich magma chambers. Volcanic 'bombs' and large deposits of vesicular pumice and vent-scoured ashes were strewn over wide areas blasted out by volatile explosions, to be quickly followed by atmospheric cooling. Intense outgassing and crustal instability led to wide scale faulting and rapid deflation (collapse) of the volcanic piles. Mount Snowdon (1,085m), is the highest peak in Britain (south of the Scottish border), identified now as a remnant rim of a denuded caldera wall (collapsed crater). Vesicular pumice fragments were minutely fractured into flattened glassy cuspidate/angular tuffaceous shards called sillars - initially named by Oliver (1954) in fieldwork on the contemporaneous Borrowdale Volcanics (Lake District) who discerned their origins as originating from silica-rich rapidly cooled pumice fractionations.

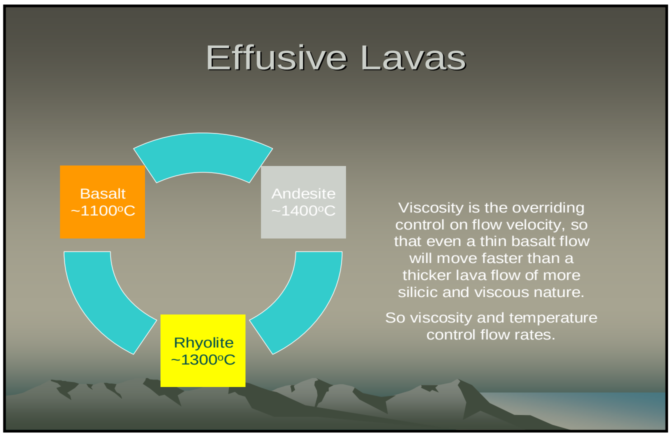


Fig 4

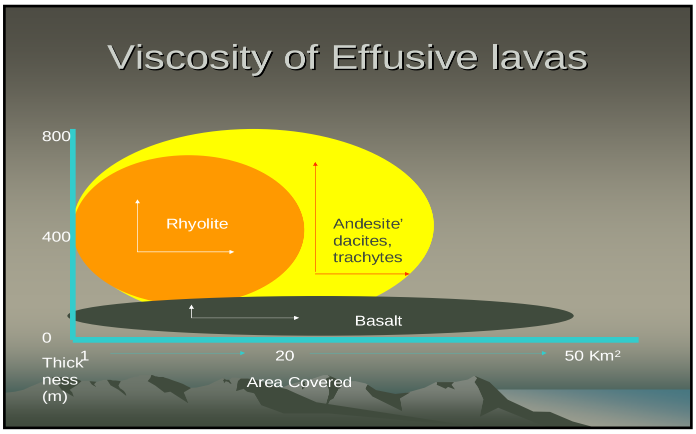


Fig 6

Sillars (a type of tuff) were thus found to be abundant and widely dispersed throughout the Snowdonia region. On closer examination sillar particles were found to be bonded together (welded tuff) indicative of intense heat and atmospheric/water cooling. Air blown crystals (separated from lavas) intermixed with ash similarly were found to form solidified crystal tuff/s - highly weathered ancient volcanic deposits, viz: Snowdonia, do not equate well with modern fresh volcanic products. Near-shore (beach/deltaic) and off-shore (shallow marine) phreatic eruptions (groundwater assimilation) resulted in deposits of glassy materials (crystalline basalts/spilites), together with submarine magmatic oozing and quenching formed distinctive so-called pillows. Pillow lavas are laid down under water from rapid cooling of magma characterised by these archetypal submarine formations. On land Vulcanian and Strombolian eruptive styles led to temperature controlled phased subaerial deposits of alkali-rich and subalkaline (acidic) lavas accompanied by thin effusive viscous lavas and rhyolitic sills, dykes and diapirs intruded beneath the volcanic masses (Howells 1970).

Lava Type Development

It is the long-term dynamic history during Caradoc times that led to magmatic mixing, temperature changes and viscosity ranges that comprise the variety of volcanic rocks found in Snowdonia today (Fig 4). Violent periodic outgassing initiated temperature ranges at over ~1400°C giving rise to elevated formations of cones and columns. This was followed by slow outpourings of sticky viscous lavas with diverse mineral compositions, which as the lavas solidified formed andesitic, trachyitic and rhyolitic lithic structures such as domes, necks and plugs (Fig 5). Welded tuff formations and pyroclastic breccias and agglomerates, some forming the base of individual ignimbrite cooling units developed curious 'pods' of so-called nodular rhyolites and other ancient topographic features (craters, lava plateaus and domes) . Hence the geomorphology and (seemingly) sculpted landscape in this part of North Wales accounts for its distinctive scenery.

Today Snowdonia represents an accumulation of ancient remnant weathered and eroded volcanic debris which is sometimes difficult to differentiate in highly faulted terrain. Ice-age retreat symptomatic of glacial scouring characterises the sweeping u-shaped valleys, rounded domes and frost-plucked angular peaks in a spectacular deflated mountain range first formed over 450 million years ago during the Caradocian stage of the late-Ordovician.

Source References:
In order to save newsletter space source references will be given on request.

John Gahan

Flint

Summary of February 2009 lecture given by Diana Smith, Open University

To most of us living in Southern England, flint is the humble pebble seen lying in our gardens, forming terraces along the river valleys and rattling in the surf on the beaches. We tend to pay it little attention but in an entertaining lecture Diana Smith showed us that flint deserves a bit more respect.

Mankind has made use of flint since the Stone Age. Indeed, for many archaeologists, flint is THE stone of the Stone Age when early hominids discovered that with careful striking, nodules of flint could be made to split into thin, but sharp flakes. Although the working of flint diminished as mankind progressed into the following metal ages, it saw a revival with the introduction of flintlock firearms. These made use of flint's property of producing sparks when struck by steel to ignite the charge in the weapon's barrel. This ensured that flint was still being worked into modern times and Diana was able to make use of old photographs of flint knappers at work to illustrate the techniques involved.

Flint suitable for working has to be freshly mined as weathered flint, found on the ground surface, does not have the same splitting characteristic that makes flint so useful. This was appreciated by Stone Age people who were prepared to dig deep into the ground to secure the best stone. Diana showed us some illustrations of Neolithic mining operations, including Grime's Graves, that had been excavated by archaeologists.

Grime's Graves are a series of mounds and hollows in Norfolk named in Anglo Saxon times after Grim, the Norse pagan god. Excavations by archaeologists have revealed around 400 open cast pits some 9 metres deep that were dug into the Chalk in the Neolithic and early Bronze Age. At the base of each pit tunnels radiated out following a band of distinctive dark flint which these pioneer miners extracted. Estimates of the quantity of flint won from the ground show that this was one of the first truly industrial sites in Europe.

In the knapping process, fresh flint is first struck by a hard hammer stone to break off a slim flake. This act often produces a flat area, where the impact took place, called the plane of percussion. The flake separates from the main block along a surface, roughly perpendicular to the plane of percussion, with a conchoidal fracture known as a bulb of percussion. The presence of these planes and bulbs of percussion enables archaeologists to distinguish worn manmade artefacts from natural pebbles. The flake is then trimmed to shape using a softer hammer such as a deer antler. Final edge trimming is achieved by pressing a bone tool against the edge of the flake to snap off thin slivers leaving behind a razor sharp edge.

Demand for gunflints has greatly diminished now and the modern use for flint is largely for building purposes. It can be seen in medieval buildings where, in the absence of more suitable rocks, flint was used to fill out a wall between quoins of more expensive materials. Today, flint tends to be restricted to more decorative purposes.

For us as geologists, the most important part of Diana's presentation was her description of the nature and origin of flint. Flint is one of a number of varieties of silica lacking large crystal structure that includes: opal; chalcedony; chert; and flint.

Opal is a hydrated form of silica that, while being truly amorphous, consists of sub-microscopic spheres, called lepispheres. It is light reflecting off the regular stacking of these spheres that gives rise to the play of colours seen in precious opal. The water content is usually between 5% and 10% percent but can be as much as 20%.

Chalcedony is the group name for the cryptocrystalline varieties where minute needles of quartz are bound together into a compact mass containing sub-microscopic pores. Normally, chalcedony is white to grey but other colours occur depending upon the presence of trace elements. Agate is a variety of chalcedony in which an assortment of colours is arranged in bands.

Chert and flint are sub-varieties of chalcedony that are characterised by being opaque and dark coloured. The darkness of the colour is based upon the fine microcrystalline nature of the mineral that absorbs, rather than reflects, light falling upon its surface. Variations in the colours are based upon the trace element content. Water content is low, perhaps less than 2%. Both chert and flint are usually found as replacement products of other rocks but over time the distinction between the two terms has become somewhat blurred. Diana stressed that the term flint should be restricted to cherts that have come from the Chalk rocks of the Upper Cretaceous epoch. These have the distinction of their pores interconnecting that allows fluids to pass through them.

Despite man's long association with flint it was only in the 1980s that the processes forming flint were determined by examining the detailed structure and chemistry of paramoudras. These are hollow, cylindrical masses of flint, up to half a meter in diameter and over a metre long found in a vertical position in the Upper Chalk of Norfolk. They are believed to represent the remains of animal burrows (*Thalassinoides*) and burrowing is the key element. It introduces organic matter into the calcareous sediment that is attacked aerobically by bacteria.

By the time the organic matter is buried to a depth of five to ten metres by later sediment, the bacteria have exhausted the oxygen and anaerobic decay commences. This produces hydrogen sulphide gas as a waste product that diffuses out from the burrow site into the surrounding sediment. It eventually reaches parts of the sediment where oxygen levels are high enough to oxidise the gas into water and sulphur dioxide; an acidic mixture. The site of this chemical change is called the redox point (from reduction/oxidation). The acid dissolves the surrounding calcareous sediment and into the resulting void cryptocrystalline silica, derived from dissolved sponge spicules, precipitates.

The presence of organic matter is crucial to the start of the process and that is why fossils are often found inside flint nodules. However, flint also occurs as layers parallel to bedding planes and usually these can be seen to coincide with hard-ground layers. These are areas of the sea floor sediment that were exposed to the water column after lithification and were extensively burrowed by bottom dwelling organisms. These introduced the necessary organic material into the sediment layer prior to subsequent reburial. While these layers of flint are conspicuous in a chalk cliff they are of limited use for stratigraphical purposes as they are discontinuous over distance. Instead, Diana told us that marl layers (chalk layers high in bentonite clay minerals derived from volcanoes associated with the opening of the Atlantic Ocean) were used as marker horizons by stratigraphers.

The worldwide occurrence of flint closely follows the presence of the Upper Cretaceous chalk rock. In North West Europe two provinces of flint type are recognised with the boundary between the two situated around Norfolk. In the southern province (Kent and Northern France) the flints are in the form of rounded black nodules. In the Northern Province (England north of the Wash) the flint forms tabular grey masses. In Norfolk, in a transition zone between the two provinces, tabular black flints are found and these were what the miners at Grimes Graves were seeking. The variation in flint type probably reflects conditions on the sea floor at the time of deposition. Repeated layers of flints have been linked to climate variations driven by Milankovitch cycles.

When a flint nodule is extracted from its chalk matrix its core is dark in colour but there is a thin white surface layer present called the cortex. This is not a layer of encrusting chalk. It is part of the flint itself that is undergoing dehydration and structural change. This loss of water is facilitated by the interconnecting pores between the silica needles. Continued exposure to the atmosphere sees the production of the familiar reddy-brown colour in the core.

Peter Wood

The Geology of London

Summary of October 2009 lecture given by Diana Clements, The Natural History Museum, London

The siting and building of London is profoundly influenced by the geology. London's origins began with the retreat of the Anglian Ice Sheet some 400,000 years ago which pushed the Thames southwards to more or less its present course through the middle of the London Basin syncline. The Chalk ridges of the Chilterns to the north and the North Downs to the south define the edge of the basin. Early geologists understood this structure and were sinking boreholes to extract water from underlying strata by the end of the18th century.

During the 19th century a number of quarries were opened up within the London Basin providing Londoners with building materials and other necessities. Thus the Thanet Sand was exploited at Charlton for foundry sands for the Woolwich Arsenal and for the manufacture of glass bottles. Elsewhere it was used for building purposes. Along the Colne at Harefield and in large quarries in East London, where Chalk is found at or near the surface, large Chalk quarries were developed, primarily to provide vast quantities of cement required for the expanding metropolis. Earlier, Chalk had been dug from underground mines at Pinner, Chislehurst and in the Plumstead area. This was used for agricultural lime and for mixing with clay to make bricks. In the case of Pinner the clay was from the Reading Beds but elsewhere it was from the London Clay.

From about 1830-1860 many tunnels were constructed as part of the new rail network. On the north side of the Thames London Clay spoil was spread on the fields to weather before being mixed with chalk, sand and ash to make bricks. The Claygate Member at the top of the London Clay is a better brick clay and was dug from the small inliers where it occurs, for example on Hampstead Heath. But the 'Brick Earth', a fine clay which is a wind-blown loess from the retreat of the glaciers, is the most suitable as it already contains particles from the Chalk. This is found in pockets overlying the gravels all along the Thames and its tributaries and has been exploited since Roman times.

Thames Gravels have been an important component in the development of London. The need for water was paramount. In the first instance this would have come from the Thames and its tributaries (mostly now the 'lost rivers' of London) but early development also relied on water extracted from the gravels, either at a spring line or from shallow wells. And of course they have been, and still are, used extensively for construction purposes. Gravels in the London Area are divided into two distinct groups. The older gravels are described as 'Pre-Anglian' and mark out the course of the Thames and its tributaries before the great Anglian glaciation which came as far south as Finchley and Hornchurch, whilst the younger gravels form terraces on either side of the present route of the Thames. The oldest gravels are at the top of the staircase with the youngest at the bottom; clay bands within each 'step' have given researchers insight into the flora and fauna of the interglacials and allowed correlation of successive ice advances and retreats with cores from the north sea.

These days the only quarries in the London area that are still in operation are the gravel quarries and these are very few and far between. To examine fresh surfaces geologists have to go outside the London area to where the same lithology is well-displayed for example the London Clay at Sheppey and the Thanet Sand at Herne Bay and Pegwell Bay. Many of the old quarries are now landfill, parks or housing or industrial estates. Occasionally important historical sections have been designated Sites of Special Scientific Interest (SSSIs) for research purposes such as the contact with the Chalk and Lambeth Group at Harefield, the Lambeth Group and Blackheath Beds at Charlton and several important Quaternary sites in East London. Elsewhere there are problems with access (such as Elmstead Rock Pit SSSI where a good section of Blackheath Beds can only be seen in a private garden) otherwise, there is little to be seen in normal circumstances. At Abbey Wood SSSI there is an annual dig where shelly sands of Blackheath age are extracted with the main purpose of finding fragments of early fossil mammals, but it is back-filled and for the rest of year there is nothing much to see. Many of the old Chalk Pits are decaying rapidly as buddleah and other shrubs take hold on the faces. The Rose and Crown pit near Purley, Croydon is an exception. The City of London City Commons department is actively conserving this old pit, partly with the use of goats and also by installing steps up a scree slope adjacent to the main face so that students and researchers have access to the strata. At Chafford Hundred new town, Essex Wildlife Trust are doing a very good job in conserving important geological features. But these locations will only remain good as long as there is a commitment to conservation. There is a great demand for good local exposures, not only for students and researchers but, increasingly, for geotechnical engineers who are responsible for tunnelling under London or constructing tall buildings. Whilst our knowledge of the underground geology increases with the plethora of boreholes and tunnels for big engineering projects in recent years, we are in grave danger of losing the geological exposures at the surface. Let's hope the new Greater London Authority plan for the Geodiversity of London will help to remedy the present situation.

Diana Clements

Valuable fossil bed rediscovered

One of the world's most valuable fossil beds has been rediscovered, having been forgotten during Victorian times. Fossils recovered near Christian Malford in Wiltshire caused a sensation when they were unearthed in 1840 because they were the first to include the flesh of Jurassic wildlife.

Phil Wilby, of the British Geological Survey, has now rediscovered the site and led the first dig there in more than 150 years. He hopes that freshly recovered fossils can help to explain why tens of thousands of animals died simultaneously in episodes repeated many times over about a million years.

Fossil hunters and academics flocked to the area in the 1840s and 1850s to dig out extraordinarily well-preserved specimens of fish and squidlike creatures. But despite its importance as an extremely rare source of fossilised soft tissues preserved along with hard bones and shells, the location of the site was lost.

None of the Victorians who visited the site, even leading researchers from universities and museums, recorded the precise place and, when digging ended, the location was forgotten.

The fossil bed was rediscovered after detective work by Dr Wilby, who realised that palaeontologists had been searching in the wrong places.

Lewis Smith, Environment Reporter, The Times, Friday 20 October 2008

FGS Lunch

This year's lunch is to be held at The Pierrepoint Hotel, Frensham, on **Sunday 1 November**. Please make a note of the date in your diaries; details to follow at a later date.